

Suiform Soundings

Newsletter of the IUCN / SSC Wild Pig,
Peccary and Hippo Specialist Groups

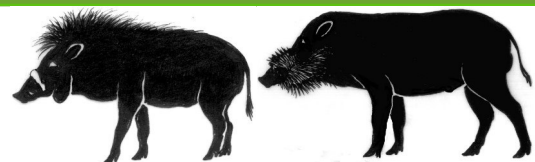
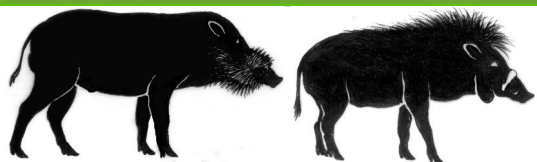


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Common hippopotamus (*Hippopotamus amphibius*). Photo taken by Andrew Plumtre.

Please email all contributions to future issues to Thiemo Braasch, email: salvanius@gmail.com. Articles, photos and comments are welcome and appreciated. **Please follow the guidelines for authors**, which can be found on the website listed above.



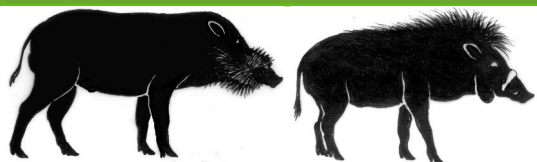
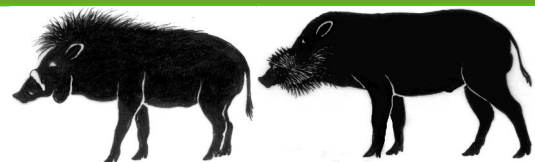


Table of Contents



EDITORIAL by *Thiemo Braasch* 4

Conservation of the common hippopotamus in Virunga National Park, eastern Democratic Republic of Congo by *D. Kujirakwinja, P. Shamavu et al.* 5

River crossing and migration of the Bearded pig (*Sus barbatus*) in Central Sarawak, Borneo by *Jayasilan MohdAzlan, Melynda Cheok Ka Yi et al.* 11

First observations on Moluccan Babirusa (*Babyrusa babirusa*). A translation from a recently rediscovered 1770 book that describes the Babirusa on Buru Island by *Emily Mae Meijaard, Erik Meijaard et al.* 16

Babirusa (*Babyrusa babirusa*) on Buru island by *Bing Tjiu and Alastair A Macdonald* 20

Global collaboration to conserve three threatened Indonesian animal taxa: Babirusa, Anoa and Banteng by *Kristin Leus, Jeff Holland et al.* 27

The 100th Pygmy Hog is released into the wild by *Ananda Banerjee* 32

A sighting of giant forest hog, *Hylochoerus meinertzhageni* Thomas, in the Mara National Reserve, Kenya by *Mark R Stanley Price* 35

Wild boar on the rise! 11th International Symposium on Wild Boar and other Suids by *E. Johanna Rode-Margono* 37

Mesoamerica's white-lipped peccaries on the brink of extinction by *Wildlife Conservation Society* 42

Chacoan Peccary *Catagonus wagneri* conservation strategy by *Mariana Altrichter, Arnaud Desbiez et al.* 44

Predicting the current distribution of the Chacoan peccary (*Catagonus wagneri*) in the Gran Chaco by *Katia Maria Paschoaletto Micchi de Barros Ferraz, Cintia Camila Silva Angelier et al.* 53

A vortex population viability analysis model for the Chacoan peccary (*Catagonus wagneri*) by *Kristin Leus, Mariana Altrichter et al.* 64

The use of white-lipped peccary (*Tayassu pecari*) vocalizations as welfare indicator by *Selene Siqueira da Cunha Nogueira, Zara Lacerda et al* 77

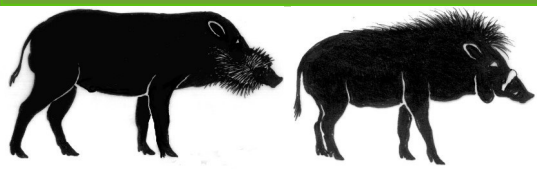
On specimens of extant warthogs (*Phacochoerus*) from the Horn of Africa with unusual basicranial morphology: rare variants of *Ph. africanus* or hybrids between *Ph. africanus* and *Ph. aethiopicus*? by *Antoine Souron* 86

NEW LITERATURE ON SUIFORMES 93

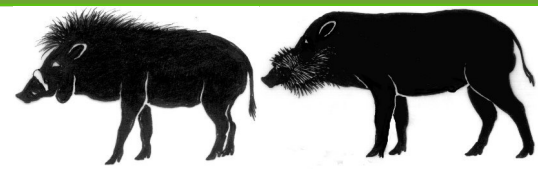
NEW BOOKS 138

ARTICLES IN THE NEWS 140





Editorial



From the Chief Editor

Dear reader,

I am glad to present this issue of Suiform Soundings. It shows the biodiversity of Suiforms including hippos, pigs of the old world like babirusas, the tiny Pygmy hog and bearded pig in Asia, Giant Forest hogs and warthogs in Africa and peccaries Mesoamerica and South America (in this issue three articles about the least known peccary species, the Chacoan peccary and two about White-lipped peccaries).



I still remember the event, which raised my interest in species conservation and my fascination about wild pigs: I visited Zurich Zoo in Switzerland as a child in the 1980 and had the chance to observe Pygmy hogs there. They were the last of this species in captivity out of India. Having seen them I wanted to know more about this species, the threatened species of the Ganges floodplains, and in general about wild pigs and species conservation. If you see photos of them (for example in this issue) you will understand, why they have become one of my favourite animal species.

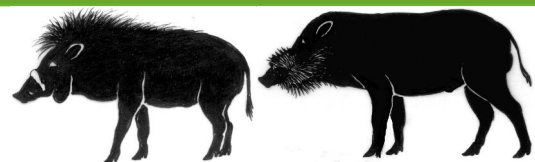
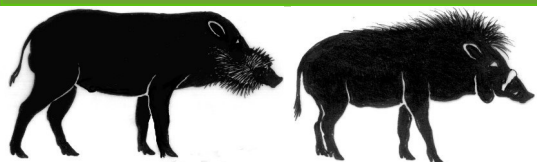
While doing the editorial work and the layout for Suiform Soundings I am always surprised, that there are still lots of gaps in the knowledge of such big mammals. There are no photos just drawings of the Mindoro warty pig and pigs of the Southern Philippines still await scientific description. The taxonomy of different populations of the well known Eurasian wild boar is still in debate. Nevertheless, there is progress for some species. For example, the Bawean warty pig was taken back from oblivion and the scientific knowledge about it has increased during the last years (see previous issues of Suiform Soundings). If you look at the conservation status of Suiforms it is a troubling view: some populations of Eurasian wild boars are rising (as mentioned in one article in this issue) while other species like Javan warty pigs, Pygmy hogs or Chacoan peccaries are on the brink of extinction. But there is hope: passionate people are working hard against all odds to save these and many other species (see articles about Pygmy hogs and Chacoan peccaries in this issue). If I read about their work and their successes I get hope that Suiforms will get a chance in the 21st century.

Thanks to the authors for their contributions to this issue, the reviewers and the editorial team who all made it possible to publish it. I hope you enjoy reading the articles as much as I had preparing this issue.

With warm regards,

Thiemo Braasch





Conservation of the common hippopotamus in Virunga National Park, eastern Democratic Republic of Congo

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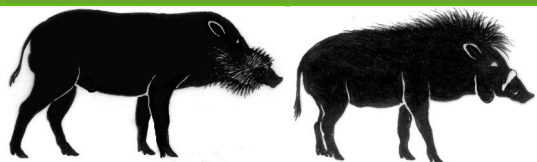


Hippopotamuses and African buffaloes (in the background) in Virunga National Park. Photo: D. Kujirakwinja

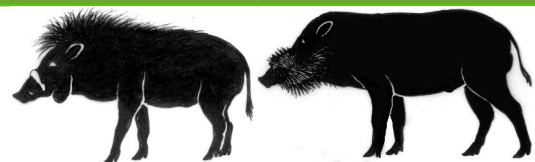
Introduction

Biodiversity conservation in eastern Democratic Republic of Congo (DRC) is threatened by armed strife and limited resources to support field interventions (Kujirakwinja 2010; Inogwabini 2014). Armed conflicts in DRC, that have lasted for more than three decades, have had considerable negative impacts on key large mammals and ecosystems (Cuvelier et al. 2013). Large mammal numbers have declined in most forests and protected areas in DRC and their habitats invaded by local communities for agriculture and pasture (Inogwabini 2014; Tranquilli et al. 2014). For example, Plumptre et al. (2016) found that Grauer's gorilla has declined across its range by nearly 80 % in the past 20 years as a result of insecurity and bush meat hunting.





Ecology and Conservation



Common hippopotamuses are still thought to be widespread in their distribution across Africa while bigger changes have been happening within their ranges leading to a decline in population numbers (Lewison & Olivier 2008). Virunga National Park is one of the oldest national parks in Africa (created in 1925) and one of the five world heritage sites (WHS) in DRC (Akeley 1931; Languy & de Merode 2006). It is known to be one of the most biodiverse conservation areas in Africa with a variety of diverse habitats that harbor different emblematic and keystone species (Plumptre et al. 2006). The park is threatened by social-political and human related economic activities, illegally conducted to respond to local, national and regional demands: eg. charcoal, bushmeat, fish, etc. (Kujirakwinja 2010; Kujirakwinja et al. 2010). The Virunga National Park, part of the Albertine Rift, was known to support the largest population of hippopotamus in the early 1970s, but their numbers have declined and their distribution has changed (Languy & de Merode 2006). For example, while the Rwindi and Rutshuru rivers supported large populations in the 1970s, recent surveys show a dramatic decline in these habitats (Delvingt 1974; Mackie 1991; Kujirakwinja 2010). The major contributing factor to these changes have been armed and traditional poaching and the invasion of some suitable habitats either for farming, pasture or human settlements (Kujirakwinja 2010; Inogwabini 2014).

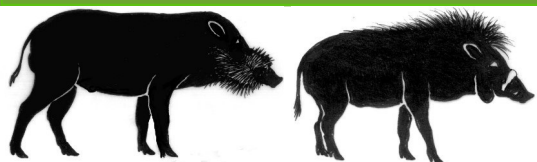
Hippopotamus surveys in Virunga National Park

This paper presents a summary of the changes in hippopotamus numbers in the Virunga National Park from the 1950s to 2014. Large mammal surveys have been carried out in the Virunga National Park since the early 1950s using aerial survey methods for hippopotamus, elephant, buffalos and antelopes (Delvingt 1974; Mackie 1991; Languy et al. 1994; Kujirakwinja et al. 2006). Although aerial surveys is one of the recommended methods for counting and monitoring large hippos, correction factors are required for animals that are under the water and missed when the plane flies over. Ground counts can be used to calculate correction factors (Norton-Griffiths 1978; Mackie 1991; Jachmann 2001). To ensure that data are comparable between years, the same areas (six subunits) were surveyed using similar methods up to 2003 (Delvingt 1974; Mankoto 1989; Mackie 1991; Languy et al. 1994; Hillman et al. 2003). These methods were improved in 2009, through a Masters' research project, and found that aerial counts using correction factors on short transects underestimate hippo populations (Kujirakwinja 2010). The study demonstrated the importance of ground/water-based counts as a better way of obtaining better estimates by producing correction factors but also combining results from both surveys. The correction factor¹ generated from previous studies had used short transects for ground count from different sectors. The 2009 study used both methods (aerial and ground counts) over a long distance within a sector to generate the average correction factor for different parts of the park, and aimed to survey most of the lake shore of Lake Edward where many of the hippo pods occur. Therefore, using the average correction factor from the 2009 study for example (see Kujirakwinja 2010), it was found that previous counts (2003) were probably underestimated by 30 %. Therefore the study recommended that ground counts should be used to not only produce correction factors but also to improve on the accuracy of estimates by minimizing aerial count biases (Caughley 1974; Caughley et al. 1976; Jachmann 2002a).

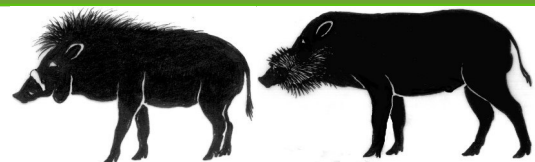
A survey was conducted in 2013 using the 2009 method and showed a stable situation for hippo with a slight increase in numbers. Another aerial survey was conducted in 2015 together with ground/water-based counts. The results presented here were generated from the ground/Water-based counts. We used total ground counts for hippos both on the lake and along the rivers.



¹The correction factor (CF) is a ratio of individual seen from ground counts and aerial counts in a given habitat. The CF is then applied to aerial count results.



Ecology and Conservation



Hippopotamus individuals were counted either from the river bank or a boat (about 20-40m distance) by at least two observers who made counts (Jachmann 2001). Each observer counted the pod and results were shared between both observers. If they didn't get the same numbers, then they repeated the count until the same number of animals was obtained. This was repeated for each pod of hippos (Jachmann 2001).

Results and Discussion

Results from the 2015 counts estimated the current hippo population to be about 2,400 in Virunga National Park (Table 1). The southern coast of Lake Edward had the largest number of pods (groups) while River Ishasha had the largest pod sizes. About 46 % of hippos counted were in the River Ishasha which runs along the border between D.R. Congo and Uganda.

Tab. 1. Number of individuals, groups and group size in Virunga National Park in December 2015 by sector of the park

Sectors	Number of individuals	Numbers of groups	Maximum group size	Minimum group size
Lake Edward South	812	63	46	1
Lake Edward North	392	43	46	1
River Ishasha	1096	56	77	1
River Semuliki	106	15	22	1
Total	2406	177		

A comparison of total estimates for the hippo population throughout time show the main decline in the population but a slight increase in the recent past between 2013 and 2015 (Fig. 1).

The numbers of hippos have changed depending on their location in the park. Hippos have increased in River Ishasha considerably (Fig. 2), while hippos on River

Rutshuru have been decimated by armed poaching during the three decades of armed conflict (Fig. 3). The transboundary nature of the Greater Virunga Landscape has been important for elephant conservation (Plumptre et al. 2007) and again it is shown here that the Ishasha river along the border between Virunga and Queen Elizabeth Park in Uganda is important for the survival of this species in the Landscape. The current population represents about 11 % of the 1950s' population of hippo in Virunga National Park although relative abundances have changed in each of the sectors.

While large numbers were found on River Rutshuru and Semliki in the past (Delvingt 1974; Mankoto 1989; Mackie 1991; Languy et al. 1994), the current distribution shows similar results with the 2009 and 2013 surveys where Ishasha River and Lake Edward South contained the most of the hippos (Fig. 4) (Kujirakwinja 2010; Balolebwami & Kujirakwinja 2014).

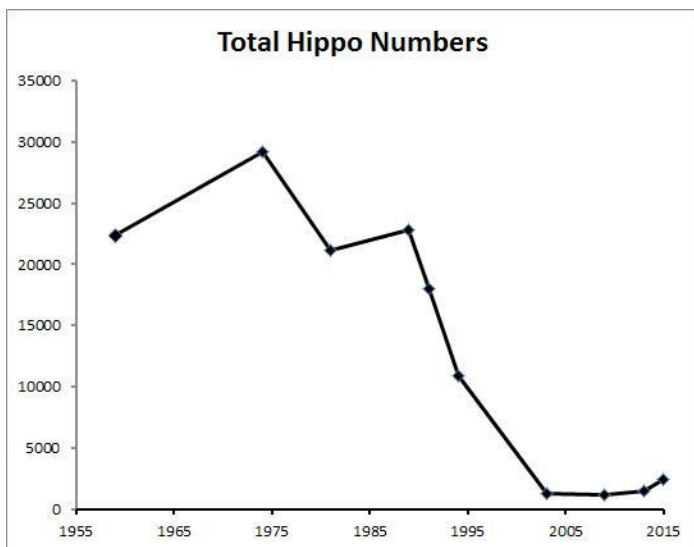
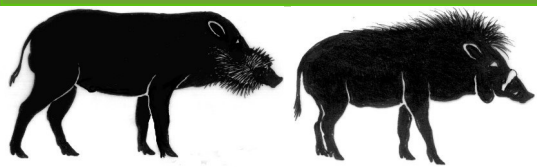


Fig. 1. Trends of hippo numbers in Virunga National Park from 1959-2015.





Ecology and Conservation

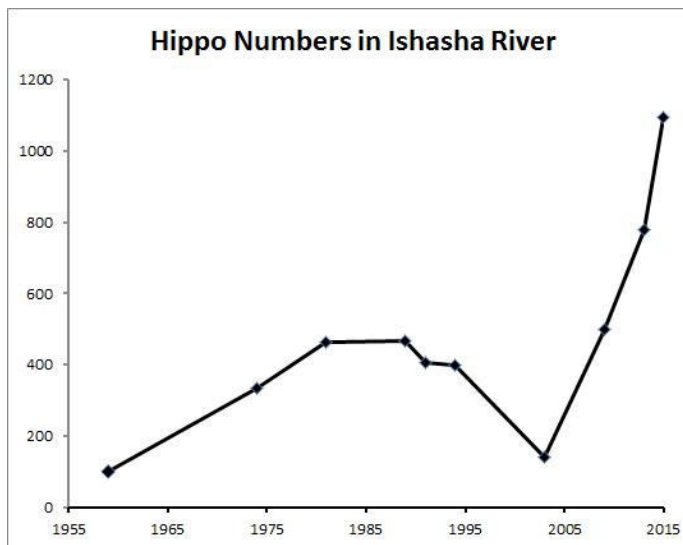
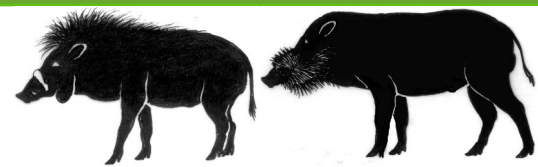


Fig. 2. Trends of hippo population on River Ishasha from 1959 to 2015

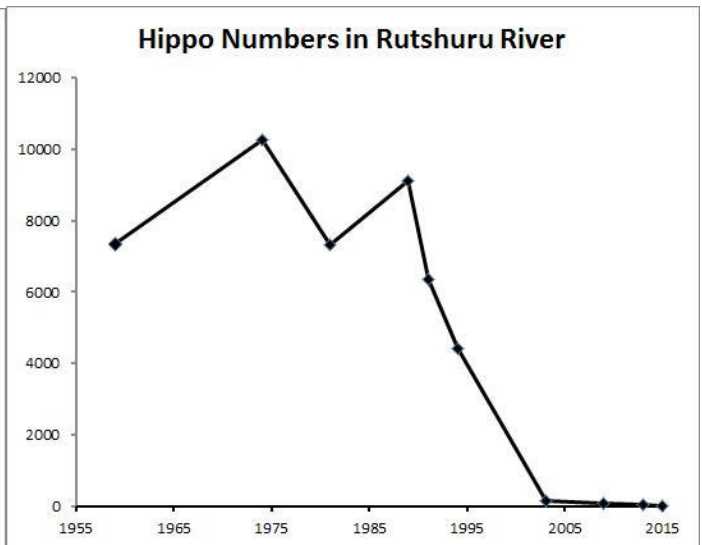


Fig. 3. Trends hippo population on River Rutshuru from 1959 to 2015

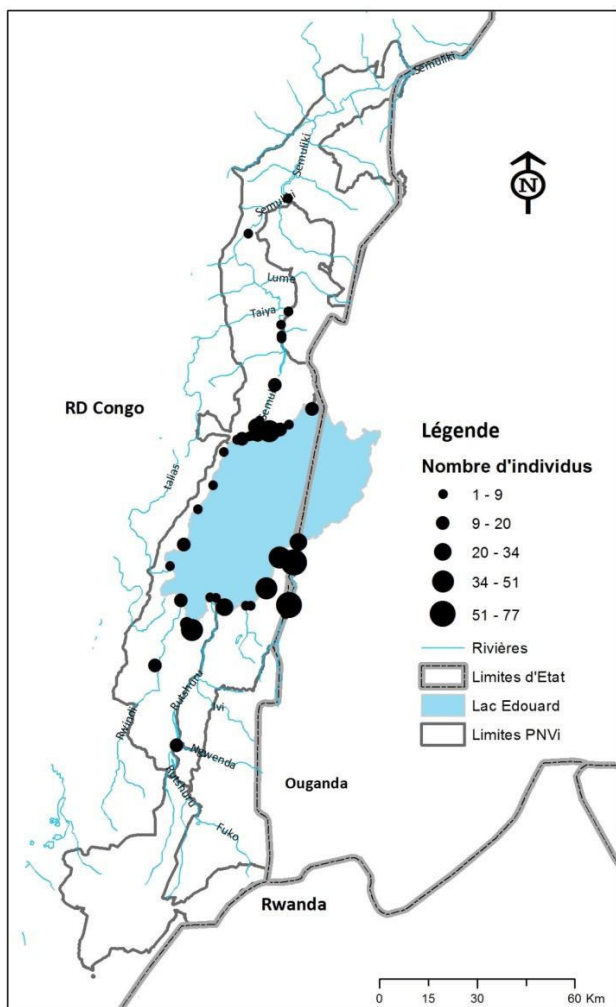


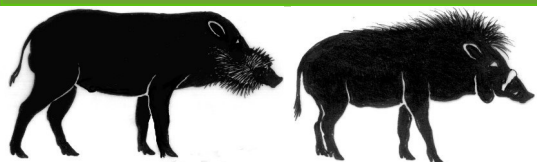
Fig. 4. Distribution of hippos in Virunga National Park

Conclusion

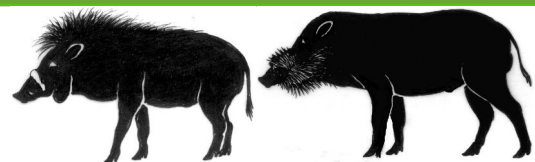
Hippo Surveys in Virunga National park were made using ground/water and aerial survey techniques (Kujirakwinja 2010). Repeated aerial counts were used to determine the hippo population and ground counts used to calculate correction factors in the past (Delvingt 1974; Mankoto 1989; Mackie 1991; Hillman et al. 2003). More recently the focus has been on making ground counts across most sites where hippos occur (only a few sites are surveyed by plane because of insecurity) as it has been found that more individuals are detected and counts are more accurate. These surveys show a recent increase of the hippo population in Virunga National Park which is encouraging after many years of falling numbers. This increase can be explained by ongoing conservation efforts (patrols) to secure the Ishasha sector and Lake Edward supported by transboundary efforts and collaboration with various stakeholders (Plumptre et al. 2007). The latter include collaboration between fishermen from Uganda and DRC, and communication between the parks authorities in DRC and Uganda; ICCN and UWA.

Despite the recent increase of the hippo population, its status in Virunga NP should be





Ecology and Conservation



considered as critical since the current population represents only 11 % of the initial population and only 8.2 % of the 1970s estimate (Verschuren 1956; Delvingt 1974).

Ongoing conservation measures should be strengthened to encourage a continued increase in numbers. Additional conservation measures should be considered:

- Joint surveys of hippopotamus between DRC and Uganda so that the hippo population of the landscape is better known and not double reported by both countries,
- Identify current bushmeat routes and target markets to minimize poaching of hippos in the region,
- Involve fishermen in hippo monitoring by encouraging reporting of key hippo pods that they may encounter,
- Maintain regular monitoring of hippos in key hippo regions (Ishasha, Semliki and Lake Edward South).
- Regular counts and increased protection activities are key for large mammal persistence in conflict and post conflict regions.

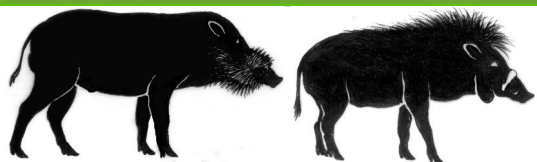
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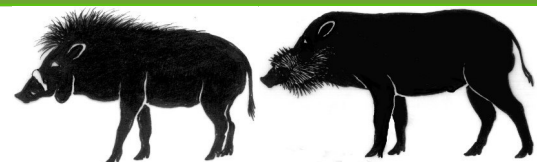
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Ecology and Conservation

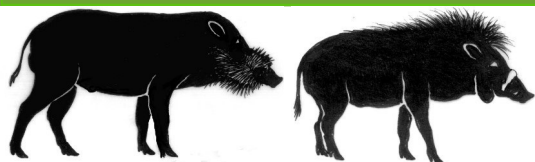


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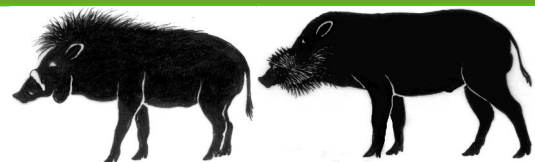


Hippopotamuses in
Virunga National Park.
Photo: D. Kujirakwinja





Ecology and Conservation



River crossing and migration of the Bearded pig (*Sus barbatus*) in Central Sarawak, Borneo

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Introduction

The bearded pig (*Sus barbatus*) is distributed from the Malay Peninsular, Sumatra, Borneo and the southwestern Philippines (Corbett & Hill, 1992; Oliver, 1995). In Borneo they can be found in coastal lowlands comprising peat swamp and dipterocarp forest with undulating hills and the mountain highlands (Payne et al., 1985). The bearded pig is an omnivorous animal that forages mainly on seeds of Dipterocarpaceae, Fagaceae, fruits, roots and invertebrates (Davis & Payne, 1982; Payne et al., 1985; Caldecott, 1988). This generalist species is known to utilize a wide variety of habitat types but lives in one location in a stable group for the majority part of the year (Navenec et al., 2016).

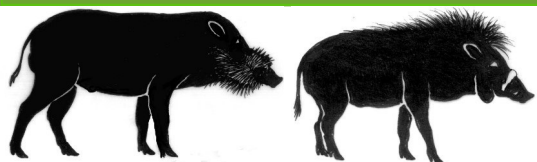
The bearded pig has been reported to be mobile and exhibit a variety of aggregation strategies, ranging from solitary and sedentary to mass aggregation with wide ranging migration (Meijaard, 2003; Hancock et al., 2006). The shortage of food resources may force pigs to migrate. Migrations of bearded pig have been reported in Borneo in response to mass fruiting occurrences in Borneo (Caldecott & Caldecott, 1985; Hancock et al., 2005; Wong et al., 2005). The mast fruiting events increases population numbers explosively and the pigs are known to migrate across large areas to feed on the oil rich Dipterocarp seeds (Hancock et al., 2005). The bearded pig is the most sought after wild meat by the non-Muslim natives in Sarawak where it plays significant role socioeconomically especially in sustaining local livelihoods. In Sarawak the bearded pig is not protected outside National Parks, Nature Reserves and Wildlife Sanctuaries. As a non-protected species, it can be hunted for local consumption. However commercial sale of bearded pig in Sarawak is prohibited according to Wildlife Protection Ordinance 1998 where offenders are liable for a fine up to 5000 Ringgit (USD\$1250) while the buyers can be fined up to 2000 Ringgit (USD\$500). Additionally if a native is found in his possession with more than five kilograms of wild meat for his own consumption he will be deemed to have the intention to sell or offer for sale and can be charged up to 5000 Ringgit.

Materials & Methods

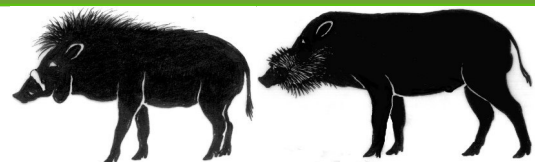
Study site

A rapid survey was carried out in Rajang River area from Kapit town to Pelagus National Park. Rajang River (also known as Batang Rejang) is the longest river in Malaysia and the largest river between Sabah and Sarawak, which originates from central highlands of Borneo. The Rajang headwaters drain the northern slopes of the Kapuas Hulu Range and western slopes of Hose and Iran mountains while the watershed of Rajang River drains the districts of Kapit, Belaga, Song, Kanowit, Julau, Sibul, Matu, Daro, Bintangor and Sarikei (Parenti & Lim, 2005). Rajang River drainage basin is about 50,000 km² in area with elevations exceeding 2,000 m (Parenti & Lim, 2005; Staub & Gastaldo, 2012). From a 30 years rainfall data calculation, the typical single-month





Ecology and Conservation



discharge rates for the Rajang River drainage basin range from about 1,000 to 6,000 m³/s, and the average monthly discharge rate is about 3,600 m³/s (Staub et al., 2000). Peak discharge rates during the northeast monsoon (December to March) can exceed 25,000 m³/s. There are several rapids with strong current distributed near the headwaters (Figure 1). This river is used as the major mode of transportation to the central regions of Sarawak. The river is busy during the mornings and in the afternoons where express and long boats frequently shuttles people. The riverbank along this stretch is dominated by secondary lowland dipterocarp forest, patches of small-scale agricultural farms (e.g. pepper, rubber and paddy rice), settlements (longhouses, school and abandoned resort), log ponds and a coal mining area. Most of the secondary forests in this area have been logged several times except for Pelagus National Park which is situated in the west side of the river.

Rapid boat survey was carried out from 18th – 21st of February 2016 along the Rajang River from Kapit (N 02°00'59.4" E 112°56'25.7") to Pelagus National Park that stretches approximately 32 km. At any one time there were at least two surveyors in the boat. During this survey we checked for any bearded pig crossing the Rajang River. We also counted the number of boats and interviewed local people involved in this hunting activity from the boats (n=20) and elders from the longhouses (n=15).

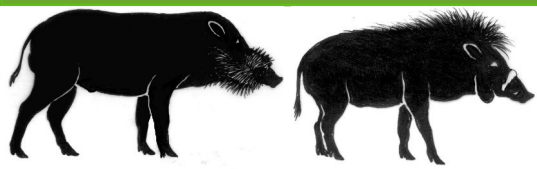


Fig 1. The fast flowing rapids of Rajang River near the headwaters close to Pelagus National Park at Kaki Wong area.

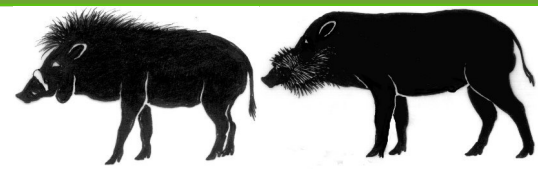
Results & Discussion

The bearded pigs have been reported to cross the river consistently for the past two weeks. This event occurred for approximately three weeks starting from the beginning of February 2016. Approximately 50 % of the hunters interviewed suggest that such migrations occur right after the young piglets were mature enough to swim across rivers for food and this can sometimes last up to two months. The pigs were crossing from west to east across the river consistently in one direction especially during early mornings and late evenings when there are fewer boats using the river. This is consistent with most of the previous river crossings reported by Meijaard (2003). However it is not known if the pigs have been crossing the river at night. In most cases the pigs





Ecology and Conservation



were reported to cross from one to two dozens and occasionally adult females with several juveniles. These pigs do not appear to be in the stages of emaciation and starvation as reported by Wong et al. (2005), which suggests that famine or prolonged scarcity of food resources may not be the driving factor in this migration.

During this rapid survey we counted approximately 90 long boats at any one time at 25 to 30 locations along the riverbank waiting for pigs to cross the river (Figure 2). Each boat had two to three individuals looking out for pigs (Figure 3). This translates to at least 180 individuals from approximately 200 villages at any one time along this 32 km stretch. Hunting using shotguns is not allowed. Local people who are caught using guns will be asked by other fellow hunters from the nearby boats to leave the area. The pigs were attacked and killed

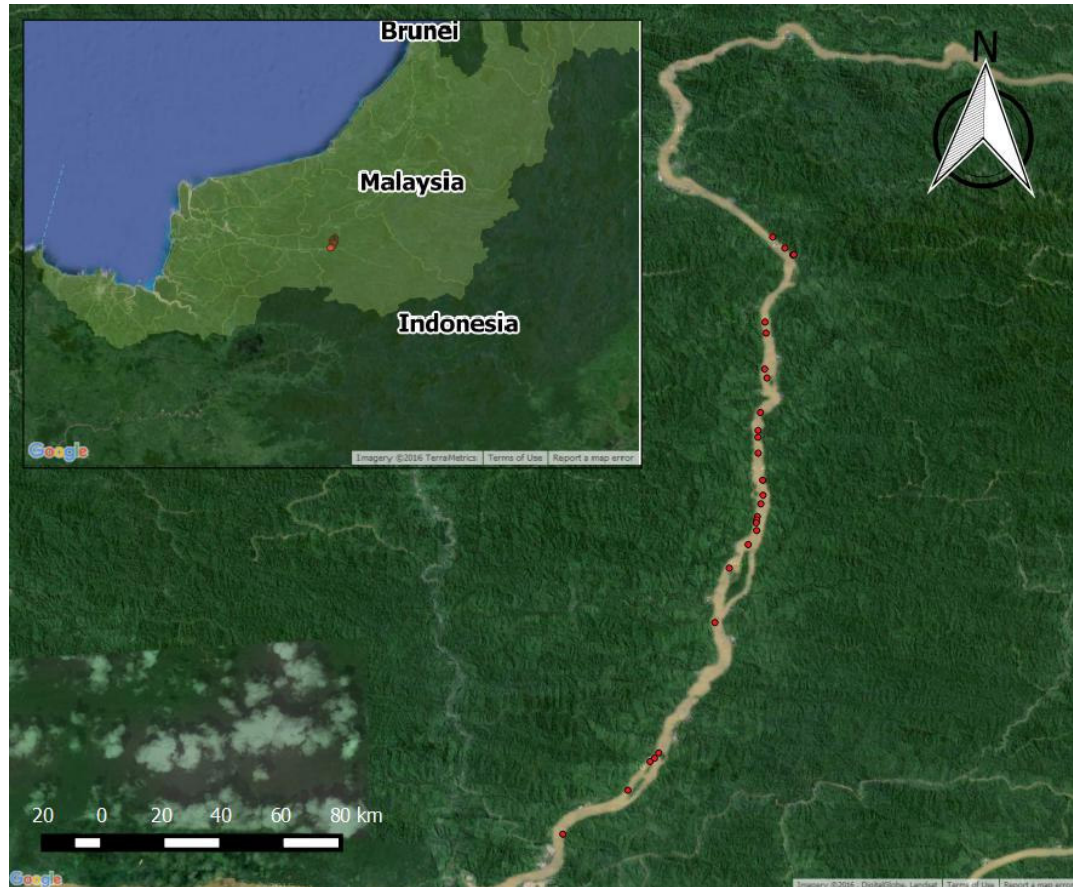


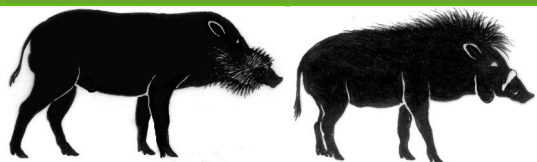
Fig. 2. Location of boats waiting along the Rajang River during the pigs' migration.



Fig. 3. Longboats with two to three individual waiting near the edge waiting to ambush the migrating pigs in Rajang River in February 2016.

using homemade spears (locally known as Jerepanq and Sanqkuh: Figure 4) and machetes. Once the pigs are spotted crossing far enough from the riverbanks, the boats will rush towards the pigs and the first boat to arrive normally kills at least one pig at a time. In general most boats will hunt at least one pig per day but boats waiting at more strategic location often take two to three





Ecology and Conservation

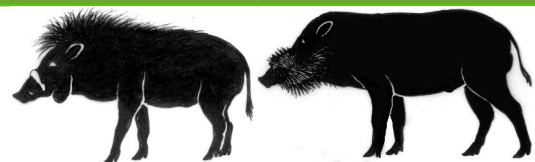


Fig. 4. Weapons used for pig hunting during river crossings (left: Jerepanq, right: Sanqkuh). The spears are about 2 meters long, with sharp ends. The hunters usually spear the forearms or hind legs of the pigs, just enough to immobilize them but not killing them, thus allowing them to stay afloat.

alternative food and cause starvation, which in turn may negatively impact local communities that depend on this resource. The dependency of pigs on mast fruiting suggests that the Bornean populations are delicate and susceptible to continuous local extinctions from human perturbation (Wong et al., 2005). Therefore local enforcement agency must work together with local communities to regulate hunting activities to ensure local populations of bearded pigs are not exterminated.

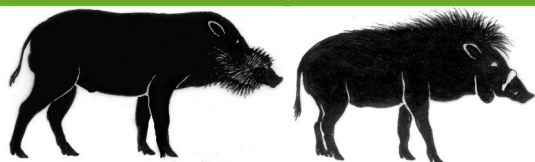
individuals in a day (Figure 5). The number of hunters in each boat also partly influences the total kill per day. A single hunter may only kill and collect as much as two individuals per day whereas boats with more hunters will collect as many as they can fill their boat with. The hunters will wait from morning until late evening, with their boats parked in parallel to the pigs' crossing direction to minimize the detection of their presence. These hunters are also opportunistic, as they kill almost all the pig crossing. As soon as a pig is captured, it is tied to a big plastic gallon bottle (to keep the pig afloat) while the hunters move on to the next target and the process continues until there are no more pigs left for the session. Occasionally juvenile pigs are reared if they are captured alive. Excess meat will be preserved through fermenting and smoking the meat. During this hunting period, if one hunting group (per boat) takes home at least one pig per day, then a modest estimate of pigs harvested during this migration session at this particular river stretch in Sarawak for a minimum of 14 days is estimated at least 1260 pigs. With an approximation of 30 kilograms of wild meat obtained from each pig on this basis, this would result in an overall catch value of 756,000 Ringgit (USD\$190,000).

The rapids, wide river crossing, boats and hunting threats did not prevent the bearded pigs from crossing the river suggesting that the instinct to seek new foraging grounds have superseded these challenges. Preventing the bearded pigs from migrating will disable them to find

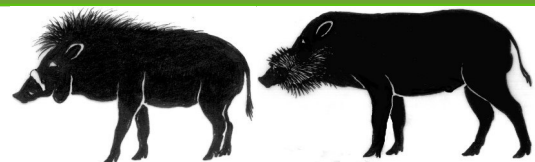


Fig. 5. Juvenile bearded pigs hunted from a long boat showing spear marks near the neck. Note the lateral black brown stripes on the abdomen indicating that these individuals are less than 6 months





Ecology and Conservation



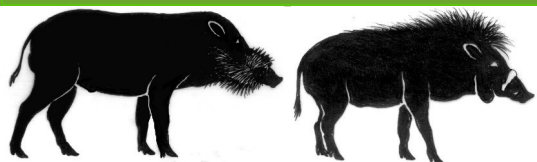
Acknowledgements

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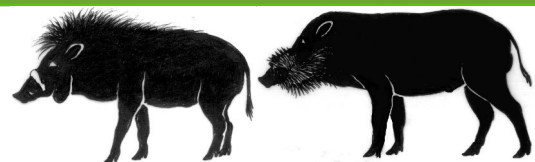
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Ecology and Conservation



First observations on Moluccan Babirusa (*Babyrousa babirussa*). A translation from a recently rediscovered 1770 book that describes the Babirusa on Buru Island

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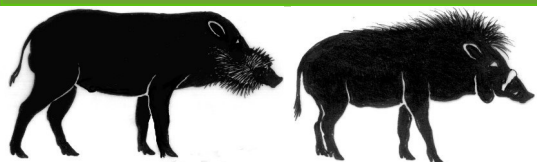
Relevance of text by Anonymous (1770)

Surprisingly little is known about the Moluccan Babirusa *Babyrousa babirussa* despite the fact that this animal was first described by Europeans in 1582 (Macdonald et al., 2016). Most of the research on the biology of the animals of the genus *Babyrousa* has been conducted on animals from, or descended from those on, the island of Sulawesi, where *Babyrousa celebensis* occurs (Macdonald, 2017). A recently rediscovered book (Anonymous, 1770), published by Jan Montere in 1770 and republished in Afrikaans as Anonymous 2011, contains information about this poorly known Babirusa; the chapter on the 'Babi-Roesa, Varkens-Hert' was compiled by an unknown author, and as acknowledged, is largely derived from the book by Valentijn (1726). The latter has been said to contain the observations collected by Georg Everhard Rumphius for his unpublished books 'concerning Land-, Air- and Sea animals of these islands' (Beekman, 1999). The general quality and accuracy of the observations in the manuscript indicate that the original author was well-informed, and this gives a sense of reliability to this historical information. Importantly, this 246 year old book chapter provides us with a glimpse of a past when apparently the Moluccan Babirusa was still very common.

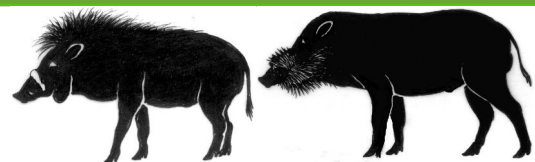
Moluccan Babirusa are presently listed as Vulnerable on the IUCN Red List of Threatened Species; in fact we know extremely little about this species and it is currently a conservation concern. It is understood to occur on the Indonesian island of Buru and on two of the Sula Islands (Mangole and Taliabu); available evidence suggests that it is now extinct on the islands of Sanana (officially Sula Besi) and Lifamatola (Meijaard et al. 2011). A survey of the north of Buru, conducted in 1990, suggested that the population of Babirusa was low and unevenly distributed (Tjiu and Macdonald, this issue). No more recent surveys, specifically focusing on determining the presence, absence and abundance patterns of the species have been conducted. However, anecdotal information suggests that it is now very rare (Eaton & Hutchinson 2015, Pattikawa, personal communication). Little is known about the Moluccan Babirusa's current habitat use; on Buru, the local Rana people report that Babirusa are most often found in hilly areas and in the mountains, where they use rocky areas.

The translated text below provides quite a different, earlier, picture suggesting that the species used to be 'plentiful' on Buru; this included the lowlands around Kajeli Bay in the north east of the island (Figure 2), where the species has not been sighted for some years. All of the information available from the last few decades indicates that the species now occurs only in the remotest parts of Buru. Hunting, forest loss, gold mining and human population migration and growth appear to be the major causative factors. Over-hunting of Babirusa has been well-documented on





Ecology and Conservation



Sulawesi (Blouch, 1990; Lee et al, 2005; Milner-Gulland & Clayton 2002; Suhari 2013).

The study of historic manuscripts thus still plays a valuable role in species conservation as it provides insights into behaviour and abundance of species at the time when you had few threats.

Translation

Page 44–49.

Description. Plate V. number 9. Babi-Rusa, Pig-Deer

The animal depicted on this plate number 9 is a very strange and little known creature; it is only, as far as we know, found on the island of Buru, and some other islands thereabouts. François Valentijn who saw the animal himself and had it drawn from life, gives the following description:

In Malay it is named the Babi-Rusa, or Pig-Deer because it seems to be a mixture of both animals.

It almost has the appearance of any other wild pig, but the male has something different about it, that other male wild pigs, or boar, don't have; because apart from the two tusks protruding from the lower jaw, as in almost all other wild pigs, it has two more on the upper jaw, opposite the others, curved backwards, almost into a half-circle, and some curled even further; giving this animal a rather handsome [could also be translated as peculiar, or kind/not-mean. Eds]

appearance. Occasionally the tusks curl so far back that they begin to grow into the forehead bone.

Apart from these it has, in the top part of its mouth, also four incisors, and in the bottom part, six others, of which the two furthest back lie flat and point forwards, after which, instead of canine teeth, it has the aforementioned protruding teeth; behind these six molars can be counted on each side, of which the furthest back are divided into three cusps.

The female does not have the large projecting teeth.

This animal has a thin and weak skin, with short hair, that is quite soft. It also doesn't have a long mane on the back, such as other wild pigs.

They are almost ash-grey in colour, although with a ruddy hue, mixed with some black through the base colour. The head is more pointed than that of other pigs. The ears are quite short, and the eyes small; also the tail is longer than that of other wild pigs; having a little tuft on the end.

On each leg there are two long and two short

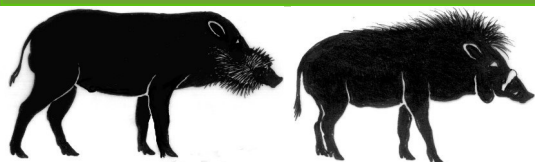
hooves, but the fore limbs are shorter than the hind limbs, which is why it has quite a slow gait, as Valentijn remarked to have seen himself.

They are easy to hunt, and during the hunt easy to get, because their skin is so thin that it can be seen through the hair and it means the dogs are usually quickly into the meat. It is true that they can do a lot of harm with the lower tusks; but the upper tusks, which are too curved, prevent them from doing harm to the dogs. This is also the reason why a dog, once it has the scent of a



Fig. 1. Plate V number 9 depicting the Buru Babirusa in Anonymous (1770). The image is a modified copy of the illustration in Valentijn's book, and it is indicated that this was the work of Theodorus van Brussel.





Ecology and Conservation

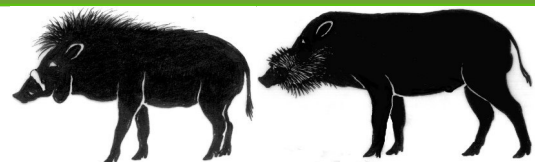


Fig. 2. Carte de l'Isle de Bouro / Kaart van 't Eyland by Boero J.v. Schley. Ca. 1753. The Bay of Cajeli is indicated.

referring to the genus *Canarium*]; it only eats grass or leaves of the Waringin tree (Weeping fig, *Ficus benjamina* Eds.) and other wild trees.

One does not need to fear that Babirusa, like other pigs, destroy gardens, root through fences, and spoil seedlings and planted crops, because it feeds primarily on tree leaves and doesn't cause any harm.

This animal is plentiful on the island of Buru, and is often obtained by soldiers in the Bay of Cajeli [near present-day Kajeli and Masarate, see Figure 2, Eds.], who very often hunt and easily catch them. They are also found on the Xoelasche islands [i.e., the Indonesian Sula Islands, Eds.], and especially on Xoela Mangoli [Pulau Mangoli, Eds.], Bangay [Pulau Banggai, off the east coast of central Sulawesi, Eds.], [and on] the [north] east coast of Celebes [Sulawesi, Eds.], and especially around Manado.

Although there is now on Buru an abundance of wild pigs, which, because the Muslims do not eat pork, are flourishing, one does not see them mix with Babirusa and the Babirusa always keep themselves away from other wild pigs.

When dogs hunt Babirusa, and the latter tire, they save themselves by running as quickly as they can towards the ocean where they can lose the dogs by their ability to swim fast and cunningly dive into the water (as well as any duck can). Thus they often outwit dogs.

The pigs can thus swim for a very long time, even between one and another island.

People have tried to keep such an animal and feed it with rice and Batata's [sweet potato, *Pomoea batatas*. Eds.] leaves, but with a lot of difficulty to keep them alive. Though I (says Valentijn) saw one at the time of Mr Padbrugge who had one at his place and which was brought up in this way.

People keep the heads of these animals. Because of the unusual shape of the teeth, and they send them as rarities to the Fatherland, where one can find them with this or that collector of rarities.

An enthusiast on Ambon also reared a Babirusa for a long time and habituated it to recognize its name, so that when the children called it by its name, it would come and when one scratched it on its back, it would allow the children to sit on top of it.

This animal ate *Canari*, rice, padi, and especially liked fish, including the guts.

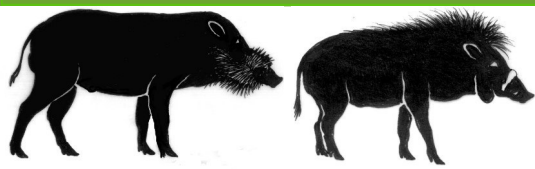
Babirusa, doesn't let go of it, and won't easily start following another wild pig.

This animal has a strong sense of smell. Quite often it stands on its hind legs against a tree, in order to smell if predators are near. It often sleeps upright in this position at night to ensure that it has the best scent of its surroundings. Sometimes hunters find them like this. It is also common for them to use their curved upper tusks to hook onto branches and vines to hang so they can sleep easier.

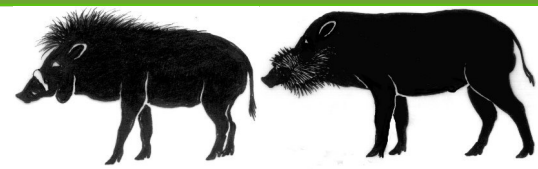
The meat from this animal is closer to venison in both taste and fineness than to pork. The meat is also very lean, with little fat so that most of it is meat.

The diet of this animal is not the same as that of other wild pigs, which eat *Canari* [Eds.: probably





Ecology and Conservation



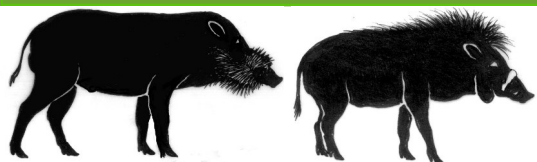
This animal was also ruddier and blacker than usual, with a more curly hair that resembled wool, but not smelling as strongly as the wild ones do.

One doesn't hear many sounds from this animal, although if it does make a sound it most closely resembles the grunting of pigs. Now that we have discussed the land animals, we will now continue with the fish and water animals.

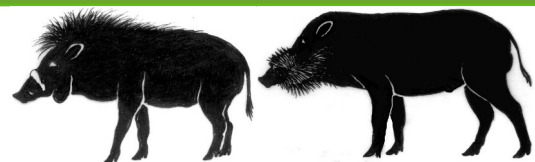
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Ecology and Conservation



Babirusa (*Babyrousa babyrussa*) on Buru island

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Introduction

The first description of Babirusa on the [Indonesian] island of Buru may be found in a letter written in 1582 by Fr. Bernardino Ferrari describing the wildlife on Buru. In his own words:

‘È l’isola del Burro molto fertile de victovaglie di queste parti, habundante de molti animali sylvestri, come de porci et altri animali di queste parti. Fra quali vi sono uni semeglianti al porco ma bianchi. E li due denti grandi, con i quali i porci combettono, questi animali le tengono diretti di modo che furan oil musso del detto animali, e uscindo sopra appariscono come due chiodi grandi.’

[amongst which [animals] there are some resembling pigs, but white. The two tusks which pigs use to fight with, these animals have straight, in such a way as to pierce the snout of the said animal, sticking out on top like two great nails] (Jacobs 1980).

Buru Babirusa depiction



Fig 1. Illustration of a recumbent Buru Babirusa from the frontispiece of Piso (1658).

published by Schotti in 1667 (Figure 3). The first author to visually place the animal in its geographical setting was Nieuhof (1682) with a new, somewhat deer-like, characterisation of the animal in a standing ‘pose’, and being hunted (Figure 4). Johan Nieuhof spent much of his life travelling, and spent a number of

It was not until the publication by Piso (1658), one hundred years later, that further anatomical information was made available (Figures 1 & 2). It is not so obvious from the first illustration, which was on the frontispiece of the book, that the Buru Babirusa has ‘long’ hair (when compared to Babirusa from North Sulawesi), but it is quite clear from the second illustration. Distribution of this information was assisted by the (rather poorly worked) copy of the image which was

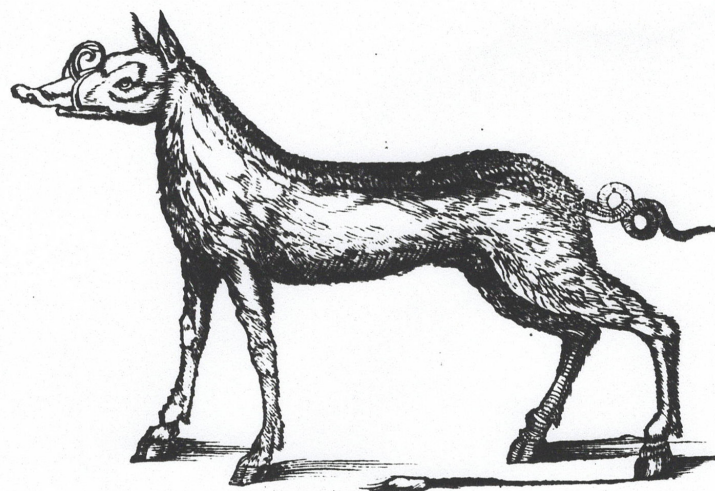
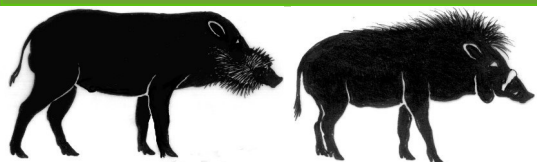


Fig. 2. The first illustration of a hair-covered Buru Babirusa, from page 61 of an appendix to ‘De Indiae Utriusque re Naturali et Medica’ by W. Piso (1658).





Ecology and Conservation

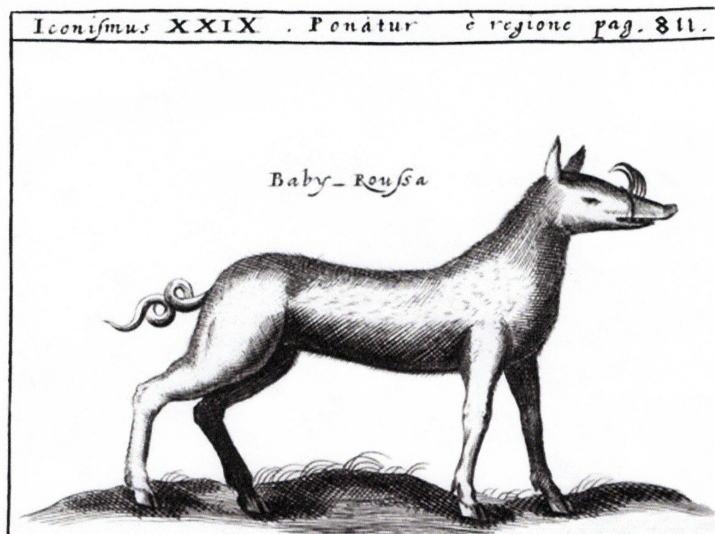
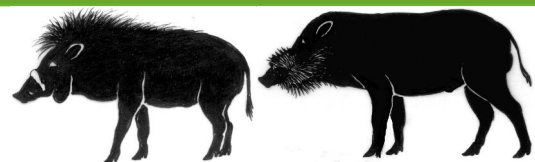


Fig. 3. Largely a mirror-image copy of the Buru Babirusa in Figure 2, published by Schotti (1667).



Fig. 4. The first image of the Buru Babirusa 'in situ', with one animal in the background being hunted (Nieuhof, 1682).

years in Batavia (now Jakarta, Java) as an employee of the Dutch East India Company (VOC). The landscape in the illustration seems to better reflect his observations on Java than the countryside of Buru. However, he has depicted the animal with hair, particularly under its chin.

Georg Eberhard Rumphius (1627-1702), was based as an employee of the VOC in Ambon from 1654, and from 1662 undertook a study of the flora and fauna of Maluku. He made considerable contributions to our knowledge, but sadly the manuscripts and illustrations of many of the animals, which were due to go into 'three other books concerning Land-, Air- and Sea-animals of these islands', were never published and were subsequently lost (Beekman, 1999).

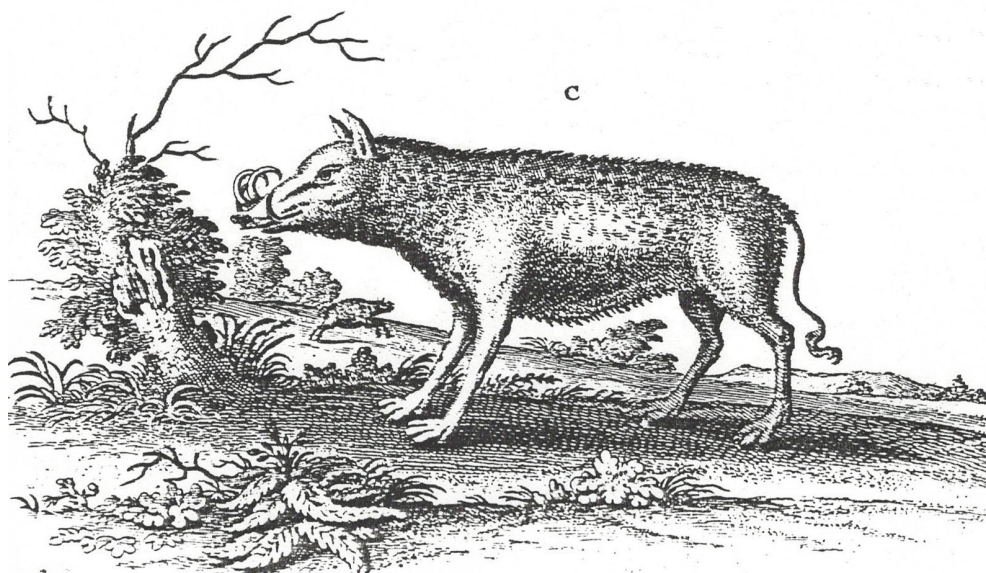
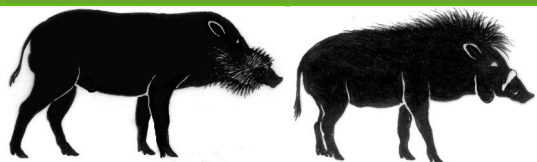


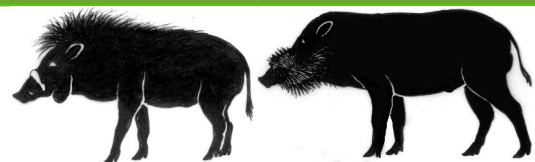
Fig. 5. The Buru Babirusa published by Valentijn (1726) clearly depicting its hair cover, and from the shape of its feet, suggesting that it may have been 'kept as a pet'. A second Babirusa can be seen running in the background.

However, we are fortunate to have the 'encyclopaedic' books of someone who knew him personally, François Valentijn; he lived in the East Indies for 16 years. Valentijn also set his much more hairy representation of the Buru Babirusa in a landscape





Ecology and Conservation



setting (Figure 5). It is most likely that he had seen one in Ambon, and the possibility that he had seen one in Batavia cannot be excluded. The portrayal is much more realistic with respect to body proportions. However the splayed anatomy of the feet suggests that the artist had seen an animal which had spent some years retained in someone's garden rather than in, or freshly caught from, the wild. Interestingly, Valentijn says that Robbert Padbrugge, the governor of Ambon (1682-1687) kept one at his place.

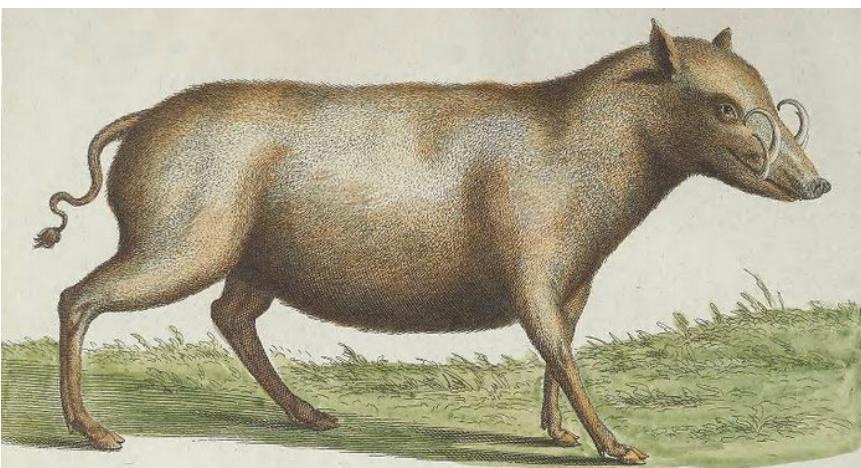


Fig. 6 This illustration of a somewhat overweight Buru Babirusa, published by Seba (1734) has also got foot problems suggesting that it too may have been drawn from a kept animal.

someone's 'yard'. The depiction published by Halle (1757) suggests that it was based on the reported observations of an animal from the hills of Buru. Goldsmith's illustration (Figure 9) perhaps suggests that the artist modified and composed the head from earlier illustrations, and put it onto the body of a local bovid. There are two instances of direct copies of earlier illustrations; that by Anonymous (1770) of the one in Valentijn (1726), as illustrated in this issue by Meijaard et al, and the depiction of Seba's 1734 image by Borowski (1780). At the turn of the century, Bewick published this picture of a robust pig with hair (Figure 10) to represent the Buru Babirusa.

Cultural observations

Somewhat surprisingly, very few people in the last 200 years have gone to Buru to learn more

There are several other illustration of the Buru Babirusa during the eighteenth century. The ones by Seba in 1734 (Figure 6), Goch in 1736 (Figure 7), Halle in 1757 (Figure 8) and Goldsmith in 1779 (Figure 9) each depicting an animal with a coat of hair. Each of these representations now show the typical anatomy of (healthier) pig's feet, and although the general morphology of the depiction carries some influence from earlier illustrations, each one is new. The illustration by Seba suggests an overly-fed animal, again suggesting reported observations of an animal in

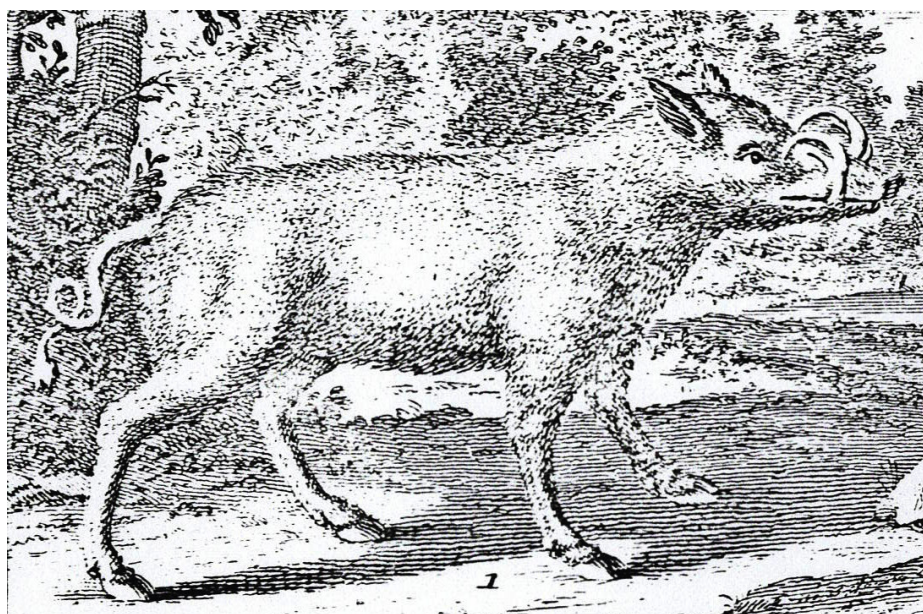
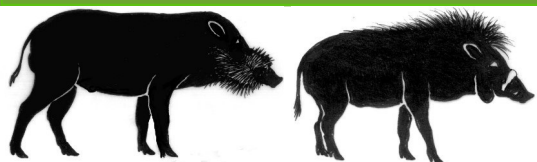


Fig. 7. The Buru Babirusa published by van Goch (1736).





Ecology and Conservation

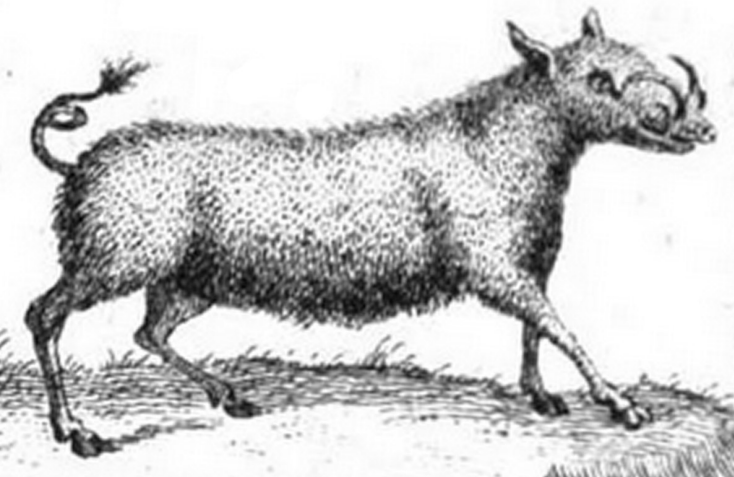
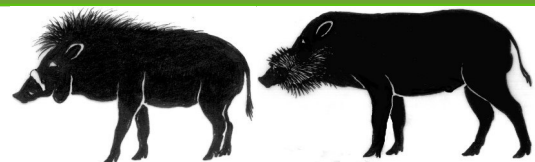


Fig. 8. The heavily haired Buru babirusa published by Halle (1757) does not suggest a portrait.

So what is the Babirusa called on the island of Buru? In the local language(s), we mean (how many languages?). Are there separate words for the male and female Babirusa, the boar and the sow Babirusa. Does the sow farrow and have a litter of Babirusa piglets? What, in the local languages, is the nest where Babirusa sleep called? What is Babirusa pork/ham/bacon called, in the local language(s)? The word 'donit' has been published as being a local word for Babirusa. But there are other words: 'gonit' and 'ronit' sound very similar, but there is also 'bodi' and 'hamune'. What do these all refer to? What language? Older people may know, but may be shy to say. Folk in more remote villages may know. And then there will be the secret hunting words – perhaps like 'he who carries his teeth high' – spoken quietly so as not to let the knowledge of the hunt escape to the ears of the forest. And we are losing these words, the local people with their bahasa Indonesia learning environment at school, are not using the local words so much – perhaps they are becoming 'not cool', or are just forgotten. When the animals 'go' the words and stories and culture to describe them will go too. What do people on Sanana island (Sula Besi) say about Babirusa? What do people on Lifamotola island say about Babirusa? What do people on the island of Banggai, near the east coast of Sulawesi, say about Babirusa?

Babirusa and wild *Sus scrofa* observations

And what do we know of the population of Babirusa on Buru? In the 1600s and 1700s there were many Babirusa (Valentijn, 1726). But what about now? In order to get a first impression, a survey

about the biology of this animal, despite many hundreds of adult male Babirusa skulls from that island finding their way into museum and private collections. The forth-coming book chapter by Sheherazade et al (2017) gives an overview of what is known. As shown above, there are pieces of knowledge which have rested on library shelves or in filing cabinets for many decades, centuries even, and have been lost to view. Recent personal experience in the Ambon area indicates that it is important to deliver that information to a wider audience.

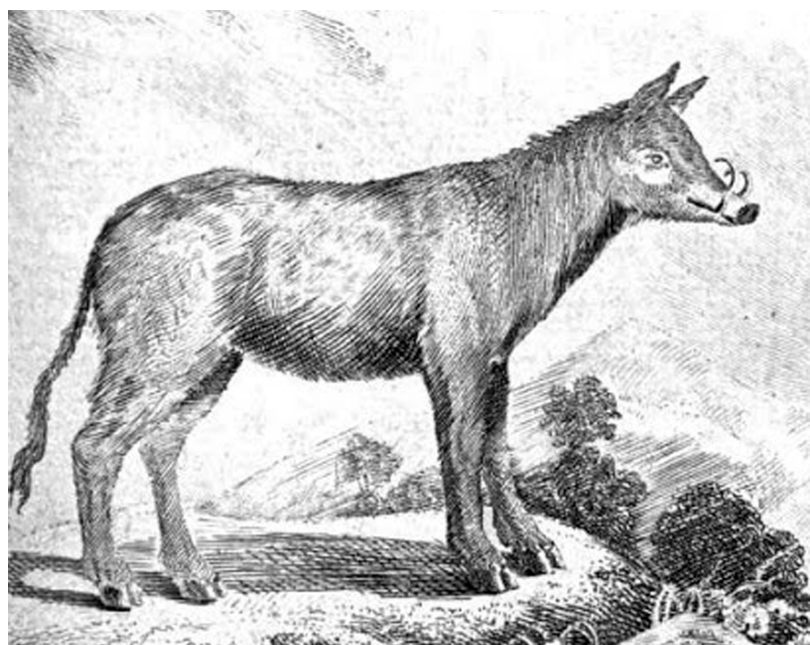
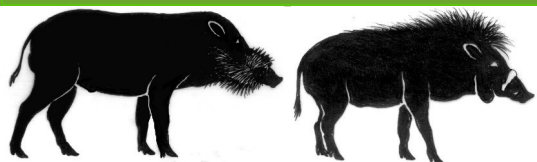
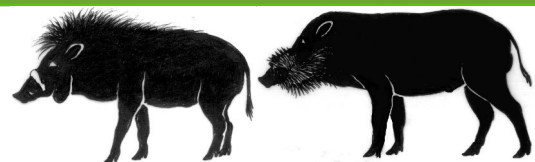


Fig. 9. It is highly unlikely that the artist who drew this illustration of the Buru Babirusa from Goldsmith (1779) ever had the opportunity to see one.





Ecology and Conservation



of the north coast of Buru was conducted in villages and settlements along the route of one of the island's few roads (then), in August 1990. It was carried out by the senior author, a resident of Ambon. For convenience, the villages were geographically categorised to the east of the village of Namsina, and to the west including Namsina. Thus the 32 villages situated in the 'North east' of the island were:

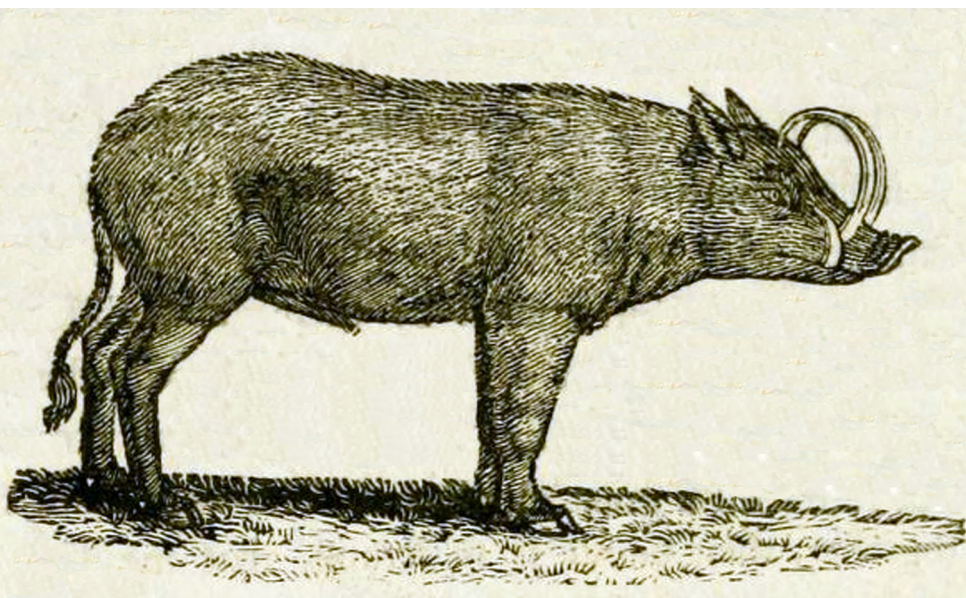


Fig. 10. This robust pig by Bewick (1800) presents the canine teeth and hair-coat characteristics of the Buru Babirusa on what seems to be a domestic pig 'frame'.

Batu Jungku, Waemorat, Saliong, Pela, Seit, Masarete, Kayeli Sael, Wa Aisil, Tifu, Kubu Lahin (unit 16), Samleko, Savannah Jaya, Unit 14, Gorea, Unit 15, Waikasar, Mako, Siahoni, Lamilun, Batuboi, Marloso, Lala, Ubung, Liku Merasa, Waimiting, Sawa, Waeperang, Rata Gelombang, Lamahang, Wa Ura, Waplau and Samalagi.

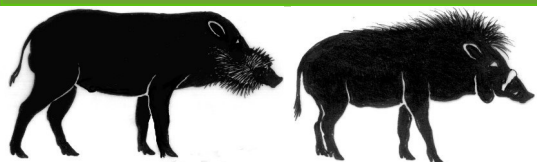
The 13 villages categorised as 'North west' villages were: Namsina, Hatawanue, Wailihang, Waprea, Wa Potin, Wa Nibe, Wae Kose, Wa Mlana, Wa Mangi, Air Beraya, Air Buaya, Wa Langa and Bara.

A total of fifty sets of data were collected from individual men in these locations. The men ranged in age from about 20 to about 75 years of age, and were categorised as: 20-29 years (13); 30-39 years (28); 40-49 years (6); 50-59 years (2); 70-75 years (1). They were asked first if they had seen Babirusa in the last five years? Thirty four said 'no' and sixteen said 'yes'. Those saying 'no' came largely from the 'North east' of Buru (26), with eight from the 'North west' saying 'no'.

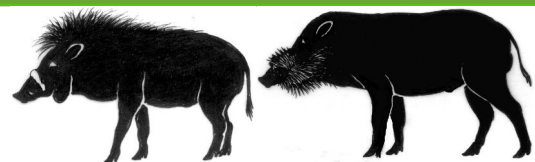
Nine correspondents from the 'North east' and seven from the 'North west' of the island had seen Babirusa in the last five years. They were asked to give an approximate number of the Babirusa seen in the last five years. Although estimates ranged from ca. 10 to ca. 75, correspondents from the 'North east' reported ca. 30 (1) ca. 50 (7) and ca. 75 (1); those correspondents in the 'North west' of the island reported ca. 10 (1), ca. 20(1), ca. 30 (1), ca. 50 (3), ca. 75 (1). When asked when they last saw Babirusa, the replies were: ca. one week ago (5); two weeks ago (6); three weeks ago (2); one month ago (1); two months ago (1), three years ago (1). When asked where they had seen Babirusa, all replied that they had been up in the mountains.

When asked if they had seen more or less babirusa in the last five years, three from the 'North east' said they had seen about 20-30 'more'; and the other 13 correspondents who had seen Babirusa said that they had seen 'less', the estimate of decline ranging from ca. 10 to ca. 30 fewer Babirusa.





Ecology and Conservation



When asked if the Babirusa have long or short hair, the hair-length estimates reported were 3-5cm long (15). They said that the hair was light brown in colour (15), with one respondent indicating it could be grey with a bit of light brown and another reporting light brown with a bit of white. There was general uncertainty when asked what the Babirusa ate; replies of grass (3), fruit (3), rotten wood (4) Meranti tree fruit (5), Rattan (5) and leaves (9) were given. Interestingly, one correspondent said Babirusa will only eat food which is on a tree branch, or is fruit; they only eat clean food which has not touched the soil, he said.

When asked for any additional comments, the following were collected: the lack of long canine teeth in the female Babirusa (8); Babirusa run uphill rapidly (6); Babirusa do not like white dogs (3); Babirusa are strong (3); Babirusa 'walk alone' or perhaps up to three together (2); although not as wild as the other forest pigs, they are still dangerous (1).

Questions were also asked about the other wild pig on the island, *Sus scrofa*. All fifty correspondents, when asked if they had seen this wild pig in the last five years, replied 'yes'. When asked 'how many', they replied: ca. 100(11); ca. 150 (10); ca. 200 (23); ca. 250 (1); ca. 300(5). When asked when last seen, they replied: yesterday (20); within the last week (29). When asked where they saw them, the general answer was: forest (47); beside the sea (13); open countryside (49). All reported that more wild pigs (*Sus scrofa*) had been seen in the last five years than previously, and that the increase was: ca. 25 (5); ca. 50 (18); ca. 75 (11); ca. 100 (13); ca. 125 (2); ca. 150 (1).

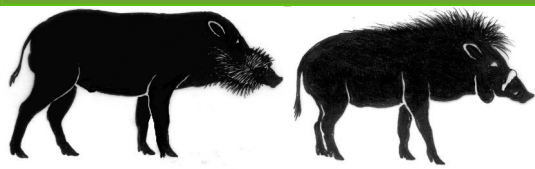
When asked for any additional comments, the following were collected: They 'go mad' when wounded (12); they have black skin (7); they are very aggressive (2); they are found in small groups of 3 to 5 animals (2); they used to sleep near the village (2); their flesh is soft (1); they sleep near holes they dig to get worms (1); their numbers are increasing because not so many are hunted now (1); they roar loudly when wounded (1).

These results indicate that the population differences between the two genera of wild pigs on Buru is striking, with *Sus scrofa* apparently increasing in number and the Babirusa in decline. This small amount of data also seems to indicate that there is a striking difference in preferred habitat; the wild *Sus scrofa* has seemingly habituated to human presence whereas the Babirusa appears to have retired into the less human-accessible regions of the island. This may be related to differences between the genera in preferred diet, and may also hint at the availability of appropriate food resources. Although no measurements appear to have been made on the litter sizes of Babirusa on Buru, experience from elsewhere (Ziehmer et al, 2010) suggests that Buru Babirusa sows may deliver fewer piglets at the end of gestation than the number of piglets born of wild *Sus scrofa* on Buru.

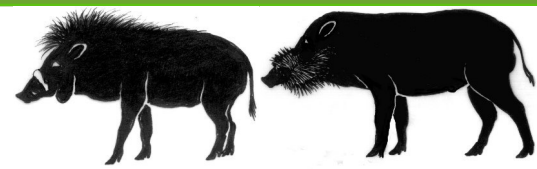
Conclusions

Simple questions asked consistently over time, or of a local population, can yield clues as to the historical and current status of knowledge of an animal and its population numbers. Sensitivity to the local culture and way of life can enable insight. Little is known about many aspects of the biology of the Buru babirusa, and perhaps the local people are forgetting what they once knew.





Ecology and Conservation

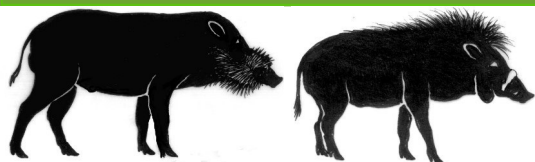


There is a need for more up-to-date information, and a need to collect the fragments of personal experience scattered through the human population on Buru. There is also a need to publish and distribute that gathered and analysed information.

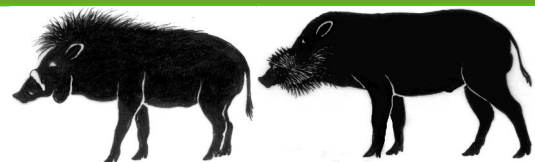
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Ecology and Conservation



Global collaboration to conserve three threatened Indonesian animal taxa: Babirusa, Anoa and Banteng

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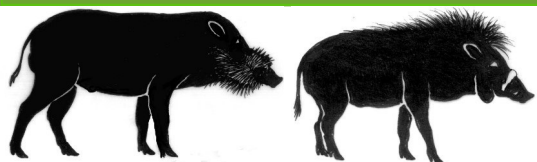
Introduction and history

To most readers this may seem like a very odd line-up. What do wild pigs have in common with wild cattle? And yet, these three unlikely partners have been developing a very meaningful relationship since 2009.

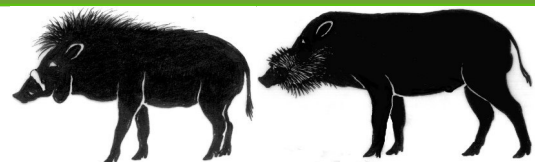
The Indonesian Ministry of Environment and Forestry has identified 25 national priority taxa that are threatened with extinction (Keputusan Direktur Jenderal – Konservasi Sumber Daya Alam dan Ekosistem – Nomor: SK.180 /IV-KKH/2015) and had published at least four action plans in 2007 and 2008, but was keen to produce new plans for more of the priority species. This was music to the ears of the IUCN SSC Asian Wild Cattle Specialist Group. In 2008 the group had facilitated a large planning workshop in Tam Dao National Park in Vietnam, resulting in the “IUCN Regional Conservation Strategy for Wild Cattle and Buffaloes in Southeast Asia (2011-2020)” (IUCN SSC Asian Wild Cattle Specialist Group, 2010). A next logical step was therefore to join forces with the Indonesian Ministry for the production of national action plans for anoa (*Bubalus* sp.) and banteng (*Bos javanicus*). Because the distribution, threat processes and stakeholders are so similar for anoa and babirusa (*Babirusa* sp.), the IUCN SSC Wild Pig Specialist Group reached out to join forces, thus creating the unlikely “marriage” between the three taxa. In 2009 more than 110 representatives from the Ministry of Environment and Forestry, provincial and national forestry departments, the IUCN specialist groups, local and international NGOs, zoo staff and scientists jointly developed National Action Plans for these three taxa (for babirusa: Direktorat Konservasi Keanekaragaman Hayati, 2015).

In parallel, important developments were taking place in the international zoo community. Firstly, zoos are taking their conservation mission increasingly seriously and are eager to participate in a One Plan Approach to species conservation planning whereby in situ and ex situ specialist together determine the most appropriate components and activities of a species conservation strategy (Byers et al., 2013; Barongi et al., 2015; Traylor-Holzer et al., 2017). In addition, in 2014





Ecology and Conservation

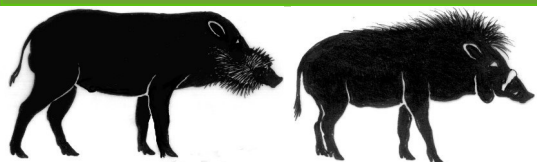


the chairs of the Taxon Advisory Groups from around the world had their first joint meeting in Alphen, the Netherlands. Many regional zoo associations have Taxon Advisory Groups (or equivalent structures), composed of specialist in particular taxa (e.g. pigs and peccaries) that occupy themselves with collection planning (which species to hold in zoos in the region, for what purpose and with which goals), breeding programme management, best practice for husbandry, determining research priorities etc.). At the 2014 meeting, representatives of the Indonesian, European, and North American zoo associations met and rallied around the idea that it would be beneficial to collaborate globally to develop in more detail the ex situ portions of the National Action Plans for the three taxa, focussing on how best the ex situ populations and the ex situ communities can contribute to their conservation. At the end of 2014 six partner organisations formalised this collaboration by signing a Memorandum of Understanding: the Indonesia Zoo Association (PKBSI), European Association of Zoos and Aquaria (EAZA), Association of Zoos and Aquariums (AZA), IUCN Species Survival Commission (SSC), IUCN SSC Asian Wild Cattle Specialist Group (AWCSG) and IUCN SSC Wild Pig Specialist Group (WPSG). The agreement was witnessed by the Indonesian Ministry of Environment and Forestry. The partners in the initiative felt that Global Species Management Plans (GSMP) as administered by the World Association of Zoos and Aquariums (WAZA) would provide a suitable framework within which to plan and implement the work ahead and decided to develop one GSMP for each taxon (<http://www.waza.org/en/site/conservation/conservation-breeding-programmes/gsm>). WAZA officially approved the GSMPs for babirusa (*Babyrousa* sp.), anoa (*Bubalus* sp.) and banteng (*Bos javanicus*) on 16th March 2016, thereby bringing the total number of GSMPs to nine.

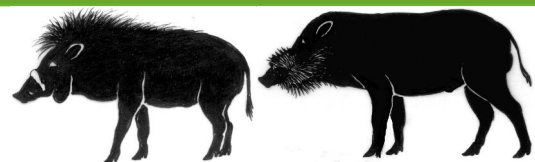


Participants to the first masterplanning meetings for the GSMPs for babirusa, anoa and banteng – Bogor Indonesia, January 2016.





Ecology and Conservation



GSMP Masterplanning

Every GSMP is required to provide a “Master Plan” that captures the role, intent and activities of all partners in the GSMP for a defined timeframe. Therefore representatives from the Indonesian, European and North American zoo associations, along with IUCN representatives, species specialists and representatives of the Indonesian government gathered in Bogor, Indonesia, from 25th to 30th of January 2016 for three 2-day workshops to agree the details of this collaboration. For each taxon, the participants jointly determined which role the world ex situ population would play in the conservation of the taxon and thus what the genetic and demographic goals of the world ex situ population should be, how expertise present in the ex situ community can help to solve particular in situ conservation problems and how to identify field conservation projects that address the most urgent threats to the taxa and that could make a lot of progress with relatively small scale financial support from the zoo community. Since this article appears in Suiform Soundings we will further highlight details of the babirusa GSMP.

The Babirusa GSMP

The data for the world captive population of Sulawesi babirusa (*Babyrousa celebensis*) is gathered in the International (global) studbook, administered under WAZA and maintained by Thomas Kauffels (Opel Zoo – Germany), who also coordinates the EAZA European Endangered species Programme (EEP) for this taxon. The PKBSI studbook for the Indonesian population is maintained by Sri Pentawati (Surabaya Zoo – Indonesia) and the AZA North American Species Survival Programme for the babirusa is coordinated by Jeff Holland (Center for Conservation of Tropical Ungulates, USA). Data from all of these sources and from the Zoological Information Management System (ZIMS) database of Species360 (<http://www2.isis.org>), leads to the conclusion that on the 31st December 2015, the world captive population of babirusa counted a total of 190 individuals, distributed over the different regions (Table 1).

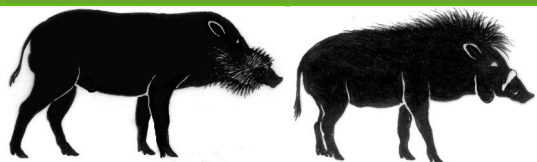
Table 1: Sulawesi babirusa (*Babyrousa celebensis*) population in different regional and national zoo associations across the world. Males.Females (Total). PKBSI: Perhimpunan Kebun Binatang Se-Indonesia; EAZA: European Association of Zoos and Aquaria; AZA: Association of Zoos and Aquariums.

Region	# Individuals	# Institutions
PKBSI (Indonesia)	30. 45. (75)	9
EAZA (Europe)	7. 16. (23)	7
AZA (N. America)	28. 32. (60)	17
Singapore	12. 20. (32)	1*
TOTAL	77.113. (190)	34

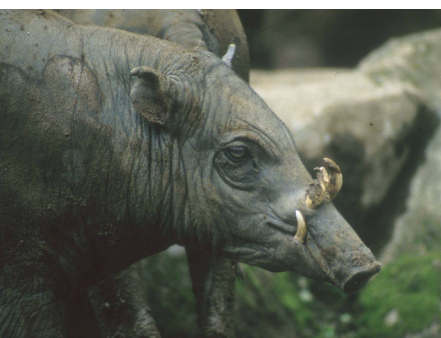
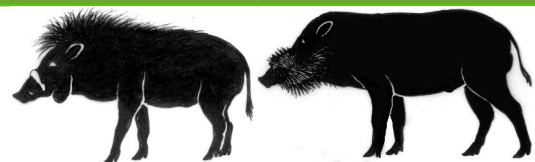
*Total for all locations of Wildlife Reserves Singapore.

Up until 1998, the world zoo population was derived from an unknown number of founders that entered Surabaya Zoo at unknown times pre 1974. From Surabaya Zoo, animals were transferred to other zoos in Indonesia and the world. Molecular genetic analysis shows that there must have been at least five founders, but the exact number is uncertain. In 1998, seven additional wild origin babirusa arrived in Surabaya Zoo, six of which have left living descendants, but only in the Indonesian zoo population.





Ecology and Conservation



Young babirusa male. Photo: A. A. Macdonald

Considering the continuing severe threat from hunting (especially on Sulawesi) and habitat loss and degradation, the workshop participants agreed that the global ex situ population of babirusa should ideally fulfil the role of a long term insurance population. To achieve this, the world zoo population will over time need to double and very gradually add additional founders, not by proactive capture but by, where possible, making use of individuals confiscated by law enforcement and collaborating with rescue, research and other relevant centres on Sulawesi. In the long term and with the current participating regions it was believed there could be space for ~330 babirusa and thus in time a few extra holders/regions need to be

brought on board. The initial focus of the GSMP will be to establish an effective Indonesian ex situ breeding programme. Once this is established and stable, possibly after two years, an analysis will be conducted in regards to the feasibility of a small number of transfers to other global regions. This will also allow time to further clarify outstanding taxonomic uncertainties and required quarantine procedures.

The workshop participants determined in detail what would be required to successfully achieve this, which included global sharing of expertise and skills about animal husbandry, veterinary treatment, population management, breeding programme management and other areas between zoos, and also sharing of knowledge with local authorities that care for confiscated animals.

Awareness education for local communities close to protected and unprotected areas containing babirusa was considered a high conservation priority due to the consistent and devastating effect of hunting on the remaining populations. Workshop participants therefore also decided that it would be opportune for education departments of zoos to use their expertise to assist local conservation authorities and protected area management in the development of education and awareness programmes and materials. Meeting participants also stated other urgent in situ needs for all three babirusa taxa and the babirusa GSMP committee members will develop a set of selection criteria to select those projects most suitable for small scale financial support by international zoos. The latter will organise fundraising for the selected project(s).

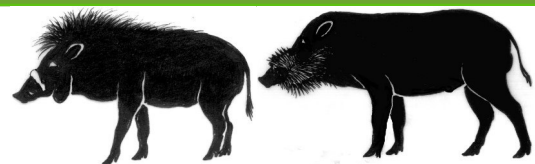
Current activities

Life certainly has been busy since the January masterplanning meeting. The Babirusa GSMP masterplan document detailing the current status of the ex situ population, all the strategies, roles and goals determined during the meeting and a long list of actions, timelines and responsibilities is being prepared for publication. Every two months the babirusa GSMP committee, composed of the authors of this article, holds a Skype meeting to follow up progress towards the actions and timelines. A Business Plan for 2017-2020 is nearing completion and a first edition of the Action Indonesia Newsletter was published. A group of western and Indonesian delegates has visited a variety of Indonesian zoos from 25-28th July to help plan for husbandry training to be held in October this year. Presentations were given to the PKBSI Zoo Directors at their annual meeting on 28th July to promote the benefits of collaborative breeding programs and share more information about the GSMPs. Visits to potential field project sites that hold priority populations of babirusa on Sulawesi have taken place to further refine the choice of priority in situ projects to





Ecology and Conservation



support. An update of the IUCN Red List accounts of the three babirusa taxa highlighted the urgent need to learn more about the status of the hairy babirusa from the Sula islands and Buru and a proposal to hold surveys on the islands is being prepared for review for by the GSMP committee as a project to be funded. DNA sampling priorities have been identified and breeding and transfer recommendations for the Indonesian population are being prepared. At the end of the annual Indonesian Zoo Association conference in October 2016, delegates will be hosting a skills sharing and training event focusing on topics such as animal husbandry and cooperative breeding programme management.

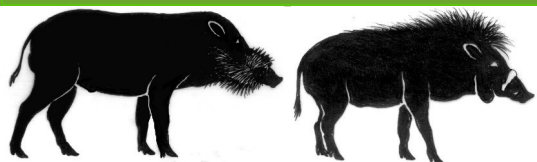
All of us involved in the GSMP very much agree with Mr Puja Utama, representative of the Indonesian government, who commented after the masterplanning meeting: "Indonesia is very proud of its unique wildlife. We are confident that our national conservation action plans in combination with the efforts of the global zoo community can help to save threatened species of Indonesia."

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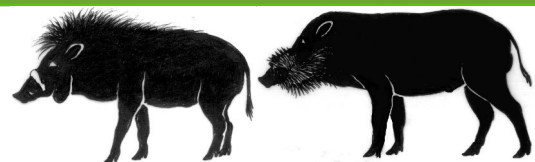
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Partner organisations (below) and supporting organisations (right)





Ecology and Conservation



The 100th Pygmy Hog is released into the wild

Ananda Banerjee

www.anandabanerjee.com

Editor's note

This article was published in live mint on 26th May 2016. Thanks to the author and live mint for their approval for publishing.

On 24 May, six little pigs trotted out of their wooden box enclosures to freedom, into the wild grasslands of Bornadi Wildlife Sanctuary in north Assam.

Those tiny pig steps could turn into a giant leap for conservationists.

Because these were no ordinary pigs but Pygmy Hogs, the smallest and rarest wild pig or hog on the planet. The sixth hog which ran out in the wild, marked the release of the 100th Pygmy Hog back in their natural environment.

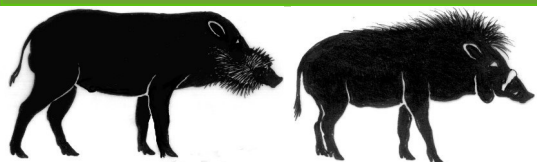
The release was part of a long-term conservation programme to boost the wild population of this critically endangered species across the landscape in which it once thrived—the tall wet grasslands in the foothills of the Himalayas.

Listed as a critically endangered species by the International Union for Conservation of Nature (IUCN), its population size is estimated to be fewer than 250 mature individuals. Today, the Pygmy Hog is found in just three places in Assam—Manas, Sonai Rupai and Orang.

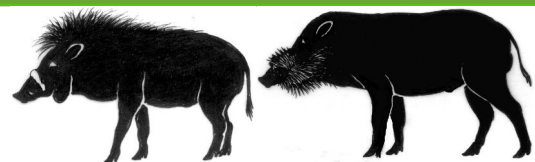


Pygmy hog with radio tag just before it was taken to Badia for release on 21st May 2016. Photo: C. Jones.





Ecology and Conservation



Pygmy hogs with radio tags emerging from release enclosure in Barnadi 24th May 2016. Photo: C. Jones

Why is the Pygmy Hog so important to the habitat?

“The hog,” says wildlife scientist Goutam Narayan, “is an indicator species for the health of tall wet grassland habitat across the southern foothills of the Himalayas. Unfortunately, this landscape have seen the most destruction due to ever-growing agricultural expansion with human and cattle populations as well as commercial plantations. The hog cannot adapt to the changing habitat.”

The Pygmy Hog is the sole representative of the genus *Porcula*, a species that was described to science by Brian Houghton Hodgson in 1847. The conservation of this diminutive pig is vital—its extinction would result in the loss of a unique evolutionary branch of wild pigs.

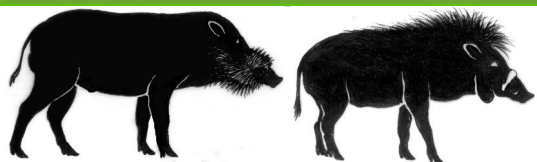
“The Pygmy Hog is as important as the tiger or the rhinoceros and more mass awareness is needed for the welfare of the species,” said Daniel Craven of Durrell Wildlife Conservation Trust.

Once thought to be extinct, the Pygmy Hog was accidentally rediscovered in 1971 by a tea planter named J. Tessier-Yandell in the same area, Bornadi, whose forests border Bhutan.

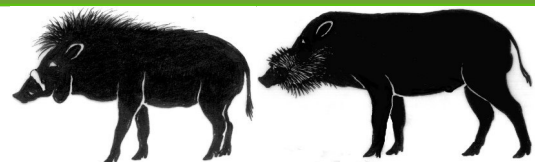
In 1995, the Pygmy Hog Conservation Programme was started by Goutam Narayan with the help of the Assam government, the Durrell Wildlife Conservation Trust (DWCT), a Jersey-based conservation organization started by naturalist Gerald Durrell, and former IUCN Wild Pig Specialist Group chair, the late William Oliver.

Initially, six Pygmy Hogs were procured for captive breeding from the original population in Manas National Park, Assam. They were bred in captivity at the Pygmy Hog Conservation Centre in Guwahati.





Ecology and Conservation



The rewilding of Pygmy Hogs began in 2008 with the release of 16 captive bred hogs into the Sonai Rupai Wildlife Sanctuary, Assam. In the following years 19 more hogs were released.

“Unfortunately, the Pygmy Hog population in Sonai Rupai Wildlife Sanctuary is still at 35, the total number released by us. The number has not increased because of the quality of grassland habitat, which has deteriorated due to human disturbance. However, we have seen that the scenario at Orang National Park is in contrast to the Sonai Rupai. Fifty-nine hogs we released between 2011 and 2015 have now doubled—thanks to better park management,” says Narayan.

“In twenty years we have made a positive difference towards fulfilling our mission—saving species from extinction and rebuilding wild populations. We want to see Indian funders and volunteers to get involved in this conservation project,” says Craven. Craven was present in Bornadi to watch the release of the 100th Pygmy Hog.

“We’ll continue to monitor the hogs and their habitat at the reintroduction sites and release a few more groups in Bornadi before moving to other potential sites. We’ll also work with Park authorities in Manas as the population continues to shrink there,” said Narayan.

“Fewer than 200 hogs may remain in Manas. Although about 50% of the total pygmy hog population is reintroduced in the wild from captive populations, we have a long way to go before its future is secure.

“Long-term funding remains an issue where the odds are stacked against tall wet grassland conservation in the Terai and Duars belt. These grasslands not only shelter a number of highly threatened species but also provide immeasurable ecosystem services for our survival. The sooner we realize this the better will be the quality of conservation efforts,” added Narayan.

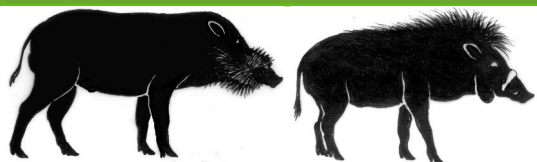
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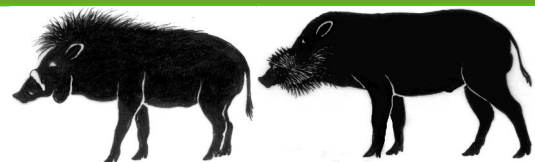


Pygmy hog sow with young entering a nest. Photo: C. Jones





Ecology and Conservation



A sighting of giant forest hog, *Hylochoerus meinertzhageni* Thomas, in the Mara National Reserve, Kenya

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On 23 December 2015, while at Naibor Camp (1o 25' 25.76" S, 35o 04' 28.05" E) in the Maasai Mara National Reserve, Kenya, at 1445 h I watched a large black suid cross the swollen Talek River, at a distance of no more than 30 m below and from me. The animal crossed the 25 m river to the side I was on, and I watched as it moved downstream along the river bank obviously trying to mount the bank.

It failed to do this and then returned across the river, using a combination of swimming and walking on the rocky bottom. Video film (<https://youtu.be/zrhuEXfnfDI>), and a series of still photos were taken (Figs. 1, 2).



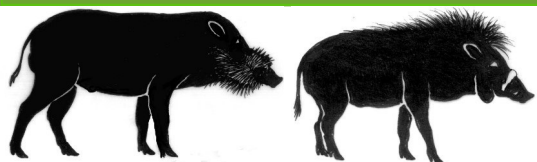
Fig. 1 and Fig. 2: Giant forest hog. Photo: M.R. Stanley Price

Familiar with the giant forest hog from the Aberdare Mountains and the Cherangani Hills in the 1960's, I immediately identified this as a female of this species. This identification was subsequently confirmed without hesitation by Jonathan Kingdon, the author of the East African Mammals. An Atlas of Evolution in Africa (Kingdon 1979).

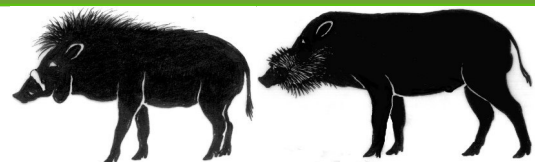
In addition to evidence of the aquatic capabilities of the hog, the location of the sighting is of interest. Stewart and Stewart (1963) show this species occupying three 10-minute grid squares in the approximate location of the Maasai Mara National Reserve (Fig.3). The central of these three sightings is approximately on the Talek River, where Naibor Camp is situated, about 1 km above its confluence with the Mara River. H. H. Henley recalls once seeing giant forest hog in the 1970's in forest along the Mara River, some 14 km north-northeast of this sighting (H. H. Henley, pers. comm., March 2016).

Naibor Camp is at 1505 m (4937 feet) (Google Earth, downloaded 26 March 2016). Stewart and Stewart (1963) caption their distribution map with the following 'Habitat: Highland forest and

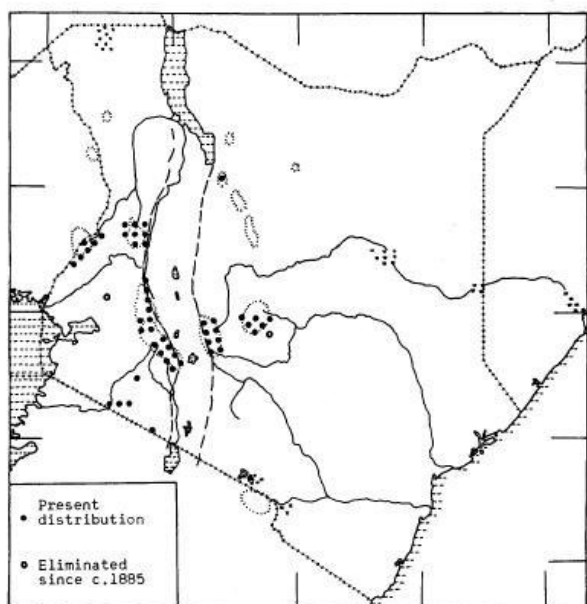




Ecology and Conservation



J.E.Afr.Nat.Hist.Soc. Vol.XXIV No.3 (107) June 1963



Giant Forest Hog (*Hylochoerus meinertzhageni* Thomas)

HABITAT: Highland forest and grouped tree-grassland from 5,000 to about 10,000 ft. above sea level.

PAST DISTRIBUTION: There is little evidence concerning the former range or numbers of this species.

Fig. 3. Distribution of the giant forest hog according to Stewart and Stewart (1963), indicating three records in the area of the Mara National Reserve.

previously recorded range indicating that, at least in this region, the species' range has not undergone reduction, re-affirming the value of protected areas.

Acknowledgements

I am grateful to Mandy Bell for taking still photographs of the Giant Forest Hog, and to Freya Stanley-Price for her presence of mind to shoot some video.

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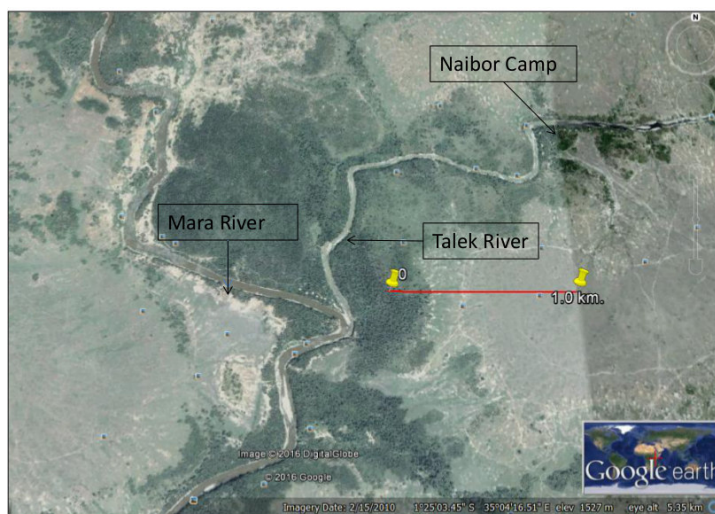
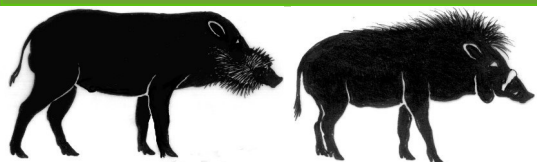


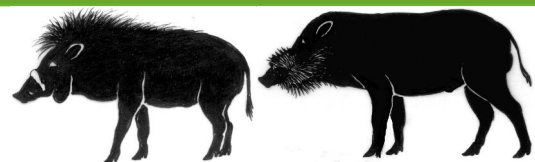
Fig. 4. The location of Naibor Camp in relation to the Talek and Mara Rivers, showing the extent of riverine forest. Downloaded from Google Earth 16 June 2016.

grouped tree-grassland from 5,000 to about 10,000 feet above sea level'. While the riverine forest of the Mara and Talek rivers (Fig. 4) would not normally be regarded as 'highland forest', the species was clearly at the lower end of its known altitude range in Kenya. Moreover, the sighting is definitely at the south-eastern extreme of





Ecology and Conservation



Wild boar on the rise! 11th International Symposium on Wild Boar and other Suids

E. Johanna Rode-Margono

The North of England Zoological Society / Chester Zoo

Four days of presentations, site visits and inspiring discussions

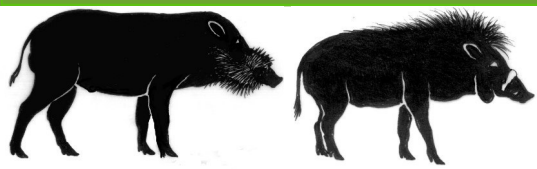
The 11th International Symposium on Wild Boar and other Suids was hosted by the Administration for Nature and Forests, part of the Luxemburg Ministry of Environment, from 5th to 8th August 2016 in Mersch, Luxemburg. The conference is held successfully already since 32 years with a biannual rhythm, which shows the importance of an exchange of advances by research teams working in Europe, but also around the world. Increasing knowledge about this economically important species, mainly with the aim to achieve effective, humane and environmentally sensitive management and conservation of suids is of high concern to conservation biologists, wildlife managers, veterinarians, policy makers and the general public. Similar to previous years, the conference this year was well attended this year with around 90 participants from over 20 European countries and Israel. The conference included three days of presentations and discussions, and ended in an excursion to the Grand Duke of Luxemburg's former hunting reserve and wild boar feeding place (historic site) and the very recently inaugurated impressive visitor's center "Biodiversum" in the commune of Schengen on the last conference day. The latter site is situated in a Natura2000 and RAMSAR wetland-area with a particularly rich avifauna, surrounded by vineyards and hosting a population of wild boar. A short summary of the contents of the symposium is given here, with no claim of completeness, and influenced by personal interest in certain topics. The abstract booklet is published on http://www.environnement.public.lu/wildboar/programme/WBS2016_abstract-booklet_V20160827.pdf (last access 29 September 2016). The next conference will take place in Czech Republic in 2018.

Main focus: the increase of wild boar populations and its implications

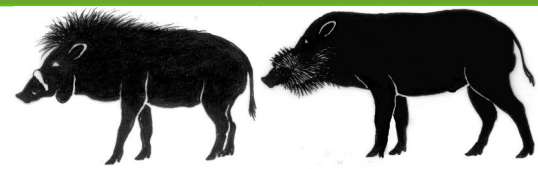
After a warm welcome by the Luxemburg Minister of Environment, Carole Dieschbourg, and the Secretary General of the Benelux Union, Alain De Muysen, the two first speakers of the conference presented introductory talks. Mario Meletti¹ (independent wildlife consultant, Rome, Italy) gave a comprehensive overview of the ecology, conservation and management of wild pigs and peccaries of the world and referred to his book to be published in 2017 (Meletti & Meijaard, in prep.). Oliver Keuling (University of Veterinary Medicine Hannover, Institute for Terrestrial and Aquatic Wildlife Research, Hannover, Germany) et al. presented their work on understanding the rapid increase in wild boar populations during recent decades. Based on over 3000 samples from female wild boar collected over 11 years, they confirmed that wild boar reproduction responds to maternal physiology, environment (e.g. higher body mass, mast conditions of oak and a low hunting index in the same year were positively correlated to high litter size and earlier parturition), hunting and/or density. More specifically, it seems that food availability is increased by intensified agriculture, global warming and supplementary feeding (mainly maize), and leads to higher reproduction.

¹Only first author mentioned throughout this article, regardless of how many co-authors





Ecology and Conservation



This introductory session was followed by the highly interesting and informative sessions, completed by the presentation of 15 posters, tackling the following topics:

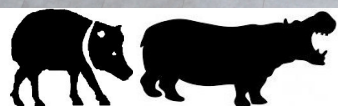
- Census methods
- Damage caused by wild boar
- Management and hunting of wild boar populations
- Urban issues
- Spatial behaviour
- Diseases
- Genetics
- Reproduction and diet

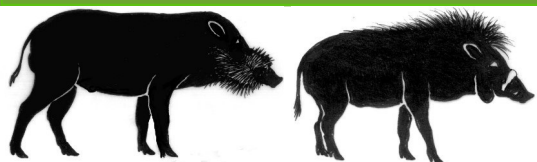
Most of the talks centred around the rapid increase of wild boar in almost all European countries. Dragan Gačić (University of Belgrade, Belgrade, Serbia) for instance reported that in Serbia wild boar populations grew from 12,390 to 23,160 individuals between 1995 and 2013 period. This

seems to be the trend for most European countries. As numbers are usually estimated on the basis of hunting statistics, an increase in numbers could be based on higher hunting activities. However, Massei et al. (2015) found a decrease in numbers of active hunters but increase of other indicators such as vehicle collisions and crop damage, suggesting that populations in deed grow. Control of wild boar populations is needed to avoid unacceptable levels of crop-raiding and other damage. This requires effective management plans which are based on estimations of wild boar population numbers. Currently a variety of methods are used to determine population sizes, including distance sampling, camera trapping, capture-mark-recapture, and total counts. The reliability and cost-benefits of each of these methods were intensely discussed. While Stefano Focardi (Institute for Complex Systems, Rome, Italy) et al. demonstrated that line transects, thermal imagery and distance sampling (nocturnal line transects) delivered reliable and robust results, Giovanna Massei (National Wildlife Management Centre, York, UK) et al. compared the relatively new method of random encounter modelling based on camera trapping with the established

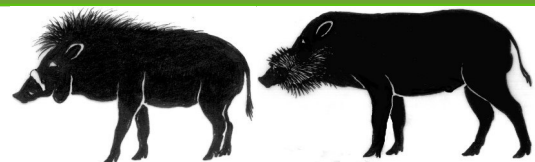


Fig. 1. Participants of the 11th International Symposium on Wild Boar and other Suids in Mersch, Luxemburg





Ecology and Conservation

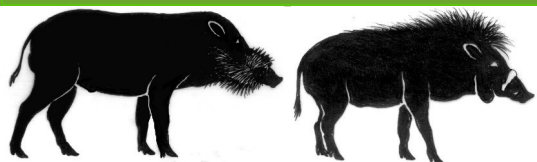


European wild boar (*Sus scrofa*). Photo taken in captivity by S. Cellina

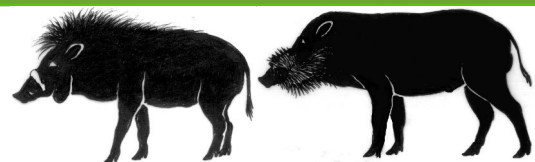
method of distance sampling. They found that both methods result in similar and reasonably accurate estimates. Two more talks tested the random encounter model, and some problems encountered in the use of this method were discussed (e.g. need for accurate measurements of daily distance travelled and mean group size, assumption that groups move randomly through the habitat). Alain Licoppe (Service Public de Wallonie, Gembloux, Belgium) et al. explained how they had used a capture-mark-recapture study to estimate a closed population in Belgium, based on capturing and marking animals. Giovanna Massei mentioned the possibility of using feeding stations that enable colouring of animals' fur as a basis for capture-mark-recapture. Finally, Cornelia Ebert (Research Institute for Forest Ecology and Forestry, Trippstadt, Germany) discussed the potential for using non-invasive genetics based on genotyping of faecal samples to receive absolute population numbers.

Camera traps are not only used for density estimation but also for many other purposes, such as supervising remote-controlled traps. This important role was acknowledged in a workshop about camera-trapping that aimed to produce a 'living' document manual that includes not only a list of standard research questions answered or methods, but also practical information. Jim Casaer (Institute of Nature and Forest Research, Brussels, Belgium), leading this workshop, presented provisional content for this manual that was then completed based on an open discussion with all conference participants.





Ecology and Conservation



Another strong topic during the conference were problems arising from the current wild boar population increase across most countries of Europe, including crop damage, migration into cities, possible disease transmission and increased traffic collisions, along with potential mitigation of these problems by population control through hunting or by crop-protection measures such as fencing. Several talks discussed crop damage, e.g. Boguslaw Bobek (Pedagogical University of Cracow, Institute of Biology, Cracow, Poland) et al. presented a very informative study on spatio-temporal characteristics of crop-damage in eastern Poland. Three contributors explained how wild boars are using urban environments. Jorge Ramón López-Olvera (Universitat Autònoma de Barcelona, Bellaterra, Spain) et al. modelled what factors explained the localisation of wild boar incidences in Barcelona, and found that the distance to the Caollserola Massif, water sources, green area surface, proximity to cat colonies (cat food as food source) and fragmentation were positively associated with wild boar presence. Alain Frantz (Museum of Natural History, Luxembourg) et al. investigated sink source dynamics between urban and rural areas of Berlin. Milena Stillfried (Leibniz Institute for Zoo- and Wildlife Research, Berlin, Germany) et al. studied the differences of home ranges between rural and urban wild boars. Two talks (Simona Pilevičienė, National Food and Veterinary Risk Assessment Institute, Vilnius, Lithuania, et al.; Tomasz Podgórski, Mammal Research Institute, Polish Academy of Sciences, Białowieża, Poland) broached the issue of African swine fever in wild boars.

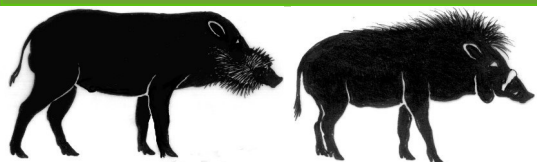
Mitigation of problems in general is attempted by reducing population sizes through hunting. Two methods are used: collective or drive hunting, and selective or single hunting. While both do reduce numbers of wild boar, qualitative management strategies through selective hunting of young reproductive females seems to be more effective (e.g. Jiří Kamler, Mendel University in Brno, Faculty of Forestry and Wood Technology, Brno, Czech Republic; Alain Licoppe et al.). All contributors add that hunters unfortunately tend to avoid pregnant females or females with piglets. Two talks on wild boar–vehicle collisions on main and secondary roads (Katarina Flajšman, Slovenian Forestry Institute, Ljubljana, Slovenia, et al.; Carme Rosell et al.) listed possible tools to avoid collision, such as fencing and wildlife crossings, temporary awareness signs, signs triggered by camera traps detecting wild boar, blue reflectors, new apps for navigation systems or mobile phone, or the removal of dense road verge vegetation.

The question of whether large predators could help to control wild boar populations was not a main topic of discussion. Adriani Settimio (University of L'Aquila, L'Aquila, Italy) et al. reported the continuing negative attitudes of wild boar hunters towards wolves, which are perceived as competitors. While the predation rate is about 50 wild boar per year per wolf, poaching of wolf removes 10-20 % of the entire wolf population. Furthermore, roe deer are declared to cause disturbance during wild boar drive hunts. This appreciation of hunting wild boar from another perspective shows that hunting is not only carried out for crop-protection but also for selling meat, trophies and as a hobby. In Poland, for instance, Baguslaw Bobek et al. found that the value of selling carcasses, hunting concessions is much higher than crop damage.

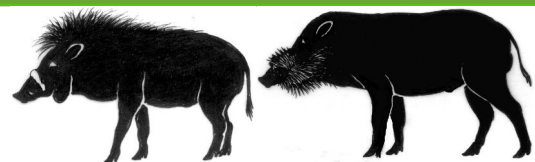
Conclusion

The 11th International Symposium on Wild Boar and other Suids was an extremely interesting and stimulating conference. The participation of researchers from many European countries, presentations of many large-scale and long-term studies with cross-border study sites or data





Ecology and Conservation



from different countries, and the general eagerness to share data and results (e.g. through EUROBOAR, an innovative European network for sharing data and experience between wild boar research groups, presented in a workshop by Kevin Morelle, University of Liège, Liège, Belgium, and Stefano Focardi), shows that the main research groups are well connected across Europe. Species movements do not follow administrative borders, and thus this cooperation will make research and management of wild boar populations more effective and beneficial for all.

Although the symposium focused primarily on wild boar, a few other taxa were included in the contents, with talks on population numbers and habitat use of Bawean warty pigs (*Sus blouchi*) using camera trapping (Johanna Rode-Margono, Chester Zoo / The North of England Zoological Society, Chester, UK, IUCN SSC Asian Wild Cattle Specialist Group, et al.) and conservation management of babirusa (*Babirusa* spp.) (Johanna Rode-Margono et al.). Claude Fischer (University of Applied Sciences of Western Switzerland, Geneva, Switzerland) et al. also presented on occupancy and habitat use of sympatric populations of bush pigs (*Potamochoerus larvatus*) and warthogs (*Phacochoerus africanus*) using camera trapping. Finally, Julien Fattebert (University of KwaZulu-Natal, Durban, South Africa) et al. discussed the spatial distribution of warthogs in relation to limiting factors and predation risk, e.g. by leopards, which may also teach lessons regarding the spatial movements of wild boar populations.

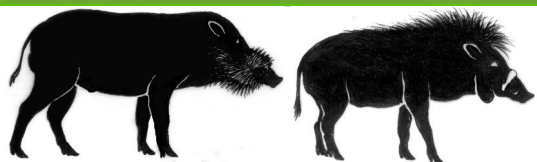
As the odd symposium participant studying species with small and declining populations as opposed to the increasing populations of wild boar, I could nevertheless take home plenty of ideas and advice from colleagues working on wild boar. Information on census techniques, crop damage and genetics are especially useful in conservation projects involving suids, but more resource-intensive methods such as radio-tracking may also be interesting for future projects. The exchange with researchers working on a related pig species for many decades and comprising a vast body of knowledge and well developed methodology can only be beneficial. I hope that collaboration can grow from this meeting to save the more threatened wild pig species of this world.

References

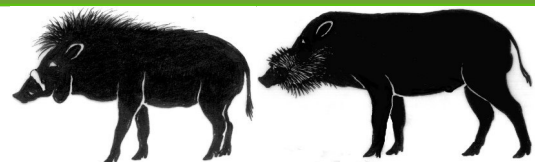
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- Massei G, Kindberg J, Licoppe A, Gačić D, Šprem N, Kamler J, Baubet E, Hohmann U, Monaco A, Ozoliņš J, Cellina S (2015) Wild boar populations up, numbers of hunters down? A review of trends and implications for Europe. *Pest Management Science* 71(4):492-500.
- Various authors (2016) Various titles. In Cellina S, Casaer J, Fattebert J, Fonseca C, Keuling O, Massei G, Nàhlik A, Pokorný B, Podgórski T, Schley L (editors). Presented at the 11th International Symposium on Wild Boar and other Suids, Luxemburg, Administration for Nature and Forests (60 pages).

11th International
Symposium on
Wild Boar
& Other Suids





Ecology and Conservation



Mesoamerica's white-lipped peccaries on the brink of extinction
Wildlife Conservation Society convenes regional experts for urgent assessment



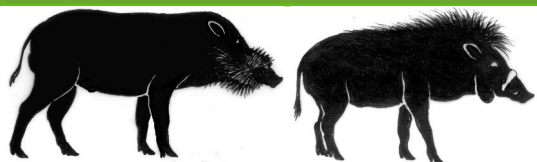
Whitelipped peccaries (*Tayassu pecari*). Photo R. Reyna.

(Belize – September 5th, 2016) The Wildlife Conservation Society (WCS) hosted a Symposium at the XX Mesoamerican Society for Conservation Biology Congress, which brought together leading scientists for an emergency assessment of the rapidly declining white-lipped peccary (*Tayassu pecari*) in Mesoamerica. The objectives of the Symposium were to document the current status of the species, to map recent reductions in its range across Mesoamerica, and to propose conservation actions to protect the species.

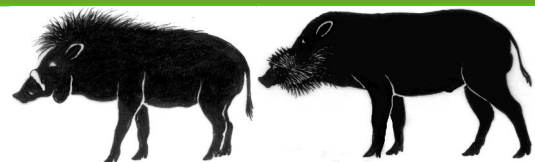
Hunting and deforestation for agriculture and cattle ranching have driven precipitous declines of the white-lipped peccary in most Mesoamerican countries. As the only large mammal that moves in large herds in forested environments, this species represents one of Central America's true wildlife spectacles, and plays a key role in ecosystem function of the region's forests. Peccary herds can number up to 200 individuals and range as widely as 120km². However, herd sizes like this are becoming ever rarer as hunting depletes populations and disrupts their social structure. In Mexico and Guatemala, the species' distribution range has been reduced by more than 84 % in the last 30 years. In Honduras and Nicaragua, only a few remnant populations remain. In El Salvador, the species is already locally extinct.

Dr. Rafael Reyna – a professor at ECOSUR in Mexico and WCS Conservation Fellow, led the Symposium which brought together leading mammal researchers from Belize, Mexico, Guatemala, Honduras, Nicaragua, Costa Rica, and Panama. The symposium was presided by





Ecology and Conservation

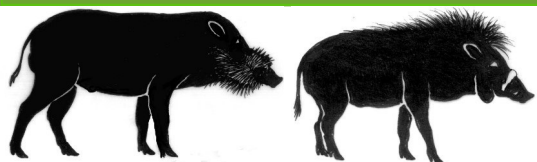


the Belizean Minister of Environment, Dr. Omar Figueroa. The group outlined the threats facing white-lipped peccary populations in each country. Collectively, the scientists mapped the current known locations of remaining white-lipped peccary populations and compared these with the past extent of their range to develop an idea of the rate of loss. This map, in addition to a call for an increase in the official International Union for the Conservation of Nature (IUCN) extinction threat level from 'Vulnerable' to 'Endangered' in Mesoamerica, will be released in the coming weeks. The group of scientists and conservationists signed a pledge committing themselves to jointly proposing and implementing conservation actions to save the species.

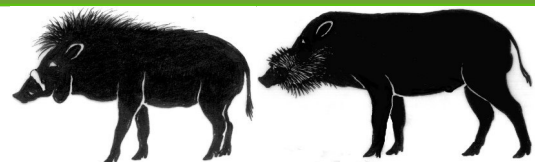


Wildlife Conservation Society saves wildlife and wild places worldwide through science, conservation action, education, and inspiring people to value nature. To achieve our mission, WCS, based at the Bronx Zoo, harnesses the power of its Global Conservation Program in nearly 60 nations and in all the world's oceans and its five wildlife parks in New York City, visited by 4 million people annually. WCS combines its expertise in the field, zoos, and aquarium to achieve its conservation mission. Visit: newsroom.wcs.org Follow: @WCSNewsroom.





Chacoan Peccary



Chacoan Peccary *Catagonus wagneri* conservation strategy

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²Prescott College,

³Royal Zoological Society of Scotland and IUCN SSC CBSG Brazil,

⁴Towson University,

⁵Guyra Paraguay,

⁶Tagua Project field coordinator, Paraguay

Summary

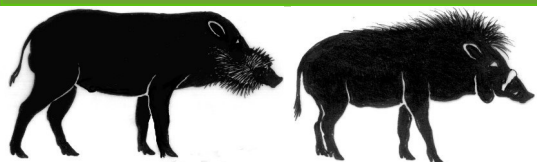
The Chacoan peccary (*Catagonus wagneri*), an endemic species of the Gran Chaco ecoregion, is endangered of extinction due mainly to habitat loss and hunting. The only conservation plan for the species was written in 1993. Because the situation continues deteriorating, and the rate of deforestation in the region is currently among the highest in the world, the IUCN SSC Peccary Specialist group saw the need to develop a new conservation strategy. A workshop was held in Paraguay, in March 2016, with representatives of different sectors and range countries. This paper presents a summary of the problems, threats and actions identified by the participants. The other two results of the workshop, a species distribution and population viability modeling, are presented separately in this same newsletter issue.

Introduction

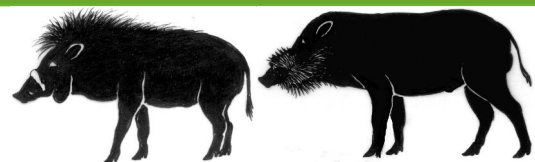
The Chacoan peccary (*Catagonus wagneri*) or Taguá, as it is called in Paraguay, is an endemic and endangered species that inhabits the thorn forests of the Gran Chaco of Bolivia, Paraguay, and Argentina. The Gran Chaco is the second largest eco-region in South America after the Amazonia. The species is listed as endangered by the IUCN Red List and in CITES I Appendix (IUCN 2016). In 1993, the entire Chacoan peccary population was estimated to be less than 5000 individuals (Taber, 1991 et al. 1993, 1994) and it has been declining since then (Altrichter & Boaglio, 2004). The situation for the Chacoan Peccary keeps deteriorating, primarily because of habitat destruction and over-hunting. Surprisingly, there is scarce knowledge on the species ecology and current conservation situation. The Gran Chaco was until recently little developed, covered by forest and inhabited by colonists and natives living on a subsistence economy. However, recent economic changes have greatly boosted the export of natural resources and agriculture production. Large areas of forest are being replaced with intensive ranching and agriculture (Huang, et al. 2009; Cardozo, et al. 2014; Caldas, et al. 2015). These trends, in addition to the already unsustainable subsistence hunting that occurs in the region (Altrichter & Boaglio, 2004), represent a major threat to the survival of the Chacoan peccary.

Despite the importance and critical situation of this species, little is being done for its protection. The last, and only, conservation plan for the species was written more than 20 years ago (Taber, et al. 1993). For this reason, the IUCN SSC Peccary Specialist group (PSG) considered imperative to review the species general status and design a conservation strategy including main stakeholders (government, NGOs, researchers, local people, among others). This strategy followed the Population Habitat Viability Assessment model which includes the participatory





Chacoan Peccary



creation of an action plan following the IUCN species conservation planning guidelines as well as habitat suitability and population viability modeling. The PSG organized a workshop in Asunción, Paraguay, with the following objectives: compile available information on the species, analyze its conservation status, identify main threats, and define actions to stop or reverse those threats. This article presents a summary of the Species Conservation Strategy, including only the goals and actions identified as necessary and feasible to stop or reverse the main threats to the conservation of the species.

Methods

Thirty one representatives from Argentina, Paraguay and Bolivia, representing various institutions, met from February 29th to March 3rd at a hotel in Asunción, Paraguay (Appendix 1). The first day, most of the researchers and people with knowledge on the species worked on reviewing the species status and distribution, and building a population viability and habitat suitability analysis. The remaining three days, participants, including government officials, representatives of the local indigenous communities or Mennonite communities and NGOs, worked on identifying a vision for the plan and the main species threats. Participants were then separated in groups to work on isolating problems and determining goals and actions to address the identified main threats: hunting, habitat loss and lack of knowledge. The third group also worked on reviewing and identifying actions for the potential roles for captive breeding programs. During these three days the population viability and habitat suitability analysis were perfected and tested with the input of the group. Other result of this event was the creation of a network of professionals and institutions committed to put into practice all the recommendations and necessary actions listed as priorities. This article presents the vision of the conservation strategy and a summary of the goals and actions determined by each of the four groups. In the Conservation plan each action is described in detail as well as the person responsible and an estimated time frame to realize the action was proposed.

Results

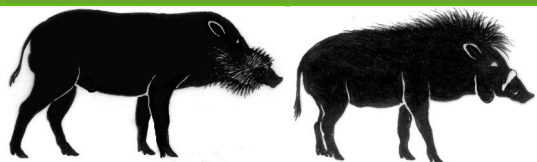
VISION: To ensure viable populations of *Catagonus wagneri* in the Chaco eco-region, maintaining the ecological integrity and connectivity throughout its distribution, within a context of sustainable and transparent development that contemplates the needs and visions of the local communities, valuing the species as emblematic.

Identified threats, goals and actions

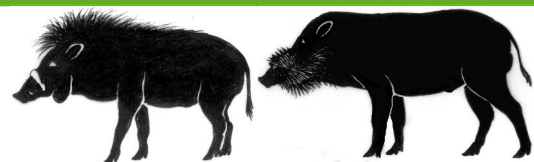
1) Summary results for Working Group 1: Hunting

Participants: Rosa Leny Cuellar, Kaa-Iya Foundation, Bolivia; Ivanna Ghione, PRODERI (Programa Desarrollo Rural Incluyente), Production Ministry, Misión Nueva Pompeya, Chaco, Argentina; Diego Jiménez, Environment Agency, Wildlife office, Paraguay; Timoteo Navarrete, chief Wichi community, Nueva Población, Chaco, Argentina; Nora Neris, Environment Agency, National University, Asunción, Paraguay; Pablo Perovic, National Parks Administration, Salta, Argentina; Silvia Saldivar, Itaipú Binational, Paraguay; Licindo Tebez, local farmer, participant of wildlife monitoring program, Chaco, Argentina.





Chacoan Peccary



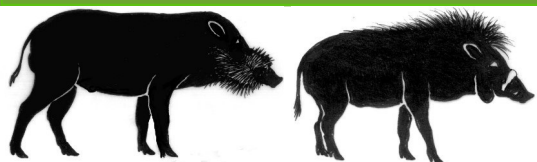
Problem

Hunting of Chacoan peccary is illegal in the three countries, although subsistence hunting practiced by indigenous peoples in Paraguay is exempt. However, throughout the species distribution there is prominent illegal hunting for consumption, and in the case of Bolivia and Paraguay, there is commercialization of its meat and hide. In Argentina there is no information if such type of market exists. High hunting pressure can decrease number of individuals, produce changes in the behavior and force animals to change territories. The stress generated under these conditions also affects the capacity to survive and reproduce.

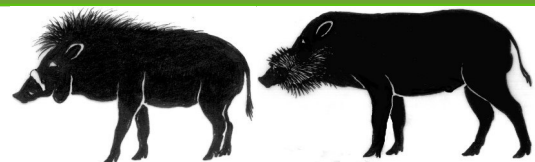
Five types of hunting were identified: illegal hunting practiced by people from towns and cities; sport or recreational hunting, which is illegal except for hunting clubs in Bolivia under regulations; subsistence hunting, practiced by local rural and indigenous people to supplement their diet; accidental, produced by roads collisions; pet trade, which is not common but it occurs, generally when the mothers are killed for food; commercial, for meat and pelt trade.

Goals	Actions
All responsible institutions for hunting control operate efficiently and in a coordinated way	Develop training courses on the conservation situation of the species.
The species is considered emblematic of Chaco conservation	Develop educational campaigns in communities and schools about the species importance and hunting regulations. Promote the use of the species as emblematic of the Chaco ecosystem. Contribute to develop coordinated hunting control efforts.
The local communities care about the species and its habitat	Develop a community based monitoring program of subsistence hunting and biological data.
The species is considered under the maximum level of protection	Petition the local governments to consider maximum level of protection.
The action plan is validated and used to inform local laws and regulations	Promote the use of the conservation plan by the local governments to inform laws and regulations.
The number of dogs is reduced to the minimum necessary	Perform education programs including workshops, talks, flyers, etc., about responsible ownership of dogs and dogs' impact on wildlife. Monitor dog population.
There is a current and up to date registration of captive Taguas	Identify and register all individuals in captivity in public and private collections.
There is no illegal hunting	Design a program to educate and inform local people and sport hunters about hunting regulations and sanctions. Promote alternative sustainable economic livelihoods, i.e. promote tourism.
There is no mortality of Tagua due to pet trade, commercialization and accidents	Identify areas of critical road mortality. Increase awareness of illegal pet trade and ownership.





Chacoan Peccary



2) Summary results for Working Group 2: Habitat loss

Participants: Daniel Brooks, Houston Natural Science Museum, US; Hugo Correa, principal technician, Quimilero project, Edge ZSL, Chaco, Argentina; Julieta Decarre, Biological Resources Institute, INTA Castelar, Argentina; Anthony Giordano, SPECIES, US; Rosalía Goerzen, Fernheim Cooperative, Filadelfia, Paraguay; Daniel Jaimes, local farmer, member of Mesa de Organizaciones 10 de Marzo, Impenetrable, Technician Proyecto Quimilero, Chaco, Argentina; Julio Monguillot, director Norwest regional office, National Park Administration, Salta, Argentina; Viviana Rojas, Guyra Paraguay, Asunción, Paraguay; Ricardo Torres, Zoology Museum, National University, Córdoba, Argentina.

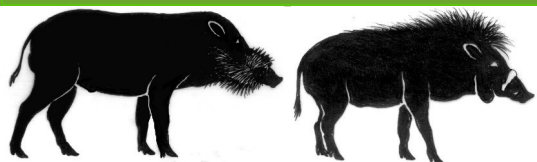
Problem

Conversion of natural vegetation to systems of intensive agricultural and livestock, or for mining operations, represents the main cause of habitat loss at a global level. In the Chaco region, the situation among the countries is similar but with particularities depending on the main economic activities. In general, large extensions of natural environment are being replaced by a matrix of productive activities, which implies not only the loss of habitat but also its fragmentation, which represents the major problem for conservation of wild species. The causes can be understood at different scales. At a global scale, the following causes were identified: climate change, together with bio-technology advancements, and a recent increase in the demand of agricultural mining and forestry resources. At national and regional levels the following causes were identified: legal deficiencies, lack of coordination among environmental regulations, lack of control, unclear land property rights, lack of coordination among main stakeholders, unrecognized value of forests and their ecological services, development policies that do not consider the environment, and overestimation of productive potential of the Chaco. All these lead to changes in land use, advancement of urbanization, and expansion of infrastructure, which in turns lead to habitat fragmentation and decrease of Tagua populations.

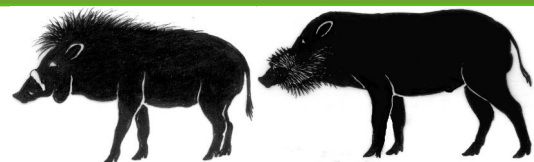


Participants of the workshop. Photo: E. Ortiz





Chacoan Peccary

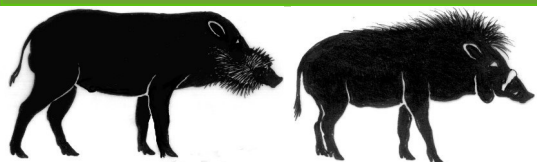


Goals	Actions
The value of the Chaco ecosystem, its resources and services, is recognized.	Implement environmental education through graphic informative material, talks and presentations at schools. Petition the incorporation of the issues of conservation and habitat loss into the official curricula of the schools that are located in the species range. Promote and perform studies on the Chaco ecosystem services. Identify areas of special conservation importance.
There is interaction and consensus among relevant actors (government, research institutions, NGOs, etc.)	Develop workshops for the exchange of information and experience among different actor that are key in the conservation of the Chaco. Promote sustainable alternatives of forest management and livestock. Promote exchange of ideas and information between academic and productive sectors. Produce multimedia material to promote the importance of the conservation of the species. Promote environmental education programs in the Mennonite communities' schools.
Regulations are improved and design to be locally appropriate and coordinated among the three countries	Contribute to improve existent laws and regulation that deal with sustainable practices in the Chaco region.
New protected areas are created and the existent ones are consolidated	To perform a diagnosis of the situation of protected areas within the species range. Promote monitoring programs. Evaluate possible programs for payments for environmental services.
Count with alternative methods to facilitate the titling of land for local people within the species range	Facilitate titling for local people, especially surrounding the Impenetrable NP

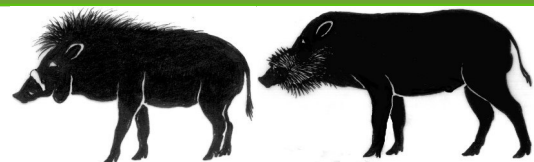
3) Summary results for Working Group 3: Lack of information

Participants: Mariana Altrichter, Prescott College, Co-chair IUCN Peccary Specialist group; Micaela Camino, Landscape Ecology and environment, National University of Buenos Aires; EDGE – SZL, CONICET, Argentina; Juan Campos, Chaco Center for Conservation and Research (CCCI), Paraguay; Jeffrey Thompson, Associate researcher Guyra Paraguay; Laura Villalba, Species conservation program WCS, Paraguay; Kathe Waltbtunner, local member of Colonia Neuland, Paraguay; Andrea Weiller, director of Biology school, National University of Asunción, Paraguay.





Chacoan Peccary

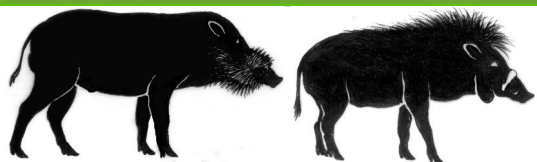


Problem

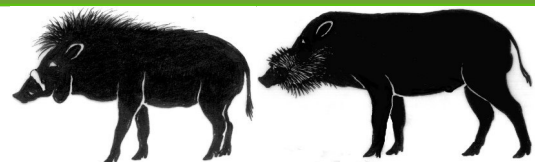
It is necessary to have more biological and ecological information of the species in order to better understand the species requirements, analyze the viability of the population and estimate abundance and density. The information about individuals in captivity has not been systematized or analyzed, and the information on wild populations is scarce and not current.

Goals	Actions
There is biological information obtained from animals in captivity	Compile and analyze existent information of captive individuals in South America, Europe and US zoos.
There is a standardized system for monitoring the species and its habitat use	Design a locally based program to monitor the species. Design an identification field guide to identify the different peccary species.
There is a data base with all relevant publications	Compile all available published and no published papers
We count with information on the distribution of populations, habitat and functional connectivity	Implement studies focused on understanding the species distribution at different spatial scales and identifying the variables of importance that are associated with the presence of the species. Design sampling methods for genetic analysis.
There is information about socio-economic value of the species and the different perceptions of stakeholders	Design and implement studies to know perceptions and the use of the species in the local communities.
There is a pilot program of environmental education that is available to local stakeholders	Evaluate different forms of education and dissemination of information about the importance of the species and its conservation in the local areas. Compile existing informative documents made by institutions such as zoos in San Diego. Make educational documents in German to be distributed among Mennonite communities.
There are standardized protocols for radio telemetry studies	Test the use of radio telemetry in animals in captivity. Compile and analyze existent information from zoos and other institutions that hold animals in captivity (CCCI, Itaipú, European and US zoos).
The research priorities identified are available at the higher education institutions to encourage research on these topics (CONICET, CONACIT, Universities, etc.)	Promote research priorities among universities and other research institutions.
There is information on ecological and biological parameters	Compile and analyze existent information about the biology of the species collected by institutions that hold animals in captivity. Perform studies on the ecological role of the species.





Chacoan Peccary



4) Summary results for Working Group 4: Ex situ conservation

Participants: Mariana Altrichter, Prescott College, Co-chair IUCN Peccary Specialist group; Micaela Camino, Landscape Ecology and environment, National University of Buenos Aires; EDGE – SZL, CONICET, Argentina; Juan Campos, Chaco Center for Conservation and Research (CCCI), Paraguay; Jeffrey Thompson, Associate researcher Guyra Paraguay; Laura Villalba, Species conservation program WCS, Paraguay; Kathe Waltbtunner, local member of Colonia Neuland, Paraguay; Andrea Weiller, director of Biology school, National University of Asunción, Paraguay.

Problem

Land use changes in the Tagua range represent a high threat to the conservation of the species. Protected areas are scarce and these do not provide necessary conditions for the survival of the species. For all these reasons, it considered important to count with a captive breeding program that complements in situ conservation and that allows a safeguard for the genetic diversity of the species.

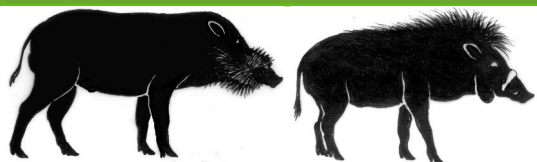
This group reviewed the main functions or potential roles of ex situ conservation. The identified functions were: 1) Ensure the existence of individuals of the species, 2) provide individuals for restoration of wild populations (reintroductions, translocations, etc.), 3) research and training, 4) environmental education.

Goals	Actions
Count with a standardized protocol for captive management	Create a protocol for captive breeding.
Captive breeding centers provide obtain and provide biological information on the species	Facilitate research on biological parameters at captive breeding centers.
There is current genetic information on captive individuals in Paraguay	Perform a genetic study of captive individuals in CCCI.
There is a collaborative system among captive breeding centers, the IUCN Specialist group and CCCI	Consolidate collaborating among the different centers that hold individuals in captivity and the specialist group.
Count with information on the need to expand the current system of ex situ conservation	Evaluate the need to expand ex situ conservation.
CCCI Works as a key center for educational activities about the species	Develop a program and plan for environmental education at the CCI facilities.

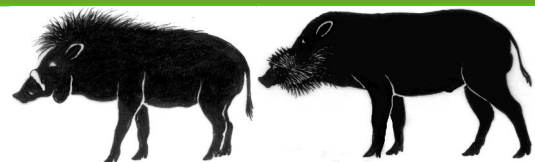
Conclusion

Reviewing he species status in the three range countries, and identifying the main threats, it became clear that the populations are fragmented and populations are declining. It also became apparent that there is need for more research, especially dealing with basic ecological and biological parameters. It was also identified the need to coordinate with local and international captive breeding centers, which can help not only by providing individuals for potential reintroductions, but also by facilitating research and sharing information on the biology of the species.





Chacoan Peccary



The decline in the range and numbers of Chacoan Peccary is due to a combination of factors. The workshop participants agreed that more recently, habitat destruction has become the most concerning factor. The rate of clearance for agriculture and cattle pasture in the Paraguayan and Argentinean Chaco is extremely high (Cardozo et al. 2016). This situation, combined with hunting, pose a major threat as habitat loss and high mortality can only lead to an increasing likelihood of extinction.

We recognized that many underlying causes of these major challenges are unsurmountable and beyond our capacities to address. However, we do believe that we can make positive changes and increase the chances of survival for the species and for the Chaco ecological integrity. We trust that the governments of the three range countries will incorporate our results in their planning process as these are based on the best available scientific research and created by a representative group of stakeholders.

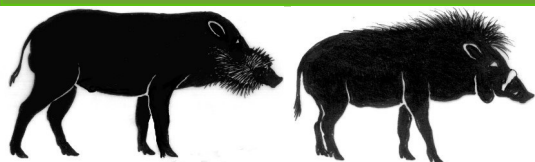
Acknowledgements

The workshop was organized and planned by Mariana Altrichter, Harald Beck, Alberto Yanosky, Arnaud Desbiez, and Juan Campos. Kristin Leus (Copenhagen Zoo, CBSG Europe) and Katia Ferraz (Wildlife Ecology, Management and Conservation Lab (LEMaC, Forest Science Department - ESALQ/USP) led the population viability and habitat suitability analysis. Arnaud Desbiez facilitated the workshop. Micaela Camino, member of GEPAMA, UBA, CONICET and EDGE, helped in the organization of the workshop. Mark Stanley, chair of the IUCN SSC Sub-Committee for Species Conservation Planning provided constant encouragement and support. The staff of the NGO Guyra Paraguay, especially Irene Gauto, took care of all the logistical details; they enabled the workshop to run effortlessly and provided the participants with a wonderful stay at the hotel Quinta Ykua Sati with incredible food. This workshop was possible due to the generous contribution of the Mohamed bin Zayed Species Conservation Fund, the IUCN SSC sub-committee for Species Conservation planning, the IUCN SSC Conservation Breeding Specialist Group, World Land Trust, the Paraguay Secretaría del Ambiente (SEAM) and Copenhagen Zoo.

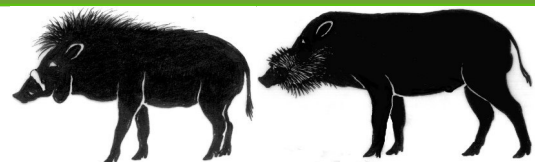
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Chacoan Peccary



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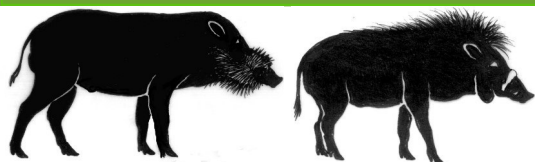
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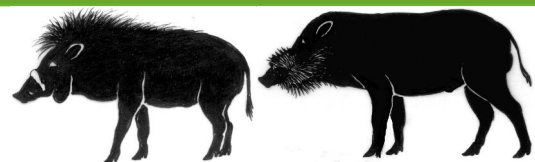
Appendix 1. Workshop participants

NAME	INSTITUTION	COUNTRY
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Evelyn Britez	Guyra Paraguay	Paraguay
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Diego Giménez	Secretaria del Ambiente, Dirección de Vida Silvestre	Paraguay
Anthony Giordano	Fundador y Director Ejecutivo de SPECIES	USA
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Timoteo Navarrete	Cacique Comunidad Wichi, Nueva Población, Chaco, Argentina	Argentina
Nora Neris	Secretaria del Ambiente, Universidad Nacional de Asunción	Paraguay
Edder Ortiz	Guyra Paraguay	Paraguay
Pablo Perovic	Administración de Parques Nacionales, Salta	Argentina
Viviana Rojas B.	Guyra Paraguay	Paraguay
Silvia Saldivar Bellasai	Itaipú Binacional	Paraguay
Licindo Tebez	Agricultor familiar, participante del monitoreo de animales silvestres	Argentina
Jeffrey Thompson	Investigador Asociado de Guyra Paraguay	Paraguay
Ricardo Torres	Museo de Zoología, Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba	Argentina
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Laura Villalba	Coordinadora del Programa de Conservación de Especies WCS Paraguay	Paraguay
Kathi Waldbrunner	Colonia Neuland	Paraguay
Andrea Weiller	Directora de la Carrera Biología, Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Asunción, Paraguay	Paraguay





Chacoan Peccary



Predicting the current distribution of the Chacoan peccary (*Catagonus wagneri*) in the Gran Chaco

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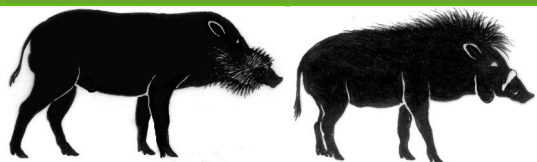
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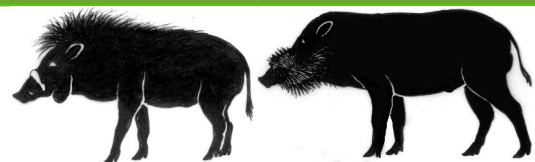
Abstract

The Chacoan peccary (*Catagonus wagneri*), or Tagua, an endemic species living in the Chaco eco-region, is endangered by highly increasing deforestation rates across the region, particularly in the last decade. This situation highlights the need to better understand the current distribution of the species, as well as how environmental conditions affect habitat suitability. This study predicts the distribution of the Chacoan peccary and evaluates the current environmental conditions in the Chaco for this species. Using six environmental variables and 177 confirmed occurrence records (from 2000 to 2015) provided by researchers, we developed a Species Distribution Model (SDM) applying the Maxent algorithm. The final model was highly accurate and significant ($p < 0.001$; AUC 0.860 ± 0.0268 ; omission error 1.82 %; post-hoc validation of omission error using independent presence-only records 1.33 %), predicting that 46.24 % of the Chaco is suitable habitat for the Chacoan peccary, with the most important areas concentrated in





Chacoan Peccary



the middle of Paraguay and northern Argentina. Land cover, isothermality and elevation were the variables that better explained the habitat suitability for the Chacoan peccary. Despite some portions of suitable areas occurring inside protected areas, the borders and the central portions of suitable areas have recently suffered from intensive deforestation and development, and most of the highly suitable areas for the species are not under protection. The results provide fundamental insights for the establishment of priority Chacoan peccary conservation areas within its range.

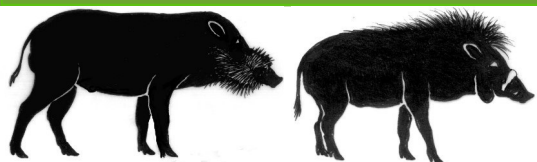
Introduction

The Chacoan peccary (*Catagonus wagneri*) is an endemic species living in the Chaco eco-region (Mayer and Wetzel, 1986; Redford and Eisenberg, 1992; Taber, 1993). Evolutionary speaking, the species represents a very distinctive and unique pattern (Gasparini et al., 2011). Due to a serious decline in numbers and range size of Chacoan peccary, it is considered “Endangered” by the IUCN Red List (Altrichter et al., 2015). The species’ geographical range has been reduced in the three countries it occupies: Argentina, Bolivia and Paraguay (Altrichter, 2006; Neris et al., 2002). Due to their behavior and their low reproductive rate, Chacoan peccaries are vulnerable to human disturbance (Taber et al., 1993; Altrichter and Boaglio, 2004). The presence of the species is associated to native forests (Taber et al., 1993; Altrichter and Boaglio, 2004; Saldivar-Ballesai, 2015; Camino, 2016) and therefore Chacoan peccaries may be seriously threatened by the increasing deforestation rates in the Gran Chaco (Cardozo et al., 2014; Vallejos et al., 2014). This threatening situation attracted the attention of conservation scientists in an attempt to protect the Gran Chaco, and develop a current strategy to prevent the peccary’s extinction. One of our most urgent goals was to re-assess the current distribution of the species, as well as understand how habitat conditions and characteristics (e.g. land cover, climate and topographic variables) affect the suitability of the habitat for implementing proper conservation measures.

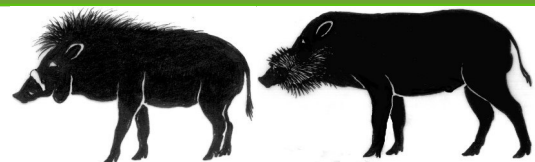
Species Distribution Models (SDMs) are an important tool often used to assess the relationship between a species, its distribution, and the environmental conditions. They integrate species occurrence records and environmental variables to develop environmental suitability maps for a species in space and time (Peterson, 2006; Pearson, 2007; Elith and Leathwick, 2009). SDMs have been used not only to describe the environmental requirements of a species, but also to be applied for: identifying sites for translocation and reintroduction of species (Peterson, 2006; Jiménez-Valverde et al., 2008), identifying priority areas for conservation (Morato et al., 2014), managing invasive species (Ficetola et al., 2007), assessing species distribution in human-modified landscapes (Ferraz et al., 2010; Angelieri et al., 2016) and finally predicting biodiversity response to both climate change (Adams-Hosking et al., 2012; Freeman et al., 2013; Lemes and Loyola, 2013) and land use change (Ficetola, 2010; Angelieri et al., 2016). In summary, SDMs also provide important elements for future conservation planning and management (Araújo and New, 2006).

With the goal of determining priority conservation areas and generating information for appropriate conservation strategies, we used a SDM with occurrence records provided by researchers, and then corroborated by the attendants to the Chacoan peccary conservation planning workshop held in Asuncion, Paraguay. The objectives of this study were: (1) to predict the Chacoan peccary distribution, and (2) to evaluate the current environmental conditions of the





Chacoan Peccary



Chaco for the species occurrence. The SDM developed was evaluated for accuracy by the specialists considering the current known distribution of the species.

Materials and Methods

Study area

Predictive models for the Chacoan peccary were generated for the full extent of the Gran Chaco region (1,076,035 km² in the central South American, Fig 1). The Chaco ecoregion (Olson, 2000) includes territories of western and central Paraguay, southeastern Bolivia, northwestern Argentina, and a small part of Brazil. The predominant habitats in the Gran Chaco include a seasonal, open to semi-open palm savanna and grassland (Wet or Humid Chaco), and a low, closed-canopy seasonal or semi-arid deciduous thorn forests (Dry Chaco); many areas incorporate a gradient between this two environments. The Dry Chaco is dominated by thorny bushes, shrubs, and cacti, with dense, closed canopy trees up to 13 m high called “Quebracho woodland” (Short, 1975). Some of this impenetrable primary thorn forest still remains in the region, and its isolation led to the discovery of new species of endemic vertebrates, including the Chacoan peccary, as recently as the 1970’s (Wetzel et al., 1975). Since then however, this region has become more developed and deforestation has increased rapidly in the last few years; total deforestation in the Chaco account for 265.169 ha in 2010, 336.445 ha in 2011, 539.233 ha in 2012, and 502.308 ha in 2013 (Cardozo et al., 2014).

Data collection

Through expert consultation we gathered 177 Chacoan peccary presence records (e.g. sightings, camera trapping, capture, feces, tracks, interviews, etc.) occurring between 2000 and 2015 (Fig 2a). All presence points used for modeling and validation represented accurate records with exact

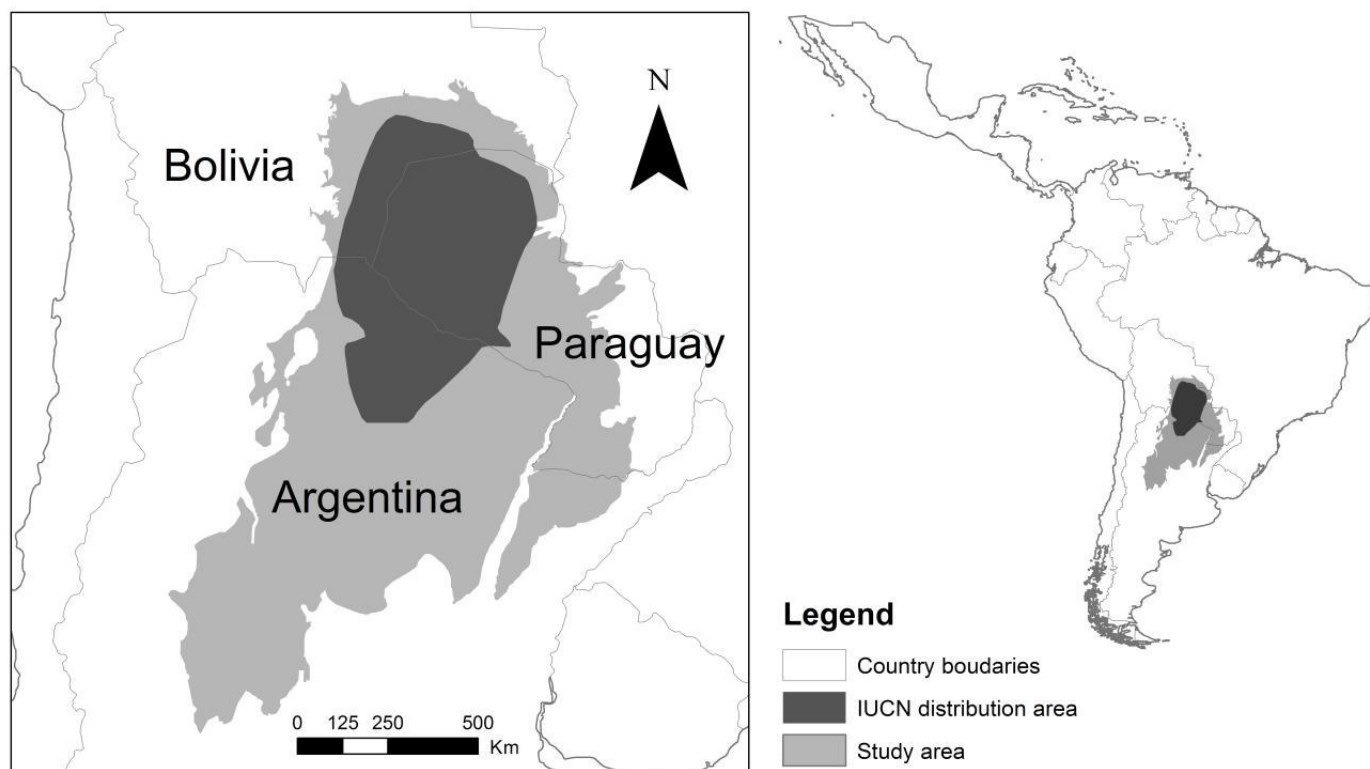
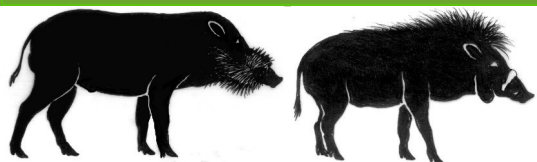
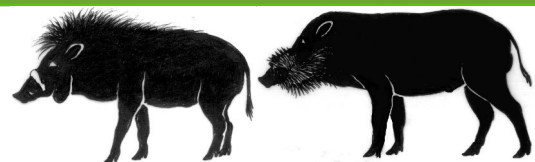


Fig 1. Map of the study area for the Chacoan peccary distribution model.





Chacoan Peccary



locations. In order to reduce spatial autocorrelation and to compensate biases in data that usually occur when some areas in a landscape are sampled more intensively than others (Elith et al., 2011), we used the spatially rarefied occurrence data to produce SDMs via the SDM Toolbox v1.1b (Brown, 2014), which resulted in 87 spatially independent presence points used for the modeling process (Fig 2a). The predictive ability of the average SDM was tested by plotting a new, independent dataset (not used for modeling, N = 990), against species presence records sampled after 2000 (Fig 2b).

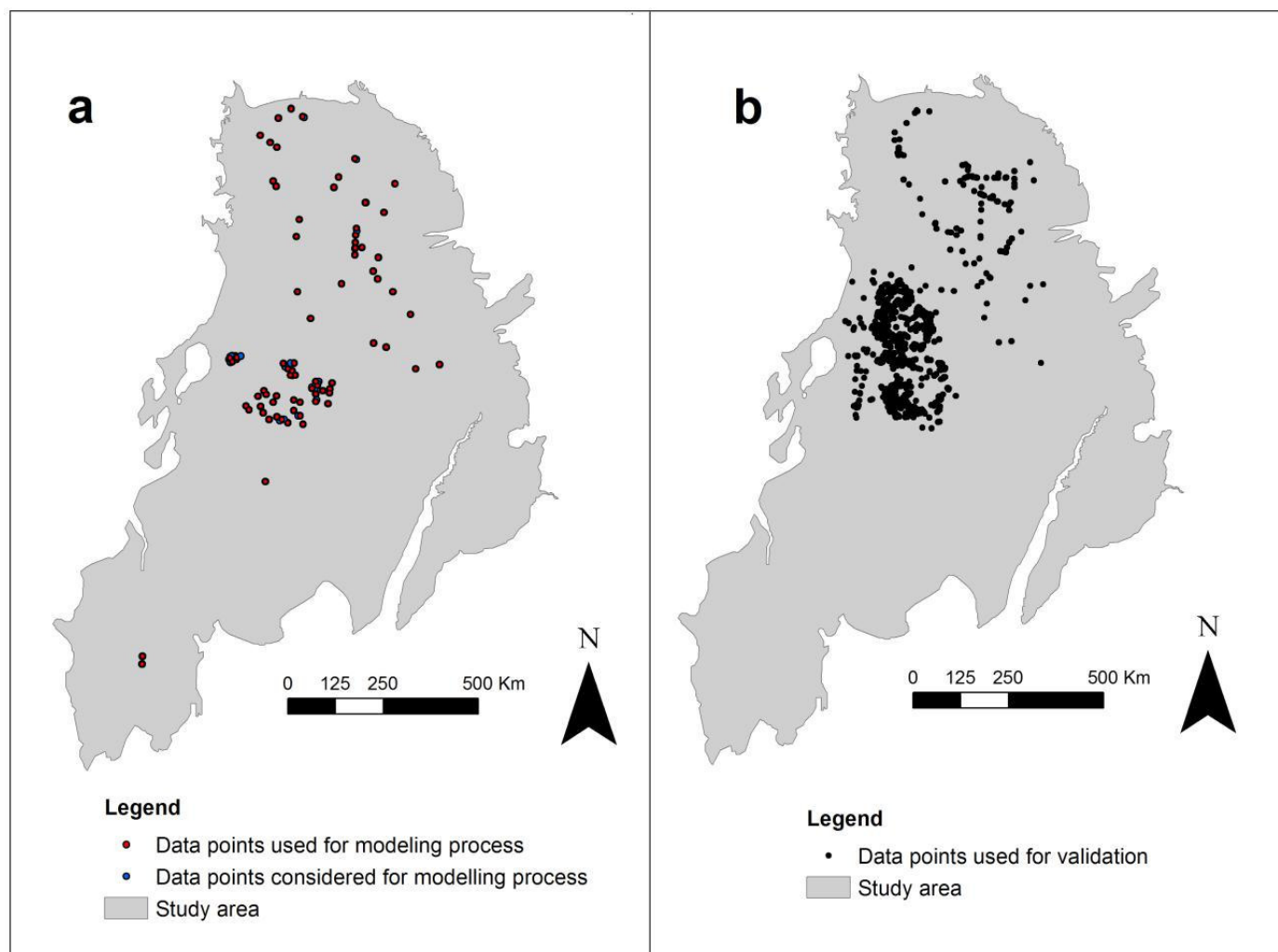
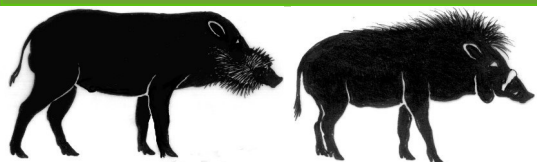


Fig 2. Chacoan peccary presence records considered (N=177) and used (N=87) for modeling (a) and presence points used for model validation (N=990) (b).

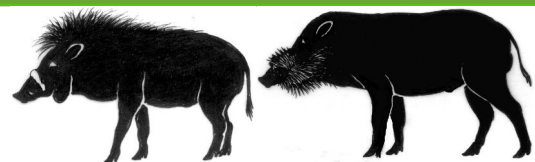
Environmental variables

We initially selected 21 environmental variables (i.e., 19 bioclimatic variables plus elevation and land cover) to examine for inclusion in our SDM's. After analyzing autocorrelation among variables, 15 were discarded (correlations > 0.7), leaving only six environmental variables to be used as model predictors (Table 1; Figure 3) at a spatial resolution of 0.0083 decimal degrees (~1 km²).





Chacoan Peccary



Tab. 1. Environmental variables used for predictive models.

Variable	Description	Year	Source
Elevation	Map of elevation	2004	NASA Shuttle Radar Topography Mission
Globcover with deforestation	Map of land cover classes, with deforestation included	2009	Globcover map from ESA GlobCover 2009 Project Deforestation map from Guyra Paraguay
Bioclimatic variables	Bio 1 = Annual mean temperature Bio 2 = Mean diurnal range Bio 3 = Isothermality* Bio 12 = Annual precipitation		Data layers from Worldclim global climate variables

Isothermality = Mean diurnal range (Mean of monthly (max temp - min temp))/Temperature annual range (100)

Modeling procedures

Species Distribution Models (SDMs) were generated using a maximum entropy algorithm via the program Maxent, version 3.3.3.k (Phillips et al., 2006; Phillips and Dudik, 2008). Maximum entropy is a widely accepted and used algorithm for modeling species distribution, generally performing better than alternative approaches (Elith et al., 2006; Elith and Graham, 2009). In particular, Maxent proposes a target probability distribution for a species by

estimating the distribution of maximum entropy (i.e., the distribution that is closest to uniform, or most “spread out”) as it is constrained by missing information about that target distribution (Phillips et al., 2006).

SDMs were generated using bootstrapping methods with 10 random partitions with replacement using 70 % of the full dataset for training models and 30% for testing (Pearson, 2007). Parameters set for all runs were based on a convergence threshold of 10⁻⁵ with 500 iterations, and with 10,000 background points. The average model was cut off by the

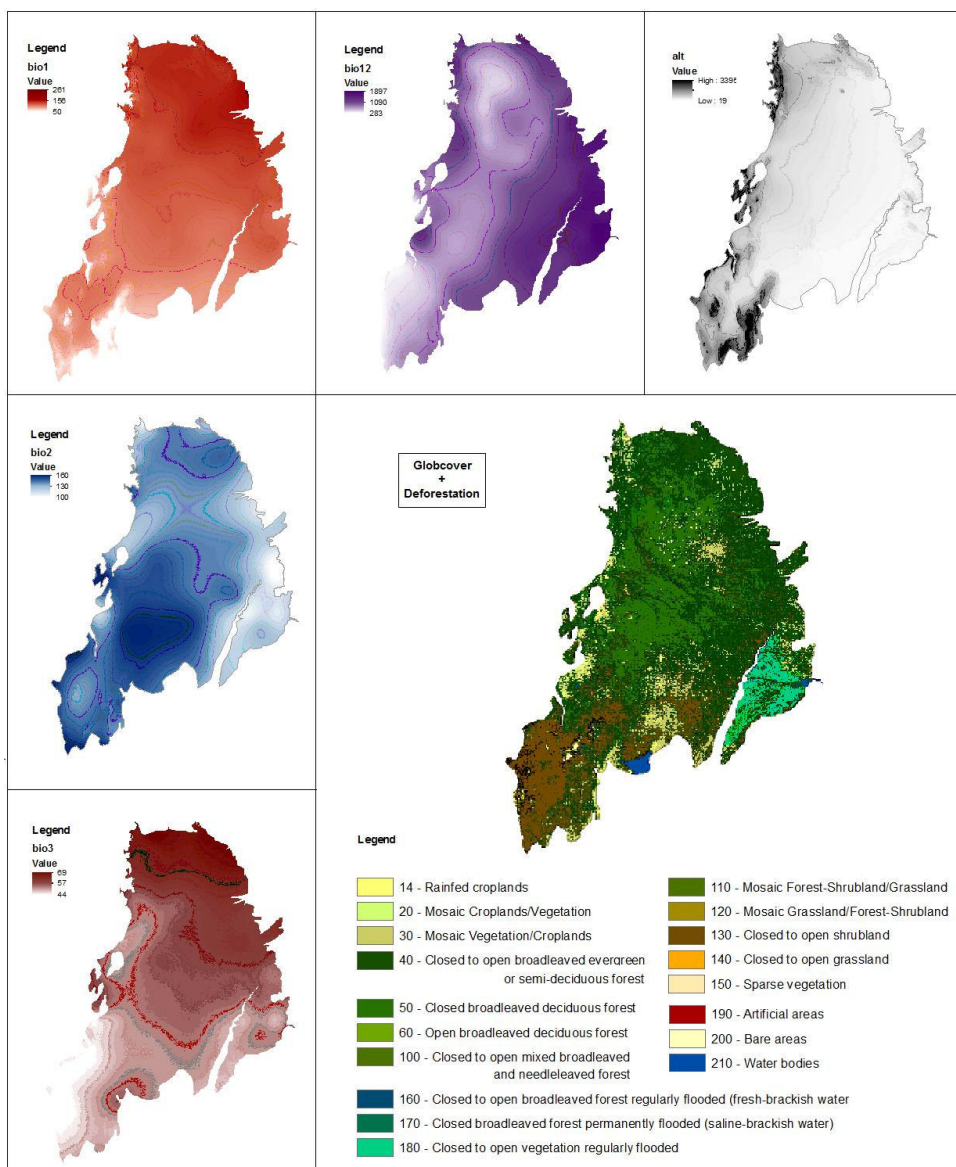
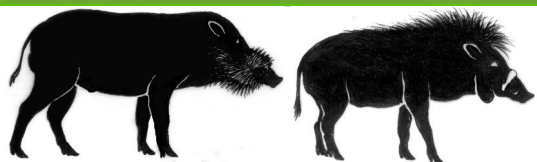
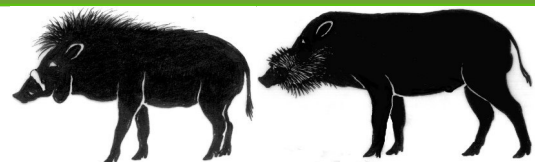


Fig 3. Environmental variables used in the Chacoan peccary model.





Chacoan Peccary

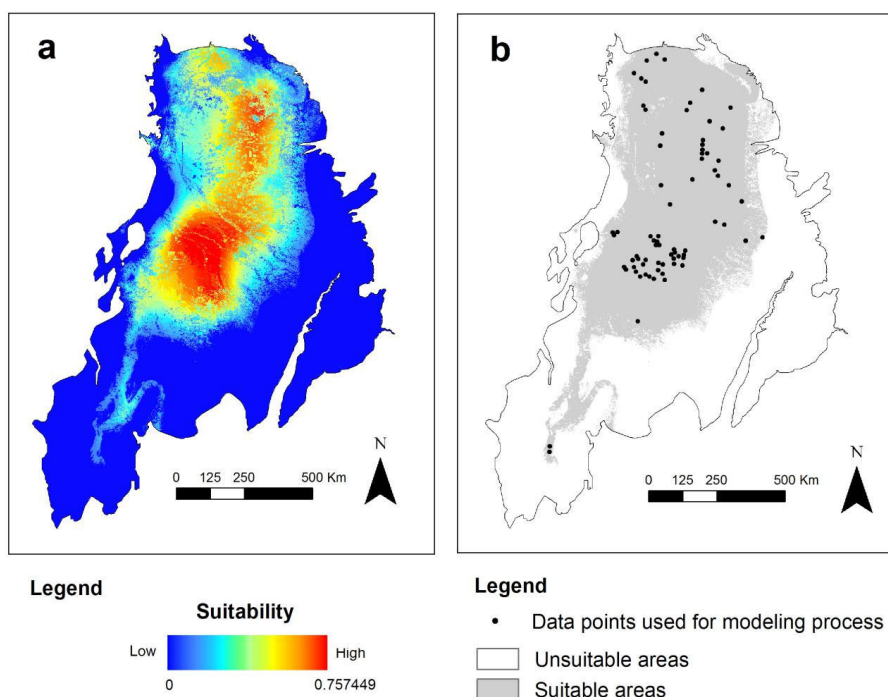


minimum training presence logistic threshold (0.0975), which resulted in a binary map (0 = unsuitable, 1 = suitable). When multiplied by the average model, this binary map yielded the final model describing the probability of the species occurrence in the biome. The final model was evaluated by AUC value, binomial probability and omission error (Pearson, 2007).

Maxent's average distribution model was also categorized into three habitat suitability classes: low suitability (values from $0.0975 \leq 0.25$), medium suitability ($0.25 \leq \text{values} \leq 0.50$) and high suitability ($0.50 \leq \text{values} \leq 1$) with the manual classification method using the reclassify tool in ArcGIS 10.1 Spatial Analyst. A shapefile of areas of varying protection levels was provided by the IUCN PSG [Peccary Specialist Group], 2016, which and converted into a raster dataset to create the current protected areas file. ArcGIS 10.1 Spatial Analyst Zonal tool was then applied to cross-tabulated areas between the suitability area classes and the protected areas zone.

Results and Discussion

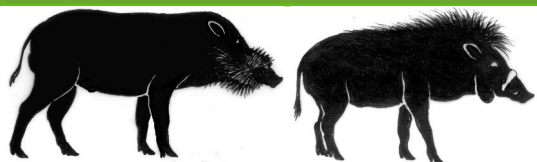
Predictive distribution model for the Chacoan peccary (0.860 ± 0.0268) was highly significant ($p < 0.001$) with low omission error (1.82 %) (Fig 4a). The post-hoc validation using the independent presence-only records confirmed that the model was highly accurate, with only 1.33 % of omission error. The model predicted that 46.24% (~497,577.34 Km²) of the Gran Chaco is suitable for the Chacoan peccary (Fig 4b). Suitable areas are concentrated in the Paraguayan department of Presidente Hayes, Boqueron and Alto Paraguay, and in northern Argentina, especially near the borders of Formosa, Chaco, Salta and Santiago del Estero Provinces, as well as in the north-central portions of the Bolivian Chaco. The limits of the current distribution area have suffered intensive habitat loss due to recent land cover conversion, especially in Paraguay (Caldas et al., 2013; Cardozo et al., 2014), suggesting that the Chacoan peccary distribution range is probably retracting rapidly.



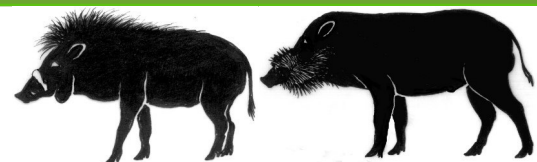
Deforestation rates in Chaco were among the highest of the world between 2000 and 2010 (Aide et al., 2013; Hansen et al., 2013) and potentially affecting the distribution of Chacoan peccaries. In Bolivia, deforestation remains low, however, in both Argentina and Paraguay deforestation is associated to intensive agriculture and cattle production (Caldas et al., 2013; Piquer-Rodriguez et al., 2015). Moreover, there is an expanding urban area (i.g.



Fig 4. Predictive distribution model of Chacoan peccary. (a) Maxent average model shows the continuous suitability of the Chaco for the species. (b) Categorical suitable and unsuitable areas.



Chacoan Peccary



the city of Filadelfia) in the center of the high suitability area in Central Paraguay and the species is one of the most hunted animals in the Dry Paraguayan Chaco (Neris et al., 2010).

The three variables that better explained the predictive distribution model were land cover (31.57 %) (Fig 5a), isothermality (22.52%) (Fig 5b) and elevation (21.60%) (Fig 5c). Suitable areas for Chacoan peccary were characterized by closed broadleaf deciduous forest so called Chaco-Quebracho (Paraguay) and Chiquitano (Bolivia) woodlands (57.93 %), closed to open broadleaf forest/shrubland (21.86 %) and by mosaic vegetation/cropland (13.67 %). The association between suitable habitat and forest cover is probably positive, as found in previous studies (Taber et al., 1993; Altrichter and Boaglio, 2004; Camino, 2016). However, this is the first published study that shows that the species' habitat is composed of closed and semi-deciduous forests, and forests with shrublands. As far as we know, no other study differentiated the type of forests used by this species.

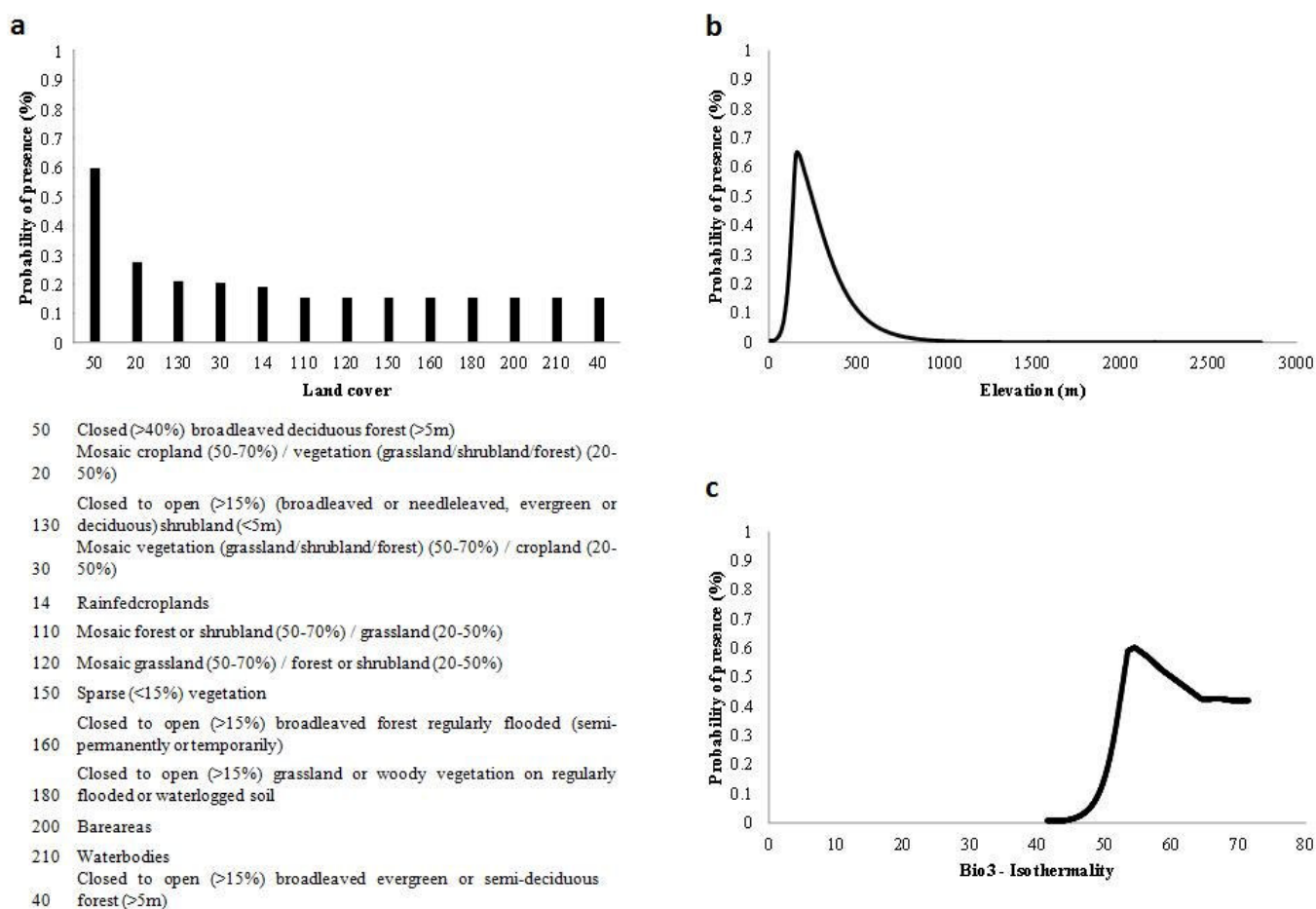
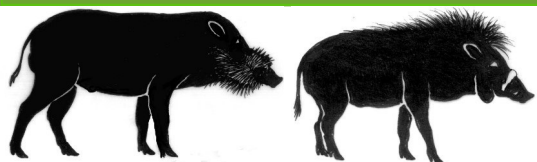


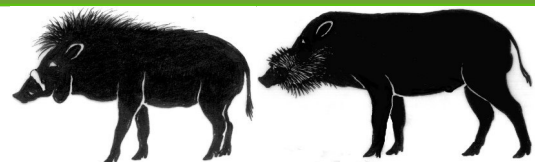
Fig 5. Response curves of probability of presence (%) according to Land Cover (a), Elevation (b) and Bio 3 – Isothermality (c).

Despite that some portions of suitable areas are legally protected, most parts of highly suitable areas for the species are not included in an official protection system. Less than 17 % of the areas under some type of protection occur in areas suitable for the Chacoan peccary (Figure 6b), and only 12 % of high suitability areas for Chacoan peccary are protected in the Chaco (Table 2). Furthermore, when analyzing suitable areas by country, only 7 % of the high suitability areas in

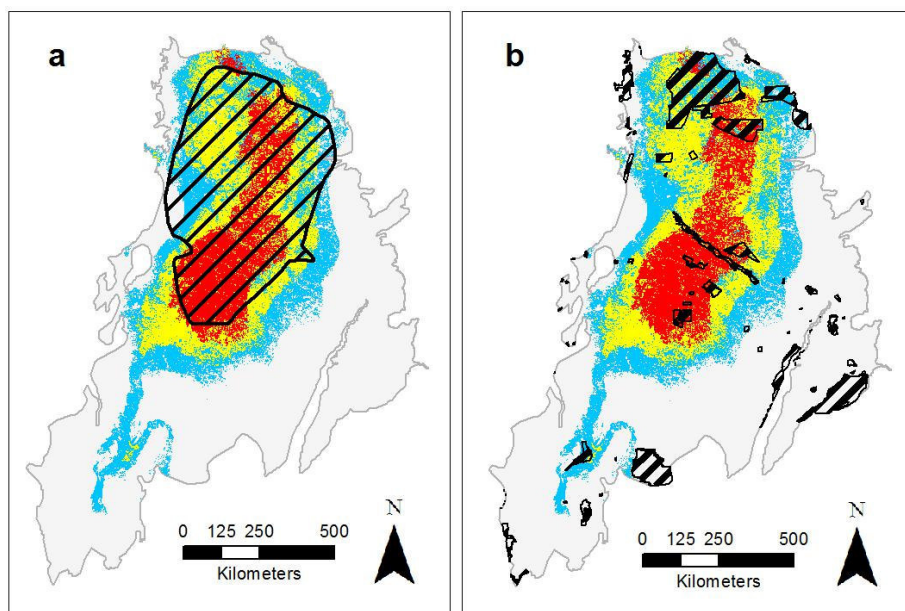




Chacoan Peccary



Argentina, and 13% in Paraguay, are currently under some kind of protection. Therefore, the existent protected areas are not effective at protecting suitable areas for the Chacoan peccary. In Bolivia, almost 79% of the high suitability areas for the species are already under protection in the Kaa-ly-a del Gran Chaco National Park; however, we believe that the suitability inside this inaccessible area may be underestimated due to a lack of presence records.



Legend



Fig 6. Suitable areas for the Chacoan peccary showing low suitability in blue (probability of presence from 0.0975 to 0.25), medium suitability in yellow (probability of presence from 0.25 to 0.50) and high suitability in red (probability of presence from 0.50 to 0.76), overlain with IUCN distribution area (a) and protected areas (b).

Finally, high suitability areas for the Chacoan peccary showed here must be considered as key localities for conservation efforts aiming to protect the species and its habitat, and to avoid human conflicts (e.g., hunting pressure), particularly if these areas are not protected by law. Such areas might also guide the establishment of new protected areas and their connectivity should be considered in land-use planning. A key factor for the successful conservation of the species will be to involve the indigenous people and the local pheasants, that historically occupied some of these areas (Camino et al., 2016). Regardless of which combination of approaches

Argentina Bolivia

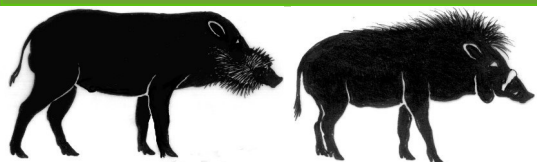
Suitability	Argentina			Bolivia		
	Total area (km ²)	Protected (km ²)	%	Total area (km ²)	Protected (km ²)	%
Low	93,637.81	2,462.29	2.63	49,192.99	17,674.56	35.93
Medium	66,336.67	2,779.66	4.19	37,218.70	16,638.37	44.70
High	68,124.66	5,021.85	7.37	4,137.34	3,265.19	78.92

All Paraguay countries

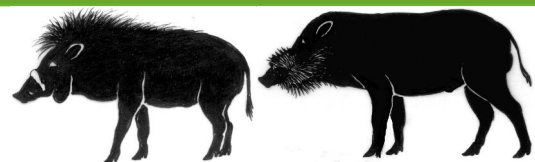
Suitability	Paraguay			All countries		
	Total area (km ²)	Protected (km ²)	%	Total area (km ²)	Protected (km ²)	%
Low	50,978.50	2,128.43	4.18	193,809.30	22,265.28	11.49
Medium	80,849.08	4,620.40	5.71	184,404.46	24,038.42	13.04
High	46,940.08	6,163.55	13.13	119,202.07	14,450.58	12.12

Tab 2. Suitable areas for Chacoan peccary (i.e. low, medium and high suitability) protected by country and in total across all countries.





Chacoan Peccary



are employed, urgent measures are needed to stop deforestation across the Gran Chaco, one of the most threatened ecological regions in South America today.

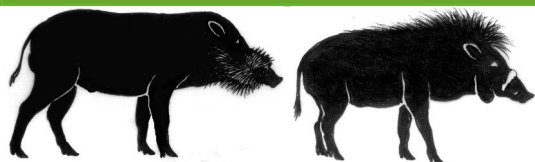
Acknowledgements

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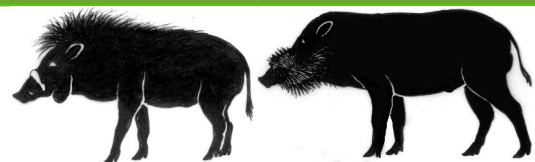
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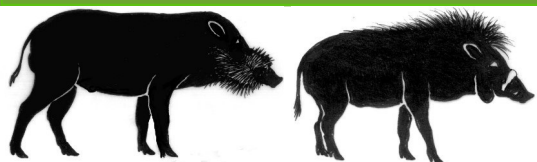


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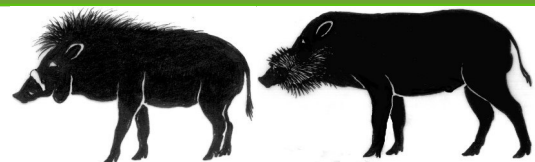


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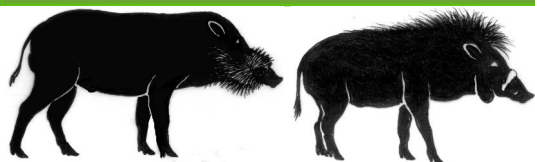


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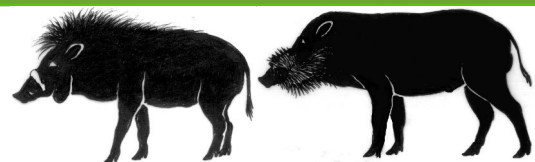


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Chacoan Peccary



A vortex population viability analysis model for the Chacoan peccary (*Catagonus wagneri*)

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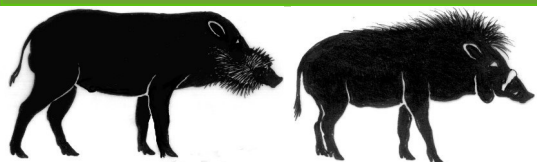
Introduction

From February 29th to March 3rd 2016, a range wide, multi-stakeholder species conservation planning workshop took place for the Chacoan peccary (*Catagonus wagneri*) in Asuncion, Paraguay. Details on the status of the Chacoan peccary, the workshop and its outcomes can be found in Altrichter et al. elsewhere in this Volume of Suiform Soundings. This paper focusses on the use of the population viability analysis software “Vortex” (Lacy and Pollak, 2015) as an integral component of the workshop.

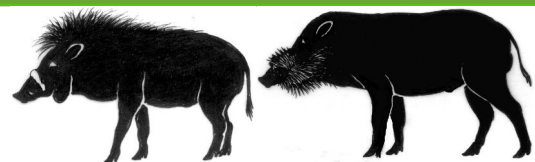
Populations of threatened species face a multitude of threats. Often, human-caused threats cause populations to become small and fragmented. At this stage, stochastic threats, including genetic (genetic drift and inbreeding) and demographic (environmental variation, demographic variation and catastrophes) threats, automatically come into play as well. They feedback on each other and may lead the population to enter an extinction vortex, even if human-caused threats can be halted or reversed (Gilpin and Soulé, 1986). Conservation strategies thus need to evaluate how severe the chance of continued decline or extinction may be for a given set of circumstances, and which conservation measures addressing which threats, are likely to have the best chances to pull the species out of the “extinction vortex” and achieve a viable population for the future. Vortex is particularly suited to explore how these complex and interacting factors influence survival probabilities, as well as the demographic and genetic status, of small, wild and/or captive populations of threatened vertebrate species. This is because it is an agent or individual-based model that also incorporates environmental, demographic and genetic stochasticity – the effects of which become increasingly magnified in small populations (Lacy et al., 2015).

Depending on the type, amount and reliability of quantitative data available on the life history of the species and the threats it is facing, the Vortex model can be used for different purposes





Chacoan Peccary



(Miller, 2007), including: Simulating the effect of particular human-caused threats or particular management scenarios for a given population; testing thresholds for threat effects; prioritising data collection on threats; investigating likely relative changes in the face of different threats or management options; evaluating the likely viability in the absence of human caused threats; identifying priorities for research in basic natural history parameters; and demonstrating the general risk inherent to small populations to people without population management knowledge; among others.

Only a limited amount of data on life history parameters, population sizes, quantitative population trends and quantitative effects of threats exists for Chacoan peccaries. The aims of this Vortex simulation model were to:

- Create a baseline model for a non-threatened population of Chacoan peccaries based on the current best estimates for the various model parameters,
- Examine the scale of change in the results of the model when using minimum and maximum values around the baseline values in order to test the model's sensitivity to the uncertainty (and thus suggest priorities for research),
- Investigate minimum viable population sizes within the spread of uncertainty, and
- Run a first preliminary simulation of the potential effects of hunting on a population of this species.

Materials and methods

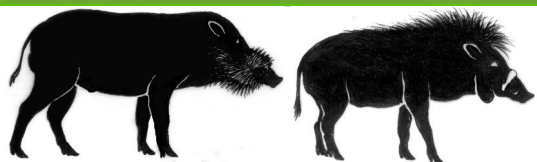
Vortex Simulation Model

We used the simulation software program Vortex (v10.1.5.0) (Lacy and Pollak, 2015) (www.vortex10.org) version 10.1.5.0 to conduct our predictive analyses. It is a Monte Carlo simulation of the effects of deterministic forces as well as demographic, environmental, and genetic stochastic events on wild or captive small populations. Vortex models population dynamics as discrete sequential events that occur according to defined probabilities. The program begins by either creating individuals to form the starting population, or importing individuals with a known pedigree from a studbook database, and then sequentially progressing through life cycle events (e.g., births, deaths, dispersal, catastrophic events), typically on an annual basis. Events such as breeding success, litter size, sex at birth, and survival are determined based upon designated probabilities that incorporate annual environmental variation, demographic stochasticity and catastrophes. Inbreeding depression is modelled as a reduction in first year survival of inbred individuals and Vortex simulates Mendelian transmission of alleles. Consequently, each run (iteration) of the model gives a different result. By running the model hundreds of times, it is possible to examine the probable outcome and range of possibilities. For a more detailed explanation of Vortex and its use in Population Viability Analysis, see Lacy (1993, 2000), Brook et al. (2000) and Lacy et al. (2015).

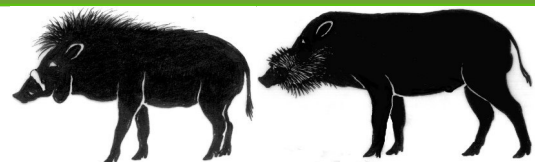
Model input parameters

The input parameters were jointly developed during the conservation planning workshop by taking into account published literature (where available), information provided in advance of the workshop (by the authors of this paper and Ricardo Torres and Verónica Quiroga), and unpublished data and personal experiences from other workshop participants. The baseline





Chacoan Peccary



scenario created intends to represent a Chacoan peccary population not affected by human-caused threats, and a full overview of all the input parameters used can be found in Table 2. A detailed justification for the choice of input parameters can be found in the modeling chapter of the workshop report (Altrichter et. al, in prep) that will soon be available at www.cbsg.org, but below follows a summary for some of the important parameters.

Inbreeding

Because no information is available on the presence or absence of inbreeding depression in Chacoan peccary populations, how it might manifest, or how many lethal equivalents are present per diploid individual, the default settings for inbreeding depression were included in the Vortex model with 6.29 Lethal Equivalents per diploid individual (based on O'Grady et al. (2006), and 50% of the genetic load due to recessive lethal alleles.

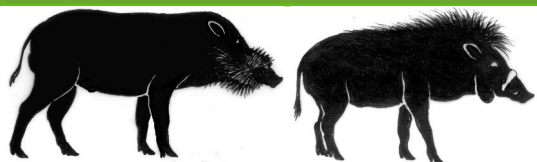
Reproductive parameters

The Vortex mating system option that most closely describes that of the Chacoan peccary is “long-term polygyny”, which implies that one male may breed with more than one female, and selected pairings will stay together for subsequent years until one partner dies. Wild Chacoan peccaries appear to live in small family groups (see section on ‘maximum number of female mates’ below), and both polygynandry (Brooks, 1992, 1996) and polygyny are thought to be possible breeding systems. It is also thought that pair bonds likely last for more than one year (Taber et al., 1993; Campos, pers. comm.).

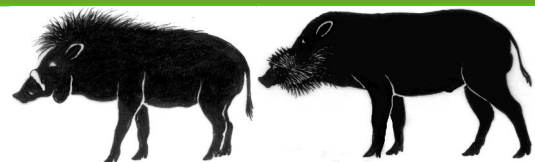
We set the age of first reproduction to “1” for both males and females. Chacoan peccaries in captivity appear to be able to have their first litter between their first and second birthday (Brooks, 1992; Campos pers. comm, Meritt et al., 2014; Yahnke et al., 1997), and we considered this was equally possible in the wild. We also assumed wild Chacoan peccaries are able to breed for their entire lifespan and, adjusting data from captivity (see Meritt et al., 2014; Altrichter et al., 2015), workshop participants believed that a lifespan of 15 years for both males and females would be possible for wild peccaries. However, we also tested a minimum value of 10. All the three extant species of peccary appear to reproduce once per year in the Paraguayan and Bolivian Chaco (Taber et al., 1993; Noss, 1999; Noss et al., 2003). Combining various reports on litter sizes from the wild (Mayer and Brandt, 1982; Taber et al., 1993; Altrichter, 2005) and captivity (Yahnke et al., 1997; Brooks, 1992; Unger 1993; Meritt et al., 2014; Campos, pers. comm), we used the baseline, minimum and maximum litter size distributions reported in Table 2. Based on information from captivity, an equal sex ratio at birth was also assumed for the wild (Yahnke et al., 1997).

The percentage of adult females breeding every year was difficult to determine, as pregnancy data from wild populations usually take the form of % hunted females pregnant for Chacoan peccaries (Altrichter, 2005), collared (*Pecari tajacu*) (Hellgren et al., 1995; Bodmer, 1989; Gottdenker and Bodmer, 1998; Mayor et al., 2005; Noss et al., 2003; Jorgenson, 2000), and white-lipped peccaries (*Tayassu pecari*) (Bodmer, 1989; Gottdenker and Bodmer, 1998; Noss et al., 2003). Pregnancy rates among hunted females per year does not necessarily equate to % breeding females per year because, a) although Chacoan peccaries do reproduce year round, there is also a seasonal peak in reproduction during certain months (Taber et al., 1993; Yahnke et





Chacoan Peccary



al., 1997; Sowls, 1997; Altrichter, 2005) the possibility that early pregnancies may be underreported (Mayor et al., 2005) c) there must be no preferential hunting of pregnant or non-pregnant females, and d), pregnancy lasts for only about 41% of the year. In addition, we found a rate of 86% females breeding per year for white-lipped peccaries in the Peruvian amazon (Mayor et al., 2005; Mayor pers. comm.). In considering a) the drier conditions in the Chaco, and b) a lower rate of pregnancies detected among harvested females for Chacoan peccaries (20%) (Altrichter, 2005), workshop participants felt it prudent to adopt a conservative value estimate of 50% breeding females as a baseline, while also testing a minimum of 40%, and a maximum of 70%. The actual input in Vortex was then adjusted so the % of females breeding per year is halved in years when “catastrophe 1” hits (see catastrophe section below).

There is no information on the percentage of males in the breeding pool for wild Chacoan peccaries. Participants in the workshop agreed on a rate of 100 % for males that are 3 years and older, and 50% for males between 1 and 3 years, as this latter grouping of males although physically able to breed they are perhaps socially less likely to obtain access to females. Similarly, there is no data on the maximum number of female mates per male. Chacoan peccaries appear to live in smallish family groups with ranges of about 1 to 9, averaging between 2.6 and 4.5 (Altrichter, 2005; Maffei et al., 2008; Taber et al., 1993; Mayer and Brandt, 1982; Sowls, 1997). Breeding males would thus have access to a limited number of breeding females, therefore, participants of the workshop agreed to limit the “maximum number of female mates” per breeding male to 3 for the baseline scenario, while also testing a minimum number of 2 and a maximum of 5.

Mortality parameters

There is no data on age specific mortality rates of wild Chacoan peccaries. Based on information from wild collared peccaries (Day, 1985; Hellgren et al., 1995; Gabor and Hellgren, 2000; Hellgren et al., 1995), wild white-lipped peccaries (Fuller et al., 2002) and captive Chacoan peccaries (Yahnke et al., 1997, Meritt et al., 2014, Campos pers. comm.) workshop participants suggested the following baseline, minimum, and maximum values as their best guess:

First year mortality: baseline 55%, min 40%, max 65%

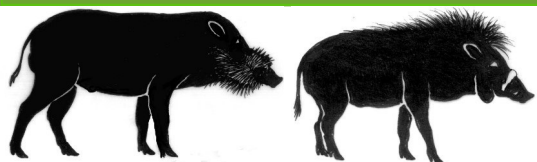
Adult mortality: baseline 10%, min 8%, max 13%

The actual input into Vortex was then adjusted as in Table 2 so that mortality rates increase in years when catastrophes hit (see catastrophe section below).

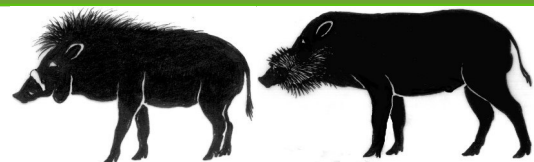
Catastrophes

A catastrophe is defined as an event that happens very infrequently (e.g. only a few times per 100 years) and lasts a short time. However when it happens, it has a large negative effect on reproduction and/or survival of the species that is much larger than normal environmental variation – e.g., drought, fire, disease, civil war, etc. Possible catastrophes for Chacoan peccaries include disease (Altrichter, pers. comm.; Brooks, pers. comm.; Taber, 1991; Toone and Wallace, 2002), drought (Altrichter, pers. comm.; Giordano, pers. comm.) and fire (Altrichter, pers. comm.; Giordano, pers. comm.). Because there was no quantitative data on catastrophes, and because it is very unlikely that a given wild population will be spared from catastrophes (Reed et





Chacoan Peccary



al., 2003), it was agreed to incorporate two ‘theoretical’ catastrophes into the model – drought and disease. According to participants, a drought on average can be expected about every 13 years, and last around 2 years. According to the same participants, epidemic diseases might occur once every 100 years and last only a year. The frequency and effect on the population was entered as follows:

Tab 1. Values for frequency, duration and impact of catastrophes on Chacoan peccaries used for the Vortex model.

	Freq.	Duration	1 st Year Mortality	Adult Mortality	% Females breeding
Catastrophe 1 Drought	7.7%	2 years	20% increase	10% increase	50% decrease
Catastrophe 2 Disease	1%	1 year	50% increase	30% increase	50% decrease

Because a drought can be expected to last two years, the effect on mortality of catastrophes 1 and 2 was modelled by entering formulas in the fields for mortality, and the % females breeding in Vortex (see Table 2). For catastrophe 2, the effect on reproduction was modelled by entering 0.5 in the severity field for

catastrophe 2. Because there is a 7.7% risk every year of the onset of a 2-year drought regardless of whether or not a drought began the year before, there is a chance droughts might “piggyback” and last 3 years. There is an even smaller chance that another one might hit in year 3 thus making it a 4 year drought, etc. This is not unlike reality, where some droughts can last longer.

For the baseline scenario, the effects of the catastrophes can thus be summarized using the following functions to represent the impacts described above (Table 1):

1st Year Mortality = 55; 66; 82.5; 93.5% in the case of no Cat, Cat1, Cat2, and Cat1&2, respectively

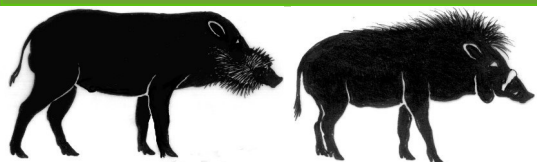
Adult Mortality = 10; 11; 13; 14% in the case of no Cat, Cat1, Cat2, and Cat1&2, respectively

% Females Breeding = 50; 25; 25; or 12.5% in the case of no Cat, Cat1, Cat2, and Cat1&2, respectively

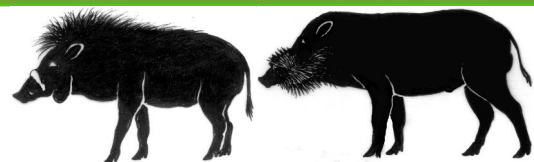
Tab. 2. Summary of Vortex model input parameters

	Minimum	Baseline	Maximum
Number of iterations	/	500	/
Number of years	/	100 (or ~19 generations)	/
Inbreeding depression	/	6.29 LE/50% due to recessive lethal alleles	/
Mating system	/	Long term polygyny	/
Age first breeding F&M	/	1	/
Max age reproduction	10	15	/
Longevity	10	15	/
Sex ratio at birth	/	50	/
Max #litters./year	/	1	/
Litter size distribution	(1)25%; (2)65%; (3)10%; (4)0%	(1)18%; (2)63%; (3)16%; (4)3%	(1)10.2%; (2)40%; (3)43.8%; (4)3.8%
% Adult females breeding	40-(20*(CAT(1)<2))	50-(25*(CAT(1)<2))	70-(35*(CAT(1)<2))
% Males in breeding pool	/	100-(50*(A<3))	/
Max nr mates/male	2	3	5
1 st yr Mortality	40+(8*(CAT(1)<2)) +(20*(CAT(2)<1))	55+(11*(CAT(1)<2)) +(27,5*(CAT(2)<1))	65+(13*(CAT(1)<2)) +(32,5*(CAT(2)<1))
Adult Mortality	8+(0,8*(CAT(1)<2)) +(2,4*(CAT(2)<1))	10+(1*(CAT(1)<2)) +(3*(CAT(2)<1))	13+(1,3*(CAT(1)<2)) +(3,9*(CAT(2)<1))





Chacoan Peccary



Results

Deterministic models

For deterministic projections, Vortex performs standard life table calculations assuming that age-specific birth and death rates are constant through time (i.e., no stochastic fluctuations); no inbreeding depression, harvest, or supplementations are included. The limitation of female mates was set to “0”, and catastrophes were not incorporated. The baseline scenario for this resulted in:

Yearly growth rate (r)	0.1142
Yearly growth rate (lambda)	1.1210
Generational growth rate (R0)	1.8225
Generation time:	5.26
Proportion of individuals in age class 15:	0.003

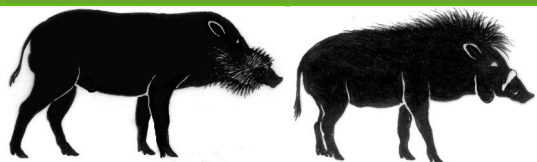
No census based growth rates for wild Chacoan peccary populations exist that can be used for validation purposes. The only conclusion from the results of this projection is that it is not unrealistic for a species with these natural history characteristics to exhibit a deterministic growth rate of 0.1142 (or 11.4% growth per year). Because this calculation did not account for stochastic fluctuations, inbreeding depression, or the effect of catastrophes, this growth rate is an overestimation under stochastic circumstances. However, it is still useful to that the input values do not cause a deterministic decline, or a growth rate that is unrealistic for the general natural history characteristics of the species.

Stochastic model and sensitivity testing

Using a theoretical population with an initial size and carrying capacity of 500 individuals, stochastic projections of the baseline scenario resulted in a zero probability of extinction, a stochastic growth rate (r) of 0.0778 (SD 0,1104), a retention of gene diversity of 96.13% (SD 0,61) and an average population size of 478.96 (SD 41.23) after 100 years

Figures 1 a-c below demonstrates the variability present among the minimum, baseline or maximum values are input into the Vortex model. The uncertainty in the % of female breeding and the 1st year mortality have the biggest influence on the population's stochastic growth rate (r), whereas uncertainty in the maximum number of female mates for breeding males has almost no effect on “r”. Longevity, which in the case of the Chacoan peccary is thought to equate to the maximum breeding age, unsurprisingly has the biggest effect on the proportion of gene diversity retained; this is because it influences generation time, one of the important parameters driving the amount of genetic diversity that can be retained for a given amount of time. Uncertainty in 1st year mortality caused the second biggest difference in the proportion of gene diversity retained. First year mortality also had the largest effect on the average population size at the end of 100 years, followed by longevity, percentage of adult females breeding, and adult mortality. Since there is doubt regarding these key parameters, confidence in the model will increase as more reliable data to estimate these parameters becomes available. These parameters, i.e., the % female breeding and the 1st year mortality, should become priority research questions for the future.





Chacoan Peccary

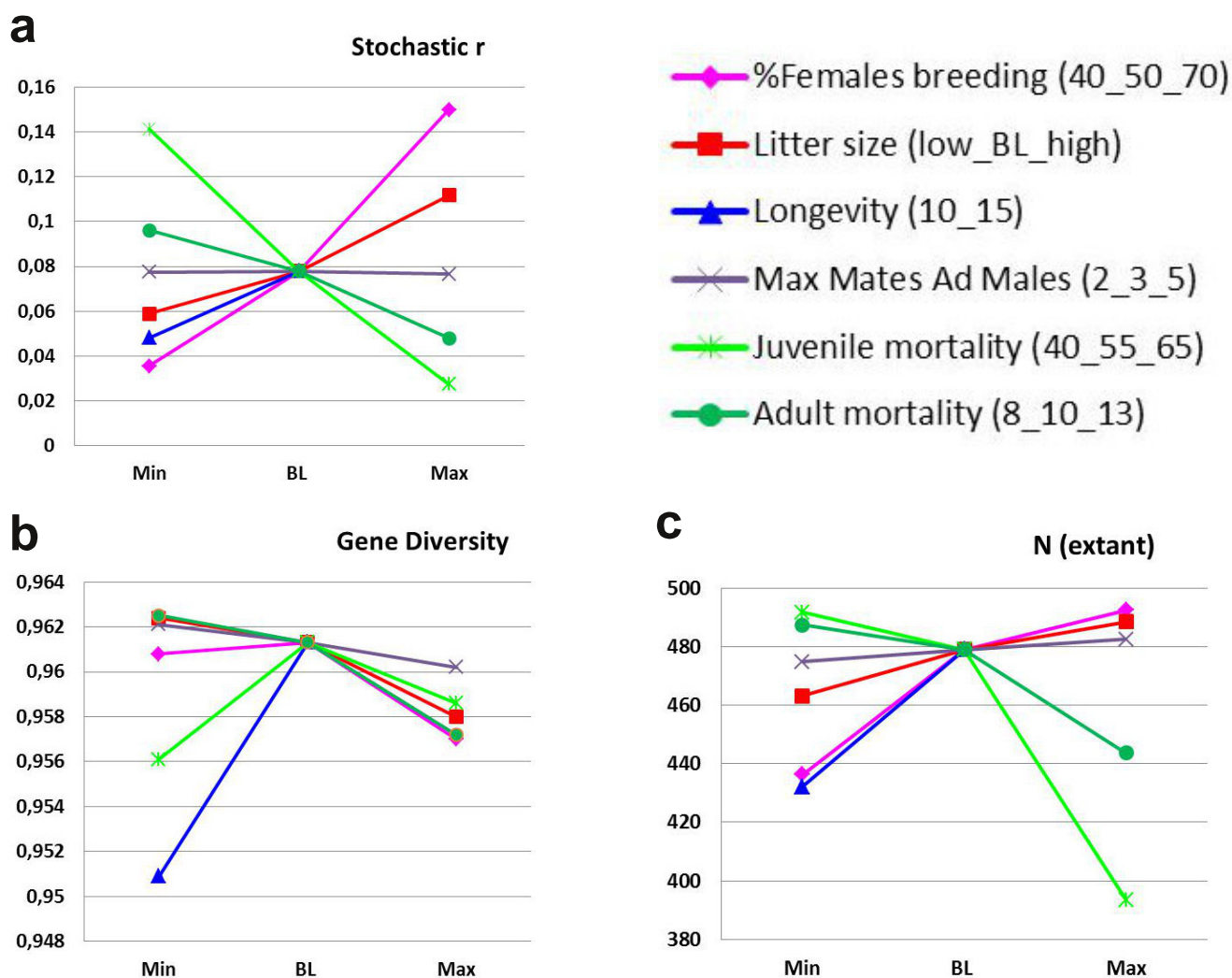
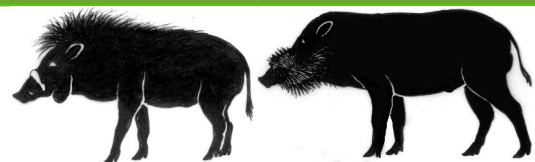


Fig.1 a-c: Sensitivity of the stochastic growth rate (r) to (a), proportion of gene diversity retained, (b) mean size of extant populations after 100 years of simulation ($N(\text{extant})$), and (c), variations in % breeding females (min 40, baseline 50, max 70), litter size (min 1.85, baseline 2.04, max 2.37), longevity/max breeding age (min 10, baseline 15), maximum number of female mates for adult males (min 2, baseline 3, max 5), 1st year mortality (min 40, baseline 55, max 65), and adult mortality (min 8, baseline 10, max 13).

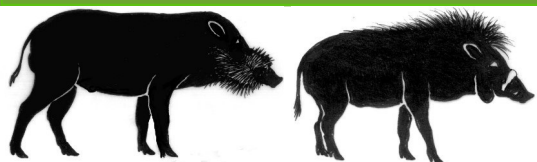
Minimum Viable Population Size

The full range of uncertainty for input parameters was tested (Table 3) to obtain an initial idea of scale for a minimum viable population of the Chacoan peccaries in the absence of human caused threats. For these analyses, we defined “viable” as a population that is able to retain a minimum of 98% gene diversity after 100 years with a zero probability of extinction.

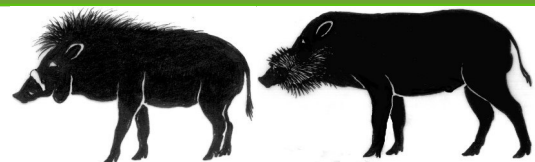
Tab. 3. Minimum population size required in the absence of human caused threats to achieve zero probability of extinction and a minimum of 98% retention of gene diversity after 100 years: under minimum, baseline, or maximum input values for % breeding females (min 40, baseline 50, max 70), litter size (min 1.85, baseline 2.04, max 2.37), longevity/max breeding age (min 10, baseline 15), maximum number of female mates for adult males (min 2, baseline 3, max 5), 1st year mortality (min 40, baseline 55, max 65) and adult mortality (min 8, baseline 10, max 13).

Scenario	Minimum population size needed IN THE ABSENCE OF HUMAN CAUSED THREATS (tested in steps of 100 individuals)		
	Minimum	Baseline	Maximum
%Females breeding	1000	1000	1100
Litter size	1000	1000	1100
Longevity	1300	1000	/
Max # mates/male	1000	1000	1100
1 st year mortality	1200	1000	1100
Adult mortality	1000	1000	1100





Chacoan Peccary



Under the most optimistic scenarios, a population of at least 1000 Chacoan peccaries is required for a minimum viable population, in the absence of human caused threats; under the most pessimistic scenario, a minimum of 1300 is needed with no human-caused threats. For current levels of uncertainty, we would be wise to be conservative and treat these numbers as an index of scale, rather than absolute results. We should also underscore that these results assume a peccary population experiencing genetic and demographic stochasticity, including inbreeding depression and catastrophes, but no human-caused threats such as hunting, habitat loss, etc. To be clear, even protected areas frequently experience some low levels of anthropogenic threats.

Effect of Hunting

Altrichter (2005) studied the hunting of all three peccary species in a 1.2 million hectares area of the semi-arid Argentine Chaco called Impenetrable, located in western Chaco Province of Argentina. She estimated that 870 Chacoan peccaries were hunted per year. During the workshop, we estimated this area to contain about 1 million ha of habitat for the Chacoan peccary. Ages of harvested individuals were fairly evenly distributed with one exception: fewer old animals were being harvested, not unexpected given that fewer animals were present in that age class. For the model, we applied the same rate of mortality to both 1st year individuals, and adults of both sexes. The density of peccaries in non-hunted sites was found to be 0.44 individuals/ km² (Altrichter, 2005). In applying this to a potential area of occurrence of 1 million ha, it suggests a starting population size of 4400 individuals; 870 peccaries is 20% of 4000 individuals.

Hunting was incorporated into the baseline model, and the increased mortality due to hunting was entered in the mortality fields rather than the harvest section because 0-1 year old individuals were also harvested. We used the following formulae:

$$\begin{aligned} \text{Juveniles:} &= (55 + (11 * (\text{CAT}(1) < 2)) + (27,5 * (\text{CAT}(2) < 1))) + 9 \\ \text{Adults:} &= (10 + (1 * (\text{CAT}(1) < 2)) + (3 * (\text{CAT}(2) < 1))) + 18 \end{aligned}$$

If we assume that without hunting, 1st year mortality is approximately 55%, then hunters kill 20% x 45% = 9% of those that otherwise would have lived, resulting in a total first year mortality of 64%. The above formula also accounts for higher natural mortality in catastrophe years; using the similar reasoning, we did the same for adults. We modeled harvest rates of 10% and 5% respectively by adjusting the formulas accordingly.

In addition, because of the current level of uncertainty with regard to both lifehistory parameters for the Chacoan peccary, and quantitative measures of hunting pressure,

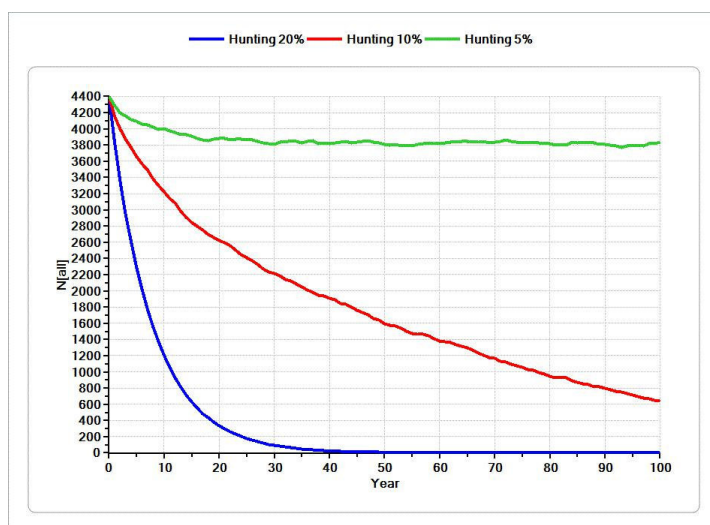
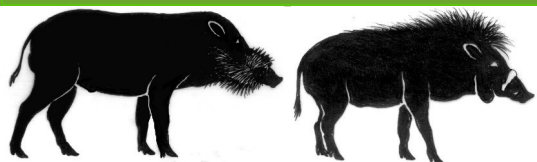
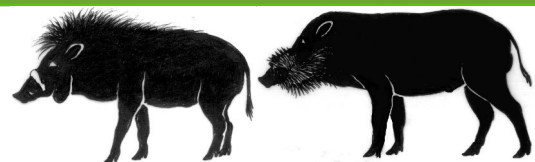


Fig. 2. Average size of all populations (N(all) – including those that went extinct) over time for the baselines scenario with 20% (blue), 10% (red) or 5% hunting (green).





Chacoan Peccary



different hunting rates were tested with the minimum and maximum values for those parameters that caused the biggest fluctuations in model results: % breeding females; longevity; first year mortality; and adult mortality. Baseline parameters, 20% and 10% of hunting (as it was entered into the model), were not considered sustainable, whereas 5% was (Fig. 2).

When we tested the effect of uncertainty of input values for % breeding females, 1st year mortality, longevity (maximum breeding age) and adult mortality, we determined that 20% hunting was unsustainable for all input values (Fig. 3), 10% hunting became sustainable only with the maximum entry for % breeding females (70%) and the minimum entry for 1st year mortality (Fig. 4), and 5% hunting was sustainable only under baseline conditions, the maximum entry for % breeding females (70%), the minimum entry for 1st year mortality and the minimum entry for adult mortality (Fig. 5).

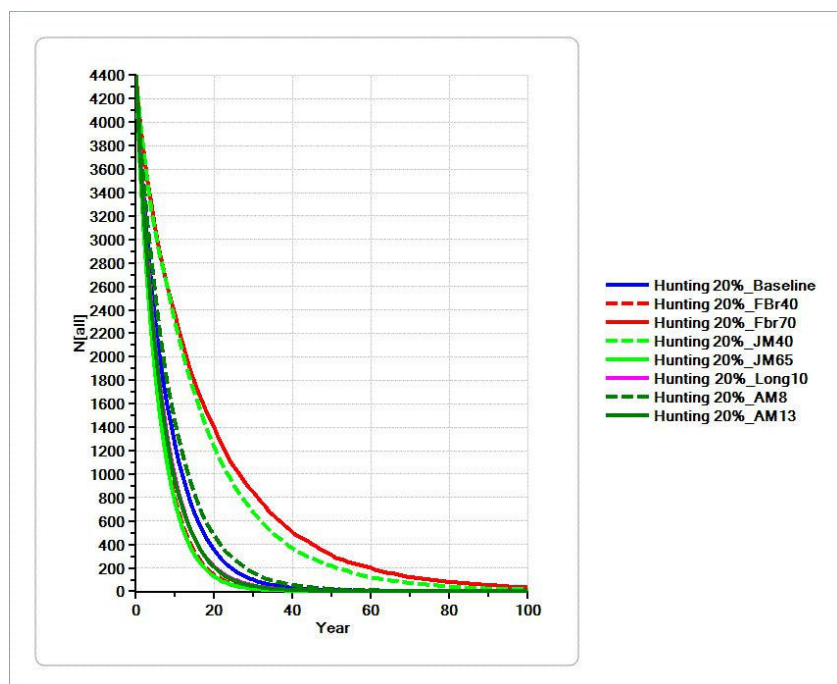
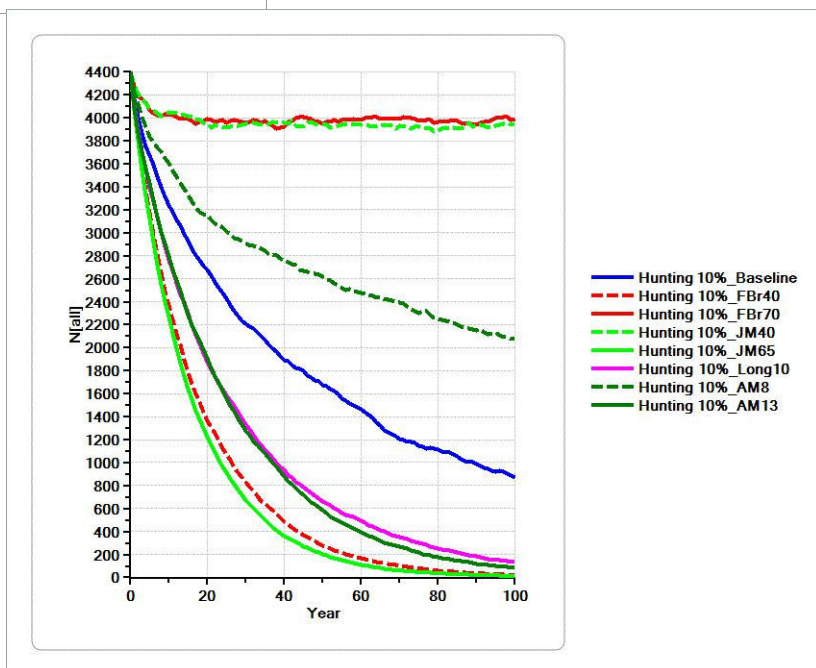
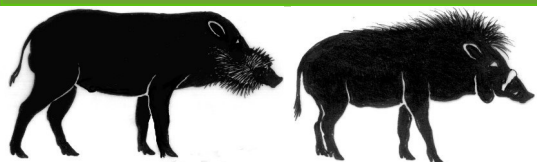


Fig. 3. Average size of all populations ($N(\text{all})$) – including those that went extinct) over time for 20% hunting, with the baseline scenario, and under minimum or maximum input values for % breeding females (min 40, max 70), 1st year mortality (min 40, max 65), longevity/Max breeding age (min 10), and adult mortality (min 8, max 13).

Fig. 4. Average size of all populations ($N(\text{all})$) – including those that went extinct) over time for 10% hunting, with the baseline scenario, and under minimum or maximum input values for % breeding females (min 40, max 70), 1st Year mortality (min 40, max 65), longevity/max breeding age (min 10), and adult mortality (min 8, max 13).





Chacoan Peccary

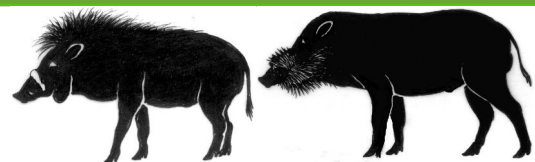
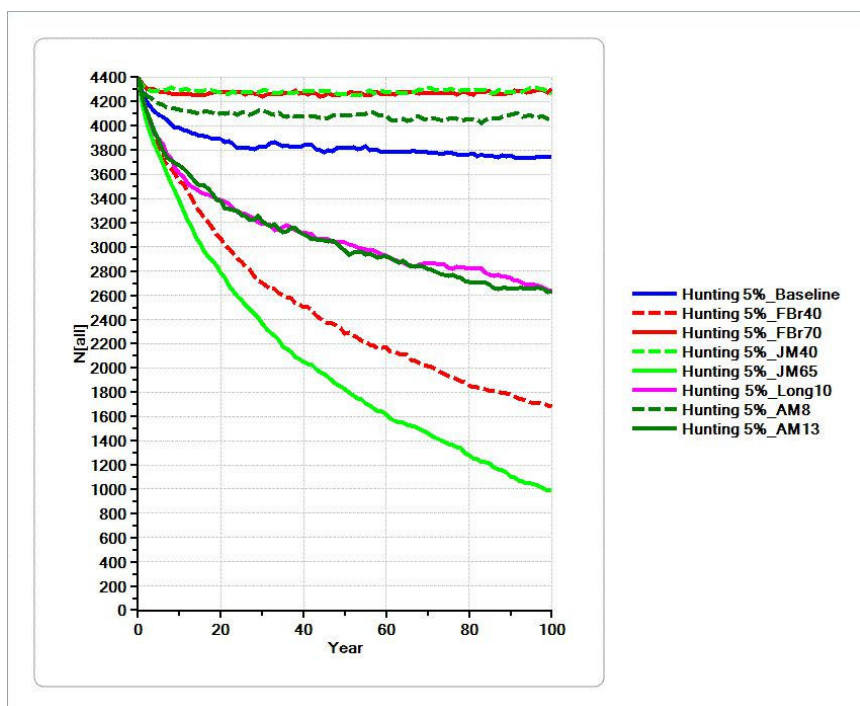


Fig. 5. Average size of all populations (N_{all}) – including those that went extinct) over time for 5% hunting, with the baseline scenario, and under minimum or maximum input values for % breeding females (min 40, max 70), 1st year mortality (min 40, max 65), longevity/max breeding age (min 10), and adult mortality (min 8, max 13).



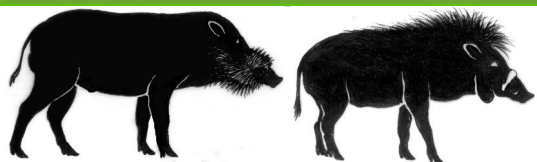
Discussion and Conclusions

The uncertainty in life history parameters, and particularly the % of breeding females, 1st year mortality, longevity/maximum age of breeding and adult mortality, can all cause considerable variation in model outcomes. Learning more about these parameters through field research should be considered one of the biggest research priorities for the Chacoan peccary.

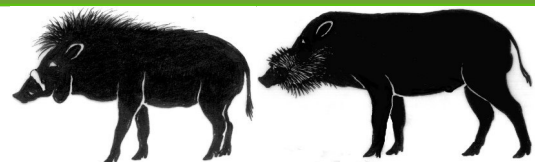
Given current levels of uncertainty, it is not possible to make confident predictions regarding the viability, sensitivity to threats, or effects of hypothetical management scenarios, for a specific Chacoan peccary population. However, by testing the full range of possible input parameters, we obtained our first estimate of the parameters impacting population viability of Chacoan peccaries. As further information on these most important life history parameters become available, these estimates should be refined in consecutive Population Viability Analyses.

Having tested a full spectrum of uncertainty using reasonable parameters, the most pessimistic of these scenarios suggests that in the absence of human-caused threats, a population of at least 1300 Chacoan peccaries would be required to maintain 98% of gene diversity after 100 years to achieve a zero probability of extinction. Under the current levels of uncertainty, and keeping in mind that these results assume a peccary population that experiences no human caused threats, the precautionary principle should apply here, and these numbers should merely indicate scale and magnitude, and not be treated as absolutes. The new vision statement for the Chacoan peccary as defined during the workshop calls for the maintenance of viable populations in contiguous habitat across the distribution of the species. The scale suggested by the Vortex model of minimum viable population size (upwards of 1300 – perhaps 1500-2000) can be of assistance in determining priority areas for conservation. Given a declining current population (Altrichter et al., 2015) in rapidly disappearing habitat, perhaps it may be possible to retain or establish 2- 3 viable and connected populations. However it appears that almost all populations, even in the most remote areas, are subject to some level of human threat, especially





Chacoan Peccary



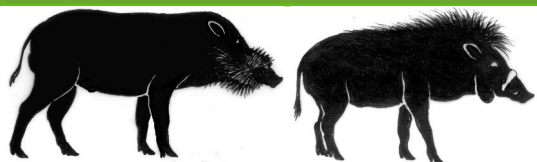
deforestation and fragmentation (Ferraz et al. this issue). Additionally, as the interaction between fragmentation, climate change/ drought, and disease intensifies, it might be necessary to consider more frequent “catastrophes” in future analyses incorporating more complex models.

Finally, uncertainty regarding life history parameters, population densities, and quantitative measures of hunting pressure on the Chacoan peccary prevent us from making confident predictions on the current impact hunting is having on populations, or the hunting intensity that a population of a given size is able to withstand. If we assume hunting was indeed 20% in the population we studied, and if the way it is currently modelled accurately reflects what has been occurring in real life, it appears that this is unsustainable, regardless of the uncertainty in life history parameters. Altrichter (2005), in using the Unified Harvest Model and the estimated density data to evaluate the sustainability of the harvest of Chacoan peccaries in the Argentine Chaco, concluded that Chacoan peccaries were overharvested, but deemed sustainable when density and reproduction data from the literature were used in the harvest model. Altrichter (2005) reported hunting rates from the year 2000. If these rates had continued to the present day, our Vortex model would suggest a population crash to very low numbers, however current data on population estimates do not reflect this crash. In fact, hunting has significantly decreased since 2000 in the Argentine Chaco in part due to government programmes promoting alternative sources of food for local people, as well as to changes in the main livelihoods of local people (Camino et al., 2015). There are no recent data regarding hunting levels, but participants at the workshop felt hunting pressure may well have halved since then. As hunting activity and the need for wild protein among local people varies following larger economic changes (Altrichter, 2006), one cannot expect hunting pressure to remain low. Strict enforcement of regulations, as well as participatory research involving local people, are needed to eliminate hunting completely, or at least maintain it at minimum levels.

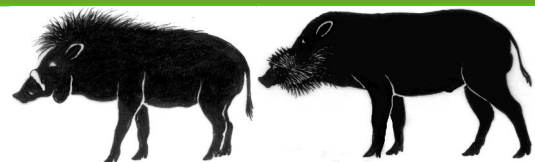
Acknowledgements

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Chacoan Peccary

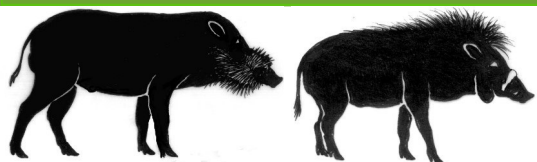


We would very much like to thank Ricardo Torres and Verónica Quiroga, who provided data in preparation for the workshop as well as all thirty one representatives of Argentina, Paraguay and Bolivia who participated in the workshop and helped build the model by providing feedback on and extra data or information.

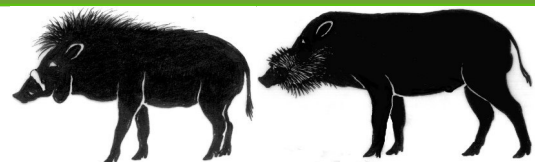
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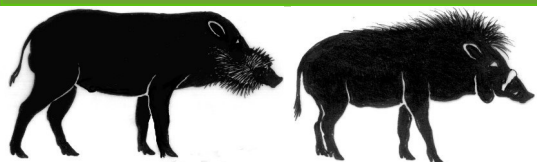


Chacoan Peccary

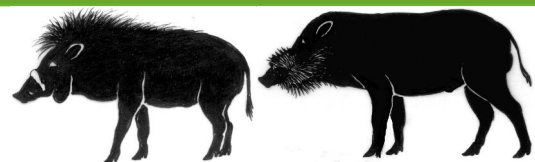


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Behaviour and Physiology



The use of white-lipped peccary (*Tayassu pecari*) vocalizations as welfare indicator

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Abstract

We evaluated the use of vocalizations of 12 captive adult white-lipped peccaries (*Tayassu pecari*) as a welfare indicator. For this, we collected all occurrences of vocalizations during a feeding enrichment schedule, which followed the ABABA model (A phases-predictable; B phases-B1-unpredictable signaled and B2- unpredictable non-signaled). We described the vocalizations' acoustic parameters and their behavioral context. We also compared these data with the fecal glucocorticoid metabolite concentrations in each phase. Three types of vocalizations were recorded: tooth clicking, grumbling, and loud bark. The maximum frequency of the tooth clicking and grumbling, which occurred during disputes for food, was lower during both enriched phases than during control phases. There were no differences in the fecal glucocorticoid metabolite concentrations. Our results showed that the vocal acoustic parameters of white-lipped peccaries were altered by the feeding enrichment schedule and may be useful as a non-invasive tool to measure animal welfare in this species.

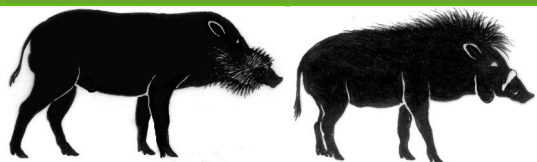
Introduction

The white-lipped peccary is classified as a vulnerable species mainly due to lost habitat and overhunting (Cullen Jr. et al., 2001; Reyna-Hurtado et al., 2008; Altrichter et al., 2011; Keuroghlian et al., 2013). There are some attempts to breed them in captivity, aiming for reintroduction (IUCN, specialist group) or as an alternative to subsistence hunting (Nogueira-Filho & Nogueira, 2004; Nogueira & Nogueira-Filho, 2011). This species, however, is considered aggressive and hard to handling (Nogueira et al., 2015), which increase the human-animal conflicts and concerns on peccaries' welfare (Nogueira et al., 2015).

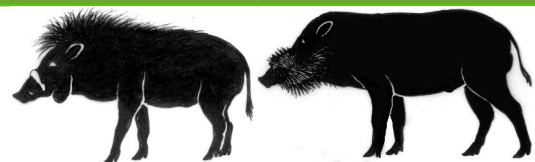
Sowls (1987) reported that the closer the animals were during feeding, the more grunt calls were emitted. Thus, this call seems to indicate aspects of animals discomfort or mood (Nettle & Bateson, 2012) and may be used as conflict avoidance (Oliveira et al. submitted). During feeding periods is common that the dominant individuals show some aggressive displays against conspecific to guarantee food priority and to maintain their social status privilege (Nogueira-Filho et al., 1999, Dubost, 2001). Besides grunt calls, other vocalizations are also emitted during peccaries interactions, and may indicate the animals' mood or preferences, and therefore, may be useful as welfare indicator.

Studies on livestock vocalizations showed that animals' vocal expressions could be used as indicators of animal emotions, because they indicate the animals' motivational condition and consequently their state of welfare (Weary et al., 1997; Jon & Stookey, 1999; Grandim, 2001,





Behaviour and Physiology



Manteuffel et al. 2004). Briefer et al. (2012) showed evidences that an increase in animal respiration could produce tension in respiratory muscles; changing vocal parameters such as to induce more frequent vocalization, longer call durations, higher amplitudes and higher fundamental frequencies. Behavioral and physiological measures must be used to validate the vocal expressions and their acoustic parameters as a reliable animal welfare indicator (Webster, 1998). Thus, a specific experimental design needs to be applied to develop accurate associations between vocal structural parameters and animal welfare. In this context, our aim was to evaluate the acoustic parameters of some vocalizations of the white-lipped peccaries (WLP; *Tayassu pecari*) as welfare indicator by monitoring animals' vocalizations and their physiological stress (Mendoza et al. 2000) during a feeding enrichment schedule.

Materials and Methods

Ethical note

This work followed the "Principles of laboratory animal care" (NIH publication No. 86-23, revised 1985) and was approved by the Committee of Ethics for Animal Use (CEUA) at the Universidade Estadual de Santa Cruz (proc. #003/07).

Animals and study area

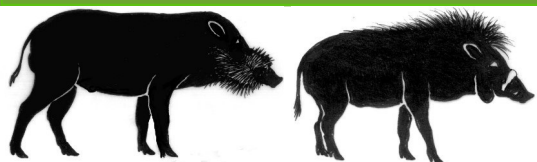
We observed twelve adult white-lipped peccaries, six males and six females, kept at the Laboratório de Etologia Aplicada, Universidade Estadual de Santa Cruz-UESC, Ilhéus, Bahia, Brazil (14°47'39.8"S, 39°10'27.7"W). The animals were individually identified with plastic ear tags of different shapes and colors. They were housed in an experimental paddock (940 m²), which represented a space allowance of c.a. 80 m² per animal. The paddock was divided in two areas: feeding and exercise field area. The feeding area had a dirt floor with shrubs and trees; while the exercise field area contained higher vegetation density, providing natural shade and hiding spots. The animals remained in the exercise field area most of the time and came to the feeding area just to eat. Both areas had one water holder (0.6m length × 0.3m breadth) each. A 1.5 m-high wire netting fence surrounded the paddocks

Environment enrichment schedule and procedures

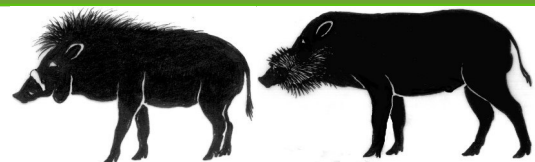
We provide a more complex and unpredictable captive environment by using feeding enrichment schedule during treatments B1 and B2 (Nogueira et al., 2014). The experimental design followed the ABABA model (Hefner, 2004). By this paradigm the A phases (A1, A2 and A3) represented the control phases or predictable - the animals ate at the same feeders, here called traditional feeders (TF), at the same time and spot as they were habituated before this study. The B phases represented the feeding enrichment phases that we used a different type of feeder, called here as challenge feeders (CF), because animals must learn how to open the door of feeders to get food (see details below). Thus, the B1 unpredictable and non-sigaled phase, was called unpredictable because we change the time of feeding routine and non-sigaled, because we did not signal the food delivery for animals. During B2 unpredictable and sigaled phase, we maintained the same unpredictability of food delivery used in B1, however, we sign the food delivery for animals.

During the control phases (As), eight traditional feeders (TFs) (1.0 m diameter × 0.3 m height) were available in the paddock; however, we fed the animals in just four of them, which were always the same and were also located in the same spot in the paddock. The TFs were made from truck tires cut in half and laid horizontally. Up to six WLPs can eat side by side standing





Behaviour and Physiology



around these circular feeders. We provided one feeder for every three animals, placing them 5.0 m apart, based on the results obtained by Nogueira et al. (2014). During feeding routine, the animals were fed twice a day, at 10:00 a.m. and 4:00 p.m. The diet comprised a mixture of maize grain, soybean meal, and mineral salts, providing 12% crude protein and 3,300 kcal/kg of gross energy. The total daily-furnished feed corresponded to 3.5% of live weight per animal on a dry matter basis. The water was available ad libitum. During control phases (As), therefore, we used the TFs plus spatial and temporal predictability: same feeding time and location (A1, A2, and A3). In the B phases (B1 and B2), enrichment was applied by using eight challenge feeders (CFs) plus spatial and temporal unpredictability. The CFs followed the same design and dimensions employed for collared peccaries by Nogueira et al. (2011) and for WLP by Nogueira et al. (2014). They were made with 1.0 m-long PVC tubes (diameter 150 mm) and fitted with a sprung door (0.30m height × 0.15 m breadth). Each CF received a number for later identification during the random choice. To provide spatial and temporal unpredictability for the enriched phases (B1 and B2), we filled only four of the eight CFs in each paddock (Nogueira et al (2014). These feeders were placed 5.0m apart, as were TFs during the control phases (A1, A2, and A3). We filled up the four chosen feeders with 1.2 kg of feedstuff and then put them back in the feeding area, presenting the animals with a level of uncertainty in B1 without any signal, while during B2 we signaled the feeding time by using a plastic whistle (Ilhéus, Bahia, Brazil, no registered brand) to condition animals to come over to the feeding area as suggested by Nogueira et al. (2011; 2014) in order to increase animals' activity.

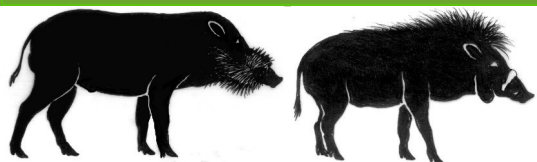
Each phase (A1, B1, A2, B2, and A3) lasted 10 days. During control phases (A1, A2, and A3) feed was offered in the usual TFs. During enrichment phases (B1 and B2) feed was offered in the CFs. Each CF contained enough feed for three animals, following the same protocol employed for the TF: total daily feed corresponded to 3.5 % of live weight per animal on a dry matter basis. Additionally, before each session started, we randomly chose the position of the four CFs that would be filled, by drawing lots. Thus, the animals had to search for food among the ten feeders. During the second enriched phase (B2), we add a whistle signal exactly when feed was provided. During B1 and B2 phases, the feed was offered twice daily, following the same protocol adopted in the control phases (Nogueira et al., 2014). The two feeding times, however, were randomly chosen by a draw of times between 08:00 a.m. and 5:00 p.m., following the normal routine of peccaries in captivity and not at fixed times as in the control (A).

Vocalization data collection

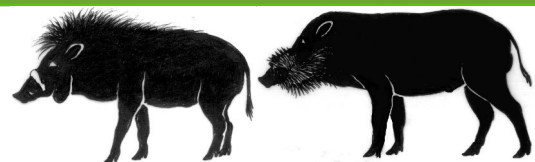
We habituated the peccaries to the presence of an observer 10 days before the data collection. The observer recorded the data from an observation spot located outside the paddock fences. All individuals were continuously visible during the behavioral data collection. We observed the animals for one hour on the same days in at least one of the two feeding periods (As- at 10:00 a.m. and 4:00 p.m. and Bs - between the hours of 08:00 a.m. and 5:00 p.m.).

We collected all occurrences of vocalizations of WLP during the ABABA observation sessions using a Marantz-PMD670 digital recorder (D&M Holdings Inc, Mahwah, NJ) coupled to a Sennheiser ME67 unidirectional microphone (Sennheiser Communications A/S, Solrod Strand, Denmark). Among recorded vocalizations, we analyzed only those that had fewer noises and where it was possible to identify the behavioral context. The recordings were made in mono format with a sampling frequency of 48 kHz, generating WAV files that were transferred directly into a Compac PC (Inspiron 1225, Dell Inc., Brazil) for storage and analysis. The microphone was





Behaviour and Physiology



placed approximately 3-5 m from the animals. When an animal started to emit the calls, the digital recorder was manually operated, and remained on while the animal was vocalizing.

Fecal glucocorticoid metabolite

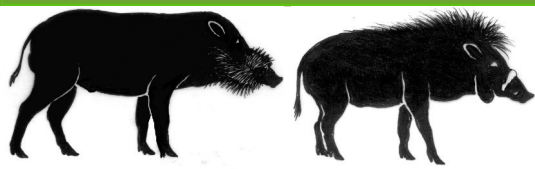
We collected the voided feces during all experimental phases to analyze the fecal glucocorticoid metabolite concentrations. During the observation sessions we noted the feces spot location and corresponding animal for collection after animals' feeding time (about one hour later). The samples were identified with animal, date and time in plastic containers and immediately frozen at -20°C . After defrosting, the feces were homogenized and 2g were sub-sampled to address the freeze-dried (FreeZone® Plus 4.5 Liter Cascade Benchtop, LABCONCO) process, according to Wasser et al. (2000). Lyophilization eliminates variation in water content and avoids proliferation of microorganisms. Next, each sample was ground by hand and placed in an individual 2.0mL plastic tube, which was then sent to the Laboratório de Endocrinologia Comportamental, Universidade Federal do Rio Grande do Norte, Natal, Brazil, for glucocorticoid metabolite measurement.

The fecal glucocorticoid metabolite concentrations were assayed using enzyme immunoassay (ELISA - Enzyme Linked ImmunoSorbent Assay), with a polyclonal antibody for cortisol (R4866; 1:8500 dilution) and a cortisol-HRP conjugate (1:20000) obtained from Coralie Munro (California University, Davis, CA, USA). The cross-reactivity for the antibody was 100% with cortisol, 9.9% for prednisolone, 6.3 % for prednisone and 5% for cortisone (Young et al., 2004). Instead of the usually recommended 1:50 dilution in ethanol (Brown et al., 2004), we determined that 1:10 dilution was better to extract FGM, as previously recommended in assays with white-lipped peccaries (*Tayassu pecari*) (Nogueira-Filho et al., 2012). The intra- and inter-assay coefficients of variation (CV) were 10.7% and 3.8%, respectively. The limit of detection, also called the analysis of sensitivity, was calculated by subtracting two standard deviations from the mean counts and was 0.2 ng.g⁻¹ of dry feces.

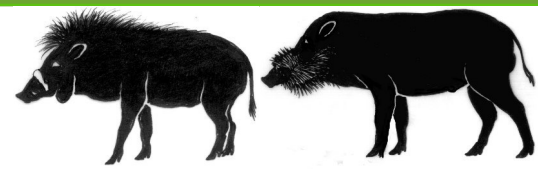
Data analyses and statistical methods

The sonographic analyses of vocalizations were performed employing Avisoft -SAS Lab Pro version 4.3 (Avisoft Bioacoustics, Berlin, Germany), with Hamming window type, window size 100%, fast Fourier transformation (FFT) 512 and 93.75% overlap, creating a time resolution of 0.73ms. We selected emissions with least interference from ambient noise and best sonographic image quality. We described the mean parameters of each vocalization recorded, such as element number (En: number of a single energy unit of vocalization), element duration (ED: the element duration in time), maximum frequency (max.F: the highest point of call frequency) and dominant frequency (DF: the frequency that presents the highest amplitude or volume of vocalizations recorded). We discarded analysis of the minimum frequencies recorded due to many noises in this structural frequency, which made interpretations difficult. We compared the parameters of the vocalizations by one-way ANOVAs followed by Unequal N HSD's post hoc test (Statistica version 7.0 - StatSoft, Tulsa, OK, USA), when appropriate. We included in the model just the effects of the experimental phases (A1, B1, A2, B2, and A3), because sometimes it was not possible to identify the animal which emitted the vocalization. To compare the fecal glucocorticoid metabolite concentrations we applied ANOVA with repeated measures (Statistica version 7.0 - StatSoft, Tulsa, OK, USA), including in the model the effects of the experimental phases (A1, B1, A2, B2, and A3) and the sex (male vs. female) as independent factors. Log (x+1)





Behaviour and Physiology



transformations were used when necessary to meet the assumption of normality. All analyses used a < 0.05 significance level.

Results

We recorded three types of vocalizations (Figure 1) during the experiment, totaling 81 records (Table 1). The tooth clicking call was the most frequent vocalization (n = 34; Figure 1a), followed by grumbling (n = 27; Figure 1b), and loud bark call (n = 7 Figure 1c;). The loud barks, related to alarm (Sowls, 1997) were emitted by three different individuals only during A1 and A2 phases.

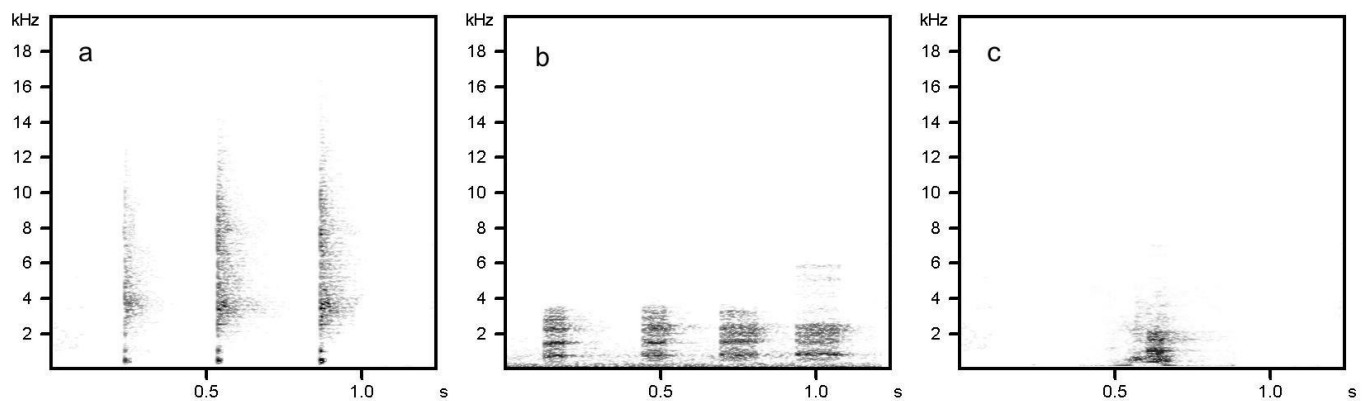


Fig. 1. Spectrograph of white-lipped peccary vocalizations emitted during the experimental phases. Tooth clicking call (a), grumbling (b), and loud bark call (c).

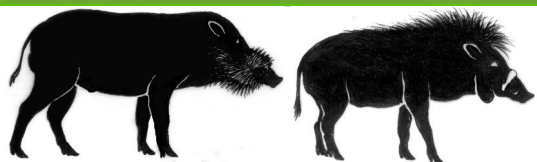
Tab. 1. The structural components of vocalizations recorded during the experimental phases: number of elements (*En*), element duration (*ED*), maximum frequency (*max.F*) and Dominant frequency (*DF*) of vocalizations recorded.

Vocalization	Elements number	Elements duration (s)	Maximum frequency (Hz)	Dominant frequency (Hz)
Grumbling call (n=27)	3.04 (±1.4)	48.10 (±244.63)	2,496.80 (±680.85)	941.05 (±1,060.39)
Tooth clicking (n=34)	4.45 (±2.06)	0.029 (±0.017)	4,960.37 (±1,784.33)	699.87 (±671.54)
Loud bark (n=7)	1.29 (±0.49)	0.116 (±0.025)	2,487.14 (±689.60)	568.57 (±160.08)

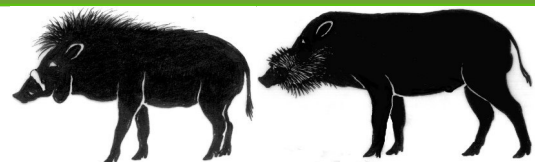
The tooth clicking and grumbling, both related to threatening behavior (Sowls, 1997), allowed more detailed analyses because they were emitted by the WLP in almost all experimental phases.

For the tooth clicking call the statistical model showed differences in the *max.F* of this vocalization according to the experimental phases ($F_{4, 36} = 7.17$, $P = 0.0002$). The post hoc test showed that





Behaviour and Physiology



the max.F did not differ between both enrichment phases (B1 and B2) ($P = 0.96$) and were lower than the ones emitted during the control phases (A2, A2, and A3, $P_s < 0.04$) (Figure 2). Moreover, the DF of tooth clicking vocalization also changed according to the experimental phases ($F_4, 36 = 3.81, P = 0.01$). The post hoc test showed that the DF was higher ($P_s < 0.016$) during the first control phase A1 than during the two enrichment phases (B1 and B2) (Figure 2). This vocalization parameter did not differ ($P_s > 0.66$) among the other phases (B1, A2, B2, and A3).

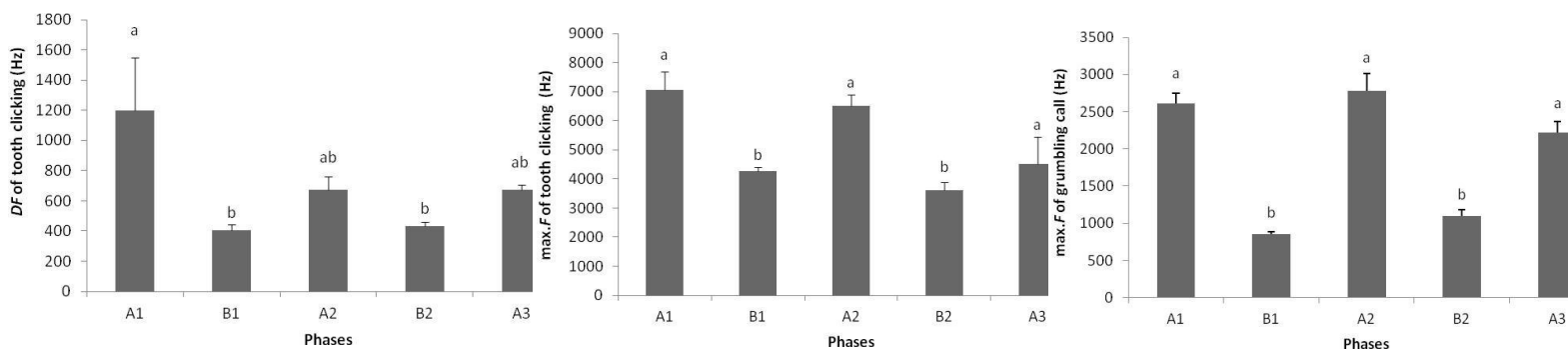


Fig. 2. Dominant frequency (DF) (a, left), maximum frequency (max. F) of tooth clicking (b, centre), and maximum frequency (max. F) of grumbling call vocalization (c, right) by white-lipped peccaries ($N = 12$) during the experimental phases.

The statistical model also showed differences in the max.F of the grumbling call among the phases ($F_4, 12 = 28.33, P = 0.0001$) (Figure 2b). The post hoc test showed that during both enriched phases the grumbling max.F of peccaries did not differ among themselves ($P = 0.63$) and were lower than the ones emitted during the control phases ($P_s < 0.02$) (Figure 2b).

It was possible to collect feces from only eight (four males and four females) of the 12 peccaries during all the experimental phases. The statistical model revealed no differences in the fecal glucocorticoid metabolite concentrations among the different phases ($F_4, 12 = 0.08, P = 0.99$) (Figure 3).

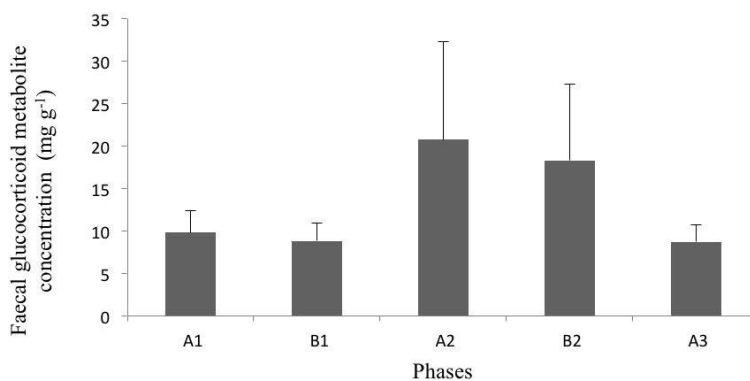


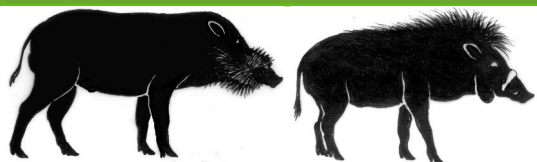
Fig. 3. Faecal glucocorticoid metabolites (ng g^{-1} dry feces) of white-lipped peccaries ($N = 8$) during the experimental phases.

Discussion

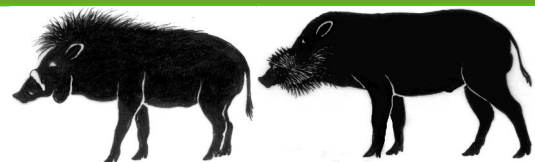
Two of the vocalizations emitted by the WLPs showed differences in structural acoustic parameters according to the experimental phases, probably because they were competing for food. SOWLS (1997), studying free-range white-lipped peccaries in the Brazilian Atlantic forest, reported that this species often emits aggressive calls during feeding time - tooth clicking and grumbling, which were associated with threatening events. The consulted literature was inconsistent in determining which type of frequency (high or low) is associated with negative or positive states (see Briefer, 2012). In this study the maximum frequency of both the tooth clicking and grumbling were lower during both the enrichment phases than during the control phases. This lowest frequency in these threatening calls may reflect less tension among the individuals during the enriched phases, possibly because they were busy looking for food among feeders.

Hernandes et al. (1995) and SOWLS (1997) studying white-lipped in wild and captive, respectively, reported that when many animals were closer during





Behaviour and Physiology



feeding time they emitted more tooth clicking, probably revealing space threshold tolerance toward each other. Thus, it is possible that in our study, during the control phases, the individuals demonstrated more negative emotions because there was less space allowance among them than during the feeding enrichment phases. During the control phases the TFs allowed more than six individuals to eat together, which may have promoted more conflicts among animals. In addition, our results could be also explained because during enrichment, peccaries spend more time to get food than during control phases. Such effect may have positive effects to peccaries welfare as reported before by Nogueira et al. (2014). The authors applying the same enrichment schedule for WLP, found positive welfare, because through this program, animals increased their exploratory behavior in captivity and increase activity. Patel et al. (2011), however, highlighted that it is difficult to distinguish emotional valences (positive or negative) by acoustic parameters. Otherwise, Briefer (2012) pointed out that changes in respiration can cause tension in respiratory muscles, altering vocal parameters, inducing longer durations, higher amplitude and higher fundamental frequencies. Besides Hernandez et al. (1995) and Sowls' (1997) observations, our experimental design and results suggest that the animals' motivational states can be reflected in the structural acoustic parameters of tooth clicking and grumbling emitted by the WLP, as reported for other species (*Suricata suricatta*: Manser, 2001; equine: Pond et al., 2010).

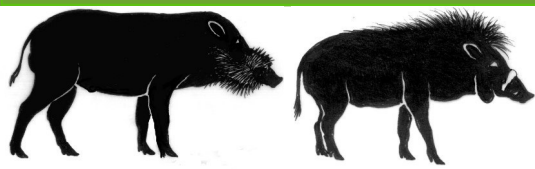
On the other hand, the fecal glucocorticoid metabolite concentrations of WLP did not change during the experimental phases (enriched and non-enriched), possibly because captive environment in our study did not represent a big challenge for animals independent of environmental enrichment or not and consequently no distress could be measured. The fecal glucocorticoid metabolite concentrations recorded in the present study were below the basal levels reported for this species (118.3 ± 54.1 ng.g⁻¹; Nogueira-Filho et al., 2012). This result may be explained by the better conditions in which the animals were kept in the present study in both experimental phases, in comparison with the previous study about basal levels of glucocorticoids in WL, when animals were maintained in individual concrete-floor pens to validate the methodology. In the present study, during all experimental phases, an exercise field area were available for animals for most of the day, contained trees, branches and enough space allowance, which mimics conditions in the wild, except for free range; possibly resulting in relatively low fecal glucocorticoid metabolite concentrations.

Although fecal glucocorticoid metabolite concentrations have been used as an indicator of stress that may reflect animals' welfare conditions (Palme et al., 1999; Mendoza et al. 2000; Sapolsky et al., 2000), this physiological measurement may sometimes not be enough to evaluate suitable welfare conditions. Other indicator measurements, such as animal behavior parameters, must be considered to better evaluate animal welfare (Dawkins, 2003; 2008). Thus, our results suggest that peccary's vocalization may be better welfare indicator than glucocorticoid metabolite concentration.

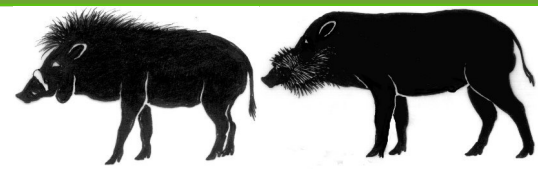
Conclusion

The vocal acoustic parameters of white-lipped peccaries were altered by the feeding enrichment schedule and may be useful as a non-invasive tool to measure animal welfare in this species. However, further studies need to be done to better understand and accurately analyze the mean valences (positive or negative) of such parameters, providing a range of tolerance for acoustic parameters used in animal welfare.





Behaviour and Physiology



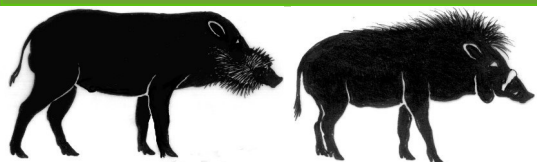
Acknowledgments

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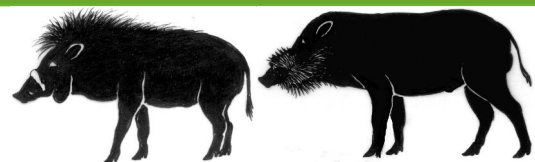
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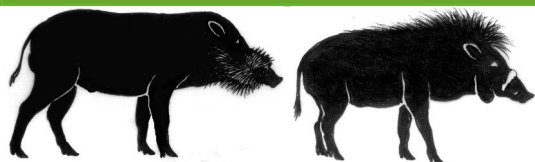


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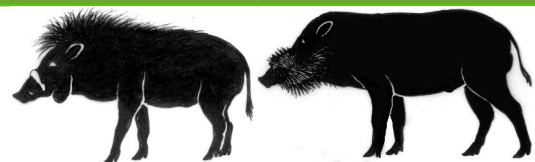


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Taxonomy



On specimens of extant warthogs (*Phacochoerus*) from the Horn of Africa with unusual basicranial morphology: rare variants of *Ph. africanus* or hybrids between *Ph. africanus* and *Ph. aethiopicus*?

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Introduction

The common warthogs (*Phacochoerus africanus*) and desert warthogs (*Ph. aethiopicus*) are the only extant suids that display major morphological adaptations to diets dominated by tropical grass in open habitats. They are the only extant descendants of the paraphyletic extinct genus *Metridiochoerus*, widespread through the whole African continent during the Plio-Pleistocene and represented by several other grass-eating species (Harris & White, 1979; Cerling et al., 2015). Genetics, morphology, habitat, diet, and behavior of the two extant species of *Phacochoerus* have been the focus of detailed investigations, notably to detect potential interspecific interactions and differences in ecological niches (Grubb, 1993; d’Huart & Grubb, 2001; Randi et al., 2002; d’Huart & Grubb, 2005; De Jong et al., 2009; Grubb & d’Huart, 2010; Obanda et al., 2011; Muwanika et al., 2012; Souron, 2012; De Jong & Butynski, 2014).

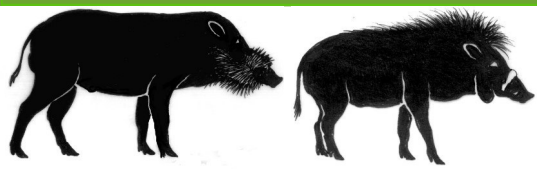
Previous studies indicate that the two extant species of *Phacochoerus* differ in various parts of their cranio-mandibular and dental morphology. Grubb (1993) and d’Huart & Grubb (2005) summarized the main criteria as follows: *Phacochoerus aethiopicus* differs from *Ph. africanus* by (1) the proportions of its skull (relatively shorter and broader); (2) the presence of a well-developed spherical hollow knob near the caudal extremity of the zygomatic arch; (3) the absence of upper incisors; (4) vestigial, non-functional lower incisors; (5) third molars with delayed closure of the pulp canals; and (6) a peculiar basicranial morphology (to be described in detail below). Ewer (1958) also described additional potential differences between the two species in their upper and lower canines.

Grubb (1993) states that: “the characters of the incisors, cheek teeth, zygoma and sphenoid region are trenchant, discrete and functionally quite independent. There is no indication of intermediate states and no likelihood that the morphological differences merely indicate intra-population variation, particularly as one of the species is itself discontinuously distributed”. Here I present a preliminary analysis of morphological data of several *Phacochoerus* specimens that come from the Horn of Africa and display unusual morphology of the basicranium, seemingly intermediate between the morphologies of the two recognized extant species. I thereafter discuss the potential implications for our understanding of the morphological variability and systematics of the two species and highlight the numerous perspectives.

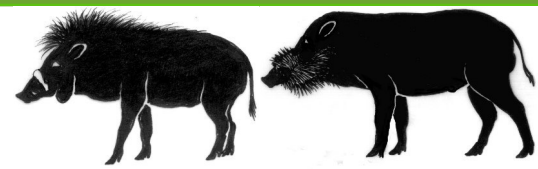
Material and Methods

Since 2009, I have been collecting data on the morphological variability of the cranium (including the basicranium), mandible, and teeth in extant *Phacochoerus* using the large collections of the following institutions: MNHN, Muséum National d’Histoire Naturelle, Paris; NHM, Natural History Museum, London; MRAC, Musée Royal de l’Afrique Centrale, Tervuren; MZUF, Museo di Storia





Taxonomy



Naturale “La Specola”, Firenze; MCA, Comparative Anatomy, Authority for Research and Conservation of Cultural Heritage (ARCCH); and OM, Kenya National Museums (KNM), Nairobi. The total sample comprises more than 500 specimens covering most of the geographic ranges of both species. I observed the basicranial morphology of the whole sample and documented selected specimens using digital photography.

Results

My observations mostly confirm the major differences in basicranial morphology between the two species of extant *Phacochoerus*. In *Ph. africanus*, the basicranium displays two deep and well-delimited fossae, named “sphenoidal pits”, separated by a low vomerine ridge (Grubb, 1993; d’Huart & Grubb, 2005). In ventral view, the “sphenoidal pits” are partially covered caudally by two thin bony sheets that bear very shallow fossae positioned just rostrally to the auditory bullae (Fig. 1a). This morphology is unique among suids and is recognized very early in this species, the “sphenoidal pits” being visible in the crania of juvenile specimens at every stage of the ontogeny, even in neonates (Fig. 1b illustrates the basicranial area of a juvenile specimen with fully erupted upper M2 but unerupted upper M3).

The morphology of the basicranium is dramatically different in *Phacochoerus aethiopicus*, making it one of the most useful diagnostic features between the two species of extant warthogs. Adult specimens of *Ph. aethiopicus* display a basicranium with two rostro-caudally elongated and deep

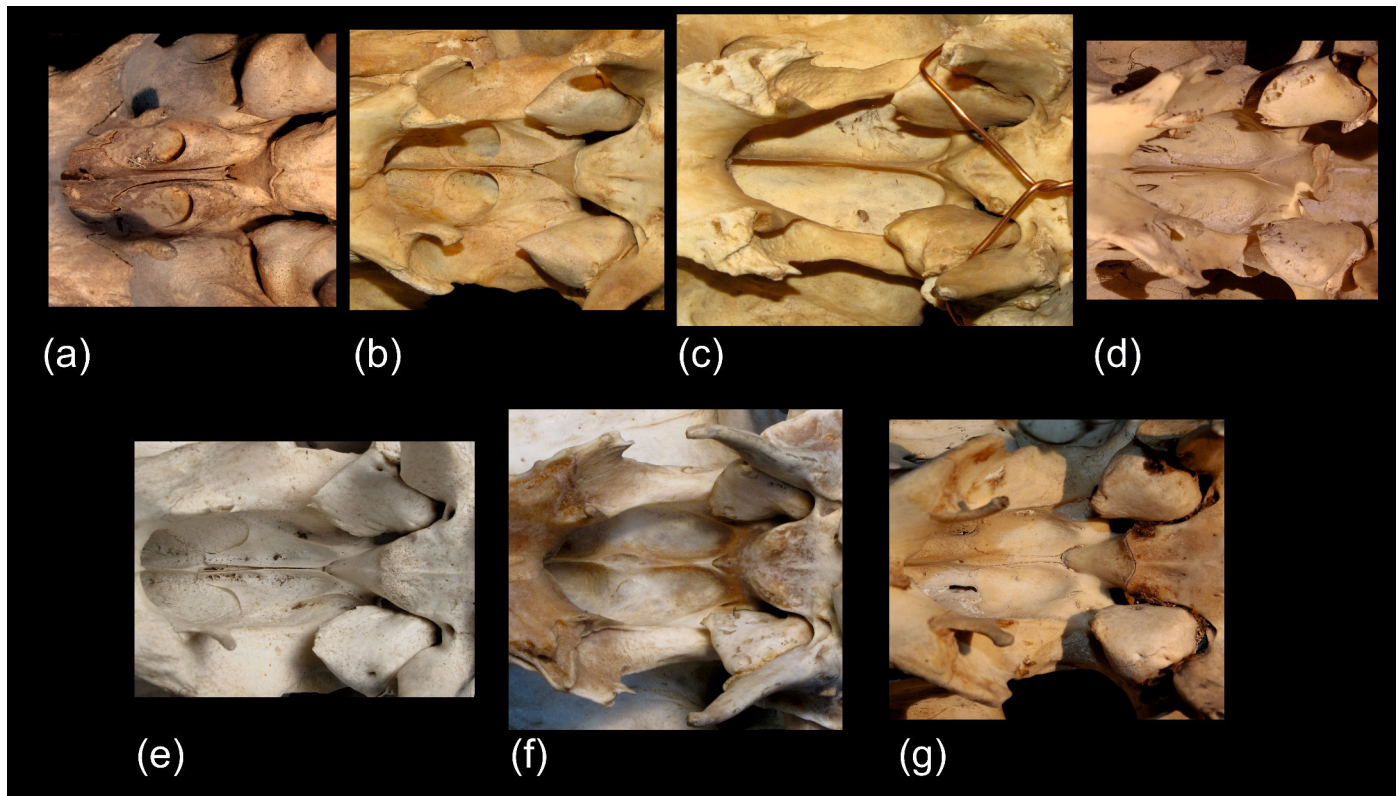
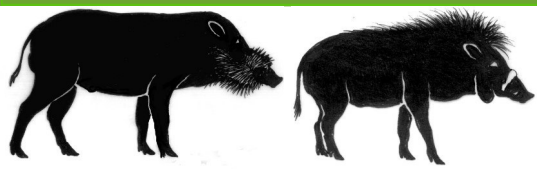
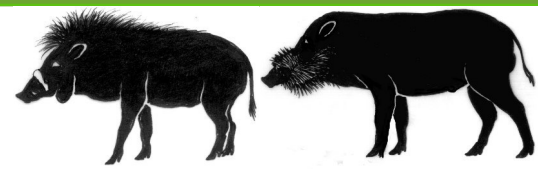


Fig. 1. Basicranial morphologies of selected specimens of extant *Phacochoerus* in ventral views (not to scale; caudal is on the right). (a): no number (personal collection of the author), adult, *Ph. africanus*, unknown provenience; (b): OM 3312, juvenile (upper M2 erupted), *Ph. africanus*, Kenya; (c): OM 7849, adult, *Ph. aethiopicus*, Moyale, Kenya; (d): MZUF 2444, juvenile (upper M1 erupted), *Ph. aethiopicus*, Bal’ad, Somalia; (e) MCA 158, adult, *Phacochoerus* sp., unknown provenience (likely from Ethiopia); (f) OM 2165, adult, *Phacochoerus* sp., West Meru, Kenya; (g) MZUF 1112, juvenile (upper M2 erupted), *Phacochoerus* sp., Keren, Eritrea.





Taxonomy



fossae separated by a high vomerine ridge (Fig. 1c; Grubb, 1993; d’Huart & Grubb, 2005). Grubb (1993) suggests that the two deep fossae characteristic of *Ph. aethiopicus* originated from the enormous expansion of the “sphenoidal pits” visible in *Ph. africanus*. However, it seems equally plausible that those deep fossae are homologous with the two shallow fossae born by the thin bony sheets covering the caudal part of the “sphenoidal pits” in *Ph. africanus*. This will have to be tested by more thorough morphological descriptions of the basicranium in *Phacochoerus*.

The ontogeny of the basicranial area is very poorly known in *Phacochoerus aethiopicus* because juvenile specimens are very rare in the osteological collections. Contrary to what is observed in

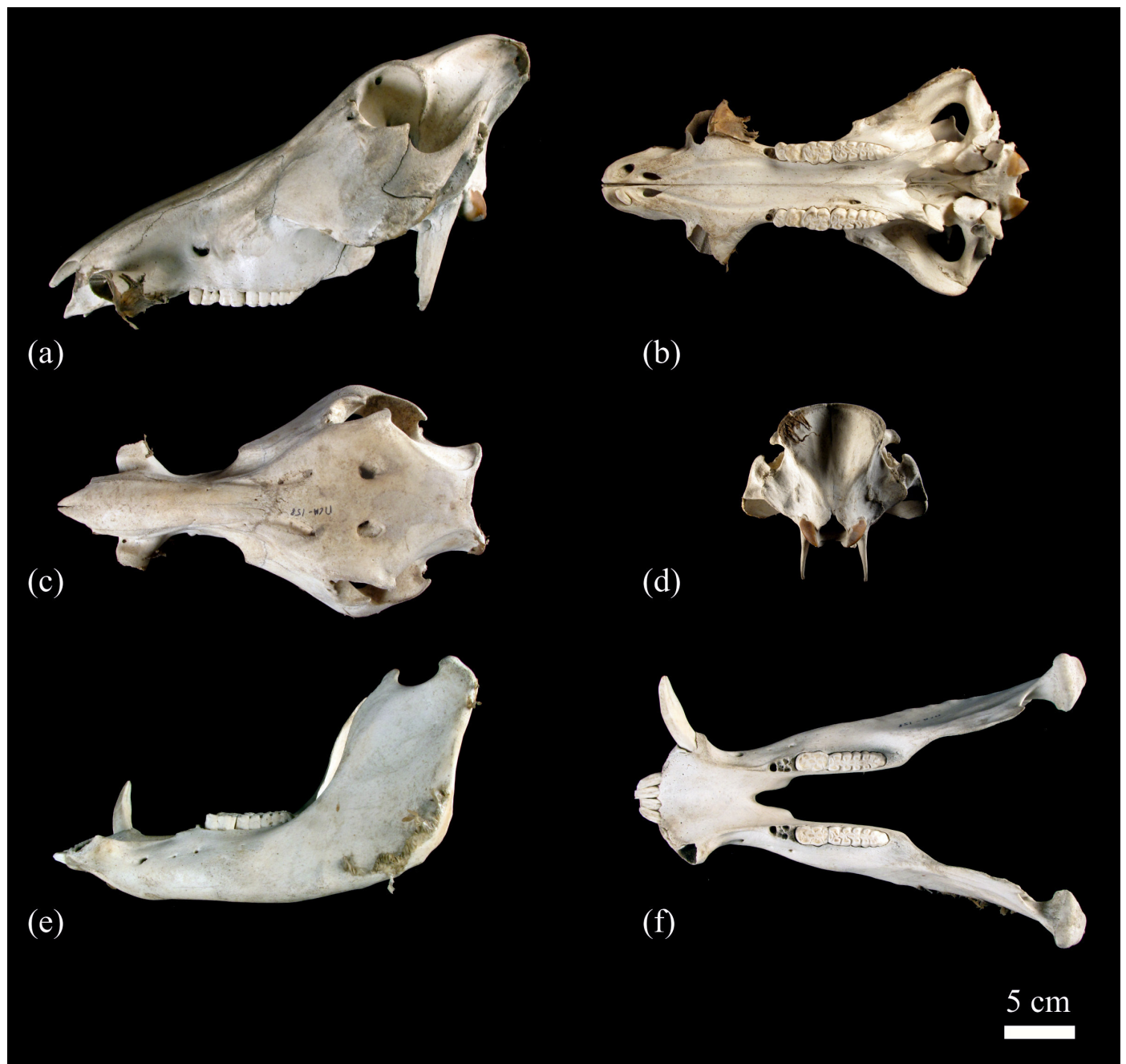
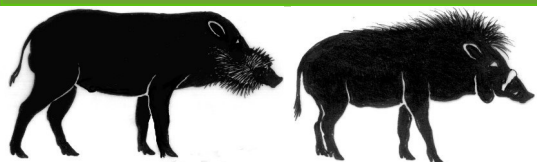
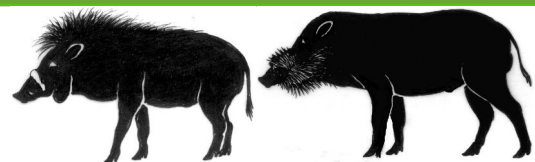


Fig. 2. Skull of the adult specimen MCA 158, extant *Phacochoerus* sp., unknown provenience but likely from Ethiopia. Cranium in left lateral (a), ventral (b), dorsal (c), and caudal (d) views. Mandible in left lateral (e) and dorsal (f) views. The 5 cm scale is approximately positioned at the level of the cheek teeth in (a), (b), (e), and (f) views. It is approximately at the level of the nuchal crest in (c) and (d) views.





Taxonomy



Ph. africanus, the peculiar basicranial morphology of *Ph. aethiopicus* is visible only in adults (with most of their upper and lower third molars erupted). In the few juveniles of *Ph. aethiopicus* that I observed, the fossae are very shallow and separated by a low vomerine ridge (Fig. 1d illustrates a juvenile specimen with upper M1 fully erupted).

Three specimens of *Phacochoerus* display unusual basicranial morphologies. The specimen MCA 158 is stored in the comparative anatomy collections of the ARCCH in Addis Ababa, Ethiopia. It preserves the cranium and mandible of a young adult, with the upper and lower third molars almost fully erupted (based on the size and orientation of the upper canine alveoli, likely a female) (Fig. 2). No geographic provenience is known for that specimen, but based on the history of the collections of the ARCCH, this specimen very likely comes from Ethiopia. The specimen OM 2165 is from the osteological collections of the KNM in Nairobi, Kenya. It preserves the cranium and mandible of an old adult, with the upper and lower third molars fully erupted and heavily worn (based on the size and orientation of the upper canine alveoli, likely a female). It comes from West Meru in Kenya, where *Ph. aethiopicus* is known to occur (De Jong & Butynski, 2014). The specimen MZUF 1112 is from the osteological collections of the Museo di Storia Naturale “La Specola” in Firenze, Italy. It preserves the cranium and mandible of a male juvenile, with the upper and lower second molars fully erupted, but unerupted third molars. It comes from the area of Keren in Eritrea, where *Ph. africanus* is known to occur (d’Huart et al., 2016).

The three aforementioned specimens display cranio-mandibular and dental features typical of *Phacochoerus africanus*, including well-developed upper (one pair) and lower (three pairs) incisors and a caudal extremity of the zygomatic arch lacking a spherical hollow knob (Fig. 2). However, they differ from *Ph. africanus* by their basicranial morphology lacking the well-delimited, deep “sphenoidal pits”. They also differ from adult specimens of *Ph. aethiopicus* as their basicrania do not display the rostro-caudally elongated and deep fossae separated by a high vomerine ridge. Overall, their basicranial morphology is similar to the one observed in juvenile specimens of *Ph. aethiopicus* (compare Fig. 1e, f, and g with Fig. 1d), and represent a potential intermediate stage between morphologies of adult *Ph. africanus* and *Ph. aethiopicus*.

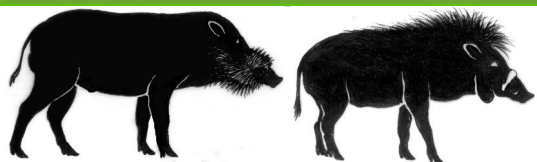
Discussion and conclusions

The three specimens presented here display a unique combination of an unusual basicranial morphology with other features typically observed in *Phacochoerus africanus*. Until more data are available, I therefore tentatively assign those specimens to *Phacochoerus* sp. Two main hypotheses could explain their unusual morphology: (1) rare morphological variants of *Ph. africanus*, or (2) potential hybrids between *Ph. africanus* and *Ph. aethiopicus*.

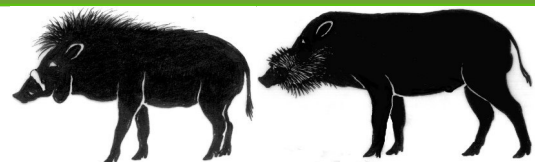
Those specimens could represent very rare variants within the intra-specific variability of *Phacochoerus africanus*. They could for example stem from developmental pathologies peculiar to those specimens (although they do not display any evidence for other kinds of pathologies).

It is puzzling that out of more than 500 specimens of extant *Phacochoerus* observed, those unusual basicranial morphotypes only occur in three specimens coming from the Horn of Africa where the ranges of the two species of extant *Phacochoerus* meet. The Kenyan specimen notably comes from West Meru, an area where both extant species are sympatric (De Jong & Butynski, 2014). The Eritrean specimen comes from an area where only *Ph. africanus* is reported, and located around 600 km from the closest occurrence of *Ph. aethiopicus*. However, distributions of both extant species of *Phacochoerus* are still poorly known in Eritrea, Djibouti, and Ethiopia. Overall, the intermediate morphology displayed by those three specimens, combined with





Taxonomy



contextual data of their geographic proveniences and contrasted with the absence of those rare variants in collections from other African areas, suggests that the unusual basicranial morphology could have resulted from hybridization between both species in areas where they are sympatric. Both hypotheses are plausible and cannot be confirmed or infirmed at this stage of the research based on the limited morphological data available. The unusual specimens presented here raise many questions relevant to our understanding of *Phacochoerus* evolution, and more globally mammalian evolution. Were they hybrids between the two extant species? If so, were those hybrids fertile? Is there any overlap between the ecological niches occupied by the two species? What are the interspecific interactions between the two species? To answer those questions will require to combine analyses focused on ecology, morphology, and genetics of the extant *Phacochoerus*.

I am currently conducting more detailed analyses of the cranio-mandibular shapes of those three unusual specimens by comparing them to a large sample of extant *Phacochoerus africanus* and *Ph. aethiopicus* using geometric morphometrics methods. During my PhD, I was able to discriminate both species in terms of cranial shape as they overlap very little in the cranial morphospaces (Souron, 2012: figure 1.7, p. 118). The inclusion of the three unusual specimens into this reference data set will allow to test whether they fall within the morphospace of *Ph. africanus* or if they are intermediate between the two extant species of *Phacochoerus*.

Future research will have to investigate in more detail the differences in basicranial morphology between the two species, and especially the changes through ontogeny in *Ph. aethiopicus*. Osteological collections documenting the different ontogenetic stages of this species are therefore crucially needed.

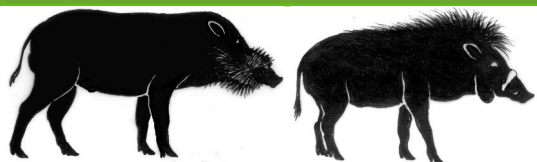
Confirming or infirming the aforementioned hypotheses to explain the unusual morphologies observed in the three *Phacochoerus* sp. specimens could notably be investigated through molecular analyses. Dried soft tissues preserved on one of the specimens were already preserved and are available for future collaborations on the molecular genetics of those peculiar specimens.

Moreover, nothing is known about potential functional correlates of the very peculiar basicranial morphologies observed in the two extant species of *Phacochoerus* when compared to the other suids. That would require some thorough descriptions of the osteology of both species, as well as the associated differences in soft tissues.

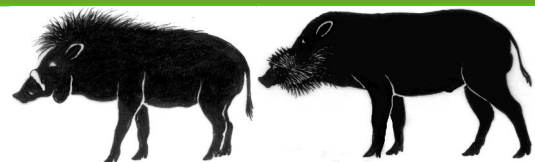
Collections of fossil and extant *Phacochoerus* from southern Africa are also in crucial need of a thorough and extensive revision that may reveal similarly unusual specimens coming from areas where *Ph. africanus* and *Ph. aethiopicus* occurred sympatrically, if any. For example, a set of South African specimens purchased in 1850 and stored at the Natural History Museum in London comprise some complete specimens that display all the diagnostic features of *Ph. aethiopicus* but also other more partial specimens of the same set (preserving only the rostrum) that display presence of upper incisors, a feature usually only observed in *Ph. africanus*. Again, that could be evidence for: (1) geographic differences between the subspecies *Ph. aethiopicus delamarei* in eastern Africa and *Ph. aethiopicus aethiopicus* in southern Africa, with occasional presence of upper incisors in the latter, or (2) sympatry (and potentially hybridization) of the two species in some areas of southern Africa prior to the local extinction of *Ph. aethiopicus* by the end of the nineteenth century.

I am also currently revising the fossil record of *Phacochoerus* and its extinct ancestors and relatives of the genus *Metridiochoerus*. The morphology of the basicranium is usually poorly





Taxonomy



preserved, but will be important to describe in order to understand the changes of characters leading to the evolution of the morphologies observed in the two extant species of *Phacochoerus*. Recognizing and confirming hybrid specimens between extant species of *Phacochoerus* would also contribute to build a valuable reference data set to investigate the potential presence of hybrids in the rich fossil record of African suids and other mammals, and thus contribute to understand the potential role of hybridization in evolution (e.g., Ackermann et al., 2006, 2010; Gilbert et al., 2011; Shurtliff, 2013).

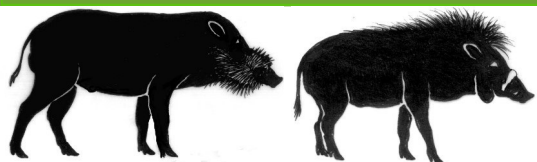
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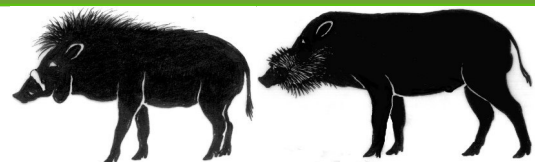
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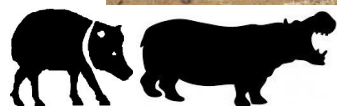
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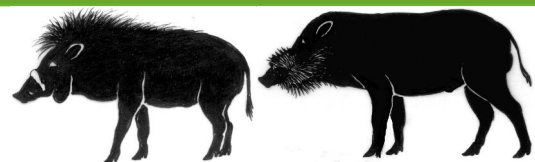
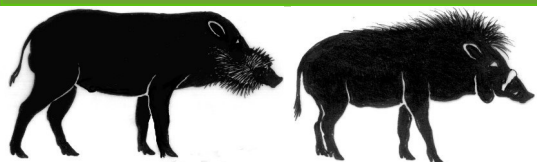


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Grazing young common warthog. Photo: A. Souron





Veterinary, Genetic and Physiological Studies

The complete mitochondrial genome of European wild boar, *Sus scrofa scrofa*

Hu, Xiao-Di. Yang, Xiao-Tian. Yang, En
Mitochondrial DNA. 2016; 27(5): 3244-3245.
AN: ZOOR15208053153

In this study, we report the complete mitochondrial genome sequence of the European wild boar, *Sus scrofa scrofa* for the first time. The genome is found to be 16,770 bp in length and has a base composition of A (34.63%), G (13.38%), C (26.21%), and T (25.78%), indicating that the percentage of A + T (60.41%) was higher than G + C (39.59%). Similar to other pigs, it contains a typically conserved structure including 13 protein-coding genes, 22 transfer RNA genes, 2 ribosomal RNA genes, and 1 control region (D-loop). Most of the genes were located on the H-strand except for the ND6 gene and eight tRNA genes. The complete mitochondrial genome sequence provided here would add a new genetic resource and new study on the evolution of the genus *Sus*.

The complete mitochondrial genome of bearded pig, *Sus barbatus*, and comparative mitochondrial genomics of Cetartiodactyla

Zhang, Shan-chuan. Xu, Bao-hua, Liu, Hong-chen.
Mitochondrial DNA. 2016; 27(4): 2417-2418.
AN: ZOOR15208052890

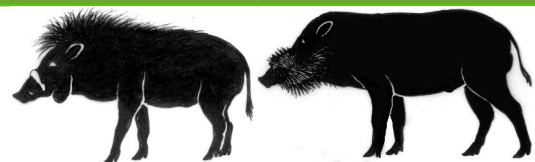
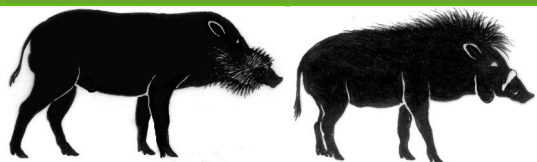
In this study, the complete mitochondrial genome sequence of bearded pig, *Sus barbatus*, with the total length of 16,480 bp, is determined for the first time. This mitogenome harbors 13 protein-coding genes, 22 transfer RNA genes, two ribosomal RNA genes, and one control region (D-loop). The overall base composition is A (34.80%), C (26.07%), G (13.12%), and T (26.01%), so the slight A-T bias (60.81%) was detected. Most of the genes are distributed on the H-strand, except for the ND6 subunit gene and eight tRNA genes. To obtain the phylogenetic relationship of the Cetartiodactyla, 11 mitochondrial genomes were used for phylogenetic analysis. The mitochondrial genome of *S. barbatus* presented here will contribute to a better understanding of the population genetics.

The complete sequence of the mitochondrial genome of Dahuabai pig (*Sus scrofa*)

Ran Mao-Liang. He, Jun. Yang, An-Qi. Li, Zhi. Dong, Lian-Hua. Chen, Bin
Mitochondrial DNA. 2016; 27(3): 2071-2072.
AN: ZOOR15208052290

Dahuabai pig is one of the most important indigenous breed of the Guangzhou province of China. It is the first time that the complete mitochondrial genome sequence of Dahuabai pig is reported in this work, which is determined through the PCR-based method. The total length of the mitogenome is 16,709 bp, which contains a control region (D-loop region), 2 ribosomal RNA genes, 13 protein-coding genes and 22 tRNA genes. The total base composition of Dahuabai pig mitochondrial genome is 34.68% for A, 26.20% for C, 25.81% for T and 13.32% for G, in the order A>C>T>G. The complete mitochondrial genome of Dahuabai pig provides an important data in studying mitochondrial DNA's role in the process of metabolism and programmed cell death.





The complete sequence of the mitochondrial genome of Luchuan pig (*Sus scrofa*)

Ran, Mao-Liang. He, Jun. Tan, Jing-Ye. Yang, An-Qi. Li, Zhi. Chen, Bin

Mitochondrial DNA. 2016; 27(3): 1880-1881.

AN: ZOOR15208052225

Luchuan pig is one of the famous native breeds in China. In this study, we report the complete mitochondrial genome sequence of Luchuan pig for the first time, which is determined through the PCR-based method. The total length of the mitogenome is 16,710 bp with the base composition of 34.67% A, 13.33% G, 25.82% T and 26.18% C, and an A + T (60.48%)-rich feature is detected, which contains 1 control region (D-loop region), 2 ribosomal RNA genes, 13 PCGs and 22 tRNA genes. The complete mitochondrial genome of Luchuan pig provides an important data in genetic mechanism and the evolution genomes.

The complete sequence of the mitochondrial genome of Sandu black pig (*Sus Scrofa*)

Wang, Ling-Yu. Xu, Dong. Ma, Hai-Ming

Mitochondrial DNA. 2016; 27(3): 1789-1790.

AN: ZOOR15208052194

Sandu black pig is one of the native breed in Guizhou province in China. The total length of mitochondrial genome of Sandu black pig is 16,741 bp. Mitochondrial genome contains a major non-coding control region (D-Loop region), 2 ribosomal RNA genes, 13 protein-coding genes (PCGs) and 22 transfer RNA genes. This is the first report of the complete mitochondrial genome sequence about Sandu black pig. The mitochondrial genome data of Sandu black pig presented is useful novel markers for further studying the population genetics of *Sus scrofa*.

The complete mitochondrial genome of Congjiang miniature pig (*Sus scrofa*)

Ran, Mao-Liang. Wang, Ming-fu. Yang, An-Qi. Li, Zhi. Chen, Bin

Mitochondrial DNA. 2016; 27(3): 1787-1788.

AN: ZOOR15208052193

Congjiang miniature pig is one of the most important local pig breeds in China. It is the first time that the complete mitochondrial genome sequence of Lantang pig is reported in this work, which is determined through the PCR-based method. The total length of the mitogenome is 16,772 bp, which contains 1 control region (D-loop region), 2 ribosomal RNA genes, 13 PCGs and 22 tRNA genes. The total base composition of Congjiang miniature pig mitochondrial genome is 34.78% for A, 26.21% for C, 25.78% for T and 13.22% for G and in the order A>C>T>G. The complete mitochondrial genome of Congjiang miniature pig provides an important data in genetic mechanism and the evolution genomes.

The complete sequence of the mitochondrial genome of Longlin pig (*Sus scrofa*)

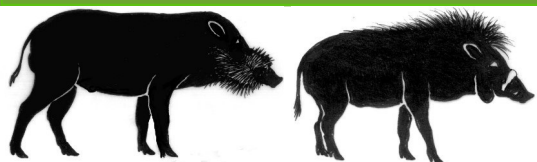
Hu, Xionggui. Xiao, Dingfu, Li, Wenping.

Mitochondrial DNA. 2016; 27(3): 1736-1737.

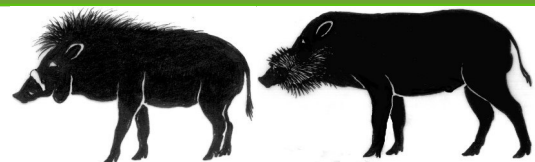
AN: ZOOR15208052172

Longlin pig is a native breed of Fujian province in China. It is the first time that the complete mitochondrial genome sequence of Longlin pig is reported in this work, which is determined through the PCR-based method. The total length of the mitogenome is 16,699 bp, which contains 1 control region (D-loop region), 2 ribosomal RNA genes, 13 PCGs and 22 tRNA genes. The total base composition of Longlin pig mitochondrial genome is 34.67% for A, 26.21% for C, 25.80% for





New literature on Suiformes



T and 13.33% for G, in the order A>C>T>G. The complete mitochondrial genome of Longlin pig provides an important data in genetic mechanism and the evolution genomes.

The complete sequence of mitochondrial genome of Wuyi Black pig (*Sus scrofa*)

Xiao, Dingfu. Hu, Xionggui, Chen, Yuguang. Gong, Zexiu. Chen, Li.

Mitochondrial DNA. 2016; 27(3): 1585-1586.

AN: ZOOR15208052115

Wuyi Black pig is a native breed of Fujian province in China. It is the first time that the complete mitochondrial genome sequence of Wuyi Black pig is reported in this work, which is determined through the PCR-based method. The total length of the mitognome is 16,709 bp, which contains 2 ribosomal RNA genes, 22 tRNA genes, 13 PCGs and 1 control region (D-loop region). The total base composition of Wuyi Black pig mitochondrial genome is 34.67% for A, 26.20% for C, 25.81% for T and 13.33% for G, in the order A>C>T>G. The complete mitochondrial genome of Wuyi Black pig provides an important data in genetic mechanism and the evolution genomes.

The complete sequence of the mitochondrial genome of Guanling pig (*Sus scrofa*)

Ran, Mao-Liang, Yang, An-Qi. Li, Zhi. Chen, Bin.

Mitochondrial DNA. 2016; 27(3): 1583-1584.

AN: ZOOR15208052114

Guanling pig is one of the native breeds in Guizhou Province in China. The complete mitochondrial genome of Guanling pig was determined by polymerase chain reaction (PCR). The result shows that the complete mitochondrial genome of Guanling pig is 16,731 bp, and it contains a major non-coding control region (D-Loop region), 2 ribosomal RNA genes, 13 protein-coding genes (PCGs) and 22 transfer RNA genes. The mitochondrial DNA control region of the Guanling pig contains repeat motif TAC ACG TGC G, 5' nucleotide of the first repeat is at the position 814 bp, and the repeat number is 13. The mitochondrial genome of Guanling pig subsequently provides important information in genetic mechanism and the evolution genomes.

Optimization of Scat Detection Methods for a Social Ungulate, the Wild Pig, and Experimental Evaluation of Factors Affecting Detection of Scat

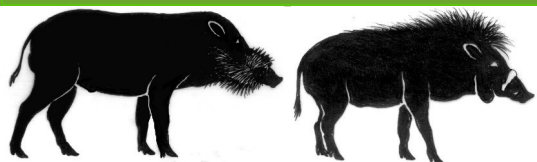
Keiter, David A., Cunningham, Fred L. Rhodes, Olin E Jr. Irwin, Brian J. Beasley, James C.

PLoS ONE. 2016 May 25; 11(5): e0155615.

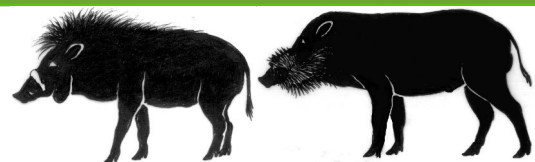
AN: ZOOR15208051281

Collection of scat samples is common in wildlife research, particularly for genetic capture-mark-recapture applications. Due to high degradation rates of genetic material in scat, large numbers of samples must be collected to generate robust estimates. Optimization of sampling approaches to account for taxa-specific patterns of scat deposition is, therefore, necessary to ensure sufficient sample collection. While scat collection methods have been widely studied in carnivores, research to maximize scat collection and noninvasive sampling efficiency for social ungulates is lacking. Further, environmental factors or scat morphology may influence detection of scat by observers. We contrasted performance of novel radial search protocols with existing adaptive cluster sampling protocols to quantify differences in observed amounts of wild pig (*Sus scrofa*) scat. We also evaluated the effects of environmental (percentage of vegetative ground cover and occurrence of rain immediately prior to sampling) and scat characteristics (fecal pellet size and number) on the detectability of scat by observers. We found that 15- and 20-m radial





New literature on Suiformes



search protocols resulted in greater numbers of scats encountered than the previously used adaptive cluster sampling approach across habitat types, and that fecal pellet size, number of fecal pellets, percent vegetative ground cover, and recent rain events were significant predictors of scat detection. Our results suggest that use of a fixed-width radial search protocol may increase the number of scats detected for wild pigs, or other social ungulates, allowing more robust estimation of population metrics using noninvasive genetic sampling methods. Further, as fecal pellet size affected scat detection, juvenile or smaller-sized animals may be less detectable than adult or large animals, which could introduce bias into abundance estimates. Knowledge of relationships between environmental variables and scat detection may allow researchers to optimize sampling protocols to maximize utility of noninvasive sampling for wild pigs and other social ungulates.

Molecular detection of tick-borne bacteria and Protozoa in cervids and wild boars from Portugal

Pereira, Andre. Parreira, Ricardo. Nunes, Monica. Casadinho, Afonso. Vieira, Maria Luisa. Campino, Lenea. Maia, Carla
Parasites and Vectors. 2016 May 10; 9 251.

AN: ZOOR15208050000

Background: Wildlife can act as reservoir of different tick-borne pathogens, such as bacteria, parasites and viruses. The aim of the present study was to assess the presence of tick-borne bacteria and Protozoa with veterinary and zoonotic importance in cervids and wild boars from the Centre and South of Portugal. Methods: One hundred and forty one blood samples from free-ranging ungulates including 73 red deer (*Cervus elaphus*), 65 wild boars (*Sus scrofa*) and three fallow deer (*Dama dama*) were tested for the presence of *Anaplasma marginale*/*A. ovis*, *A. phagocytophilum*, *Anaplasma/Ehrlichia* spp., *Babesia/Theileria* spp., *Borrelia burgdorferi* (sensu lato) (s.l.), and *Rickettsia* spp. DNA by PCR. Results: *Anaplasma* spp. DNA was detected in 33 (43.4 %) cervids (31 red deer and two fallow deer) and in two (3.1 %) wild boars while *Theileria* spp. were found in 34 (44.7 %) cervids (32 red deer and two fallow deer) and in three (4.6 %) wild boar blood samples. Sequence analysis of msp4 sequences identified *A. marginale*, *A. ovis*, while the analysis of rDNA sequence data disclosed the presence of *A. platys* and *A. phagocytophilum* and *T. capreoli* and *Theileria* sp. OT3. *Anaplasma* spp./*Theileria* spp. mixed infections were found in 17 cervids (22.4 %) and in two wild boars (3.1 %). All samples were negative for *Babesia* sp., *B. burgdorferi* (s.l.), *Ehrlichia* sp. or *Rickettsia* sp. Conclusions: This is the first detection of *Anaplasma marginale*, *A. ovis*, *A. phagocytophilum*, *A. platys*, *Theileria capreoli* and *Theileria* sp. OT3 in cervids and wild boars from Portugal. Further studies concerning the potential pathogenicity of the different species of *Anaplasma* and *Theileria* infecting wild ungulates, the identification of their vector range, and their putative infectivity to domestic livestock and humans should be undertaken.

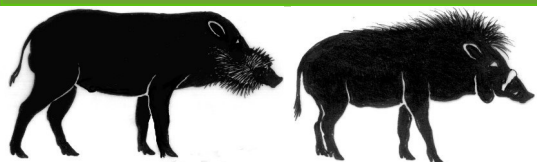
Wildlife and livestock use of extensive farm resources in South Central Spain: implications for disease transmission

Carrasco-Garcia, Ricardo. Angel Barasona, Jose. Gortazar, Christian. Montoro, Vidal. Manuel Sanchez-Vizcaino, Jose. Vicente, Joaquin

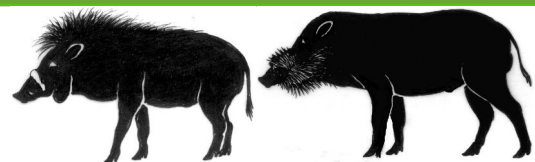
European Journal of Wildlife Research. 2016 Feb; 62(1): 65-78.

AN: ZOOR15208047991





New literature on Suiformes



The interactions of extensively farmed livestock with wild ungulates contribute to the transmission and maintenance of, among other diseases, tuberculosis (TB) at the interface in South Central Spain (SCS), where farming typically occurs close to wildlife habitats. The aim of this paper is to describe (i) the use of extensive farm resources by wildlife and livestock and (ii) the factors involved. Camera traps (CTs) were placed at a priori risk points (n = 149 points, 2145 CT days) for interspecies interactions: water points, buildings, food points, and acorn fields (which also provide rich pasture), on 11 representative extensive beef cattle (n = 6) and Iberian pig (n = 5) farms. The use of extensive farm resources by wild ungulates was frequent and widespread throughout the study area (over 50 % of daily presence per farm of either wild boar *Sus scrofa* or red deer *Cervus elaphus*). This presence increased when there was a high abundance of wild ungulates on nearby hunting estates. No direct interactions were detected, and livestock and wild ungulates partitioned resource use temporally, signifying that the interaction was mainly indirect. The wild species that used all farm resources with by far the most frequency was red deer, although its presence decreased markedly when far from woodland edges. The presence of cattle was positively associated with that of wild boar at all the CTs and specifically with red deer at water points and in acorn fields. Pig presence was negatively associated with that of wild boar, suggesting the existence of competence-mediated avoidance. We propose that interactions at the wildlife-livestock interfaces could be reduced by carrying out specific actions adapted to Mediterranean conditions and farm management: removing and segregating access to risky water points, the wise management of grazing in space and time, and protecting food-rich pasture plots and woodland edges by means of fencing, which is particularly interesting as regards attempting to prevent red deer from accessing areas occupied by livestock and vice versa. Biosecurity programs must be farm-specific, and the effectiveness, costs, and practical value of interventions should be adaptively evaluated in the field in future research.

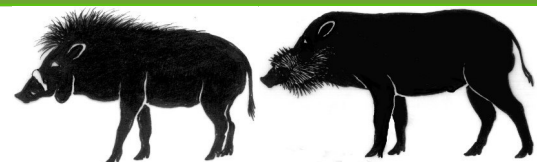
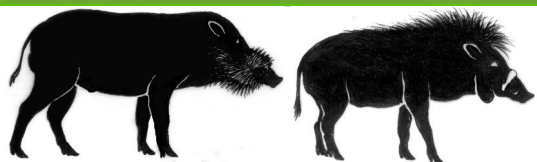
Zearalenone and its metabolites in the tissues of female wild boars exposed per os to mycotoxins

Gajecka, Magdalena. Slawuta, Piotr. Nicpon, Jakub. Kolacz, Roman. Kielbowicz, Zdzislaw. Zielonka, Lukasz. Dabrowski, Michal. Szweda, Wojciech. Gajecki, Maciej. Nicpon, Jozef. *Toxicon*. 2016 May; 114 1-12.

AN: ZOOR15206039294

The study was performed on 18 clinically healthy female wild boars with initial body weight of 35 [plus or minus] 2 kg. The animals were divided into two experimental groups (group I and group II) and one control group (group C) of 6 female wild boars per group. Group I animals were administered per os pure zearalenone (ZEN) at 150 [μ g/kg BW every two months for 7 subsequent days, whereas group II animals received feed naturally contaminated with ZEN at 50 [μ g/kg BW/day. Female wild boars were exposed to ZEN over a period of 1 year. Control group animals were fed a placebo. Tissue samples (dorsal muscles, left lobe of liver, left kidney, spleen, apical part of the cardiac muscle, cranial lobe of lung, left ovary, central part of the left horn of the uterus) were collected on the last day of the experiment within 3 min after slaughter. In group I, the highest ZEN levels were noted in the spleen (19.813 ng/g), cardiac muscle (18.105 ng/g) and kidneys (14.555 ng/g). In group II, the highest concentrations of ZEN were observed in muscle tissue (12.033 ng/g), uterus (10.821 ng/g) and kidneys (10.463 ng/g). The highest values of the carry-over factor were noted in the same tissues. In the examined female wild boars, per os exposure to natural sources of the parent substance or a combination of ZEN and its metabolites





led to different concentrations of ZEN in the analyzed tissues. Zearalenone concentrations were compatible with CF values in both experimental groups.

Occurrence of antibodies against *Neospora caninum* in wild pigs (*Sus scrofa*) in the Pantanal, Mato Grosso do Sul, Brazil

Soares, Herbert Sousa. Ramos, Vanessa do Nascimento. Osava, Carolina Fonseca. Oliveira, Solange. Juan Szabo, Matias Pablo. Piovezan, Ubiratan. Castro, Bruno Bellopede. Gennari, Solange Maria

Brazilian Journal of Veterinary Research and Animal Science. 2016; 53(1): 112-116.

AN: ZOOR15206039289

Serum samples from 83 free living wild pigs (*Sus scrofa*) from the Nhecolandia region, Pantanal do Mato Grosso, Brazil, were examined for the presence of antibodies against *Neospora caninum* by means of the indirect fluorescence antibody test (IFAT) with a cut off of 50. Antibodies were present in 10.8%, with titers of: 1:200 in one animal, 1:400 in four and 1:800 in four. [chi]2 test showed an association between sex and presence of antibodies, with females showing occurrence of 20.5% and males 2.3% ($p = 0.017$). No association was found between age and occurrences of antibodies against this parasite. This was the first observation of *N. caninum* antibodies in Brazilian wild pigs from Pantanal.

Serological surveillance for antibodies against *Erysipelothrix* species in wild boar and deer in Japan

Shimizu, Takae. Okamoto, Chiaki. Aoki, Hiroshi. Harada, Kazuki, Kataoka, Yasushi. Ono, Fumiko. Kadohira, Mutsuyo. Takai, Shinji.

Japanese Journal of Veterinary Research. 2016 Feb; 64(1): 91-94.

AN: ZOOR15206036906

We investigated the seroprevalence of antibodies against *Erysipelothrix* in wild animals in Japan. Serum samples were collected from 48 wild boar, 26 Yezo deer and 26 Japanese deer in Japan. Growth agglutination (GA) test was performed to estimate antibody titers. As a result, positive results were obtained from 32 (66.7%), 1 (3.6%) and 6 (23.1%) samples from wild boar, Yezo deer and Japanese deer, respectively. Our findings suggest that wild animals may be an important reservoir of *Erysipelothrix*.

Age- and strain-dependent differences in the outcome of experimental infections of domestic pigs with wild boar pseudorabies virus isolates

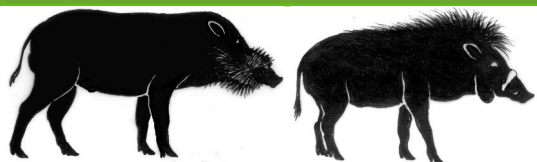
Verpoest, Sara, Cay, Ann Brigitte. Van Campe, Willem. Mostin, Laurent. Welby, Sarah. Favoreel, Herman. De Regge, Nick.

Journal of General Virology. 2016 Feb; 97(2): 487-495.

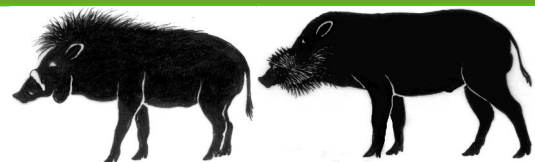
AN: ZOOR15206035923

Although pseudorabies virus (PRV) has been eradicated in domestic swine in many countries, its presence in wild boars remains a threat for a reintroduction into the currently unprotected swine population. To assess the possible impact of such a reintroduction in a naive herd, an in vivo infection study using two genetically characterized wild boar PRV isolates (BEL24043 and BEL20075) representative for wild boar strains circulating in south-western and central Europe and the virulent NIA3 reference strain was performed in 2- and 15-week-old domestic pigs. Our study revealed an attenuated nature of both wild boar strains in 15-week-old pigs. In contrast, it





New literature on Suiformes



showed the capacity of strain BEL24043 to induce severe clinical symptoms and mortality in young piglets, thereby confirming that the known age dependency of disease outcome after PRV infection also holds for wild boar isolates. Despite the absence of clinical disease in 15-week-old sows, both wild boar PRV strains were able to induce seroconversion, but to a different extent. Importantly, differences in infection and transmission capacity of both strains were observed in 15-week-old sows. Strain BEL24043 induced a more prolonged and disseminated infection than strain BEL20075 and was able to spread efficiently to contact animals, indicative of its capacity to induce a sustained infection. In conclusion, it was shown that a reintroduction of a wild boar isolate into the domestic swine population could have serious economic consequences due to the induction of clinical symptoms in piglets and by jeopardizing the PRV-negative status.

In Vitro Study of Caecal and Colon Microbial Fermentation Patterns in Wild Boar (*Sus scrofa scrofa*)

Pecka-Kielb, Ewa. Bujok, Jolanta. Mista, Dorota. Kroliczewska, Bozena. Gorecka, Justyna. Zawadzki, Wojciech

Folia Biologica (Cracow). 2016; 64(1): 31-36.

AN: ZOOR15206035356

The aim of this study was to evaluate wild boar (*Sus scrofa scrofa*) caecal and colon products of microbial activity including short chain fatty acids (SCFA), ammonia and methane concentrations. The in vitro method was applied to caecal and colon contents after 12 and 24-hour incubation with the substrate (wheat bran), or without any additive (control samples). The pH was also measured in each sample. In samples incubated with the substrate, a lower pH was noted as compared to the control ($P < 0.001$). In terms of the total SCFA concentration, the hindgut microbial fermentation pattern of wild boar was characterized by a high acetate level, followed by propionate and then butyrate at a ratio of 7:1.5:1. Substrate addition decreased acetate molar proportions ($P < 0.001$) and increased those of butyrate ($P < 0.001$) as well as propionate ($P < 0.05$). The total SCFA level in fresh, unincubated caecal samples (128 mmol/kg) was similar to that in the colon (111 mmol/kg). The ammonia concentrations were at the level of 0.8-1.5 mmol/kg of hindgut content and did not differ between the two investigated hindgut parts. Methanogenesis was also similar in the caecum and colon and after 24h was 2.69 mmol/kg and 2.27 for caecal colon control samples, respectively. The substrate increased total gas production and methane concentration ($P < 0.001$).

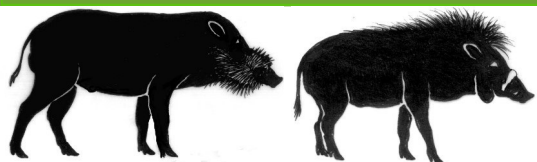
Wild and Domestic Pig Interactions at the Wildlife–Livestock Interface of Murchison Falls National Park, Uganda, and the Potential Association with African Swine Fever Outbreaks

Esther A. Kukiela, Ferran Jori, Beatriz Martínez-López, Erika Chenais, Charles Masembe, David Chavernac, Karl Ståhl

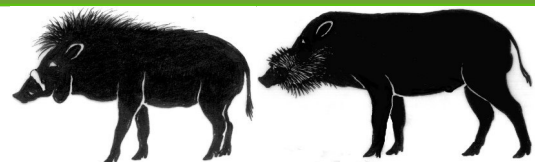
Frontiers in Veterinary Science

Bushpigs (BPs) (*Potamochoerus larvatus*) and warthogs (WHs) (*Phacochoerus africanus*), which are widely distributed in Eastern Africa, are likely to cohabitate in the same environment with domestic pigs (DPs), facilitating the transmission of shared pathogens. However, potential interactions between BP, WH, and DP, and the resulting potential circulation of infectious diseases have rarely been investigated in Africa to date. In order to understand the dynamics of such interactions and the potential influence of human behavior and husbandry practices on them, individual interviews ($n = 233$) and participatory rural appraisals ($n = 11$) were carried out





New literature on Suiformes



among Ugandan pig farmers at the edge of Murchison Falls National Park, northern Uganda. In addition, as an example of possible implications of wild and DP interactions, non-linear multivariate analysis (multiple correspondence analyses) was used to investigate the potential association between the aforementioned factors (interactions and human behavior and practices) and farmer reported African swine fever (ASF) outbreaks. No direct interactions between wild pigs (WPs) and DP were reported in our study area. However, indirect interactions were described by 83 (35.6%) of the participants and were identified to be more common at water sources during the dry season. Equally, eight (3.4%) farmers declared exposing their DP to raw hunting leftovers of WPs. The exploratory analysis performed suggested possible associations between the farmer reported ASF outbreaks and indirect interactions, free-range housing systems, dry season, and having a WH burrow less than 3 km from the household. Our study was useful to gather local knowledge and to identify knowledge gaps about potential interactions between wild and DP in this area. This information could be useful to facilitate the design of future observational studies to better understand the potential transmission of pathogens between wild and DPs.

Using non-invasive faecal hormone metabolite monitoring to detect reproductive patterns, seasonality and pregnancy in red river hogs (*Potamochoerus porcus*)

Jocelyn Bryant, Nadja Wielebnowski, Diane Gierhahn, Tina Houchens, Astrid Bellem, Amy Roberts, Joan Daniels

Journal of Zoo and Aquarium Research

Few studies have been conducted on red river hog (*Potamochoerus porcus*) reproductive biology in zoos. Furthermore, in spite of regular breeding efforts in zoos, reproductive success has been relatively poor for this species, particularly in the North American population. In this study, we used faecal hormone metabolite monitoring to analyse near daily samples from two males and three females over several years to gain insight into their patterns of reproductive hormone secretion. Both a progesterone and a testosterone enzyme immunoassay (EIA) were validated and subsequently used to monitor reproductive patterns, seasonality, ovulatory activity and a successful pregnancy. The findings indicate that female red river hogs are seasonally polyoestrous. Regular cycles were observed from approximately December through August and an annual period of anoestrous was observed from approximately September until December. Average cycle length for all females was 23 days \pm 1.19, range 13–30 days. Androgen excretion patterns of the two males did not show clear seasonal patterns. Only one male experienced an increase in androgen levels (141.53 \pm 45.55 ng/g) corresponding with the female seasonal oestrous period. There was, however, some evidence of possible androgen suppression between the two males, and a potential 'boar effect' on a young female upon first introduction to a male. Ultimately, this information may increase our understanding of this species' reproductive biology and serve as a baseline for more in-depth follow-up studies to identify specific patterns associated with reproductive success.

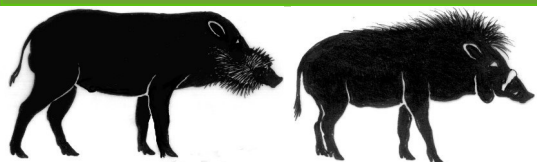
Magnetic alignment in warthogs *Phacochoerus africanus* and wild boars *Sus scrofa*

Jaroslav Červený, Hynek Burda, Miloš Ježek, Tomáš Kušta, Václav Husinec, Petra Nováková, Vlastimil Hart, Veronika Hartová, Sabine Begall, E. Pascal Malkemper

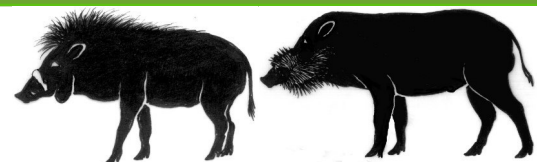
Mammal Review

Magnetic alignment (MA) results from the preference of animals to align themselves along the field lines of the geomagnetic field, a behavioural expression of a magnetic sense. MA is well





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documented for ruminants and might demonstrate a general magnetic sensory ability among artiodactyls. We measured body-axis alignment in 1614 foraging or resting wild boars *Sus scrofa*, 1849 wild boar beds, and 1347 warthogs *Phacochoerus africanus*, and found a highly significant north–south preference. The magnetic field was the only common denominator of all observations. Thus, we provide the first data suggesting a magnetic sense in the Suidae.

Application of Rapid Serologic Tests for Detection of *Mycobacterium bovis* Infection in Free-Ranging Warthogs (*Phacochoerus africanus*) - Implications for Antemortem Disease Screening

Michele Miller, Peter Buss, Lin-Mari de Klerk-Lorist, Jennifer Hofmeyr, Guy Hausler, Konstantin Lyashchenko, Emily P. Lane, Louise Botha, Sven Parsons, Paul van Helden

Warthogs (*Phacochoerus africanus*) have been implicated as potential maintenance hosts of *Mycobacterium bovis*. Our preliminary investigation of bovine tuberculosis in three warthogs describes pathologic findings and associated positive serologic results in two infected animals. This demonstrates the potential use of serodiagnostic tests for *M. bovis* infection in this species.

Mammalian interspecies substitution of immune modulatory alleles by genome editing

Simon G. Lillico, Chris Proudfoot, Tim J. King, Wenfang Tan, Lei Zhang, Rachel Mardjuki, David E. Paschon, Edward J. Rebar, Fyodor D. Urnov, Alan J. Mileham, David G. McLaren, C. Bruce A. Whitelawa

Scientifics Reports

We describe a fundamentally novel feat of animal genetic engineering: the precise and efficient substitution of an agronomic haplotype into a domesticated species. Zinc finger nuclease in-embryo editing of the RELA locus generated live born domestic pigs with the warthog RELA orthologue, associated with resilience to African Swine Fever. The ability to efficiently achieve interspecies allele introgression in one generation opens unprecedented opportunities for agriculture and basic research.

Haematological Values and Body Measurement of Gazella Dorcus, Reed Buck, Water Buck and Warthog

Mohammed, Reem Rabie

World's Veterinary Journal

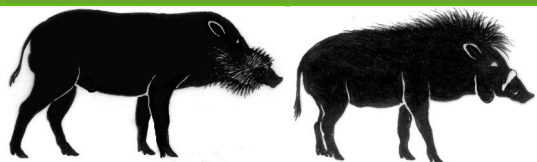
There is a lack of information of physiological parameters and reference values of wild animals which are necessary knowledge for the successful breeding and management of these animals. Laboratory examination was undertaken for determination of certain values of hematological parameters of blood of gazelle dorcas, reed buck, water buck and warthog and their physiological values. Normal values for hemoglobin, packed cell volume, total count of red blood cells, total count of white blood cells and differential count of white blood were obtained from blood of males of wild animals including Dorcas gazelles, Waterbuck, Reed buck and Warthog. The measurement of different parts of the body of these animals were also recorded.

Large mammals in Ruaha National Park, Tanzania, dig for water when water stops flowing and water bacterial load increases

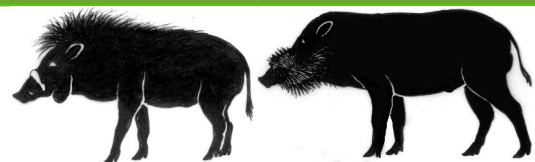
Claudia Stomme, Heribert Hofer, Mirjam Grobbel, Marion L. East

Mammalian Biology





New literature on Suiformes



As water is essential for life, animals have adaptations that increase their ability to survive during periods of water shortage. Accessing water by digging is one behavioural adaptation to water shortage used by some African mammals. Digging might also provide access to higher quality water below ground when surface water quality is poor. We investigated the digging of waterholes by wildlife in the Ruaha National Park (NP), in central Tanzania, during three dry seasons (June to November from 2011 to 2013). We monitored surface water availability and water quality at 10 sites along the Great Ruaha River (GRR) and eight non-GRR sites. We used camera-traps and direct observations to determine when and where digging to access water occurred. Elephant (*Loxodonta africana*), plains zebra (*Equus quagga*), warthog (*Phacochoerus africanus*) and yellow baboon (*Papio cynocephalus*) dug waterholes and a further four species drunk from these holes. Waterholes were dug later in the dry season along the GRR (October) than at other sites (July). The likelihood of digging and drinking from waterholes was lower along the GRR than at non-GRR sites and did not depend on the absence of surface water but increased when surface water stopped flowing. Digging of waterholes was also significantly more likely when the bacterial load in available surface water increased but was independent of salinity levels. *Escherichia coli* load, indicative of faecal contamination, significantly increased with total aerobic bacterial load. Our results suggest that digging is an adaptation to avoid the ingestion of poor quality surface water highly contaminated with faeces, and thereby possibly also potentially pathogenic microbes, in addition to providing access to water when surface water is absent. Our findings also highlight (1) the essential role of the GRR as the key water source for wildlife in the Ruaha NP during the dry season, and (2) that maintenance of water flow throughout the dry season is essential to prevent deterioration of water quality in the GRR.

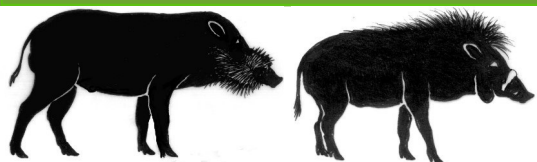
The African swine fever control zone in South Africa and its current relevance

Noluvuyo R. Magadla, Wilna Vosloo, Livio Heath, Bruce Gummow

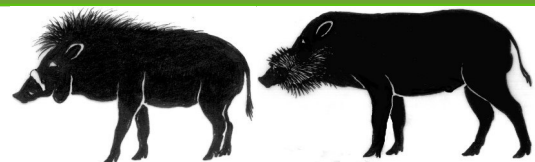
Journal of Veterinary Research

African swine fever (ASF) has been reported in South Africa since the early 20th century. The disease has been controlled and confined to northern South Africa over the past 80 years by means of a well-defined boundary line, with strict control measures and movement restrictions north of this line. In 2012, the first outbreak of ASF outside the ASF control zone since 1996 occurred. The objective of this study was to evaluate the current relevance of the ASF control line as a demarcation line between endemic ASF (north) areas and ASF-free (south) area and to determine whether there was a need to realign its trajectory, given the recent outbreaks of ASF, global climate changes and urban development since the line's inception. A study of ASF determinants was conducted in an area 20 km north and 20 km south of the ASF control line, in Limpopo, Mpumalanga, North West and Gauteng provinces between May 2008 and September 2012. The study confirmed that warthogs, warthog burrows and the soft tick reservoir, *Ornithodoros moubata*, are present south of the ASF control line, but no virus or viral DNA was detected in these ticks. There appears to be an increasing trend in the diurnal maximum temperature and a decrease in humidity along the line, but the impact of these changes is uncertain. No discernible changes in minimum temperatures and average rainfall along the disease control line were observed between 1992 and 2014. Even though the reservoirs were found south of the ASF boundary line, the study concluded that there was no need to realign the trajectory of the ASF disease control line, with the exception of Limpopo Province. However, the provincial surveillance programmes for the reservoir, vector and ASF





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virus south of this line needs to be maintained and intensified as changing farming practices may favour the spread of ASF virus beyond the control line.

Physical and Chemical Characteristics of Warthog (*Phacochoerus africanus*) Meat

Monlee Swanepoel, Alison J. Leslie, Marieta van der Rijst, and Louwrens C. Hoffman

African Journal of Wildlife Research: Vol. 46, Issue 2, pg(s) 103-120

The common warthog (*Phacochoerus africanus*) has been introduced to parts of South Africa outside of its known range. The species is considered an agricultural pest and a threat to the natural environment. As some farmers are employing a shoot on sight strategy, our study aimed to investigate the physical and chemical characteristics of warthog meat according to sex. Five muscles from male warthogs had higher shear force values (i.e. were less tender) compared to females. All muscles had a total protein content $>20\%$ and total lipid content $\leq 2.2\%$. The ratio of polyunsaturated to saturated fatty acids of the Longissimus lumborum muscle was <0.45 . We also provide descriptive data on the characteristics of carcass yields and meat from juvenile sows and boars. It is suggested that warthog meat should be produced and marketed as whole muscle cuts and not as the typical commercial cuts used for domestic animals.

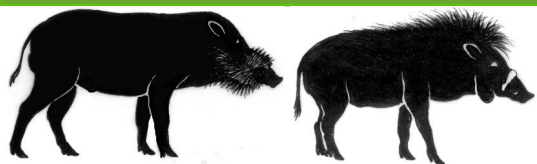
Dominance relationships between collared peccaries *Pecari tajacu* (Cetartiodactyla: Tayassuidae) in intensive breeding system

Suleima do Socorro Bastos da Silva, Diva Anelie Guimarães, Cibele Biondo, Otávio Mitio Ohashi, Natália Inagaki de Albuquerque, Ana Carolina Dalla Vecchia, Cristina Yumi Miyaki, Yvonnick Le Pendu

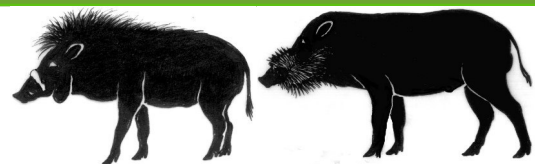
Applied Animal Behaviour Science

The collared peccary (*Pecari tajacu*) is a species with great potential for breeding in captivity since it adapts well to a variety of foods, has a high breeding capacity and there is an existing market for its meat and leather, which is of excellent quality. However, it is necessary to understand its social structure, when maintained in intensive breeding, to adequately manage groups and limit potential aggressions to the stockman. Four family units (dam, sire and descendants) were monitored (phase 1); female descendants were subsequently relocated into four new experimental social groups (phase 2). In these experimental groups, the female descendants were grouped with adult males, without the presence of the parents. Interactions were filmed three times per week, during two months, for each treatment (phase 1 = family units and phase 2 = experimental groups). A matrix of aggressive and submissive behaviors was developed and the dominance relations were evaluated with the Elo-rating method. A stability index of rank orders, the steepness and the degree of linearity were calculated to analyse the hierarchy in each family unit and experimental group. The parents remained on the highest hierarchical levels in three of the four family units and female descendants occupied the highest hierarchical levels in experimental groups. A linear hierarchy composed of adults of both genders was found in two family units and a mono-sexual linear hierarchy with females at the highest-ranking positions was evidenced in two experimental groups. Hierarchy was stable (all stability indexes values ≥ 0.94), while steepness was variable among family units and experimental groups (range: 0.23–0.84). The ranking-position of a female descendant in a family unit was not a good predictor of her ranking position in experimental units. Male descendants received significantly less friendly behaviors than female descendants did ($p = 0.01$), dams ($p < 0.01$) and sires ($p < 0.05$) in the family units. There was no significant increase in the frequency of aggressive





New literature on Suiformes



behavior after relocation of the animals. Our results indicate that collared peccaries raised in small group present stable dominance relations, form hierarchies of variable steepness and show females as the highest-ranking individual.

Extramedullary plasmacytoma in a captive collared peccary (*Pecari tajacu*)

Roberio G. Olinda, Geysa A. Viana, Carla M.F. Rodrigues, Taciana M.F. Silva, Ricardo B. Lucena, Francisco S.B. Bezerra, Jael S. Batista

Pesquisa Veterinária Brasileira

An extramedullary plasmacytoma case in a captive collared peccary (*Pecari tajacu*) is reported. The animal, a female aging three years old, had a medical history of diffusely distributed skin and mucocutaneous junction lesions, associated with swollen lymph nodes. Clinical examination and complementary exams (complete blood count, biochemical analysis, skin scraping to search mites and fungal culture) were performed. Thirty days after examination, the animal died. At necropsy, multiple consistent nodules, aseptic pustules and swollen lymph nodes were found. On histological exams of the skin and oral mucosa, we observed a large number of round cells forming masses organized in nests, sheets, and cords of cells in a well-vascularized fibrovascular tissue. Neoplastic plasma cells infiltrated between the fibers and the lamina propria of smooth muscle. Spaces among the cell masses were filled with some eosinophil and fluid. Most of the cells were well differentiated, presenting a perinuclear clear zone. In some points, the cells were pleomorphic. The plasma cells presented eccentric, basophilic and spherical nuclei, showing a dense to organized chromatin with distinct nucleoli. Binucleate cells were observed, but multinucleated giant cells were rare. Oral mucosa and lymph nodes tested by immunohistochemical analyses were positive for Mb-1, with a multifocal distribution. In regard to Bcl-2, the neoplastic cells were intermittent weakly positive. So, an extramedullary plasmacytoma was diagnosed in the collared peccary considering the location, the histopathological and immunohistochemical findings.

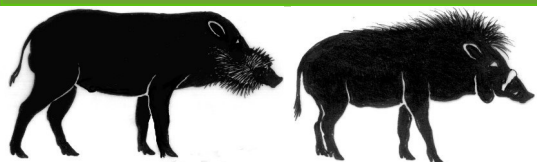
Use of Non-invasive Methods for Evaluating the Testicular Biometry in Collared Peccaries (*Pecari tajacu* Linnaeus, 1758)

G. C. X. Peixoto, M. A. Silva, G. L. Lima, L. B. Campos, A. L. C. Paiva, V. V. Paula, A. R. F. Ricarte, A. R. Silva

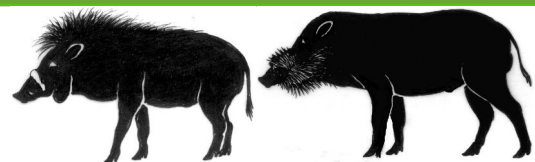
Anatomia, Histologia, Embryologia

The aim of this study was to compare the accuracy of two methods used to estimate testicular volume in the collared peccary. Calliper and ultrasonographic measurements of testicular dimensions (length, width and height) of both testes were taken on five adult collared peccaries. The testicular volume was calculated by Lambert's empiric formula: length (L) × width (W) × height (H) × 0.71, the formula of an ellipsoid $L \times W \times H \times 0.52$, and Hansen's formula: $L \times W^2 \times 0.52$. The calculated volumes were then compared with the actual ones, which were estimated by water displacement. The mean of true testicular volume was 22.65 ± 1.52 ml. Lambert's formula estimated testicular volume more accurately when ultrasound measurements were taken. However, when the calliper was the methodology used, the results were closest to the true volume, especially when Ellipsoid formula and Hansen's formula were applied, and underestimated the true volumes by 1.53 ± 1.75 ml and 1.53 ± 1.65 ml, respectively. This specific application of technologies in wild animals has the potential to revolutionize the selection process for the collared peccary entering artificial insemination or natural breeding programmes.





New literature on Suiformes



Measurement of cognitive bias and cortisol levels to evaluate the effects of space restriction on captive collared peccary (*Mammalia, Tayassuidae*)

Flávia R.M. Oliveira, Sérgio L.G. Nogueira-Filho, Maria B.C. Sousa, Carlos T.S. Dias, Michael Mendl, Selene S.C. Nogueira

Applied Animal Behaviour Science

We use the judgement-bias paradigm to evaluate whether space restriction in metabolism pens affects the emotional state of collared peccary (*Pecari tajacu*) during a nutritional experiment. We trained individual adult males to 'go' to a specific location within 30 s when a positive auditory cue (whistle; CS+) was given in order to receive cassava root pieces as a reward, and to 'no-go' when a negative cue (caxixi percussion instrument; CS-) was sounded to avoid punishment (jet of water) and no reward. An 'ambiguous' auditory cue (a drumstick hitting an aluminum plate; CSA) was presented to probe decision-making under ambiguity. Individuals were subjected to five 8-day housing conditions in the order: H1 (control-no space restriction-metabolism pen and additional area), H2 space restriction without environmental enrichment (metabolism pen only), H3 (control-no space restriction), H4 (space restriction with environmental enrichment), and H5 (control-no space restriction). On the eighth day of each housing condition, each animal was exposed to 10 judgement bias trials of each of the three cue types: CS+, CS-, and CSA. We recorded whether animals showed the 'go' or 'no-go' response after each type of cue and collected fecal samples to assess fecal glucocorticoid metabolite concentrations. Peccaries learnt to discriminate CS+ and CS- and maintained this discrimination during the five housing conditions tested. The response to the ambiguous cue (CSA) varied according to the housing condition. During H1, the peccaries made a similar proportion of 'go' responses to all three types of cue ($P_s > 0.07$). During H2 and H3, 'go' responses to CSA and CS- cues occurred in similar proportions ($P_s > 0.70$), but peccaries showed more go responses to CS+ ($P_s < 0.03$) indicating that they were responding to CSA as if it were more likely to predict the waterjet than food. During H4 and H5, peccaries again made a similar proportion of 'go' responses to all three types of cue, as in H1. During H2 and H3, fecal glucocorticoid metabolite concentrations were higher than during the other tests (208.0 ± 16.4 vs. 141.6 ± 25.9 ngg⁻¹ dry feces, $P_s < 0.03$). Our results suggest that space restriction may induce physiological stress and influence judgement bias and affective state in peccaries, and that these effects may be offset by environmental enrichment. However, the possibility of a general habituation to the housing conditions across time cannot be ruled out.

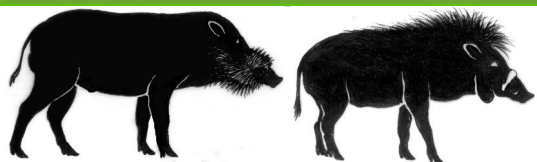
Morphology and vascularization of the corpus luteum of peccaries (*Pecari tajacu*, Linnaeus, 1758) throughout the estrous cycle

M.T.M. Miranda-Moura, G.B. Oliveira, G.C.X. Peixoto, J.M. Pessoa, P.C. Papa, M.S. Maia, C.E.B. Moura, M.F. Oliveira

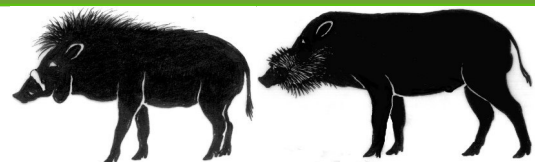
Arquivo Brasileiro de Medicina Veterinária e Zootecnia

The current paper characterizes the changes in morphology and vascularization of the corpus luteum of collared peccaries during the estrous cycle and correlates progesterone synthesis (P4). Twenty females were subjected to a treatment for estrus synchronization; an ear implant containing 1.5 mg of norgestomet was implanted on D0, whereas on D9 the peccaries received an IM injection of eCG 200UI and 50g of PGF2a. The animals were divided into four groups (G1, G2, G3 and G4) and euthanized on post-ovulation days 3, 12, 18 and 22. The ovaries were





New literature on Suiformes



collected and the corpora lutea were measured and processed for histological and vascular density (Dv). Blood was collected for dosage of P4 serum. The morphology of the ovaries, the corpora lutea and P4 varied significantly during the estrous cycle ($P < 0.001$). There was a significant co-relationship between weight and length of the ovaries and CL ($r = 0.66$, $r = 0.52$, $P < 0.05$, respectively) and between weight, length and width of the CL and P4 ($r = 0.51$, $r = 0.54$ and $r = 0.68$, $P < 0.05$, respectively). The luteal Dv was highly influenced by the estrous cycle phase ($P < 0.0001$). The P4 and luteal Dv concentrations were higher in G2 and evidenced maximum secretory activity, with a highly significant correlation ($P < 0.0001$). Assessed lutein parameters may estimate the phase of the estrous cycle in peccaries and the functional activity of the corpus luteum.

Ticks collected from humans, domestic animals, and wildlife in Yucatan, Mexico

R.I. Rodríguez-Vivas, D.A. Apanaskevich, M.M Ojeda-Chi, I. Trinidad-Martínez, E. Reyes-Novelo, M.D. Esteve-Gassent, A.A. Pérez de León

Veterinary Parasitology

Domestic animals and wildlife play important roles as reservoirs of zoonotic pathogens that are transmitted to humans by ticks. Besides their role as vectors of several classes of microorganisms of veterinary and public health relevance, ticks also burden human and animal populations through their obligate blood-feeding habit. It is estimated that in Mexico there are around 100 tick species belonging to the Ixodidae and Argasidae families. Information is lacking on tick species that affect humans, domestic animals, and wildlife through their life cycle. This study was conducted to bridge that knowledge gap by inventorying tick species that infest humans, domestic animals and wildlife in the State of Yucatan, Mexico. *Amblyomma* ticks were observed as euryxenous vertebrate parasites because they were found parasitizing 17 animal species and human. *Amblyomma mixtum* was the most eryxenous species found in 11 different animal species and humans. Both *A. mixtum* and *A. parvum* were found parasitizing humans. *Ixodes* near *affinis* was the second most abundant species parasitizing six animal species (dogs, cats, horses, white-nosed coati, white-tail deer and black vulture) and was found widely across the State of Yucatan. Ixodid tick populations may increase in the State of Yucatan with time due to animal production intensification, an increasing wildlife population near rural communities because of natural habitat reduction and fragmentation. The diversity of ticks across host taxa documented here highlights the relevance of ecological information to understand tick–host dynamics. This knowledge is critical to inform public health and veterinary programs for the sustainable control of ticks and tick-borne diseases.

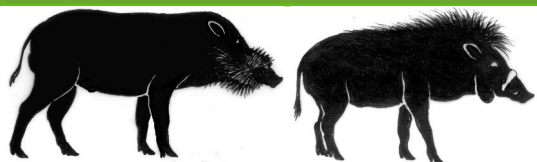
Isolation, Expansion, Differentiation and Growth Kinetics Essay in Mesenchymal Stem Cells Culture from the Bone Marrow of Collared Peccaries (*Tayassu tajacu*)

Napoleão Martins Argôlo Neto, Matheus Levi Tajra Feitosa, Simony Silva Sousa, Pablo Brandão Fernandes, Gérson Tavares Pessoa, Dayseanny de Oliveira Bezerra, Hatawa Melo de Almeida, Yulla Klinger Pereira de Carvalho, Andressa Rego da Rocha, Laís Meireles Costa Silva, Maria Acelina Martins de Carvalho

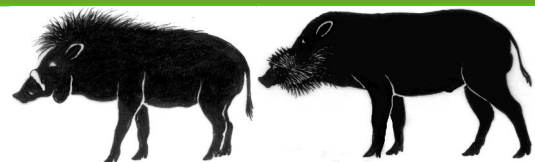
Acta Scientiae Veterinariae

There are few studies on stem cell isolation in wild animals that provide isolation and culture protocols of these cells in vitro. Among the wild species studied, we present the collared peccary (*Tayassu tajacu*) as a model with potential to obtain and use MSC in preclinical studies. These





New literature on Suiformes



animals are phylogenetically close to the domestic pig, popularly known as peccaries and found naturally in South America, Central America and the South of the United States. The aim of the present study was to establish a protocol for the isolation, in vitro cell expansion, differentiation and assessment of the stromal MSC growth curve before and after thawing. Mesenchymal stem cells (MSC) from collared peccary bone marrow (*Tayassu tajacu*) were isolated and expanded by centrifuge in Ficoll® solution and cultured in DMEM® High Glucose medium. The culture was assessed by assays of colony forming units CFU-F and growth curve by saturation (GCS). Cultures in the third passage, with 70% confluence, were replicated at 105 cells/mL concentration in the culture media to induce osteogenic cell differentiation and adipogenic cell differentiation, respectively. The MSC were frozen in nitrogen for 40 days, thawed and re-assessed for cell viability and GCS. The bone marrow collected presented high mononuclear cellularity, with a mean variability of 94.5% and 60.83 ± 4.27 UFC were identified in the samples and cells with fibroblast-like-cell morphology were observed. When they were expanded, the mean cell viability was 95%, the mean cell concentration obtained was 233.31 ± 20.04 cells per 25cm² bottle and the culture reached the growth plateau in GCS between the 13th and 16th day. The osteoblastic cell differentiation assay showed after 18 days, morphology similar to osteoblasts, with irregular cytoplasm limits, cell prolongation formation and flattened appearance. After staining with Alizarin Red, the nucleus presented a wine red coloring and the cytoplasm, more basophilic and well-defined, with calcium deposits inside the cells. The cultures submitted to adipogenic differentiation were large, hexagonal, irregular and presented birefringent cytoplasm granules after the third week of culture. When stained with Oil Red it was observed that the cytoplasm granules were scattered small fat vacuoles and stained maroon. The viability after thawing was 78% and the mean cell concentration obtained in GCS was 199.71 ± 14.72 cells per 25 cm² bottle. The curves reached the saturation plateau early, on the eighth day of observation. From then onwards the cultures entered became exhausted and the cell concentration of the samples decreased progressively until minimum values. These results showed the presence of a well-defined MSC population in the collared peccary bone marrow with a high rate of replication in vitro and potential for differentiation confirmed by the adipogenic and osteogenic lines. The cryopreservation technique adopted presented satisfactory results, but indicated a significant cell stress after thawing that justifies investigation of the apoptosis rates induced post thawing in the species. Furthermore, the bone marrow collection did not harm the animals and the facility of stromal MSC isolation and culture qualifies the collared peccary as a viable alternative model to obtain MSC and for studies in the area of cell therapy

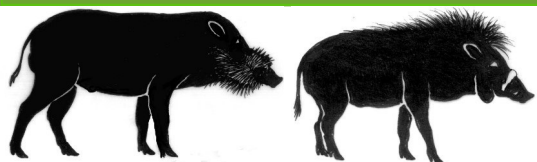
Methane production by two non-ruminant foregut-fermenting herbivores: The collared peccary (*Pecari tajacu*) and the pygmy hippopotamus (*Hexaprotodon liberiensis*)

Catharina Vendl, Samuel Frei, Marie Theres Dittmann, Samuel Furrer, Sylvia Ortmann, Arne Lawrenz, Bastian Lange, Adam Munn, Michael Kreuzer, Marcus Clauss

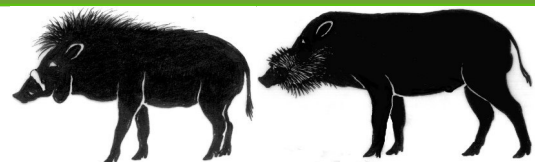
Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology

Methane (CH₄) production varies between herbivore species, but reasons for this variation remain to be elucidated. Here, we report open-circuit chamber respiration measurements of CH₄ production in four specimens each of two non-ruminant mammalian herbivores with a complex forestomach but largely differing in body size, the collared peccary (*Pecari tajacu*, mean body mass 17 kg) and the pygmy hippopotamus (*Hexaprotodon liberiensis*, 229 kg) fed lucerne-based diets. In addition, food intake, digestibility and mean retention times were measured in the





New literature on Suiformes



same experiments. CH₄ production averaged 8 and 72 L/d, 18 and 19 L/kg dry matter intake, and 4.0 and 4.2% of gross energy intake for the two species, respectively. When compared with previously reported data on CH₄ production in other non-ruminant and ruminant foregut-fermenting as well as hindgut-fermenting species, it is evident that neither the question whether a species is a foregut fermenter or not, or whether it ruminates or not, is of the relevance previously suggested to explain variation in CH₄ production between species. Rather, differences in CH₄ production between species on similar diets appear related to species-specific differences in food intake and digesta retention kinetics.

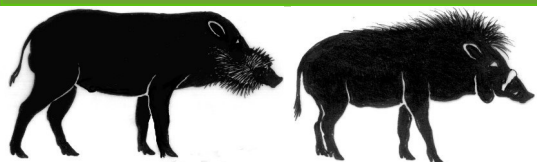
Hippopotamus (*Hippopotamus amphibious* and *Choeropsis liberiensis*) shoulder osteology and function compared with Suids (*Sus scrofa*, *Phacochoerus aethiopicus*, *Potamochoerus porcus* and *Hylochoerus meinertzhageni*) and Tayasuids (*Tayassu peccary* and *Tayassu tajacu*)

Virginia L. Naples

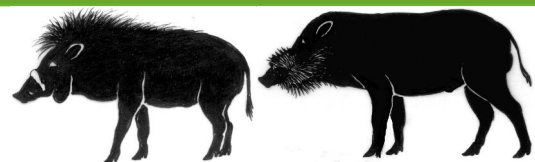
The FASEB Journal

Abstract: Pectoral girdle and forelimb bones of the hippopotamuses, *Hippopotamus amphibious* and *Choeropsis liberiensis* were examined and compared to those of the suids, *Sus scrofa*, *Phacochoerus aethiopicus*, *Potamochoerus porcus*, *Hylochoerus meinertzhageni* and the tayassuids, *Peccary tajacu* and *Tayassu peccari*. Although no longer considered close hippo relatives, these comparison taxa share similar body shapes with hippos, making the groups ecomorphs. This study identifies specific anatomical characters among the adaptations equipping these animals to occupy partially overlapping ecological niches. Even though their habits differ (hippos are semiaquatic; pigs and peccaries are fully terrestrial) similar selective forces obtain because all three groups must accommodate the use of extremely large and robust canine teeth in intraspecific combat and self-defense. The pygmy hippo and suids also use the canines during feeding; all compared taxa show adaptations for support of large heads although cranial dimensions in hippos, especially *H. amphibious*, are maximized. The relative proportions of the forelimb girdles and limb bones differ between the hippos and among the suids compared to the tayassuids. Not only is *H. amphibious* far greater in body size, but this taxon also has, relatively speaking, the shortest legs. The fully terrestrial pigs and peccaries range in weight from less than 1/10th of that of the common hippo to approximately the size and mass of the pygmy hippo. Scapular glenoid fossae in both hippo taxa are rounded concavities, while the humeral heads are rounded convexities. Comparable features in suoids are more elongate although all groups show some degree of humeral head circumduction. The supraspinous fossa in the hippos is relatively much larger than that of the suoids; the latter all show more gracile scapulae than in either hippo taxon. All compared taxa have prominent scapular spines. In the hippos, the spine is a large, sharp lateral projection, recurving distally, to become a greatly ventrally expanded acromion process. In the peccaries it arises nearly from the anterior scapular border, while at the origin, the ridge is located increasingly posteriorly in the progressively larger-bodied taxa (in order: *P. porcus*, *S. scrofa*, *P. aethiopicus*) until it arises directly halfway anteroposteriorly from the neck in *H. meinertzhageni*. In most of the suoids this feature arises as a gently sloping lateral projection from the scapular neck, without an acromion process. The exception is *H. meinertzhageni* in which the spinous process projects slightly farther laterally along the distal half of the bone. Both hippos show an additionally widened and thickened bulge midway along the spine, which does not extend toward the posterior border, as would a true metacromion process. In contrast, in all





New literature on Suiformes



suoids, a metacromion process is prominent, triangular, with an often rounded, thickened and rugose posteriorly pointing projection. Although these differences are subtle, they reflect differing emphases on muscle groups that perform similar fore and aft as well as circumductive forelimb movements.

Carnivory in the common hippopotamus *Hippopotamus amphibius*: implications for the ecology and epidemiology of anthrax in African landscapes

Joseph P. Dudley, Bernard Mudenda Hang'ombe, Fabian H. Leendertz, Leejiah, J. Dorward, Julio de Castro, Amanda L. Subalusky, Marcus Clauss

Mammal Review

The common hippopotamus *Hippopotamus amphibius* ('hippo') is a keystone species whose foraging activities and behaviour have profound effects on the structure and dynamics of terrestrial and aquatic ecosystems within its habitat. Although hippos are typically regarded as obligate herbivores and short-grass grazing specialists, field studies have demonstrated that hippos are facultative carnivores that consume flesh and intestinal tissues from the carcasses of other animals. Carnivory by hippos is not an aberrant behaviour restricted to particular individuals in certain localities, but a behaviour pattern that occurs within populations distributed in most of the hippo's current range in eastern and southern Africa. Carnivory is frequently associated with communal feeding involving multiple individuals or entire social groups of hippos. The observed tendency of hippos to feed on carcasses, including those of other hippos, has important implications for the ecology and epidemiology of anthrax and other ungulate-associated zoonotic diseases in African landscapes. Scavenging and carnivory by hippos may explain why the spatiotemporal patterns and dynamics of anthrax mortality among hippos often differ markedly from those of other anthrax-susceptible herbivores within the same habitats, and why levels of hippo mortality from anthrax may be orders of magnitude higher than those of other anthrax-susceptible ungulate populations within the same localities. Recognition of the role of carnivory as a key factor in modulating the dynamics of mass anthrax outbreaks in hippos can provide a basis for improved understanding and management of the effects of anthrax outbreaks in hippo and human populations.

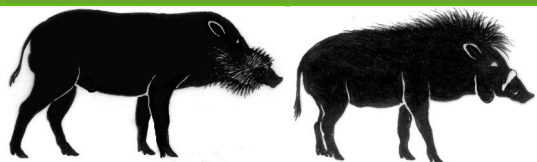
Organization of the sleep-related neural systems in the brain of the river hippopotamus (*Hippopotamus amphibius*): A most unusual cetartiodactyl species

Leigh-Anne Dell, Nina Patzke, Muhammad A. Spocter, Mads F. Bertelsen, Jerome M. Siegel, Paul R. Manger

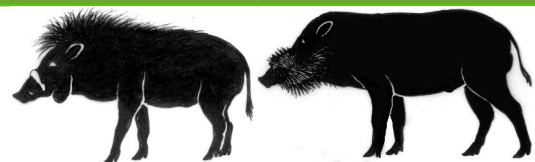
The Journal of Comparative Neurology

This study provides the first systematic analysis of the nuclear organization of the neural systems related to sleep and wake in the basal forebrain, diencephalon, midbrain, and pons of the river hippopotamus, one of the closest extant terrestrial relatives of the cetaceans. All nuclei involved in sleep regulation and control found in other mammals, including cetaceans, were present in the river hippopotamus, with no specific nuclei being absent, but novel features of the cholinergic system, including novel nuclei, were present. This qualitative similarity relates to the cholinergic, noradrenergic, serotonergic, and orexinergic systems and is extended to the γ -aminobutyric acid (GABA) ergic elements of these nuclei. Quantitative analysis reveals that the numbers of pontine cholinergic (259,578) and noradrenergic (127,752) neurons, and hypothalamic orexinergic neurons (68,398) are markedly higher than in other large-brained mammals. These features,





New literature on Suiformes



along with novel cholinergic nuclei in the intralaminar nuclei of the dorsal thalamus and the ventral tegmental area of the midbrain, as well as a major expansion of the hypothalamic cholinergic nuclei and a large laterodorsal tegmental nucleus of the pons that has both parvocellular and magnocellular cholinergic neurons, indicates an unusual sleep phenomenology for the hippopotamus. Our observations indicate that the hippopotamus is likely to be a bihemispheric sleeper that expresses REM sleep. The novel features of the cholinergic system suggest the presence of an undescribed sleep state in the hippopotamus, as well as the possibility that this animal could, more rapidly than other mammals, switch cortical electroencephalographic activity from one state to another.

Epididymal spermatozoa from *Hippopotamus amphibius*

Izabella Pazzoto Alves, Sergio Diniz Garcia, Thiago Luís Magnani Grassi, Gabriela Ribeiro de Araújo Rocha, Douglas Augusto Franciscato, Bruna Helena Kipper, Marion Burkhardt de Koivisto
Animal Reproduction Science

The common hippopotamus was first included in the list of endangered species in 2006 and listed as vulnerable to extinction. The aim of this study was to describe the morphology, morphometry and condensation of chromatin from spermatozoa of the epididymis. Testis–epididymis complexes were obtained from a male *Hippopotamus amphibius*, 37 years old, which belonged to the Araçatuba Zoo and died on 21/07/2015 due to Total Intestinal Obstruction. The epididymides were dissected and divided into caput, corpus and cauda.

Systemic Histiocytic Sarcoma in a Common Hippopotamus (*Hippopotamus amphibius*)

Luciana Fachini da Costa, Marcelo Campos Cordeiro Malta, Herlandes Penha Tinoco, Lilian Botelho de Medeiros, Ana Luiza Sarkis Vieira Bittar, Aline Rodrigues Hoffmann, Felipe Pierezan, Tatiane Alves da Paixão, Renato Lima Santos
Journal of Zoo and Wildlife Medicine

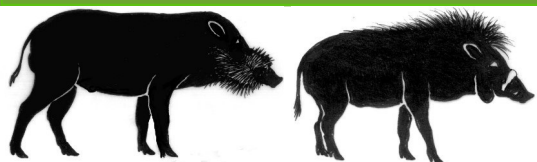
A 37-yr-old captive common hippopotamus (*Hippopotamus amphibius*) developed lethargy and decline in mobility that progressed to death, despite supportive therapy. Histopathologic examination revealed severe, diffuse, intravascular and interstitial infiltration of neoplastic histiocytes in the spleen, liver, lymph nodes, lungs, large intestine, kidneys, and thyroid gland. Neoplastic cells were pleomorphic with marked anisocytosis and anisokaryosis, scattered multinucleated giant cells, numerous bizarre mitotic figures, and marked erythrophagocytosis. Immunohistochemistry demonstrated that neoplastic cells were positive for ionized calcium-binding adapter molecule 1 (a histiocytic marker) and negative for CD3 (a T-cell marker) and myeloperoxidase, confirming the diagnosis of systemic histiocytic sarcoma.

Mitochondrial DNA sequence variation in *Hippopotamus amphibius* from Kruger National Park, Republic of South Africa

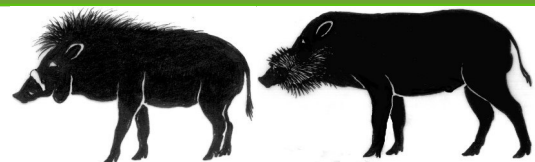
Richard Beckwitt, Jessica Barbagallo, Nickolas Breen, Julia Hettinger, Angelo Liquori, Cesar Sanchez, Nathalia Vieira, William Barklow
African Zoology Journal

Populations of *Hippopotamus amphibius* have declined throughout Africa in recent years, and are expected to decline further. An understanding of the population genetics of individual populations of hippos is necessary for effective management. To that end, we sequenced a portion of the mitochondrial DNA (mtDNA) control region or D-loop from 37 *H. amphibius*, from six herds in the





New literature on Suiformes



central region of Kruger National Park (KNP), Republic of South Africa. We amplified a 453 bp segment by PCR, and identified 21 polymorphic sites and seven haplotypes. All of these haplotypes are private alleles, not found in other populations of hippos from southern Africa. Overall nucleotide diversity (π) was 0.01739, and haplotype diversity (hd) was 0.8273, within the range observed in other parts of Africa. Mismatch analysis conformed more closely to a model of constant population size than either rapid demographic or spatial expansion. An analysis of molecular variance demonstrated no significant differentiation among herds, and Mantel tests showed no significant relationship between geographic and genetic distance among herds separated by up to 47 km (measured as Euclidean [x,y] distance) or 77 km (measured along rivers). Over this range, the population appears to be a single panmictic unit. A test of the hypothesis that calves are more likely to share a mtDNA haplotype with an adult female in the same herd than an adult female from a different herd was not significant.

Evaluación de la calidad Espermática Epididimal en Hipopótamos *Hippopotamus amphibius* (Artiodactyla: Hippopotamidae) ubicados en el Magdalena Medio, Colombia

Giovanni Restrepo Betancur, Elizabeth Varela Giraldo, Alexandra Usuga Suarez

Acta Zoológica Mexicana (nueva serie)

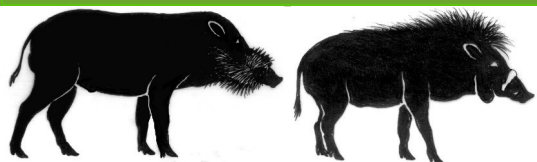
El hipopótamo común (*Hippopotamus amphibius*) es un mamífero del orden Artiodactyla, que habita en África, con una población decreciente a nivel global. Con fines de conservación genética, se han realizado procesos de biotecnología reproductiva, entre los que se reporta, la recuperación de espermatozoides por métodos como la electroeyaculación y la extracción desde epidídimos. Este mamífero es considerado una especie invasora exótica y fue introducido en Colombia en 1985; actualmente se reproduce de forma descontrolada en la región del Magdalena Medio. Como medida de control poblacional, se ha realizado la esterilización quirúrgica de algunos ejemplares. El objetivo de este estudio fue evaluar diferentes parámetros espermáticos e histológicos, relacionados con la calidad seminal epididimal de hipopótamos comunes ubicados en el Magdalena Medio, Colombia. Dos hipopótamos fueron orquiectomizados quirúrgicamente y los espermatozoides fueron recuperados por los métodos combinados de lavado retrógrado e inyección de medio. Se realizó la evaluación de la movilidad (sistema SCA®), la vitalidad espermática y la morfología espermática (prueba supravital), el potencial de membrana mitocondrial (JC-1), la integridad acrosómica (FITC-PNA), y la integridad estructural (SYBR14/IP) y funcional (prueba HOS) de la membrana plasmática. Asimismo, se realizó un análisis histológico de testículos y epidídimos. A excepción de la movilidad progresiva, la integridad funcional de membrana y la morfología espermática, se hallaron resultados muy similares para los parámetros de calidad seminal de ambos individuos. Las anomalías espermáticas predominantes fueron gota citoplasmática y cola enrollada. El análisis histológico evidenció un proceso activo de espermatogénesis. Se concluye que la extracción epididimal de espermatozoides, posterior a la orquiectomía de hipopótamos comunes ubicados en un hábitat no nativo, permite obtener muestras espermáticas de buena calidad.

Taxonomic, Biogeographic and Evolutionary Studies

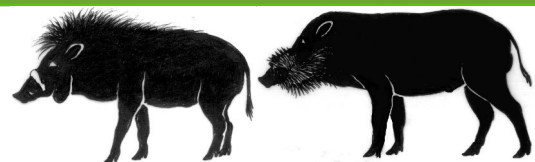
The Evolution of Suidae

Frantz, Laurent, Meijaard, Erik. Gongora, Jaime. Haile, James. Groenen, Martien AM. Larson, Greger.





New literature on Suiformes



Annual Review of Animal Biosciences. 2016; 4 61-85.

AN: ZOOR15205030951

The Suidae are a family of Cetartiodactyla composed of 17 species classified in a minimum of five extant genera that originated at least 20 million years ago. Their success is evident in the multitude of habitats in which they are found as both natural and feral populations in tropical Island Southeast Asia, the high plateau of the Himalayas, Siberia, North Africa, the Pacific Islands, Australia, and the Americas. Morphological and molecular analyses of these species have revealed numerous aspects of their biology, including the ease with which many lineages have and continue to hybridize. This trait has made them an ideal model for evolutionary biologists. Suid species have also shared a deep history with humans, from their association with early hominids in Africa to their domestication. Here we review the current knowledge of this fascinating group and provide a comprehensive evolutionary history from the Oligocene to the present day.

Evolutionary patterns of Toll-like receptor signaling pathway genes in the Suidae.

Darfour-Oduro, Kwame A. Megens, Hendrik-Jan. Roca, Alfred L. Groenen, Martien AM. Schook, Lawrence B

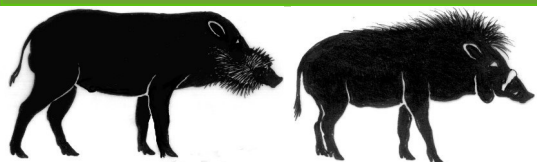
BMC Evolutionary Biology. 2016 Feb 9; 16 33.

AN: ZOOR15204025928

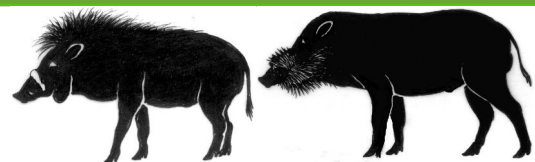
Background: The Toll-like receptor (TLR) signaling pathway constitutes an essential component of the innate immune system. Highly conserved proteins, indicative of their critical roles in host survival, characterize this pathway. Selective constraints could vary depending on the gene's position within the pathway as TLR signaling is a sequential process and that genes downstream of the TLRs may be more selectively constrained to ensure efficient immune responses given the important role of downstream genes in the signaling process. Thus, we investigated whether gene position influenced protein evolution in the TLR signaling pathway of the Suidae. The members of the Suidae examined included the European *Sus scrofa* (wild boar), Asian *Sus scrofa* (wild boar), *Sus verrucosus*, *Sus celebensis*, *Sus scebifrons*, *Sus barbatus*, *Babyrousa babyrussa*, *Potamochoerus larvatus*, *Potamochoerus porcus* and *Phacochoerus africanus*. Results: A total of 33 TLR signaling pathway genes in the Suidae were retrieved from resequencing data. The evolutionary parameter, (dn/ds) had an overall mean of 0.1668 across genes, indicating high functional conservation within the TLR signaling pathway. A significant relationship was inferred for the network parameters gene position, number of protein-protein interactions, protein length and the evolutionary parameter dn (nonsynonymous substitutions) such that downstream genes had lower nonsynonymous substitution rates, more interactors and shorter protein length than upstream genes. Gene position was significantly correlated with the number of protein-protein interactions and protein length. Thus, the polarity in the selective constraint along the TLR signaling pathway was due to the number of molecules a protein interacted with and the protein's length. Conclusion: Results indicate that the level of selective constraints on genes within the TLR signaling pathway of the Suidae is dependent on the gene's position and network parameters. In particular, downstream genes evolve more slowly as a result of being highly connected and having shorter protein lengths. These findings highlight the critical role of gene network parameters in gene evolution.

Fallen in a dead ear: intralabyrinthine preservation of stapes in fossil artiodactyls





New literature on Suiformes



Maeva J. Orliac, Guillaume Billet
Palaeovertebrata

The stapes is the last of the middle ear ossicle chain and the smallest bone of the mammalian skeleton. Because it rests on the membrane of the fenestra vestibuli during life, the stapes may often fall within the bony labyrinth cavity when soft structures decay after death. In this work, we highlight the unexpected role that the bony labyrinth plays in the preservation of the stapes. Systematic investigation of the bony labyrinth of 50 petrosal bones of extinct and extant artiodactyls led to the discovery of eight cases of “intralabyrinthine” stapes. Three dimensional reconstructions of these stapes allow documenting stapes morphology of four extinct artiodactyl taxa: *Microstonyx erymanthius* (Suidae), *Elomeryx borbonicus* (Hippopotamoidea), ?*Helohyus plicodon* (Helohyidae), and an undetermined Cainotheriidae; and four extant ones *Choeropsis* and Hippopotamus (Hippopotamidae), and *Tayassu* and *Phacochoerus* (Suoidea). ?*Helohyus plicodon* from the Middle Eocene documents the oldest stapes known for the order Artiodactyla. Morphological study and metric analyses of our sample of artiodactylan stapes show that stapes are likely to carry relevant phylogenetic characters/signal within artiodactyls, and a potential Euungulata signature.

Environment and space as drivers of variation in skull shape in two widely distributed South-American Tayassuidae, *Pecari tajacu* and *Tayassu pecari* (Mammalia: Cetartiodactyla)

Carla D. Hedges, Jamile M. Bubadué, Nilton C. Cáceres
Biological Journal of the Linnean Society

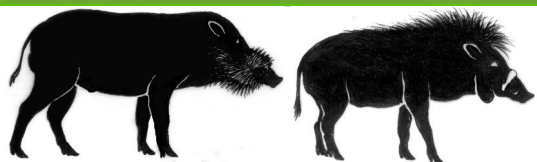
The influence of the environment on the geographical variation of morphological traits has been recognized in a number of taxa. *Pecari tajacu* and *Tayassu pecari* are ideal models to investigate intraspecific geographic variation in skull because of their wide and heterogeneous geographical distribution in South America. We used geometric morphometric procedures to examine the geographical variation in skull shape of 294 adult specimens of these species from 134 localities. We quantified to what extent skull shape variation was explained by environment, skull size and geographical space using variation partitioning analysis. We detected a strong pattern of geographic variation for *P. tajacu* skull shape, but not for *T. pecari*. The environment seems to be the major selective force that drives skull shape variation in both species. Nevertheless, other spatially structured processes (e.g. genetic drift, gene flow) might also have affected variation in the skull shape of the more widespread species *P. tajacu*. Allometric relationships might reflect the biomechanical constraints that are thought to be strong enough to limit size-related changes in *T. pecari* skull shape.

Fossil peccaries of Late Pleistocene/Holocene (Cetartiodactyla, Tayassuidae) from underwater caves of Serra da Bodoquena (Mato Grosso do Sul State, Brazil)

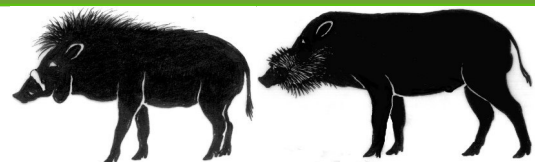
Rodrigo Parisi Dutra, Rafaela Velloso Missagia, Fernando Araujo Perini, Mario Alberto Cozzuol, Germán Mariano Gasparini, Patricia Gonçalves Guedes, Leandro de Oliveira Salles
Historical Biology

New records of *Catagonus stenocephalus* and *Tayassu pecari* are reported from the karst of Serra da Bodoquena, located at a south-western portion of Brazil near the border with Paraguay. Skull and lower jaw fragments at different stages of mineralisation were retrieved from two limestone underwater caves, Japonês and Nascente do Formoso, associated with clay and sand





New literature on Suiformes



deposits with no retrievable stratigraphy. C14 dating of fossil mammals from these caves was attempted, but so far no success was achieved, but the inferred age for the associated paleofauna of these caves is Late Pleistocene and Holocene. The morphology of these fossil peccaries, from the most south-western known population in Brazil, is detailed and paleoecological implications are considered.

Description, Taphonomy, and Paleoecology of the Late Pleistocene Peccaries (Artiodactyla: Tayassuidae) from Bat Cave, Pulaski County, Missouri

Aaron L. Woodruff

Tesis para optar el grado de maestro en la East Tennessee State University

The late Pleistocene faunal assemblage from Bat Cave, central Ozarks, Missouri provides an opportunity to assess specific aspects of behavior, ecology, and ontogeny of the extinct peccary *Platygonus compressus*. All identifiable elements referable to this taxon were catalogued and examined, and a minimum number of individuals of 70 was determined for the sample. The presence of distinct, non-overlapping age groups suggests that *P. compressus* utilized Bat Cave on a seasonal basis. A predator-prey relationship with *Canis dirus*, the second most abundant vertebrate from the Bat Cave site, is also described in this study. Damage patterns suggest that the feeding patterns of *C. dirus* at Bat Cave were consistent with its extant relative, and that these predators would periodically enter the cave to hunt and/or scavenge peccaries. Overall, the fossil material from Bat Cave is virtually unweathered and represents one of the most extensive and well-preserved late Pleistocene faunas from the Ozarks.

Ecological, Behavioural and Conservation Studies

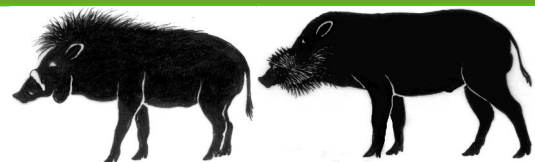
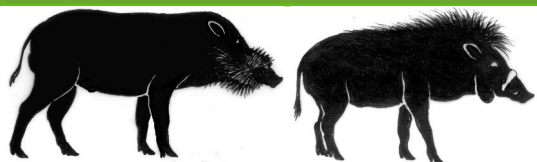
Plant community shifts caused by feral swine rooting devalue Florida rangeland

Bankovich, Brittany. Boughton, Elizabeth. Boughton, Raoul. Avery, Michael L. Wisely, Samantha M

Agriculture Ecosystems and Environment. 2016 Mar 15; 220 45-54.

Invasive species threaten agriculture by changing agroecosystem structure and function, reducing habitat value, decreasing biodiversity and ecosystem services and increasing management costs. Grazing lands in south central Florida are a mosaic of sown pastures, native grasslands, wetlands and woodlands that provide a variety of ecosystem services. Disturbance of these pastures and native grasslands by invasive feral swine (*Sus scrofa*) can have negative consequences for both economic productivity and biodiversity. In this study, we show that the effect of rooting on plant diversity depends on ecosystem type and initial levels of plant species diversity. For example, in native grassland pasture, rooting was initially associated with declines in plant species richness, while in sown pastures, rooting was associated with more sustained increases in plant species richness. In both sown pastures and native grasslands, swine rooting altered plant community composition reducing agricultural productivity. Forage grasses were primarily associated with unrooted areas, whereas low quality forage species or nuisance species were found in rooted areas. We provide an example of monetary losses that cattle ranches can incur when feral swine are abundant on the landscape and control is minimal. Ranch managers and government agencies are encouraged to consider implementing more stringent feral swine management programs to minimize negative effects of feral swine rooting on ecological and economic value of grazing lands.





Variation of Wild Boar Reproductive Performance in Different Habitat Types: Implications for Management.

Sprem, N., Piria, M. Prdun, S. Novosel, H. Treer, T.
Russian Journal of Ecology. 2016 Jan; 47(1): 96-103.
AN: ZOOR15206036983

The aim of this study was analyze reproductive performance of wild boar in different habitat over a 7-year period (2006-2012). A total of 468 pregnant females and 2.819 fetuses were analyzed, the mean number of fetuses was 6.02 (median = 6) per animal (4.62 per juvenile, 6.39 per yearling and 6.77 per adult). In litters, male-biased fetuses occurred significantly more often than female, the overall fetal sex ratio is 1 : 0.86. Positive reproductive traits increased up to 90 kg of live body weight and then decreased. The reproductive parameters observed in our study reflect a relatively high reproductive capacity compared to the populations in southern and northern Europe, but are comparable with some populations in central Europe. Concerning habitat conditions, it is obvious that they influence the reproductive performance of females, and therefore must be included in management plans.

Farmers' perceptions of the extra-limital common warthog in the Northern Cape and free state provinces, South Africa

Swanepoel, Monlee. Leslie, Alison J. Hoffman, Louwrens C
Wildlife Society Bulletin. 2016 Mar; 40(1): 112-121.
AN: ZOOR15206036609

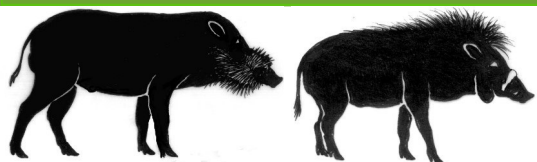
The common warthog (*Phacochoerus africanus*) has been extra-liminally introduced onto various farms and reserves in parts of the Northern Cape and Free State provinces of South Africa. Warthogs are considered as a game animal for wildlife tourism and hunting but are a known agricultural pest in their natural range. We investigated the perceptions, attitudes, and actions of farmers and landowners toward the common warthog on their farms. We identified participants using the Snowball technique and interviewed them during semistructured personal interviews, conducted from June to October 2012, using a standardized questionnaire. Most farmers and landowners were of the opinion that warthogs were introduced to the area and considered warthog populations to be increasing. Warthogs were held responsible for causing damage to aspects of the natural and agricultural environment, and respondents were increasingly negative toward warthogs as the levels of perceived damages increased. There were, however, also a number of respondents who regarded and utilized the species as a game animal. The majority of respondents hunted warthogs and utilized their meat for consumption; therefore, the study proposes that scientifically based hunting efforts for meat production be implemented to control population numbers and mitigate negative impacts experienced.

Occupancy and demographics of red river hog *Potamochoerus porcus* on Tiwai Island, Sierra Leone

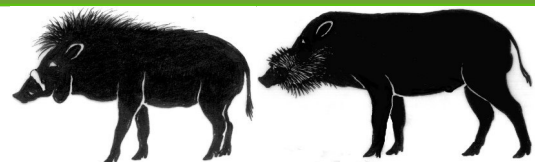
Kathryn R. McCollum, April L. Conway, Myung-Bok Lee, John P. Carroll
African Journal of Ecology

The red river hog (*Potamochoerus porcus*, Linnaeus) is a species of Suidae with populations ranging from western to central Africa. Little is known about the population status of red river hog, and few studies have investigated habitat characteristics associated with their occupancy which is





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critical in determining possible reasons behind suspected population declines. We used camera traps and site occupancy models to examine the effects of habitat covariates on occupancy of red river hog on Tiwai Island and in surrounding forests of Sierra Leone during two field seasons, 2008–2011. We also estimated group size and composition and growth patterns of juveniles. In both sampling periods, understory vegetation strongly influenced red river hog occupancy with greatest association with riparian and swamp vegetation types. Red river hogs seemed to avoid habitats of high human impact such as farmbrush and secondary growth forests. Average group size was 2.46 ± 0.28 (SE) hogs per group. Growth patterns of juveniles suggested the majority of piglets were born during the middle of dry season (January–February). Our research suggests landscape use by red river hog is influenced by presence of riparian habitats with dense vegetation.

First Ecological Study of the Bawean Warty Pig (*Sus blouchi*), One of the Rarest Pigs on Earth

Mark Rademaker, Erik Meijaard, Gono Semiadi, Simen Blokland, Eric W. Neilson, Eva Johanna Rode-Margono

PLOS ONE, <http://dx.doi.org/10.1371/journal.pone.0151732>

The Bawean warty pig (*Sus blouchi*) is an endemic pig species confined to the 192 km² large island of Bawean in the Java Sea, Indonesia. Due to a lack of quantitative ecological research, understanding of natural history and conservation requirements have so far been based solely on anecdotal information from interviews with local people and study of captive and museum specimens. In this study we provide the first assessment of population and habitat preferences for *S. blouchi* by using camera trapping. From the 4th of November 2014 to January 8th 2015, we placed camera traps at 100 locations in the forested protected areas on Bawean. In 690.31 camera days (16567.45 hours) we captured 92 independent videos showing *S. blouchi*. Variation in *S. blouchi* trapping rates with cumulative trap effort stabilized after 500 camera days. An important outcome is that, in contrast to the suggestion of previous assessments, only *S. blouchi* was detected and no *S. scrofa* was found, which excludes hybridization threats. We fitted a Random Encounter Model, which does not require the identification of individual animals, to our camera-trapping data and estimated 172–377 individuals to be present on the island. Activity patterns and habitat data indicate that *S. blouchi* is mainly nocturnal and prefers community forests and areas near forest borders. Next to this, we found a positive relationship between *S. blouchi* occupancy, distance to nearest border, litter depth and tree density in the highest ranking occupancy models. Although these relationships proved non-significant based on model averaging, their presence in the top ranking models suggests that these covariables do play a role in predicting *S. blouchi* occurrence on Bawean. The estimated amount of sites occupied reached 58%. Based on our results, especially the estimation of the population size and area of occupancy, we determine that the species is Endangered according to the IUCN/SSC Red List criteria.

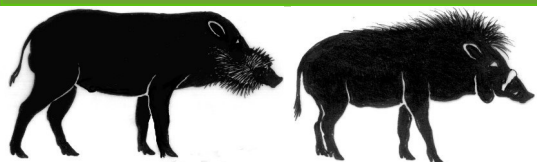
The use of faeces counts to estimate relative densities of wild boar in a Mediterranean area.

Ferretti, Francesco, Fattorini, Lorenzo. Sforzi, Andrea. Pisani, Caterina.

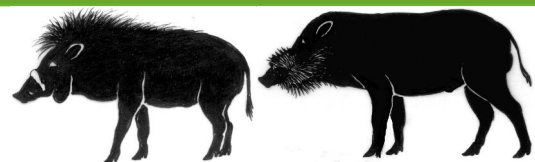
Population Ecology. 2016 Apr; 58(2): 329-334.

AN: ZOOR15206035961





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The monitoring of population trends of wild ungulates is important to evaluate their population dynamics and to develop sound conservation/management plans. The wild boar *Sus scrofa* can impose heavy impacts on ecosystems and human activities, as well as be responsible for disease transmission. Estimating abundance of wild boars is a challenging issue, because of some peculiar biological and ecological traits of this ungulate. Indices of relative abundance could be used to evaluate its population trends. In a Mediterranean area we used faeces counts, through a two-stage stratified sampling, to estimate relative densities of wild boars, between 2007 and 2014. Faeces density estimates increased not significantly between 2007 (151.5 faeces/100 ha) and 2010 (203.8 faeces/100 ha) and decreased significantly from 2010 to 2014 (95.5 faeces/100 ha). The decrease in faeces density estimates was consistent with the increased harvest effort (number of harvest days), performed from 2010 to 2013 to limit impact on ecosystems and reduce damages to crops. The variation of faeces density estimates was also consistent with that of harvest indices (total harvest to harvest effort), with significantly positive values of Pearson and rank correlation coefficients. Results suggest that faeces density estimates achieved with the adopted sampling strategies can be effectively used as indices of relative abundance.

Disturbance of the herbaceous layer after invasion of an eutrophic temperate forest by wild boar

Brunet, Jorg, Hedwall, Per-Ola. Holmstrom, Emma. Wahlgren, Emmelie.

Nordic Journal of Botany. 2016 Feb; 34(1): 120-128.

AN: ZOOR15204027694

This study presents a detailed account of gEvolutionary patterns of vegetation in permanent plots surveyed before and after invasion of wild boar (*Sus scrofa*) to a temperate deciduous broadleaf forest. Specifically, we aimed to quantify the effect of wild boar rooting on cover, richness and composition of spring ephemerals, summer green herbs and saplings of woody species in relation to tree canopy cover. Rooting frequency in sample plots increased from 0% in 2010 to 61% in 2013. In heavily rooted plots, the mean cover of spring ephemeral geophytes (mainly *Anemone nemorosa*, *A. ranunculoides* and *Ranunculus ficaria*) decreased from 75% to 39% between 2010 and 2013. Species richness of summer green herbs generally increased between 2010 and 2013 and was additionally positively affected by heavy rooting and low canopy cover. Rooting also caused heterogenization of the herbaceous layer and amplified ongoing compositional changes induced by changing light conditions. Frequency and richness of spring ephemeral and woody species remained unchanged. We conclude that overall species richness of the herbaceous layer may increase in the short-term as a result of increased plant recruitment and seed dispersal. However, wild boar rooting can greatly reduce the ground cover of spring ephemerals in eutrophic broadleaf forests, thereby threatening their important ecological function. To avoid long-term losses of characteristic spring flora elements, local population control of wild boar is necessary to reduce abundance and frequency of soil rooting.

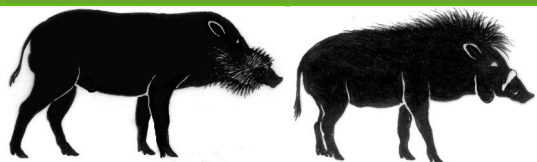
The Use of Genomics in Conservation Management of the Endangered Visayan Warty Pig (*Sus cebifrons*)

Nuijten, RJM, Bosse, M, Crooijmans, RPMA, Madsen, O, Schaftenaar, W, Ryder, OA, Groenen, MAM, Megens, HJ

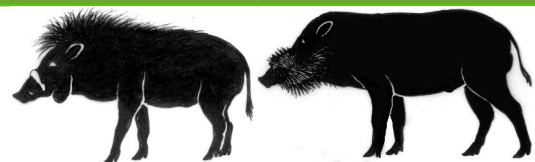
INTERNATIONAL JOURNAL OF GENOMICS 5613862 DOI: 10.1155/2016/5613862

The list of threatened and endangered species is growing rapidly, due to various anthropogenic





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causes. Many endangered species are present in captivity and actively managed in breeding programs in which often little is known about the founder individuals. Recent developments in genetic research techniques have made it possible to sequence and study whole genomes. In this study we used the critically endangered Visayan warty pig (*Sus cebifrons*) as a case study to test the use of genomic information as a tool in conservation management. Two captive populations of *S. cebifrons* exist, which originated from two different Philippine islands. We found some evidence for a recent split between the two island populations; however all individuals that were sequenced show a similar demographic history. Evidence for both past and recent inbreeding indicated that the founders were at least to some extent related. Together with this, the low level of nucleotide diversity compared to other *Sus* species potentially poses a threat to the viability of the captive populations. In conclusion, genomic techniques answered some important questions about this critically endangered mammal and can be a valuable toolset to inform future conservation management in other species as well.

Multiple Origins and Admixture of Recently Expanding Japanese Wild Boar (*Sus scrofa leucomystax*) Populations in Toyama Prefecture of Japan

Yamazaki, Yuji, Adachi, Fuminari. Sawamura, Akira.

Zoological Science (Tokyo). 2016 Feb; 33(1): 38-43.

AN: ZOOR15204025731

Japanese wild boar (*Sus scrofa leucomystax*) populations have expanded drastically throughout the Japanese Archipelago in recent decades. To elucidate the dispersal patterns of Japanese wild boar in Toyama Prefecture in central Japan, we used a multi-locus microsatellite DNA analysis to determine its population structure and the degree of admixture. The deviation from Hardy-Weinberg equilibrium was detected in either total or separate regional wild boar samples from Toyama Prefecture. This result could be explained by the Wahlund effect resulting from the mixture of samples from different sources. Bayesian structure analysis, assignment test, and factorial correspondence analysis suggested that wild boars around Toyama Prefecture derive from at least two ancestral sources. The migration and possible mating of each individual may have occurred recently and continued in each geographically neighboring region. The present genetic results may be useful for prediction of future dispersal patterns of Japanese wild boar, as well as other animals in expansion.

Mitochondrial DNA perspectives on the introduction and spread of wild pigs in California

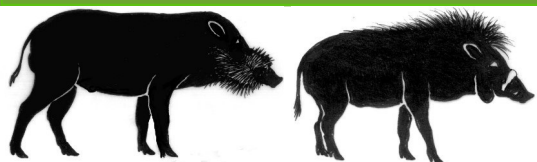
Sweitzer, Rick A., McCann, Blake E. Loggins, Ronald E. Simmons, Rebecca B.

California Fish and Game. 2016 Spr; 101(2): 131-145.

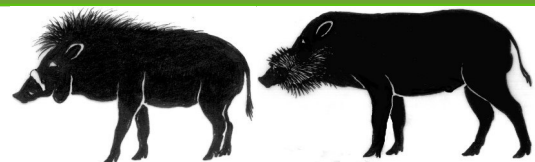
AN: ZOOR15204025153

Domestic pigs were first introduced to California by Spanish explorers and missionaries in the 1700s and were soon established as feral populations in coastal regions. Feral pigs are currently abundant in mainland California where their presence in 56 of the state's 58 counties is ecologically problematic. We used molecular techniques to inform on an incomplete record of human introductions associated with escape or purposed release of domestic and European-type wild swine in California, and to provide insight on the mechanisms that produced an accelerated expansion dynamic in the state after the 1970s. We developed mtDNA sequence data for 151 tissue or blood samples from wild pigs spanning their distribution in California, and a 550 base pair segment of the control region was used in phylogenetic analysis. Phylogenetic analyses





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included our data and 904 published sequences for wild and domestic swine from elsewhere in the U.S. and around the world. Gene flow indicative of natural spread in California was assessed from population-level mtDNA sequence relationships for five population groupings, and we assessed mtDNA haplotypes associated with different periods of invasion by partitioning samples originating from "Historic" occupied counties (before 1968), and "Recent" occupied counties. Nine mtDNA haplotypes were identified among wild pigs California, including three that were unique to California, three that were common elsewhere in the United States, two that were known from Hawaii or other Pacific Islands, and one that was known only from Kentucky, USA. Apparent gene flow between Recent and Historic ranges indicated that pigs dispersed at the regional level, and we identified evidence for expansion by anthropogenic and natural processes from presence of several haplotypes only in Recent range. MtDNA sequence data provided new insight on wild pig expansion in California, including evidence that contemporary translocations promoted hybridization and subsequent spread by natural population growth. Considered together, information on the distribution of common and unique haplotypes and gene flow suggests that range expansion by wild pigs in California is progressing by natural and human-facilitated dispersal, and new introductions from outside of the state. We advocate against additional anthropogenic movement of wild pigs within the state or from other U. S. states because these animals are known to be detrimental to native plants and animals in California ecosystems.

Interspecific association in ungulates of the Bale Mountains National Park, Ethiopia Adissu Asefa

African Journal of Ecology

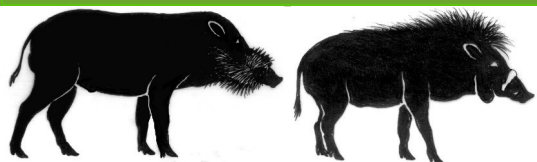
The aim of the study was to determine the frequencies of interspecific association formation and species preferences among five ungulates [bohor reedbuck (*Redunca redunca*), common warthog (*Phacochoerus africanus*), grey duiker (*Sylvicapra grimmia*), Menelik's bushbuck (*Tragelaphus scriptus meneliki*) and mountain nyala (*Tragelaphus buxtoni*)] in the northern Bale Mountains National Park, Ethiopia. Data were collected in three forest patches and in open grassland using total count technique in 2009 and 2011. The total number of ungulate groups found in interspecific associations was 444, comprising 26.8% of the total 1657 groups recorded. For the five study species, the relative frequency with which a given species occurred in interspecific association deviated significantly from the expected mean relative frequency (i.e. 26.8%). Each study species showed preferences to form interspecific associations with one or two other species. Interspecific association formation increased mean group sizes for bohor reedbuck and mountain nyala. And most of the species had greater overall mean group sizes in the open habitat compared to forest habitat. In general, the association pattern reported here could be attributed to antipredator response and/or mutual grazing facilitation, which might be beneficial to one or all of the species involved.

Does variation between dry and wet seasons affect tropical forest mammals' occupancy and detectability by camera traps? Case study from the Udzungwa Mountains, Tanzania

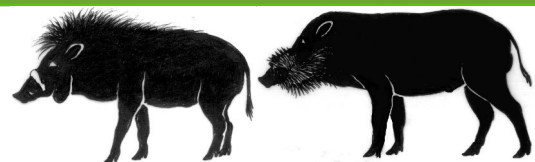
Emanuel H. Martin, Vedasto G. Ndibalema, Francesco Rovero

The increasing use of camera trapping coupled to occupancy analysis to study terrestrial mammals has opened the way to inferential studies that besides estimating the probability of presence explicitly consider detectability. This in turn allows considering factors that can potentially confound the estimation of occupancy and detection probability, including seasonal





New literature on Suiformes



variations in rainfall. To address this, we conducted a systematic camera trapping survey in the Udzungwa Mountains of Tanzania by deploying twenty camera traps for 30 days in dry and wet seasons and used dynamic occupancy modelling to determine the effect of season on estimated occupancy and detection probability for species with >10 capture events. The sampling yielded 7657 and 6015 images in dry and wet seasons, respectively, belonging to 21 mammal species. Models with no season dependency and with season-dependent detectability were best supported, indicating that neither colonization nor extinction varied with seasons and hence occupancy did not vary. Only bush pig (*Potamochoerus larvatus*) showed a significant decrease in detectability from dry to wet seasons. Our study indicates that seasonal variation in rainfall may have limited effect on occupancy and detectability of resident mammals in Udzungwa rainforests; however, it remains a factor to consider when designing future studies.

Diet Composition of the Large Herbivores in Mkambati Nature Reserve, Eastern Cape, South Africa

Jan A. Venter, Margaret J. Kalule-Sabiti

African Journal of Wildlife Research

We used stable carbon isotopes from feces to investigate the proportional contribution of C3 and C4 plant forms to the diet of the herbivores in Mkambati Nature Reserve, a grassland dominated ecosystem on the east coast of South Africa. Our results indicate that *Equus burchellii*, *Damaliscus pygargus phillipsi*, and *Alcelaphus buselaphus* utilize mainly C4 grasses. *Tragelaphus oryx*, *Potamochoerus larvatus*, *Tragelaphus scriptus* and *Antidorcas marsupialis* utilized mainly C3 plant forms but *Redunca arundinum* utilized an approximately equal amount of C3 and C4 plants. The results indicated similar trends compared to the more arid savanna systems (i.e. Kruger National Park in South Africa and several national parks in Kenya) with a few notable differences in some species (i.e. red hartebeest, southern reedbuck, eland, bushbuck and bushpig).

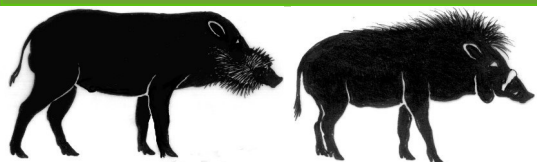
Distribution, utilization and management of the extra-limital common warthog (*Phacochoerus africanus*) in South Africa

Monlee Swanepoel

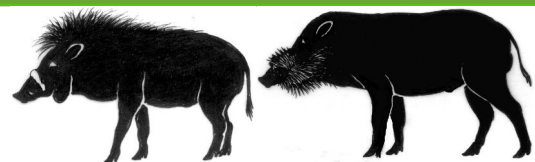
Dissertation presented for the degree of Doctor of Philosophy. Stellenbosch University

In South Africa, the recognition of wildlife as a natural resource has developed into a lucrative game farming industry where wildlife has value for tourism, recreational hunting and commercial hunting, including meat production and live sales. The modern game ranching industry is largely influenced by the demand of tourists and hunters for certain species and a great diversity of species, which has resulted in South Africa having the second highest rate of ungulate introductions globally. The common warthog (*Phacochoerus africanus*) was extra-liminally introduced to various game farms and reserves in the Eastern Cape, Northern Cape and the Free State provinces of South Africa for conservation and game farming purposes. Warthogs are not enclosed by the standard fencing used on agricultural lands and nature reserves, and have become free-roaming in the introduced habitats. The species currently inhabit both private and public lands on which major agricultural activities are practiced in South Africa and as a known agricultural pest, have become a managerial problem in traditional agricultural settings. The meat from hunted warthog carcasses is still relatively under-utilized by hunters and/or the commercial sector likely from a lack of information regarding the safety and preparation of the meat. The



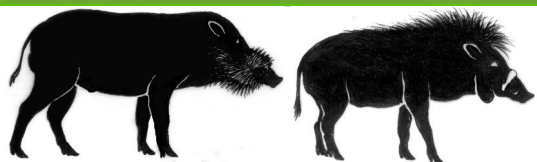


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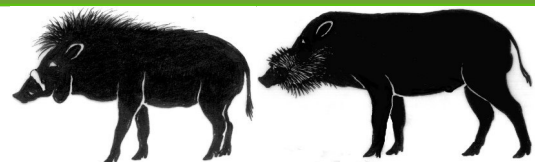


study found that introduced warthogs are simultaneously considered and managed as an agricultural pest and game animal by agricultural producers. This conflicting approach to management results in unethical and unsustainable control practices with undesirable outcomes for both farmers and warthogs. Since the majority of agricultural producers indicated that they would be more likely to utilize the meat if presented with information on its nutritional profile, the study proposed the production and utilization of warthog meat as fresh game meat or processed game meat products as a strategy to purposefully manage introduced warthog populations. There is a general concern that introduced warthogs could be responsible for introducing and transmitting diseases to animals and humans, and the consumption of warthog meat could cause diseases or parasitic infections in humans. The study found the first record of the tick *Rhipicephalus gertrudae* on warthogs in South Africa to date, while the low abundance of *R. simus* was attributed to the fact that the study area largely fell outside the ticks' preferred distribution range. Overall, the parasite species richness in the host population was low. These results may suggest that introduced warthogs can alter the distribution of parasites, and/or act as host to parasites not previously associated with warthogs. However, although warthogs are able to carry and transmit diseases to animals and humans, there is a lack of documented cases of this occurring in southern Africa outside of disease-controlled areas. In addition, no warthogs culled during this study showed obvious symptoms of diseases or carriers of parasites potentially harmful for human consumption, albeit this was not explicitly investigated in this study. The yields and meat quality characteristics of warthogs, and the use of warthog meat in processed products as determined in this study provides evidence that the species can be considered and utilized as a game animal for formal meat production. The overall carcass yields of warthogs were favourable and comparable to those of other wild ungulates, indicating production of warthog meat is economically feasible. Considering the effect of intrinsic factors such as sex and age, age appeared to have a more pronounced effect on the quality characteristics of warthog meat, while adult male warthogs had heavier body weights and higher yields compared to females. The study concluded that warthog meat should be marketed and labelled as whole muscle cuts considering the differences in quality characteristics among skeletal muscles. However, differences between sex, age and among muscles are considered negligible in terms of its nutrition and healthiness as the raw and cooked meat is high in protein (~ 20%) and low in fat (~ 2%) with a favourable polyunsaturated to saturated fatty acids ratio (PUFA:SFA) of < 0.45 and omega 6 to omega ratio 3 ($\omega 6:\omega 3$) ratio < 4, which is the recommended ratio for the human diet. However, the Longissimus lumborum (LL) muscle from warthogs culled on agricultural lands had a $\omega 6:\omega 3$ ratio > 4 compared to warthogs culled on a game reserve, while warthogs culled on the game reserve had higher levels of arachidonic acid. These differences were attributed to the differences in the regional and seasonal diet of warthogs. The sensory profile of warthog meat was dominated by pork aroma and flavour and tenderness, and it was proposed that total moisture content is an important factor influencing the sensory profile of warthog meat considering the overall low total fat. The meat was not described as being gamey, which raises the question of whether gamey attributes should be described as 'associated with game meat', and its aptness to distinguish among meat from different species. The study found the undesirable aroma and flavour described as "sour/sweaty" was not found only in adult males and was scored higher for juvenile warthogs of both sexes. The use of game meat in processed products could extend the value chain of game meat production, and the study found that warthog meat can be converted to healthy processed products without compromising the sensory attributes associated with the product,





New literature on Suiformes



while providing further evidence that processes such as curing and smoking is able to reduce or 'mask' undesirable flavours. Neither sex nor age ultimately influenced the sensory profile of warthog back bacon produced from the Longissimus thoracis et lumborum muscle, which was overall high in total protein (~29%) and low in fat (< 2%) with a favourable fatty acid (FA) profile. The use of warthog meat in a ready-to-eat product known as cabanossi found that warthog and pork cabanossi had similar total protein (26.3% and 24.2%, respectively) contents, while the warthog cabanossi was lower in total fat content (6.9% and 13.7%, respectively), which did not affect consumer preference. Despite the encouraging results found in this study regarding the quality and properties of warthog meat, there are still many research questions regarding the distribution, impacts, utilization and management of warthog populations in South Africa. The study in its entirety provides baseline information pertaining to and influencing warthog yields and meat quality characteristics, and concludes that warthogs can be utilized as a game animal for meat production and utilization, with the benefit of producing an overall lean meat with desirable properties for processing.

Ecological Monitoring and Health Research in Luambe National Park, Zambia: Generation of Baseline Data Layers

Neil E. Anderson, Paul R. Bessell, Joseph Mubanga, Robert Thomas, Mark C. Eisler, Eric M. Fèvre, Susan C. Welburn
EcoHealth

Classifying, describing and understanding the natural environment is an important element of studies of human, animal and ecosystem health, and baseline ecological data are commonly lacking in remote environments of the world. Human African trypanosomiasis is an important constraint on human well-being in sub-Saharan Africa, and spillover transmission occurs from the reservoir community of wild mammals. Here we use robust and repeatable methodology to generate baseline datasets on vegetation and mammal density to investigate the ecology of warthogs (*Phacochoerus africanus*) in the remote Luambe National Park in Zambia, in order to further our understanding of their interactions with tsetse (*Glossina* spp.) vectors of trypanosomiasis. Fuzzy set theory is used to produce an accurate land cover classification, and distance sampling techniques are applied to obtain species and habitat level density estimates for the most abundant wild mammals. The density of warthog burrows is also estimated and their spatial distribution mapped. The datasets generated provide an accurate baseline to further ecological and epidemiological understanding of disease systems such as trypanosomiasis. This study provides a reliable framework for ecological monitoring of wild mammal densities and vegetation composition in remote, relatively inaccessible environments.

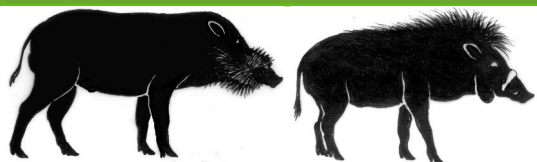
Dominance relationships between collared peccaries *Pecari tajacu* (Cetartiodactyla: Tayassuidae) in intensive breeding system

Suleima do Socorro Bastos da Silva, Diva Anelie Guimarães, Cibele Biondo, Otávio Mitio Ohashi, Natália Inagaki de Albuquerque, Ana Carolina Dalla Vecchia, Cristina Yumi Miyaki, Yvonnick Le Pendu

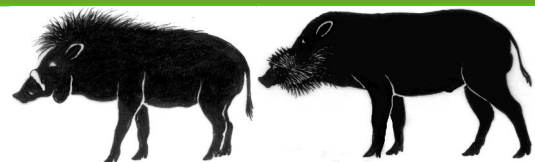
Applied Animal Behaviour Science

The collared peccary (*Pecari tajacu*) is a species with great potential for breeding in captivity since it adapts well to a variety of foods, has a high breeding capacity and there is an existing market for its meat and leather, which is of excellent quality. However, it is necessary to





New literature on Suiformes



understand its social structure, when maintained in intensive breeding, to adequately manage groups and limit potential aggressions to the stockman. Four family units (dam, sire and descendants) were monitored (phase 1); females descendants were subsequently relocated into four new experimental social groups (phase 2). In these experimental groups, the female descendants were grouped with adult males, without the presence of the parents. Interactions were filmed three times per week, during two months, for each treatment (phase 1 = family units and phase 2 = experimental groups). A matrix of aggressive and submissive behaviors was developed and the dominance relations were evaluated with the Elo-rating method. A stability index of rank orders, the steepness and the degree of linearity were calculated to analyse the hierarchy in each family unit and experimental group. The parents remained on the highest hierarchical levels in three of the four family units and female descendants occupied the highest hierarchical levels in experimental groups. A linear hierarchy composed of adults of both genders was found in two family units and a mono-sexual linear hierarchy with females at the highest-ranking positions was evidenced in two experimental groups. Hierarchy was stable (all stability indexes values ≥ 0.94), while steepness was variable among family units and experimental groups (range: 0.23–0.84). The ranking-position of a female descendant in a family unit was not a good predictor of her ranking position in experimental units. Male descendants received significantly less friendly behaviors than female descendants did ($p = 0.01$), dams ($p < 0.01$) and sires ($p < 0.05$) in the family units. There was no significant increase in the frequency of aggressive behavior after relocation of the animals. Our results indicate that collared peccaries raised in small group present stable dominance relations, form hierarchies of variable steepness and show females as the highest-ranking individual.

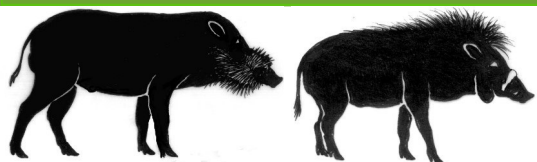
Uso local de los mamíferos no voladores entre los habitantes de Metzabok, El Tumbo y Laguna Colorada, Selva Lacandona, México

Jenner Rodas-Trejo, Alejandro Estrada, Jaime Rau Acuña, Manuela de Jesús Morales-Hernández

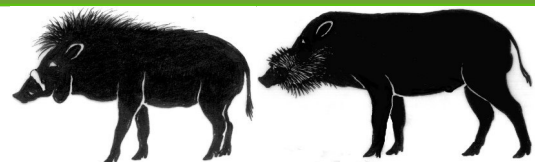
Revista Etnobiología

En el presente estudio se realizó un diagnóstico, sobre usos de la mastofauna por miembros de dos grupos étnicos, en tres comunidades que interactúan en un mismo territorio. El estudio se realizó en la comunidad lacandona Metzabok y en dos comunidades del grupo étnico tselal. Se realizaron entrevistas individuales a partir de cuestionarios semi-estructurados. Se calculó el Índice de Valor de Uso (IVU) y se determinaron las diferencias en las categorías de uso mencionadas. Se realizaron 129 entrevistas; 18 en Metzabok, 32 en Laguna Colorada y 79 en El Tumbo. Se reconocen 26 especies de las que 19 son aprovechadas bajo seis categorías de uso: alimento, medicinal, control de daños, ornamental, mascota y ritual o tradicional. Los mayores IVU presentado en las tres comunidades coinciden en tres especies: pecarí de collar (*Pecari tajacu*), tejón (*Nasua narica*) y tepezcuintle (*Cuniculus paca*). Doce son utilizados como alimento, 11 especies son utilizadas para tratar 13 enfermedades, 11 como control de daños. El uso de los mamíferos silvestres por parte de las tres comunidades de estudio es común y similar entre ellas, se realiza principalmente para cubrir necesidades básicas de alimentación, medicamento y para el control de animales considerados plaga. La cacería solo es permitida por autoridades de las comunidades para el control de ciertas especies que ocasionan daño a las áreas de cultivo. Esta reglamentación se basa en acuerdos entre las autoridades de las tres comunidades y personal administrativo de la reserva para proteger a otras especies y áreas de selva, sin embargo es





New literature on Suiformes



necesario involucrar a otras comunidades que habitan en los alrededores. Por último, el uso de la mayoría de las especies de mamíferos silvestres reportados para el APFF Metzabok denota la importancia de la mastofauna en poblaciones de la zona.

Sexual behavior of *Pecari tajacu* (Cetartiodactyla: Tayassuidae) during periovulatory and early gestation periods

Suleima do Socorro Bastos da Silva, Yvonnick Le Pendu, Otavio Mitio Ohashia, Eunice Oba, Natália Inagaki de Albuquerque, Alexandre Rossetto Garcia, Pedro Mayor, Diva Anelie de Araujo Guimarães

Behavioural Processes

The goal of this study was to describe the sexual behavior in female and male collared peccary. Twenty females and twelve males were monitored in familiar and non-familiar units for two 60 days periods. During both phases, we recorded 2747 sexual interactions initiated by 20 different females toward males and 4461 sexual interactions initiated by 12 males toward females. The frequency of sexual interactions initiated per female significantly increased from proestrus to estrus, and they were significantly more frequently courted. Females initiated olfactory inspections 15.42 times more and were mounted 22.6 times more during estrus than during proestrus. Nulliparous and primiparous females copulated only when exposed to non-parental males. After estrus, the frequency of sexual interactions received by females sharply decreased. One mating event was recorded during the first gestation week and 31 mountings were observed after the second week. In conclusion, the behavioral monitoring is a useful procedure for the recognition of estrus. Our results suggest that ovulation may be associated with the end of the estrus, which will support future work in assisted reproduction in this species. To promote good handling practices, females of reproductive age should be removed from their family unit of origin.

A camera trap assessment of terrestrial mammals in Machalilla National Park, western Ecuador

Laura Cervera, Diego J. Lizcano, Violeta Parés-Jiménez, Sueanny Espinoza, Diana Poaquiza, Enrique de la Montaña¹, Daniel M. Griffith

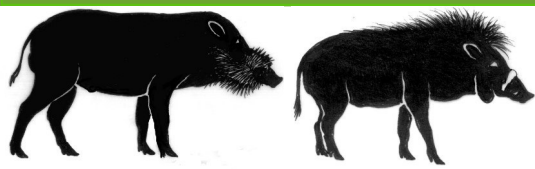
Checklist: the journal of the biodiversity data

Understanding the abundance, geographic distribution, and conservation status of terrestrial mammals is vital to promote effective wildlife management in protected areas. Located in the Tumbes-Chocó- Magdalena hotspot of western Ecuador, Machalilla National Park contains high levels of biodiversity and endemism but suffers from habitat loss and degradation. This study provides an updated inventory of medium sized to large mammals in the park and assesses changes in species richness over the past 20 years. Surveying 70% of Machalilla's 562-km² terrestrial area with 60 camera trap points, we detected 18 species of mammals belonging to 13 families. Richness of terrestrial species has declined in recent decades, due to the disappearance of keystone species like Jaguar (*Panthera onca*), White-lipped Peccary (*Tayassu pecari*), and possibly the Sechuran Fox (*Lycalopex sechurae*). We recommend specific management improvements to ensure conservation of the unique ecosystems and biodiversity of Machalilla, the only national park in Ecuador containing dry forest.

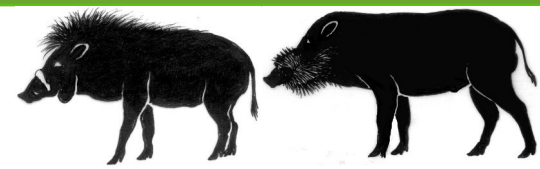
International Trade of Peccaries and Conservation Status

Marina Rosales Benites de Franco





New literature on Suiformes



Weber Earth Science & Environmental Engineering

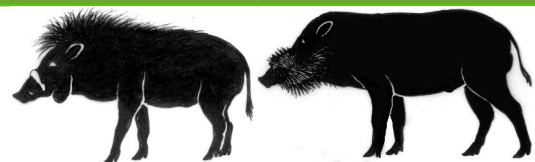
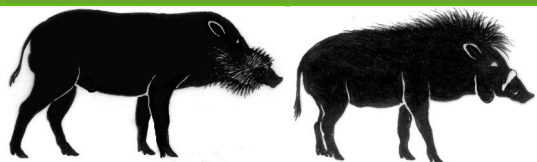
Pecari tajacu Linnaeus, 1758 "Collared Peccary" and *Tayassu pecari* Link, 1795 "White-lipped Peccary" populations of Peru have low ecological sustainability to maintain international trade of their skins from livelihood, subsistence hunting. This economic activity is not managed with sustainable approach. The international trade of their skins adversely affects its conservation status, considering also the cumulative effects caused by deforestation, pollution from mining and oil areas. It is important to recognize that peccary's populations and their habitats have not been managed in the field. It is proposed to categorize the Peruvian populations of *P. tajacu* and *T. pecari* in Vulnerable situation, manage subsistence hunting through areas of communal management in situ, promoting governance of indigenous and local populations and fill the gaps in their policies and management of these populations by regulations.

Importancia de las aguadas para el pecarí de labios blancos (*Tayassu pecari*) en la Selva Maya, Guatemala

José Fernando Moreira-Ramírez, Rafael Reyna-Hurtado, Mircea Hidalgo-Mihart, Eduardo Naranjo, Milton C. Ribeiro, Rony García-Anleu, Melvin Mérida, Gabriela Ponce-Santizo
Therya

El agua es considerada un nutriente esencial para la vida silvestre siendo un factor de bienestar y cuando no está en la proporción adecuada, puede ser un factor limitante para las poblaciones silvestres. Las diferencias en la dependencia del agua entre las especies de ungulados pueden surgir a través de la variedad de mecanismos fisiológicos, morfológicos y conductuales empleadas en el mantenimiento del equilibrio de la temperatura y el agua. El pecarí de labios blancos es un ungulado social que forma grupos grandes y cohesivos entre 10 a más de 300 individuos habitando en selvas tropicales densas. Nuestros objetivos fueron describir el uso de las aguadas por los grupos de pecarí de labios blancos en un sitio húmedo de la Selva Maya y evaluar el efecto que la humedad puede ejercer sobre la frecuencia de visita, tamaño de grupo y patrones de actividad. De junio a agosto del 2014 y de febrero a abril del 2015 fueron monitoreadas siete aguadas con trampas cámaras digitales. La frecuencia de visita fue estimada dividiendo el número de eventos entre el esfuerzo de muestreo por 1,000 trampas noche. El tamaño mínimo de grupo se estimó por cada evento independiente registrando adultos, subadultos y crías. Los patrones de actividad se estimaron en intervalos de una hora, para la época seca y lluviosa. Se obtuvieron 47 y 185 eventos independientes para la época lluviosa y seca, respectivamente. El esfuerzo de muestreo en cada época fue de 630 trampas noche. Para la época lluviosa y seca obtuvimos una frecuencia de visita de 74.6 y 293.7 respectivamente. Para la época lluviosa y seca se estimó un tamaño promedio de grupo de 17 (± 9.5) y 25.5 (± 12.6) respectivamente. Los grupos están compuestos principalmente por adultos. La presencia de crías se registró principalmente en agosto, marzo y abril. Los patrones de actividad se registraron principalmente entre las 10:00 h y 16:00 h.: La frecuencia de visita estimada es más alta comparada con otras áreas protegidas de la Selva Maya. El tamaño mínimo de grupo estimado es similar a los reportados en áreas secas dentro de la Selva Maya. La presencia de crías fue reportada durante todos los meses del estudio, existiendo picos en los meses de agosto, marzo y abril. El pecarí de labios blancos visitó las aguadas principalmente durante el día entre las 10:00 y 16:00 h. Las aguadas dentro del Parque Nacional Laguna del Tigre pueden ser denominadas "santuarios" para el pecarí de labios blancos ya que son sumamente importantes en la ecología de este ungulado social.





Papel de los mamíferos en los procesos de dispersión y depredación de semillas de *Mauritia flexuosa* (Arecaceae) en la Amazonía colombiana

Juan Fernando Acevedo-Quintero, Joan Gastón Zamora-Abrego

Revista de Biología Tropical

Mammals and palms are important elements of fauna and flora in the Neotropics, and their interactions, such as fruit consumption and seed dispersal, are one of the most important ecological relationships in these ecosystems. The main objective of this study was to identify the relative importance of mammals in the dispersal and predation of *Mauritia flexuosa* palm fruits. We installed camera-traps in front of palm fallen seeds and clusters with fruits. A catalog of species was prepared with the recorded videos and the foraging behaviors exhibited were classified and identified. In addition, two exclusion treatments with three repetitions each were used. In the semi-open treatment, a plot was fenced with metal mesh leaving four openings in order to allow access only to small and medium sized mammals, while in the open treatment, the small, medium and large sized mammals had free access. In both cases, seed removal was evaluated. We recorded a total of 19 species of mammals, nine of which fed on palm fruits and the other five were seed dispersers. We reported for the first time the consumption of *Mauritia flexuosa* fruits by *Atelocynus microtis*. The species with the highest relative importance was *Dasyprocta fuliginosa*, which showed the highest percentage of seed dispersal (63.5%) compared to the other species. *Tayassu peccary* was identified as an in situ consumer, eating 45.3% of seeds without dispersing them. The number of seeds consumed in situ in the open treatment showed significant differences regarding the semi-open treatment, suggesting greater involvement of large mammals in this process. In conclusion, the fruits of *M. flexuosa* are an important food source for the local mammal community. Additionally, the consumption of seeds under the canopy of the mother palm is proportionally greater than their dispersion. Generally, the pressure of frugivorous species over seeds may determine the reproductive strategies of plants. However, research on effective dispersion, dispersal distances and demographic impact should be conducted to determine the specific role of medium and large sized mammals in the ecology of this palm.

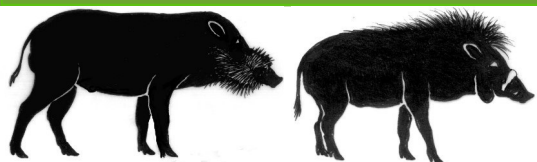
Distribución potencial de la Jagüilla (*Tayassu pecari*) en Honduras

Héctor Orlando Portillo Reyes, Fausto Elvir

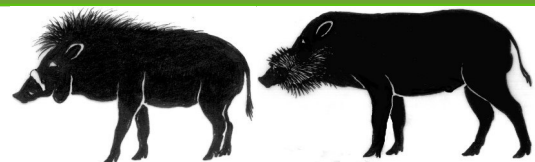
Revista Mexicana de Mastozoología (nueva época)

El conocimiento de la ecología de las poblaciones de Jagüilla (*Tayassu pecari*) en Honduras es limitada pese a ser una especie de suma importancia para los bosques tropicales. Se modeló su distribución potencial usando el programa MaxEnt 3.3.3a, para lo cual se utilizaron 16 registros de presencia y 19 variables bioclimáticas. El modelo predice una extensión territorial de 6,126 km², la mayor parte en el área protegida Reserva del Hombre y la Biósfera del Río Plátano (RHBRP), con aproximadamente el 70 % del territorio potencial de distribución (4,288 km²), un 20 % (1,225 km²) en los territorios indígenas de Rus Rus, Mocerón y Warunta y un 10 % (613 km²) en la Reserva de la Biósfera Tawahka Asagni. Su mayor extensión geográfica se localiza en el departamento de Gracias a Dios, en el bosque latifoliado con aproximadamente el 95 % del territorio y el 5% entre los departamentos de Colón y Olancho. Esta especie ha perdido desde los años 1900 a la fecha, el 81.2 % de su hábitat representado en el bosque húmedo tropical, el cual tuvo una extensión territorial histórica de 26,378 km². El cambio de uso de suelo, la





New literature on Suiformes



fragmentación del hábitat y la cacería son las principales causas de su decline. Actualmente el área potencial de distribución para *T. pecari* en Honduras cuenta con las características bioclimáticas e hidrográficas óptimas para la viabilidad de sus poblaciones. Es urgente tomar medidas de conservación para el sitio y la especie, debido a que su función ecológica como dispersor de semillas y especie presa para los altos depredadores son imprescindibles para la continuación de los procesos en el sostenimiento de los bosques primarios en la región de la Moskitia Hondureña.

Anotaciones sobre distribución y estado de conservación de los cerdos de monte *Pecari tajacu* y *Tayassu pecari* (Mammalia: Tayassuidae) para el departamento de Córdoba, Colombia

Erika Humanez-López, Javier Racero-Casarrubia, Andrés Arias-Alzate

Mammalogy Notes: Notas Mastozoológicas

En esta nota presentamos anotaciones acerca de la distribución y estado de conservación de los cerdos de monte (*Pecari tajacu* y *Tayassu pecari*) para el departamento de Córdoba, Colombia. Aportamos registros recientes y consolidamos la información disponible de las especies y resaltamos la importancia de la zona sur de este departamento (Parque Nacional Natural Paramillo) como área de vital importancia para su conservación

El Pecarí de labios blancos: símbolo de una vida social dentro de los bosques tropicales

Edwin Hernández-Pérez, José Fernando Moreira-Ramírez, Rafael Reyna-Hurtado

Biodiversitas

5:00 a.m. Fue una madrugada fría en la Reserva de la Biosfera Calakmul en Campeche. Los sonidos de la selva atenuaban la oscuridad que poco a poco empezaba a esfumarse. El equipo de El Colegio de la Frontera Sur (ecosur) ya estaba preparado para tomar un rápido desayuno, para después internarnos en la selva y caminar durante horas hasta llegar a las aguadas (cuerpos de agua superficiales frecuentados por la fauna, sobre todo durante la época seca), donde se esperaba que la especie llegaría a refrescarse con el vital líquido. 8:00 a.m. Llegamos a una aguada, buscamos un árbol alto que nos permitiera tener una visión panorámica para observar el arribo de algún grupo de pecarí de labios blancos. Habíamos pasado ya cuatro horas sobre aquel árbol, hasta que se empezaron a escuchar ruidos de algún animal en la lejanía... No pasó mucho tiempo para confirmar que eran ellos; los pecaríes de labios blancos entraban a la aguada con su peculiar formación en línea. Fue un momento maravilloso y confortable. Fue la primera vez que vi a esta magnífica especie y pude entender el motivo por el cual investigadores de ecosur han invertido más de diez años en estudiar esta especie en el sur de México.

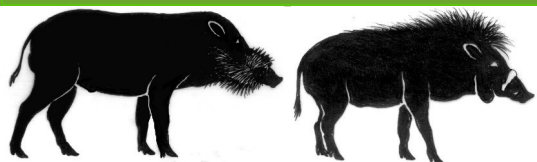
Interactions between terrestrial mammals and the fruits of two neotropical rainforest tree species

Angela A. Camargo-Sanabria, Eduardo Mendoza

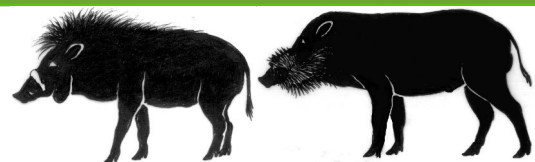
Acta Oecologica

Mammalian frugivory is a distinctive biotic interaction of tropical forests; however, most efforts in the Neotropics have focused on cases of animals foraging in the forest canopy, in particular primates and bats. In contrast much less is known about this interaction when it involves fruits deposited on the forest floor and terrestrial mammals. We conducted a camera-trapping survey to analyze the characteristics of the mammalian ensembles visiting fruits of *Licania platypus* and





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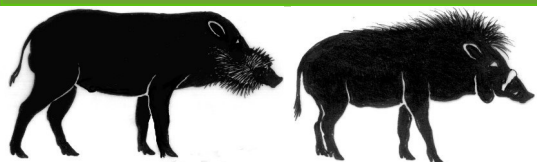
Pouteria sapota deposited on the forest floor in a well preserved tropical rainforest of Mexico. Both tree species produce large fruits but contrast in their population densities and fruit chemical composition. In particular, we expected that more species of terrestrial mammals would consume *P. sapota* fruits due to its higher pulp:seed ratio, lower availability and greater carbohydrate content. We monitored fruits at the base of 13 trees (*P. sapota*, $n = 4$ and *L. platypus*, $n = 9$) using camera-traps. We recorded 13 mammal species from which we had evidence of 8 consuming or removing fruits. These eight species accounted for 70% of the species of mammalian frugivores active in the forest floor of our study area. The ensemble of frugivores associated with *L. platypus* (6 spp.) was a subset of that associated with *P. sapota* (8 spp). Large body-sized species such as *Tapirus bairdii*, *Pecari tajacu* and *Cuniculus paca* were the mammals more frequently interacting with fruits of the focal species. Our results further our understanding of the characteristics of the interaction between terrestrial mammalian frugivores and large-sized fruits, helping to gain a more balanced view of its importance across different tropical forests and providing a baseline to compare against defaunated forests.

Buffer zone use by mammals in a Cerrado protected area

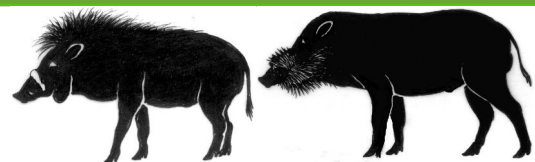
Roberta Montanheiro Paolino, Natalia Fraguas Versiani, Nielson Pasqualotto, Thiago Ferreira Rodrigues, Victor Gasperotto Krepschi, Adriano Garcia Chiarello
Biota Neotropica

Habitat loss and degradation is threatening mammals worldwide. Therefore, Protected Areas (PA) are of utmost importance to preserve biodiversity. Their effectiveness, however, depends on some management strategies such as buffer zones, which prevent/mitigate the impact of external threats and might increase the amount of available habitat for wildlife existing within reserves. Nevertheless, how intensively terrestrial mammals use buffer zones remains little studied, particularly in the Neotropical region. Aiming to analyse the use of a buffer zone (5 km wide) by medium and large-sized mammals, we modelled the occupancy probabilities of five species of conservation concern including local (interior and buffer zone) as a site covariate, simultaneously controlling for imperfect detection. Data collection was made with camera traps from April to September 2013 in a 9000 ha Cerrado PA ("interior") and in its surrounding area (39721.41 ha; "buffer zone"). This PA (Jataí Ecological Station) is immersed in a landscape where sugarcane plantations predominate in the northeastern of the state of Sao Paulo. We also conducted an inventory to compare the number and composition of species between interior and buffer zone. A total of 31 mammal species (26 natives) was recorded via camera traps and active search for sightings, vocalizations, tracks and signs. Occupancy estimates for *Myrmecophaga tridactyla*, *Leopardus pardalis* and *Pecari tajacu* were numerically higher in interior. On the other hand, *Chrysocyon brachyurus* had the highest occupancy in buffer zone, while the largest predator, *Puma concolor*, used both areas similarly. However, as the confidence intervals (95%) overlapped, the differences in occupancy probabilities between interior and buffer were weak for all these species. Additionally, regarding only the species recorded by cameras, the observed and estimated richness were similar between interior and buffer zone of the PA. Our data demonstrated that the buffer zone is indeed used by medium and large-sized mammals, including conservation-dependent ones. The lack of enforcement of current legislation regarding buffer zones is therefore a real threat for mammals, even when protection is guaranteed in the interior of protected areas





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Implications of climatic seasonality on activity patterns and resource use by sympatric peccaries in northern Pantanal

Gabriel Selbach Hofmann, Igor Pfeifer Coelho, Vinicius Augusto Galvão Bastazini, José Luís Passos Cordeiro, Luiz Flamarion Barbosa de Oliveira

International Journal of Biometeorology

We evaluated the effects of climate seasonality from a thermal and water availability perspective on the activity patterns and resource use of *Pecari tajacu* and *Tayassu pecari* during wet and dry seasons in the northeastern Brazilian Pantanal. We used camera traps and temperature sensors to record species activity patterns in relation to temperature, established five habitat categories based on flooding intensity and local vegetation characteristics, assessed the activity patterns of each species in dry and wet periods and in artificial water bodies using circular statistical metrics, and calculated niche amplitude and overlap on three axes (temperature, time, and habitat) in both periods. Peccaries shared a strong resemblance in resource use and in their responses to seasonal variations in the tested gradients. The activity patterns of both species exhibited a significant correlation with air temperature on all the evaluated measures, and both species strongly reduced their activity when the air temperature exceeded 35 °C. High temperatures associated with low water availability were most likely responsible for the changes in species activity patterns, which resulted in an increased temporal overlap in habitat use throughout the dry season. However, the peccaries avoided intensively flooded habitats; therefore, the habitat gradient overlap was greater during the wet period. Our results show that an increase in niche overlap on the environmental gradient as a result of climatic seasonality may be partially compensated by a reduction in other niche dimensions. In this case, temporal partitioning appears to be an important, viable mechanism to reduce competition by potentially competing species.

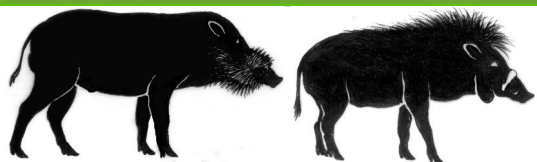
Spatial ecology of a herd of white-lipped peccaries (*Tayassu pecari*) in Belize using GPS telemetry: challenges and preliminary results

Maarten P. G. Hofman, Johannes Signer, Matthew W. Hayward, Niko Balkenho

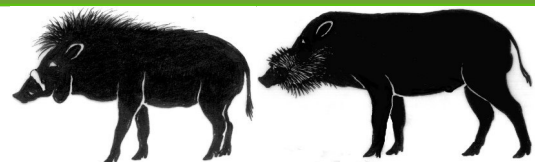
Therya

The Maya Mountains are a heavily forested mountain range in Belize and Guatemala supporting high levels of biodiversity. Due to environmental degradation around the range, it is in danger of becoming isolated from the largest contiguous forest in Central America. Forest connectivity in the area is vital for white-lipped peccaries. These social ungulates roam in herds of up to 300 individuals and need large forested areas to sustain populations. The species has not previously been studied in Belize and its distribution, population size, herd dynamics and movement patterns are unknown for the country. We aimed to estimate home range size and investigate movement patterns of the species in southern Belize. We present a preliminary 4-month data set from a herd of ca. 60 animals tracked by an individual fitted with a GPS satellite collar. We evaluated collar performance, habitat preference and movement characteristics, and estimated home range size using a semi-variogram approach, suited for sparse and irregular data. Collar performance was poor, with 38 % of the data not reaching the satellite, and a GPS fix success rate of 11.6 % for the data that did reach the satellite. The semivariogram home range size was 55.2 km². We observed a maximum daily movement distance of 3.8 km, and a preferential use of forest habitat over shrubland, savannah and cropland. We calculated a density of 1.09 ind/km² and make an informed guess of close to 100 herds in the broad-leaf forests of the Maya Mountains. Our study





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highlights some of the challenges faced when collaring white-lipped peccaries, as well as the performance of GPS-collars in tropical forests. It also provides a first glimpse of the home range and movement behaviour of white-lipped peccaries in Belize.

Wild meat: a shared resource amongst people and predators

R. J. Foster, B. J. Harmsen, D. W. Macdonald, J. Collins, Y. Urbina, R. Garcia, C. P. Doncaster
Oryx

Millions of people throughout the tropics consume wild meat. Overhunting reduces food security for people and large predators, yet little is known of the impact of hunting in systems where people and predators target the same prey species. We collate published data on predator diet in Belize with interview data about the consumption of wild and domestic meat by Belizeans, to compare the wild-meat diets of humans, jaguars *Panthera onca* and pumas *Puma concolor* and assess the sustainability of the combined offtake by humans and jaguars. Six wild mammal species (nine-banded armadillo *Dasypus novemcinctus*, paca *Cuniculus paca*, collared peccary *Pecari tajacu*, white-lipped peccary *Tayassu pecari*, red brocket deer *Mazama americana* and white-tailed deer *Odocoileus virginianus*) comprised 7% of the animal-protein meals eaten by Belizeans. Overall, 80% of these meals were eaten by 20% of interviewees, suggesting a necessary role of wild meat for the minority. The same species were found in 69 and 86% of jaguar and puma scats, respectively. We estimate a national annual harvest of c. 4,000 tonnes of these six wild mammals by humans and jaguars, of which 78% is hunted by people. Sustainability is difficult to evaluate because prey population data are lacking in Belize. However, simple models suggest that a sustainable harvest at this rate would require higher prey population densities than averages recorded in hunted Neotropical forests. We emphasize the need for robust regional estimates of game species densities, to improve assessments of sustainability and inform hunting regulations. We recommend that the requirements of predators as well as those of people be considered when assessing wild meat harvests.

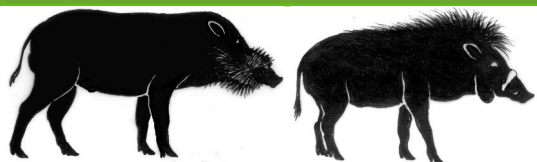
The Application of Occupancy Modeling to Evaluate the Determinants of Distribution of Jaguars *Panthera onca*, Pumas *Puma concolor*, and Valued Prey Species in a Protected Area

Holly Booker

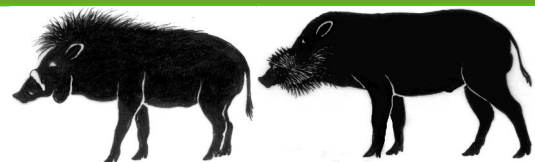
Tesis de maestría de la University of Waterloo, Canadá

In the past four decades, both biodiversity and individual populations of numerous species in the tropics have consistently declined. Tropical forests constitute only 6% to 7% of the Earth's surface, yet they contain more than half of all species richness, making them a significant reservoir for global biodiversity. Maintaining healthy populations of both predators and prey in the tropics is therefore crucial for supporting dynamic ecosystems and for preserving biodiversity. As apex predators, jaguars *Panthera onca* and pumas *Puma concolor* play a critical role in helping to support dynamic tropical ecosystems. Correspondingly, prey species of value to these felids are equally important. Ecological models have become valuable tools for facilitating an understanding of how species distribution is influenced by natural landscape variables and anthropogenic factors. The objectives of this study were to utilize hierarchical occupancy modeling to assess if jaguars, pumas, and valued prey species (brocket deer *Mazama* sp., white-tailed deer *Odocoileus virginianus*, collared peccary *Pecari tajacu*, white-lipped peccary *Tayassu pecari*, lowland paca *Cuniculus paca*, Central American agouti *Dasyprocta punctata*, and white-nosed coati *Nasua*





New literature on Suiformes



narica) are non-randomly distributed across the Calakmul Biosphere Reserve in Campeche, Mexico, and how natural and anthropogenic features are influential in shaping this distribution. Because felid distribution is thought to largely depend on prey availability, latent occupancy estimates for focal prey were also incorporated into occupancy models for jaguars and pumas. Spoor sampling was conducted using line transects in four survey areas throughout the core and buffer zone of the reserve from June 25th to August 8th, 2013. Detection histories for focal species were utilized for occupancy modeling that was completed in the 'unmarked' package in R. It was determined that distribution was random for brocket and white-tailed deer species, was largely random for collared peccary, and non-random for white-lipped peccary, large prey as a group, and medium prey species collectively. Model averaged occupancy of collared peccary was 30% higher than it was for white-lipped peccary and occupancy was weakly associated with increasing tree species richness. White-lipped peccary occupancy was lower in areas with decreased tree species richness and diminished total basal area, likely corresponding to disturbed habitat. Occupancy of large prey as a collective group had a weak negative association with proximity to water (aguadas specifically). A weak association of site (survey area) was found for occupancy of medium prey collectively, as models exhibited higher occupancy estimates for the survey areas located in the core zone of the CBR, which is an area intended to be free of disturbance. Distribution of jaguars and pumas was found to be primarily influenced by occupancy of brocket deer and medium prey species. There was also a weak negative association with proximity to an aguada. Results from this study reinforce the need for evaluating tropical species occupancy, as understanding the factors that are influential in determining distribution is quite complex. Due to the troubling status of jaguars and pumas, understanding how landscape variables, as well as prey occupancy, influences their distribution is of utmost importance to ensure that critical habitat is protected and/or restored and that human-wildlife conflicts are minimized. This study is the first to explicitly integrate both landscape variables and latent occupancy of prey species as covariates in occupancy models for jaguars and pumas and it adjoins only a handful of studies that model occupancy of the focal species in Mexico.

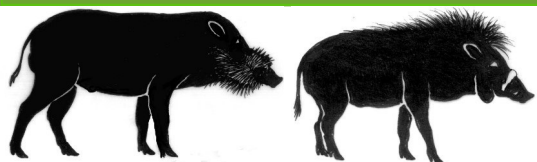
Large carnivore occupancy and human-wildlife conflict in Panamá

Fort, Jessica L.

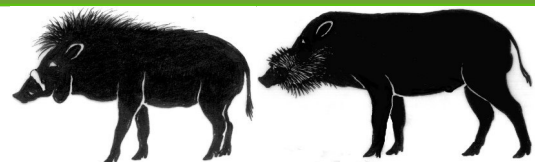
Tesis de maestría de la Southern Illinois University at Carbondale

Although Panamá is an important global hotspot for biodiversity, basic information on large carnivore and prey distributions as well as habitat needs is largely unknown. Wildlife studies in Panamá have been limited to populations located in protected areas along the Panamanian Atlantic Mesoamerican Biological Corridor (PAMBC) and have not considered potentially important refuge habitats located outside the PAMBC. Further, research on human attitudes and perceptions associated with large carnivores, such as jaguars (*Panthera onca*), is limited in Panamá. My study was conducted in 2 disparate study areas: Cerro Hoya National Park (CHNP), an isolated remnant of tropical rainforest habitat 125 km from the PAMBC that straddles the Veraguas and Los Santos provinces on the Azuero Peninsula; and Serranía de Pirre (SP), a comparative study area in the PAMBC located in Darién National Park (DNP). I used remote cameras to investigate patterns of site occupancy and detection probabilities, as affected by habitat and anthropogenic influences, for 3 species of felids (jaguars, pumas [*Puma concolor*], and ocelots [*Leopardus pardalis*]) and 2 species of peccaries (white-lipped [*Tayassu pecari*] and collared [*Pecari tajacu*]). In addition, I assessed attitudes and perceptions of rural Panamanians





New literature on Suiformes



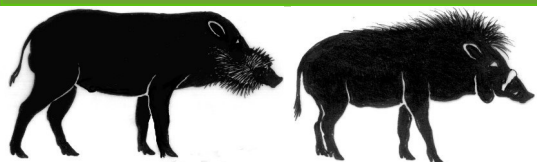
about jaguars and the conservation of CHNP and DNP via oral surveys. Site occupancy did not appear to differ between study areas for any felid or peccary, but detection frequencies and detection probabilities of focal species were overall higher in SP than CHNP. For collared peccaries, probability of detection was a function of survey year, study area, and Julian date, and estimated occupancy was higher in CHNP than SP. For ocelots, probability of detection was significantly higher in SP than CHNP when an ocelot was detected in a previous occasion. For pumas, detection increased with Julian date in CHNP but was seasonally unaffected in SP. Puma occupancy was higher closer to river systems. For jaguars, detection probability decreased with Julian date, increased with number of camera days per occasion, and was higher in SP than CHNP. Jaguars were more likely to use habitat at higher elevations in both study areas. White-lipped peccaries were never detected in CHNP, which may indicate their local extirpation in this region of Panamá. Regarding surveys measuring perceptions of rural people, factors such as gender, level of education, land ownership, and number of cattle affected knowledge and attitudes towards jaguars and criticism towards park management. Additionally, there was a higher frequency of human-jaguar conflict in SP than CHNP and coyotes (*Canis latrans*) were the most commonly reported threat to livestock in CHNP. My research elucidates previously unknown distribution limits of jaguars and coyotes in the Azuero Peninsula, as well as providing evidence for the potential local extirpation of white lipped peccaries in CHNP. I provide wildlife managers with improvements for survey design of future occupancy studies in the Neotropics. Further, my research provides targeted areas to prioritize for future wildlife conservation efforts and mitigation efforts concerning human-jaguar conflict.

The Role of Grunt Calls in the Social Dominance Hierarchy of the White-Lipped Peccary (Mammalia, Tayassuidae)

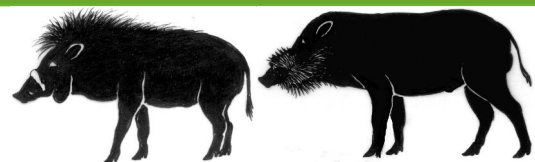
Selene S. C. Nogueira, Christini B. Caselli, Thaise S. O. Costa, Leiliany N. Moura, Sérgio L. G. Nogueira-Filho
PlosOne

Grunt-like calls are present in the vocal repertoire of many group-living mammals and seem to facilitate social interactions between lower and higher-ranking members. The whitelipped peccary (*Tayassu pecari*) lives in stable hierarchical mixed-sex groups and like nonhuman primates, usually emits grunt-like calls following aggressive interactions, mainly during feeding contexts. We investigated the possible functions of peccaries' grunt-like calls and their relationship to the individuals' social rank, identity, and sexual dimorphism. We observed that low-ranking individuals emitted grunt-like calls more often than high-ranking ones, and that the alpha male never emitted this vocalization. Moreover, the mean minimum frequency of grunt-like calls decreased as the peccary's rank increased. The findings revealed differences among individual grunts, but the low accuracy of cross-validation (16%) suggests that individual recognition in peccaries may be less important than an honest signal of individual social status. In addition, the absence of differences in the acoustic parameters of grunt-like calls between males and females points to the lack of sexual dimorphism in this species. We verified that after hearing grunt calls, dominant opponents were more likely to cease attacking a victim, or at least delay the continuation of conflict, probably decreasing the severity of agonistic interactions. Our findings are particularly important to improve the current understanding of the role of grunt-like calls in herd-living mammals with linear dominant hierarchies, and strongly suggest that they are involved in the maintenance of herd social stability and cohesion





New literature on Suiformes



Distributional patterns of living ungulates (Mammalia: Cetartiodactyla and Perissodactyla) of the Neotropical region, the South American transition zone and Andean region

Bruno Araujo Absolon, Valéria Gallo, Leonardo S. Avilla

Journal of South American Earth Sciences

To recognize the distributional patterns of living ungulates in the Neotropical region, the South American transition zone, and Andean region using the panbiogeographical method of track analysis, and to attempt to correlate these patterns with geological history. The distribution of 24 species of living ungulates (in the families Camelidae, Cervidae, Tapiridae and Tayassuidae) was studied by the panbiogeographical method of track analysis. It was performed using distributional data acquired from literature and databases of scientific institutions. Individual tracks were obtained for each species by plotting locality records on maps and connecting them by minimum-spanning trees. Generalized tracks were determined from the spatial overlap between individual tracks, indicating a common history. The intersection between generalized tracks defined a biogeographic node, implying that these locations are biogeographic composites resulting from different ancestral biotas coming into spatial contact, possibly at different geologic times. The superposition of the 24 individual tracks resulted in five generalized tracks (GTs): GT1, Mesoamerican/Choco (composed of *Mazama pandora*, *Mazama temama*, *Odocoileus virginianus* and *Tapirus bairdii*); GT2, Northern Andes (*Mazama rufina*, *Pudu mephistophiles* and *Tapirus pinchaque*); GT3, Central Andes (*Hippocamelus antisensis*, *Lama guanicoe*, *Mazama chunyi* and *Vicugna vicugna*); GT4, Chilean Patagonia (*Hippocamelus bisulcus* and *Pudu puda*); and GT5, Chaco/Central west Brazil (*Blastocerus dichotomus*, *Catagonus wagneri* and *Ozotocerus bezoarticus*). The biogeographic node was found in the Northwestern Colombia. The geological events such as tectonism and volcanism that occurred through the Neogene and mainly in the Pleistocene caused fragmentation, diversification and endemism of biota. The biogeographic node in Colombia occurred within a zone of convergence. This node emphasized the complexity of the area and it contains biotic elements with different origins, which represent a special condition for the establishment of priority conservation areas.

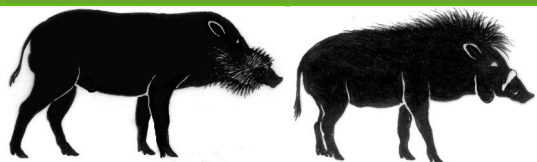
New records of the Endangered Chacoan peccary *Catagonus wagneri* suggest a broader distribution than formerly known

Ricardo Torres, Daniela Tamburini, Julián Lescano, Enzo Rossi

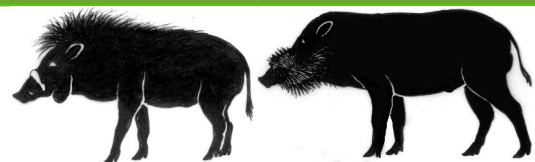
Oryx

The Chacoan peccary *Catagonus wagneri* is the rarest and most threatened of the three extant species of peccary. Its presence has been recorded in the northern Dry Chaco ecoregion, which spans northern Argentina, western Paraguay and south-eastern Bolivia. However, distribution models based on its occurrence in Argentina have predicted that suitable habitat extends southwards into central Argentina, where the species was not previously recorded. We present several records of the species outside the currently accepted distribution, including the first two records in the west of Córdoba province, > 650 km south of the southern limit of the previously known distribution. The discovery of the Chacoan peccary in central Argentina could serve as a justification for the protection of Chacoan forests in this region, where deforestation rates are among the highest worldwide.





New literature on Suiformes



Do protected areas in Panama support intact assemblages of ungulates?

Ninon F.V. Meyer, Ricardo Moreno, Edgar Sanches, Josue Ortega, Elliot Brown, Patrick A. Jansen
Therya

Ungulates play an essential role in terrestrial ecosystems, but suffer from hunting and habitat degradation which often results in their decline. Panama harbors five species of ungulate and is an important portion of the Mesoamerican Biological Corridor, but its forest habitat and its fauna are currently threatened. Protected areas have been designated to preserve the biodiversity, but studies evaluating their effectiveness in maintaining ungulates are lacking in Panama. In this study we used camera-trapping surveys to determine the occurrence and abundance of the ungulate species in 13 protected areas across Panama. There were large differences in the ungulate communities among the sites we surveyed. Some sites were impoverished with just one ungulate species recorded while just a single site harbored all five species. The white-lipped peccary was the rarest species and the collared peccaries the most common, captured in all the sites. Moreover, we found large variation in ungulate abundance across the sites. Our results indicate that few protected areas in Panama effectively maintain the entire assemblage of ungulate species.

Age structure of the Vulnerable white-lipped peccary *Tayassu pecari* in areas under different levels of hunting pressure in the Amazon Forest

Rossano Marchetti Ramos, Juarez C. B. Pezzuti, Emerson M. Vieira
Oryx

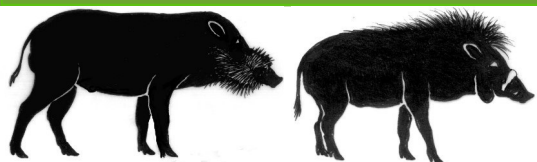
Subsistence hunting can change the demographic structure of wild mammal populations, increasing the proportion of young animals, inducing females to reproduce early and increasing litter sizes. We examined the relationship between hunting pressure and age structure in the Vulnerable white-lipped peccary *Tayassu pecari*, analysing the distribution of age classes at seven sites in the region Terra do Meio in the Brazilian Amazon. These sites differ in the number of human inhabitants and hence were subject to differing hunting pressures. We completed semistructured interviews with local people to assess the importance of hunting and of the white-lipped peccary as food. We also estimated the age of hunted white-lipped peccaries by assessing tooth eruption and tooth wear in skulls of hunted individuals. Our results indicated that the white-lipped peccary was the most frequently hunted terrestrial animal in the region. Fishing, followed by hunting, provided the main sources of animal protein. Our data suggest there is no relationship between age structure and hunting at the study sites. The social structure and mobility of white-lipped peccaries seem to minimize the effects of hunting on age structure. Our results, similar to previous studies, show that the age structure of the white-lipped peccary is robust to hunting impacts. Other factors may have stronger effects on age structure than subsistence hunting. We suggest that deforestation may explain the prevalence of older individuals in peccary populations to the north of our study sites.

Abundance, herd size, activity pattern and occupancy of ungulates in Southeastern Mexico

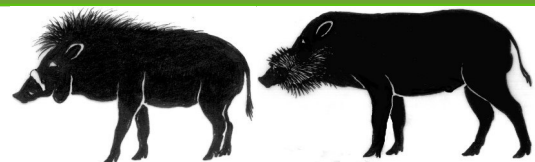
Gabriela Pérez-Irineo, Antonio Santos-Moreno
Animal Biology

This study provides information about relative abundance, herd size, activity pattern, and





New literature on Suiformes



occupancy of ungulates at Los Chimalapas, southeastern Mexico, one of the last refuges inhabited by two conservation priority ungulate species: *Tapirus bairdii* and *Tayassu pecari*. For three years, four species of ungulates were recorded using camera traps: *T. bairdii*, *T. pecari*, *Mazama temama*, and *Tayassu tajacu*, involving an effort of 8529 trap-days and 839 records. *T. pecari* was found to be highest in relative abundance, while *T. tajacu*'s abundance was lowest. Populations were composed principally of adults, but there were records of offspring for all four species. The herd size was smaller compared to other populations of *T. tajacu* and *T. pecari*. Occupancy models were used to analyze the presence of the species in the region and showed that *M. temama* and *T. bairdii* had a high occupancy probability. In comparison, the occupancy probability *T. pecari* was low. This study shows that ungulate populations are still breeding, and have higher possibility of permanence, in Los Chimalapas, Southeastern Mexico. The region is an important area for the conservation of *T. bairdii* and *T. pecari*, both disappeared from some other areas of the southeast.

Declining population of the Vulnerable common hippopotamus *Hippopotamus amphibius* in Bénoué National Park, Cameroon (1976–2013): the importance of conservation presence

Paul Scholte, Emmanuel Iyah

Oryx

Populations of the common hippopotamus *Hippopotamus amphibius* have undergone widespread decline as a result of habitat conversion and hunting for bushmeat and, increasingly, for ivory. North Cameroon holds important populations of large mammals, including the hippopotamus. The species' status and population trend are poorly known, and led CITES to suspend trade in hippopotamus trophies in 2013. Using the methodology of surveys conducted during 1976–1987, we conducted counts of the hippopotamus in Bénoué National Park during the wet season of 2011 and dry season of 2013, and drew on unpublished biannual density counts conducted by the Garoua Wildlife College, Cameroon, during 1989–2010. Counts along the 100 km stretch of the Bénoué River in the Park indicated a reduction from 400 individuals in 1987 to 188 in 2013. However, linear densities along a 15–32 km stretch in proximity to the Park headquarters and two tourist camps were constant during 1976–2013 (c. 3.7 individuals km⁻¹). Hippopotamus distribution was negatively associated with the presence of the camps of gold diggers, which occupied the northern half of the Park. Observations of antelopes suggested they had a comparable distribution, unlike primates, which were distributed relatively evenly. Our results show the importance of year-round conservation presence in the Park, which could be achieved with adequate personnel, a functional road system, and reinforcement of operations in neighbouring sport-hunting areas.

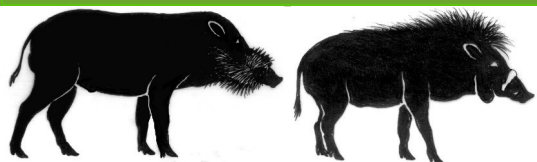
The Effect of Reduced Water Availability in the Great Ruaha River on the Vulnerable Common Hippopotamus in the Ruaha National Park, Tanzania

Claudia Stommel, Heribert Hofer, Marion L. East

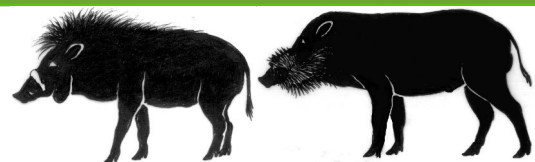
PlosOne

In semi-arid environments, 'permanent' rivers are essential sources of surface water for wildlife during 'dry' seasons when rainfall is limited or absent, particularly for species whose resilience to water scarcity is low. The hippopotamus (*Hippopotamus amphibius*) requires submersion in water to aid thermoregulation and prevent skin damage by solar radiation; the largest threat to its viability are human alterations of aquatic habitats. In the Ruaha National Park (NP), Tanzania, the





New literature on Suiformes



Great Ruaha River (GRR) is the main source of surface water for wildlife during the dry season. Recent, large-scale water extraction from the GRR by people upstream of Ruaha NP is thought to be responsible for a profound decrease in dry season water-flow and the absence of surface water along large sections of the river inside the NP. We investigated the impact of decreased water flow on daytime hippo distribution using regular censuses at monitoring locations, transects and camera trap records along a 104km section of the GRR within the Ruaha NP during two dry seasons. The minimum number of hippos per monitoring location increased with the expanse of surface water as the dry seasons progressed, and was not affected by water quality. Hippo distribution significantly changed throughout the dry season, leading to the accumulation of large numbers in very few locations. If surface water loss from the GRR continues to increase in future years, this will have serious implications for the hippo population and other water dependent species in Ruaha NP.

Good news from north-central Africa: largest population of Vulnerable common hippopotamus *Hippopotamus amphibius* is stable

Paul Scholt, Francis Nguimkeng, Emmanuel Iyah
Oryx

North-central Africa (i.e. Cameroon, the Central African Republic and Chad) once held important populations of large mammals, including the hippopotamus *Hippopotamus amphibius*. Exports of hippopotamus trophies from Cameroon were suspended in 2012 but the species' status and population trends remain poorly known. Using the same methodology as in 2000 and 2008, we counted hippopotamuses in Faro National Park and bordering hunting zones in 2014. We counted 685 individuals along 97 km of river, compared with 647 and 525 in 2000 and 2008, respectively. The stability of this population contrasts with the declines in populations of large mammals across north-central Africa. We attribute this conservation success to private efforts (i.e. safari hunting) compensating for a decline in state protection. However, the situation remains fragile, as highlighted by an influx of transhumant cattle and gold diggers. We recommend increasing public-private conservation efforts, including incentives for the safari hunting industry, which is also under pressure.

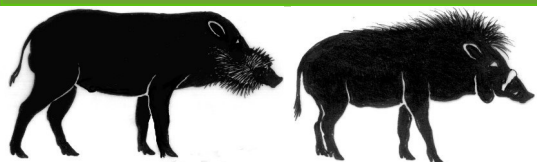
Ecological behaviour of common hippopotamus (*Hippopotamus amphibius*, LINNAEUS, 1758) in Boye wetland, Jimma, Ethiopia

Sefi Mekonen, Birnesh Hailemariam

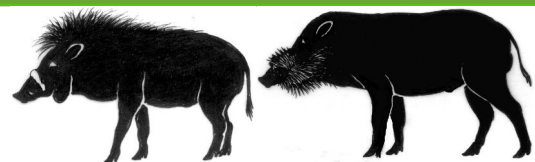
American Journal of Scientific and Industrial Research

A study on the ecological behaviour of hippopotamus (*Hippopotamus amphibius*) was conducted in Boye wetland between February and May, 2013. The behavioural activity and event patterns were studied with 30 minutes interval following a male and female focal sampled individual. The feeding preferences of hippopotamuses determined by collecting and identifying the plant species that consumed by hippopotamus. Resting comprises the majority of their activity time with 42.50% followed by moving 34.16%, feeding 19.63% and mating 3.71%. Barking and yawning events spent 51.18% and 48.82% of their time respectively. Males spent more time only in resting records than females, while females were active in all behavioural activity and event patterns except mating activity. Feeding and moving peak activities were observed early morning and late afternoon hours with resting peak during the mid-day, while barking and yawning events were mostly increased to afternoon both in male and female hippopotamus. Hippopotamus consumed





New literature on Suiformes



a total of 26 species of plant. Of these, *Eriochloa fatmensis* 11.68%, *Typha latifolia* 9.91%, *Echinochloa pyramidalis* 9.59% and *Cynodon dactylon* 8.45% were the top four species of plants contributing 39.63% of their overall diet.

A non-linear mathematical model for a three species ecosystem: Hippos in Lake Edward

Mauro Bologna, Kristopher J. Chandía, J.C. Flores

Journal of Theoretical Biology

In this work we study a non-linear mathematical model based on three different interacting species. We apply our model to Lake Edward ecosystem consisting in hippos, tilapia fishes and human inhabitants. In this case, we estimate the values of the key parameters using actual data and show the reliability of the proposed model as a predictive tool. We also show, via numerical calculations and parameter values that the ecosystem associated to the lake is very far from reaching a stable equilibrium. Through our analysis we provide the conditions for a possible coexistence among the three species.

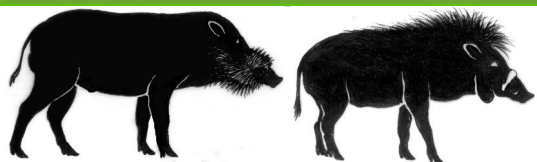
Assessing the role of large herbivores in the structuring and functioning of freshwater and marine angiosperm ecosystems

Elisabeth S. Bakker, Jordi F. Pagès, Rohan Arthur, Teresa Alcoverro

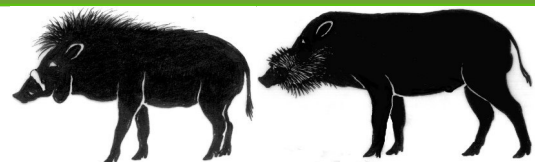
Ecography

While large herbivores can have strong impacts on terrestrial ecosystems, much less is known of their role in aquatic systems. We reviewed the literature to determine: 1) which large herbivores (> 10 kg) have a (semi-)aquatic lifestyle and are important consumers of submerged vascular plants, 2) their impact on submerged plant abundance and species composition, and 3) their ecosystem functions. We grouped herbivores according to diet, habitat selection and movement ecology: 1) Fully aquatic species, either resident or migratory (manatees, dugongs, turtles), 2) Semi-aquatic species that live both in water and on land, either resident or migratory (swans), 3) Resident semi-aquatic species that live in water and forage mainly on land (hippopotamuses, beavers, capybara), 4) Resident terrestrial species with relatively large home ranges that frequent aquatic habitats (cervids, water buffalo, lowland tapir). Fully aquatic species and swans have the strongest impact on submerged plant abundance and species composition. They may maintain grazing lawns. Because they sometimes target belowground parts, their activity can result in local collapse of plant beds. Semi-aquatic species and turtles serve as important aquatic-terrestrial linkages, by transporting nutrients across ecosystem boundaries. Hippopotamuses and beavers are important geomorphological engineers, capable of altering the land and hydrology at landscape scales. Migratory species and terrestrial species with large home ranges are potentially important dispersal vectors of plant propagules and nutrients. Clearly, large aquatic herbivores have strong impacts on associated species and can be critical ecosystem engineers of aquatic systems, with the ability to modify direct and indirect functional pathways in ecosystems. While global populations of large aquatic herbivores are declining, some show remarkable local recoveries with dramatic consequences for the systems they inhabit. A better understanding of these functional roles will help set priorities for the effective management of large aquatic herbivores along with the plant habitats they rely on.





New literature on Suiformes



Preventing crop raiding by the Vulnerable common hippopotamus *Hippopotamus amphibius* in Guinea-Bissau

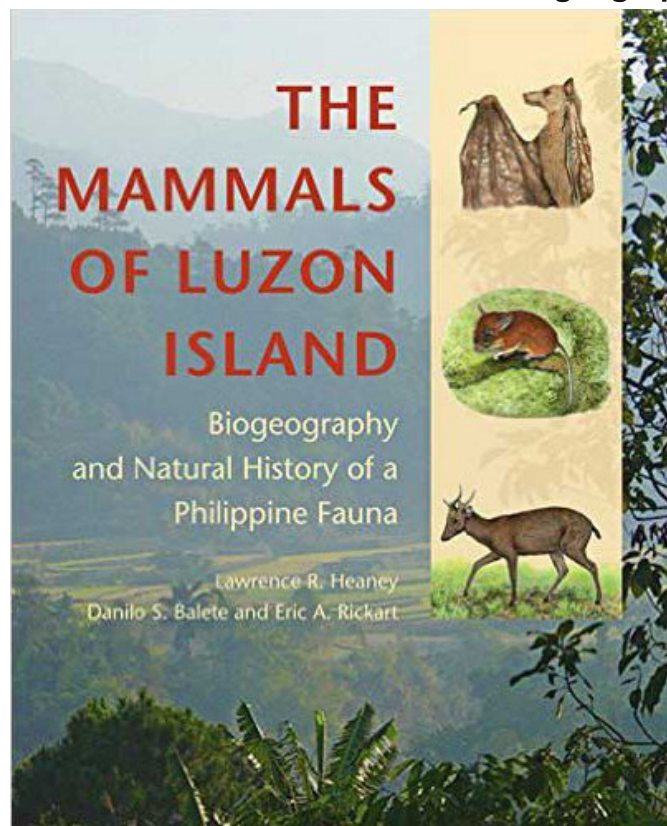
Luis M. González, Francisco G. D. Montoto, Tome Mereck, Junior Alves, José Pereira, Pablo Fernández de Larrinoa, Ana Maroto, Luis Bolonio, Nuria El-Kadhir

Oryx

Guinea-Bissau is host to the westernmost subpopulation of the common hippopotamus *Hippopotamus amphibius*, which is one of only two known populations inhabiting coastal waters. The presence of hippopotamuses causes conflict with rice farmers as a result of crop damage and the absence of effective measures to protect crops. To develop an effective method for protecting rice fields, we studied the patterns of access to flooded and rain-fed rice fields by hippopotamuses and assessed the effect of the installation of electric fences. Hippopotamuses were detected in 54% of the flooded fields (n = 100) and in 31.9% of the rain-fed fields (n = 91). They were detected more frequently in fields on offshore islands than on the mainland, in unfenced than in fenced fields, and in fields closer to running water. Hippopotamuses entered fenced flooded fields less frequently than unfenced, and were detected most frequently at the end of the rainy season and the start of the dry season, and in the period of vegetative stem growth. Electric fences were an effective deterrent and facilitated increased rice production. The maintenance and cost of the electric fencing were acceptable to farmers, and therefore the use of such fencing is recommended to resolve the conflict between hippopotamuses and farmers in Guinea-Bissau and in other areas with similar conditions.

New Books

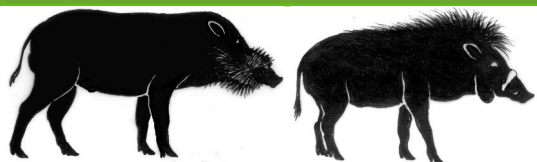
The Mammals of Luzon Island – Biogeography and Natural History of a Philippine Fauna



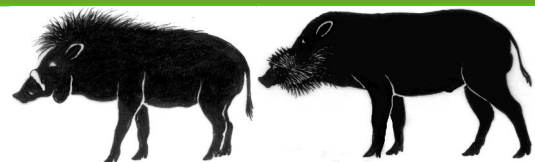
The island of Luzon is one of the main islands of the Philippines with Manila and other important cities located on it. The Philippines have lost most of their tropical rain forests and are a hotspot of global biodiversity. Luzon has one of the highest numbers of native species living on one single island. This book is the comprehensive work of 15 years of scientific research in Luzon's mammals.

In the first part, Heaney, Balete and Rickart present the geographical, ecological and evolutionary background of Luzon and its mammals. Part two deals with the natural history of them and a detailed description of each species including non-native and even invasive species. Their outward appearance is mentioned, their evolution and ecology and their conservation status. There are drawings of each species and distribution maps. Take a look and find out more about Cloud rats and





New books



Earthworm mice or the many different bat species. The Philippine warty pig (*Sus philippensis*) is the biggest native mammal on the island along with the Philippine deer (*Cervus mariannus*). Despite being such a big mammal there is limited information about its conservation status and population trends of this species in general. This book presents the only existing, comprehensive information on the ecology and conservation of this Luzon species. The pigs face many threats not only there but in their whole range, most importantly hunting and hybridisation with domestic pigs and the populations are declining.

This well written book will help to raise attention to the threatened mammals of Luzon and species conservation on Luzon and the Philippines as a hotspot for mammal biodiversity.

The Mammals of Luzon Island – Biogeography and Natural History of a Philippine Fauna

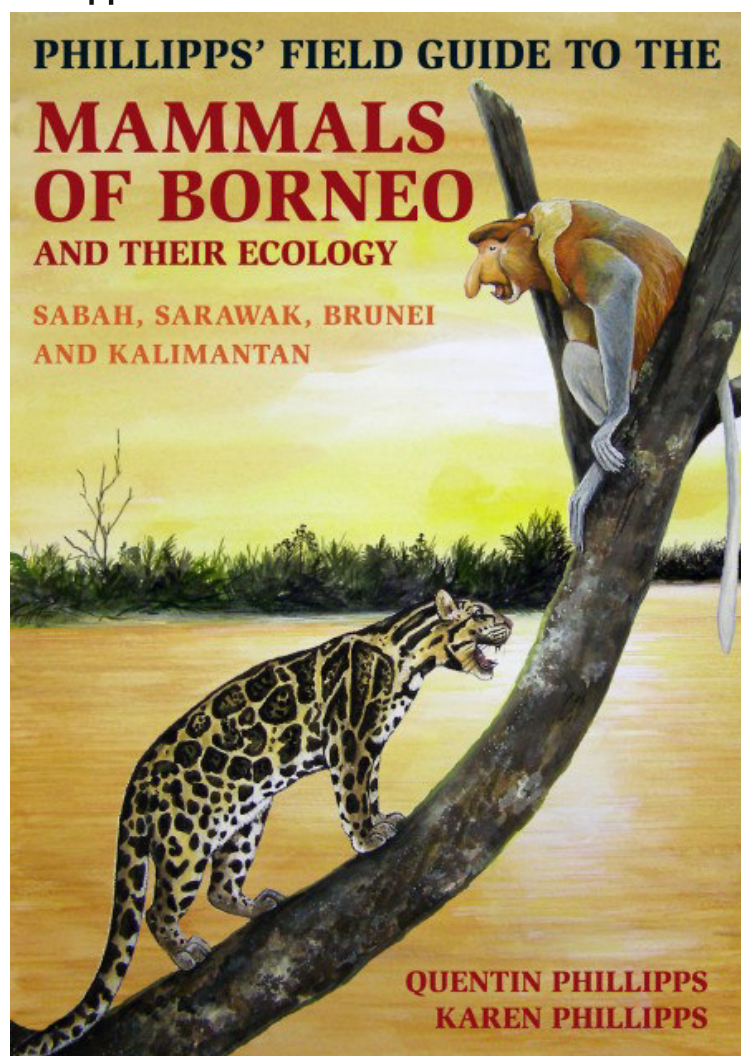
By Lawrence R. Heaney, Danilo S. Balete and Erik A. Rickart

287 pages

2016, John Hopkins University Press, Baltimore

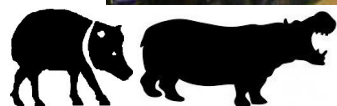
Reviewed by Thiemo Braasch

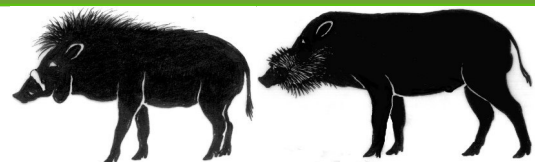
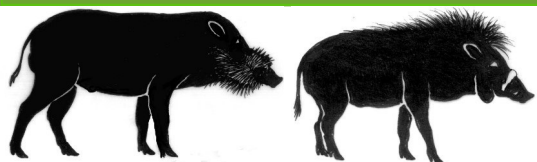
Phillipps' Field Guide to the Mammals of Borneo and their Ecology



Phillipps' Field Guide to the Mammals of Borneo and their Ecology looks like a normal species field guide to the mammals of Borneo, but as mentioned in the title, it also deals with the ecology of Borneo. Those, who are interested in the general ecology of this island will find a compact but also amazingly detailed information about different topics like Borneo's climate, the origin and evolution of Bornean mammals, human arrival on the island, and also descriptions of different plant families and their importance for Bornean ecosystems. The book answers questions like why some big mammals can still be found there while others like tigers are extinct on Borneo now.

The Bornean bearded pig is a keystone species for the island due to its ecology and its cultural importance for local tribes. Therefore, these pigs are mentioned in many different parts of the book and the description of their natural history is takes up more space than that of other species. It covers an explanation for the absence





of the Eurasian wild boar on Borneo. Bearded pigs are fascinating species because of their mass migrations. The reasons and patterns of these mass migrations are only partially understood. Go on to page 303 to see a drawing of Bornean Ground Cuckoos following bearded pigs. This species association has rarely been observed and was photographed only recently for the first time.

Having read all the interesting facts about bearded pigs and other mammals you might want to go to Borneo to observe them there yourself in the wild. The last part of the book offers descriptions of national parks and nature reserves of Borneo (including all three countries). Every described place is illustrated with a map. Information on how to access the places, important hiking trails and which mammals to see there are included.

Phillipps' field guide to the Mammals of Borneo and their Ecology is highly recommended to everyone interested in Bornean bearded pigs and other mammals of this island. It is a very good source for information not only in the field but also as a reference book for the mammals and the ecology of Borneo!

Phillipps' Field Guide to the Mammals of Borneo and their Ecology
By Quentin Phillipps and Karen Phillipps
400 pages
2016, John Beaufoy Books, Oxford, UK

Reviewed by Thiemo Braasch

The new boar war... and not Afrikaners! Meet the 20-stone beasts ramming cars and tearing up gardens in Gloucestershire

<http://www.dailymail.co.uk/news/article-3782547/The-new-boar-war-not-Dutch-Meet-20-stone-beasts-ramming-cars-tearing-gardens-Gloucestershire.html>

By Tammy Hughes and Jane Fryer for the Daily Mail
Published: 22:38 GMT, 9 September 2016 | Updated: 14:13 GMT, 10 September 2016

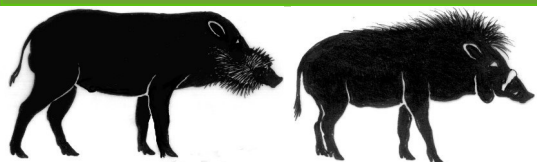
The residents of the Forest of Dean are being terrorised.

Their pretty village greens are quagmires of mud and shredded turf; their cricket pitches are unrecognisable. Their gardens have been looted and uprooted. Their (surviving) dogs are whimpering behind closed doors and their women and children are afraid to step out alone for fear of being mauled.

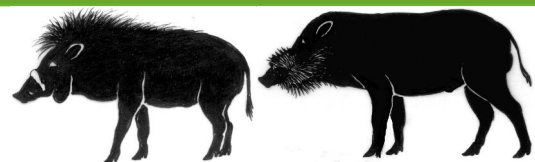
So who are these dreadful predators – freakish beasts from another world; drunken thugs bent on destruction?

Not quite. These merciless marauders are huge, hairy, 20-stone wild boar, who venture out of the forest to wreak havoc – vandalising everything in their way with their huge tusks, apparently attacking lambs with their razor-sharp fangs and chasing anyone brave enough to go out. They even charge at cars and, occasionally, the odd combine harvesters, and have caused 49 car crashes.





Article in the news



All of which, from the safety of a safe, urban home might all sound a bit, well, unbelievable. But for the terrified residents of Yorkley, Lydney, Coleford and Alvington, whose ordeal features in a new ITV programme, *Neighbourhood Nightmares*, it is all far, far too real.

'They root everything,' says Ivor Ellis, 75, a retired

decorator who lives in Coleford. 'It is like the Somme recreated all around people's properties. I can't get out of the front door sometimes.'

A pet dog has been killed. Gail Rees's 16-year-old son was left terrified after being chased by a sow with young piglets.

'She came running full pelt at him,' she says. 'There was a fence in the way and she actually tried to find a way through the fence. Soon someone is going to get seriously hurt.'

Right now, it seems things can only get worse. Over the past three years, the wild boar population in the Forest of Dean has almost tripled to 1,562, despite pledges by the Forestry Commission to keep numbers to 400.

Today they rampage like an angry mob, ploughing up grassland with their tusks to get at worms; overturning huge rocks with their snouts.

Wild boar have been native to Britain since the Ice Age and history is bursting with bloody tales of them mauling helpless peasants and disembowelling sheep.

They all but disappeared from the British countryside before the civil war but continued to flourish on the Continent, where every year they still injure hundreds of people and cause mayhem.

And now they have a growing presence here, too, thanks to a gastronomic obsession with wild boar sausages and designer ragu, a pasta sauce that showcases the meat, which began back in the Eighties. To service demand, specialist boar farms, licensed like zoos under the Dangerous Wild Animals Act, started popping up.

Which was a good idea, in principle, but boars aren't the sort to stay cooped up for long.

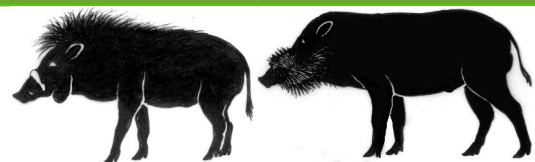
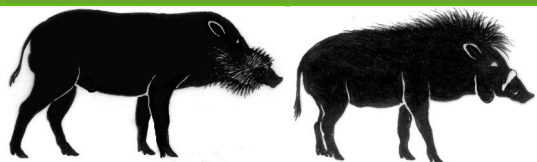
Some escaped through storm-damaged fences. Others cut their way out with their keen teeth and handy tusks. There were a few that managed moonlight flits from abattoirs. And every so often well-meaning animal rights idiots released a few more into the wild. Where they thrived – eating rabbits, voles, roots and worms and excelling at pretty much everything. They can run like the wind, swim like fish, clear 6ft fences with ease and boast such thick leathery skin that shotgun pellets just bounce off. The only thing they can't do is climb.

Which is why experts predict that, unless properly controlled – either by culling or containment – their numbers could swell exponentially over the next few years.

Today, scattered herds have been spotted in Dorset, Tyneside, Kent, East Sussex and now here, on the border of Herefordshire and Gloucestershire.

Landowners with the correct firearm licences may shoot boar on private land, but, crucially, only professional Forestry Commission rangers are allowed to shoot them on the public Forest of





Dean estate.

A spokesman for the commission says: 'We actively manage the number of boar in the forests to try and limit their population. This year our aim is to maximise the number of animals we remove to try and prevent the population growing again.'

But though the commission does cull, it clearly does not do so in sufficient numbers to control the exploding population – or to allay the fears of the poor residents of the Forest of Dean. Here, the damage to farmland, gardens, allotments, village greens and cricket pitches is now far, far beyond a joke.

It's not just a grunt: Pigs really do have something to say

<https://www.sciencedaily.com/releases/2016/06/160629100349.htm>

June 29, 2016

Source: University of Lincoln

Summary: The grunts made by pigs vary depending on the pig's personality and can convey important information about the welfare of this highly social species, new research has found.

The grunts made by pigs vary depending on the pig's personality and can convey important information about the welfare of this highly social species, new research has found.

Scientists specialising in animal behaviour and welfare devised an experiment to investigate the relationship between personality and the rate of grunting in pigs. They also examined the effect different quality living conditions had on these vocalisations.

Findings from the study, carried out by researchers from the University of Lincoln, UK, and Queens University Belfast, are published in the Royal Society journal Open Science.

The study involved 72 male and female juvenile pigs. Half were housed in spacious 'enriched' pens with straw bedding, while the other half were kept in more compact 'barren' pens with partially slatted concrete floors, which adhered to UK welfare requirements.

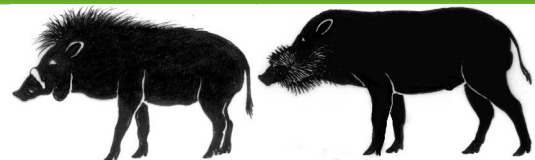
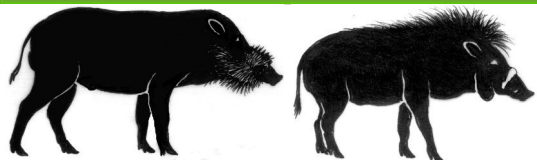
To get a measure of the pigs' personalities, the researchers conducted two tests: a social isolation test and a novel object test. Each pig spent three minutes in social isolation, and five minutes in a pen with a large white bucket or an orange traffic cone they had not previously encountered. Their behaviour, including vocalisations, were observed. These tests were repeated two weeks later, allowing the researchers to determine if the pigs' responses were repeatable -- the defining characteristic of personality (also known as 'coping style' in animals).

They also recorded the frequency of grunts they made by counting the number of grunts produced per minute of the test, and investigated the effect different quality environments had on the sounds made.

The study indicated that pigs with more proactive personality types produced grunts at a higher rate than the more reactive animals. The study also found that male pigs (but not females) kept in the lower-quality conditions made fewer grunts compared with those housed in the enriched environment, suggesting greater susceptibility among male pigs to environmental factors.

The results add to evidence that acoustic signalling indicates personality in pigs. This may have had far reaching consequences in shaping the evolution of social behaviours, the researchers believe. The findings also suggest personality needs to be kept in mind when using vocalisation





as a measure of the animals' welfare status.

Principal investigator, Dr Lisa Collins, a specialist in animal health, behaviour and welfare epidemiology in the School of Life Sciences at the University of Lincoln, said: "The domestic pig is a highly social and vocal species which uses acoustic signals in a variety of ways; maintaining contact with other group members while foraging, parent-offspring communication, or to signal if they are distressed.

"The sounds they make convey a wide range of information such as the emotional, motivational and physiological state of the animal. For example, squeals are produced when pigs feel fear, and may be either alerting others to their situation or offering assurance. Grunts occur in all contexts, but are typical of foraging to let other members of the group know where they are."

Mary Friel, lead author of the study and PhD student at Queen's University Belfast, added: "The aim of this research was to investigate what factors affect vocalisations in pigs so that we can better understand what information they convey. Understanding how the vocalisations of pigs' relate to their personality will also help animal behaviourists and welfare experts have a clearer picture of the impact those personalities have on communication, and thus its role in the evolution of social behaviour and group dynamics in social species."

Story Source:

Materials provided by University of Lincoln. Note: Content may be edited for style and length.

Journal Reference:

1. Friel M, Kunc HP, Griffin K, Asher L, Collins LM. Acoustic signalling reflects personality in a social mammal. *Royal Society journal Open Science*, June 2016 DOI: 10.1098/rsos.160178

Rare piglet, one of 300 left in the world, makes debut at Oregon Zoo

http://www.oregonlive.com/trending/2016/06/rare_piglet_one_of_300_left_in.html

By Kale Williams | The Oregonian/OregonLive

on June 28, 2016 at 1:10 PM, updated July 15, 2016 at 10:32 AM

An endangered 3-week-old piglet, one of fewer than 300 that remain worldwide, made his public debut at the Oregon Zoo in Portland this week, officials said Tuesday.

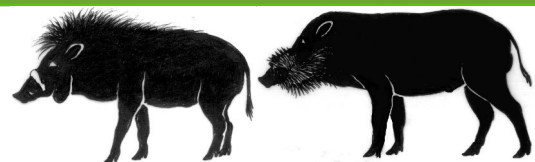
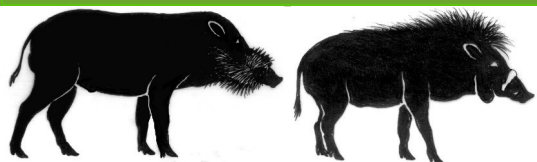
The Visayan warty piglet, who has yet to be named, was born June 9 and has been nursing well, said Julie Christie, a senior zookeeper. The petite porker still has brown and yellow stripes, a camouflage pattern that usually fades after about a year.

"He looks like a little watermelon with legs," Christie said in a statement. "There are probably fewer than 300 of these animals left in the entire world, so each birth is really something to celebrate."

Visayan warty pigs are native to just six islands in the Philippines and have already gone extinct on four of them due to slash-and-burn farming, the zoo said. Small pockets of the species remain, but they are isolated from each other and face a dwindling food supply.

The Oregon Zoo became only the fourth facility in the nation to establish a breeding group of Visayan warty pigs after an urgent appeal from the Association of Zoos and Aquariums. Samar and Maganda came from the San Diego Zoo in 2006 followed closely by Marge, the new piglet's





mother, who came from Los Angeles in 2007.

They remain a mysterious animal and were only recognized as a separate species in 1993.

Given their numbers, each new birth is an important milestone for the species, officials said, and Christie hopes the newest member of the porcine family will become an ambassador for the species at the zoo, driving home the importance of saving the rare animals.

The built-in compass that helps pigs get around: Study finds boar and warthogs are able to detect north and south

<http://www.dailymail.co.uk/news/article-3659316/The-built-compass-helps-pigs-Study-finds-boar-warthogs-able-detect-north-south.html>

By Colin Fernandez Science Correspondent For The Daily Mail

Published: 00:35 GMT, 25 June 2016 | Updated: 03:10 GMT, 25 June 2016

Pigs are often considered the cleverest animals in the farmyard.

Now new research has discovered that their wild cousins - boar and warthogs - have a built-in magnetic compass allowing them to detect north and south.

The finding may explain why pigs— just like homing pigeons – are expert navigators.

It will come as no surprise to anyone that read of the story of the Tamworth Two, the two pigs who evaded an abattoir.

Sundance, a Tamworth boar, escaped with his sister Butch from a slaughterhouse in Malmesbury in Wiltshire in 1998.

They spent a week on the run before finally being recaptured and rehomed at a rare breeds farm in Kent.

One of the pigs, Butch, was fathered by a wild boar.

Dr Pascal Malkemper, the author of the study, said that although his team's study was of wild boars and warthogs it was likely that pigs have the same skill.

He told the Daily Mail: 'We think it's absolutely possible that also domestic pigs have a magnetic sense.'

Scientists have known wild boar have good orientation abilities, a good spatial memory, and use landmarks and scent marks to find their way around.

But their eyesight is poor, and scent is not an effective way of navigating long distances.

The discovery that boars and warthogs have an internal compass came about from a study of 1,614 foraging or resting wild boars and 1,849 wild boar beds in the Czech republic, and 1,347 warthogs in Africa.

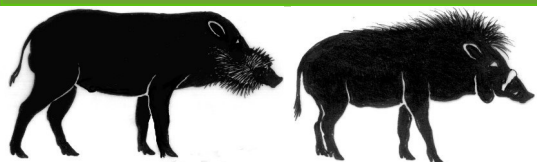
The researchers, writing in *Mammal Review*, found 'a highly significant north-south preference' that could not be explained by weather conditions or any other factor.

The boars also lined their nests up along a north-south axis – and this can only be explained by having a compass.

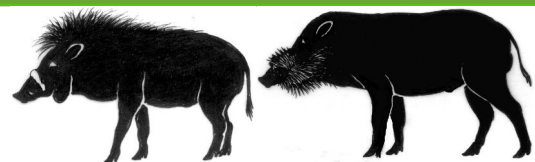
The authors, led by Jaroslav Cerveny write: 'Given the well-developed navigation skills of wild boars, it would not be surprising if they made use of a magnetic compass...a magnetic sense would, for example, help boars put several feeding grounds into global perspective, therefore facilitating quick switching between them when needed.'

As well as homing pigeons, grazing cattle and deer have also been claimed to have a magnetic





Articles in the news



compass – as have bats, and wood mice.

But the exact brain mechanism that allows mammals to detect the magnetic north pole has not yet been found.

The authors warn electric power lines may disrupt wild boars' sense of direction – and lead to them becoming disoriented and causing car accidents, the authors warn.

Wild boars became extinct in the UK around 300 years ago. But in recent years they have started to make a comeback.

The Department for Environment, Food and Rural Affairs estimate there are 1,000 wild boars in the UK, although some experts put the figure at up to ten times that.

Wild boar can run up to 30mph and weigh around 20 stone when fully grown. They can also jump 6ft.

Last year Raymond Green, 47, a technical author, was killed on the M4 after hitting a wild boar and the animal was also blamed for killing one of the Princess Royal's Gloucestershire Old Spot sows at a farm in the Cotswolds.

A record-breaking wild boar weighing an estimated 518lb was shot in Herefordshire in 2008. They are also regularly found in Kent and East Sussex and the Forest of Dean in Gloucestershire.

Across mainland Europe, however, wild boar numbers are flourishing.

Statistics from 2012 and 2013, show that in countries such as Spain, Poland, France, Italy and Germany a typical harvest of wild boar is between 200 000 and 640 000 per year.

Shy wild boars are sometimes better mothers

<https://www.sciencedaily.com/releases/2016/06/160603110252.htm>

June 3, 2016

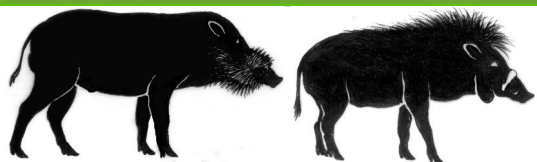
Source: University of Veterinary Medicine -- Vienna

Summary: The personality of wild boar mothers can affect the wellbeing of their young. A team of researchers has investigated whether, and under which circumstances, the personality affected the number of offspring reared. With sufficient food, shy wild boar mothers raise more young than risk-taking, aggressive females. When the availability of food becomes scarce, however, this advantage is no longer given.

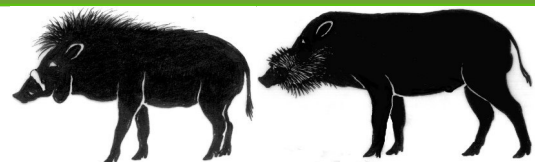
It has been known for years that personality traits of animals, such as aggressiveness, risk-taking, curiosity or sociality, may have far-reaching consequences for reproduction and survival. However, separating the effect of personality from other factors, such as environmental conditions, is not easy. If the natural environment of the animals is subjected to strong fluctuations, the different personalities may have different consequences depending on the prevailing situation.

For the first time, an extensive study by Sebastian Vetter and his colleagues at the Research Institute of Wildlife Ecology at Vetmeduni Vienna looked at the effect that personality of wild boar mothers has on the number of offspring raised. Wild boars are among the most reproductive of the large wild animals in Central Europe. Even very young females less than one year old can become pregnant if they achieve a certain body weight in the autumn. Their favourite food are acorns and beech nuts. These are not always available in the same quantity, however. In some years, so-called mast years, the trees produce many, in others only few fruits. The natural





Articles in the news



fluctuations were simulated in a trial with a wild boar population kept in a breeding enclosure at semi-natural conditions with variable feeding regimes.

Football for wild boars

To determine the personality of the wild boars, a number of objects that were previously unknown to the animals were placed in the enclosure: a football, a basket or a plastic animal, for example. The research team then analysed videotaped recordings to study the reactions of the individual animals to the nine objects. The behaviour of the females to each other was also determined. These observations were used to calculate a personality index for each animal that was later compared with the number of young raised by that female.

Variable conditions affect the success of the life history strategy

The study revealed that the personality of the females in interaction with the food availability directly affected the survival of the offspring. If enough food was available for all, the more careful mothers raised more offspring than the more aggressive and risk-taking females. The greater success of shy females in offspring rearing in good years might be explained by their more careful behaviour and high level of maternal care. "It is possible that the offspring of less explorative females grow up in a protected environment that may afford them higher survival possibilities. Wild boars are often aggressive with conspecifics and the young are therefore especially dependent on the protection of their mother. This effect, however, is no longer given when food availability is scarce," explains the study's first author, Sebastian Vetter. Vetter and his team, under none of the tested conditions, found a benefit for aggressive or bold females with regard to the success of offspring rearing; there is, however, a correlation between the personality of the animals and their juvenile body mass. Although cause and effect have not yet been fully explained, the researchers can imagine that more aggressive offspring have an advantage over their more timid siblings in the competition for teats and would therefore reach a higher weight earlier on.

Advantages early in life remain for a lifetime

Such an advantage early in life can have far-reaching consequences. Vetter and his colleagues showed a strong correlation between body mass at a young age and the reproductive success of the animals at adulthood. This may point to the so-called silver spoon effect: If an animal grows up under good conditions, this may have a lifelong benefit; it grows up with a silver spoon in its mouth, so to speak. "These results confirm our expectations that personality strongly affects life history strategy of the females. Especially interesting is that the juvenile body mass has far-reaching consequences for females and directly influences the reproductive success of the adult animals. Even more so than the body mass of the animals at the time of actual reproduction," says Vetter.

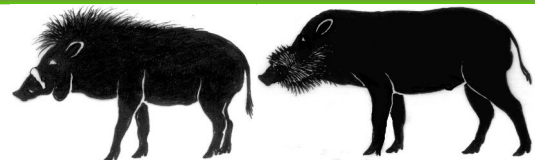
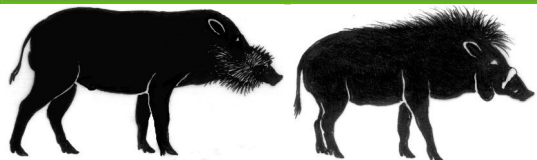
Evolutionary selection of personality differences

The different personalities have a positive or negative effect depending on environmental factors. Personality traits that are useful in one situation may present a disadvantage in another. The natural selection of different features most probably depends upon many different conditions. "In animals such as the wild boar, which experience extremely different environmental conditions from year to year, this variability also contributes to the maintenance of different personalities in a population," says Vetter in conclusion.

Story Source:

Materials provided by University of Veterinary Medicine -- Vienna. Note: Content may be edited





for style and length.

Journal Reference:

1. Sebastian G. Vetter, Constanze Brandstätter, Marie Macheiner, Franz Suchentrunk, Hanno Gerritsmann, Claudia Bieber. Shy is sometimes better: personality and juvenile body mass affect adult reproductive success in wild boars, *Sus scrofa*. *Animal Behaviour*, 2016; 115: 193 DOI: 10.1016/j.anbehav.2016.03.026

Meet the pigs with facial warts the size of grapefruit

<http://www.bbc.com/earth/story/20160406-the-worlds-ugliest-pig-can-only-be-found-on-one-tiny-island>

By Lesley Evans Ogden, BBC
6 April 2016

Male Bawean warty pigs have whopping warts on their faces, and nobody knows why. The south-east Asian archipelago is pig paradise. This region hosts the highest wild pig diversity in the world.

That is probably because rising and falling seas have connected and disconnected this large scattering of islands for over 5 million years. When animals become isolated on islands, new species can evolve, and that seems to be what has happened here with pigs.

One of the products of evolution gone hog wild is the little-known Bawean warty pig. It is found only on the island of Bawean, the remnant of an extinct volcanic mountain in Indonesia's Java Sea.

Until now, scientists did not even know how many of these pigs there were.

The Bawean Island warty pig is so named because the typical male has "three pairs of enormous warts on each side of its face," says Johanna Rode-Margono, a researcher at Chester Zoo in the UK and a member of the IUCN/SSC Wild Pig Specialist Group.

Nobody knows why the males have these grapefruit-sized warts.

"There are various different theories," says Rode-Margono's colleague Eric Meijaard, the founder of Borneo Futures and chair of the IUCN/SSC Wild Pig Specialist Group. "It could be a display function," meaning that nice-looking warts might be a means for males to impress the females.

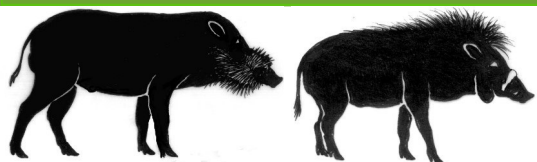
Alternatively, the warts could play a role in fighting or defense. "Wild boars fight each other by slashing with their lower tusks, and the warts would protect the face, especially the eyes," says Colin Groves of the Australian National University.

In addition to their oversized warts, some male Bawean warty pigs have white beards and large tufts of golden hair fanning out from both sides of the head. Again, it is unclear why.

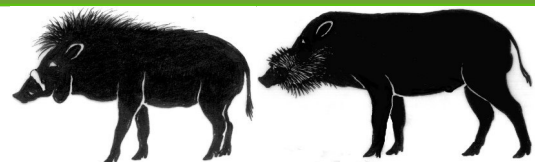
We do not even know if the Bawean warty pigs are really a distinct species. Some scientists argue that they are and should be called *Sus blouchi*, but others say they are a subspecies of the Javan warty pig (*Sus verrucosus*), in which case we should call them *Sus verrucosus blouchi*. However, "in conservation terms it doesn't really matter – it's a distinct taxon of an endangered pig species that requires conservation attention," says Meijaard.

To get a glimpse into the lives of these mysterious wild pigs, a team of six scientists including Rode-Margono and Meijaard placed video camera traps at 100 protected forest locations across





Articles in the news



Bawean island from November 2014 to January 2015.

Their findings have been published in the journal PLOS ONE.

Based on the camera trapping, the researchers calculated that there are 172 to 377 pigs living on Bawean, compared to about 90,000 human residents. For now there is no way to tell if the population is growing, stable or shrinking.

The low number is not terribly surprising. Bawean is no bigger than a small town, and the pigs are only found in a few isolated pockets of habitat.

Their small population means Bawean warty pigs qualify as a globally endangered species.

One issue is that the species is confined to a tiny island. "By definition, it always will have a small population, and small populations are just more likely to go extinct," says Meijaard. For example, they could be wiped out by a disease.

But the pigs' lifestyle also brings trouble.

The videos revealed that, like other wild swine, Bawean warty pigs are mainly nocturnal. They prefer to stay in the fringes of community forests. From there, they can launch forays into cultivated habitat, "where food is probably more abundant and rich in energy," says Rode-Margono.

This crop-raiding habit can bring them into conflict with farmers.

The main threat to the pigs is hunting, "because locals want to protect their crops from pigs," says Rode-Margono.

Luckily for the warty pigs, the local population is staunchly Muslim, so they do not eat pork, says Meijaard. They only hunt the pigs to protect their crops.

On other islands like Java, Hawaii and Monserrat, invasive pigs also pose a threat. Early European explorers introduced fast-breeding and highly adaptable wild boars to many islands, to ensure a ready food supply. These pigs can interbreed with the native species, destroying their distinctiveness.

Scientists were concerned that hybridization with wild boars might be a threat on Bawean, but it seems not to be. The camera trap data did not reveal any wild boars.

Rode-Margono is optimistic that, despite their crop-raiding reputation, she can get local people interested in conserving Bawean warty pigs.

When the researchers showed camera trap photographs to Bawean islanders, many were startled by the unusual animal. They thought their unique pig, with its charismatic warts, was "pretty cool," she says.

There are benefits to having them around. Wild pigs are "ecosystem engineers," she says: by uprooting soil in the forest, they play a role in fertilising and dispersing seeds.

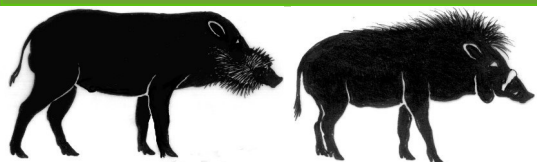
They are also an "umbrella species," says Rode-Margono. Protecting them also provides protection for other rare mammals like the critically endangered Bawean deer.

It is possible their crop-raiding habits could be reined in by simple solutions, such as "chilli-pepper-sprinkled fences, which seem to have had some success with deterring elephants," says lead researcher Mark Rademaker of VHL University of Applied Sciences in The Netherlands.

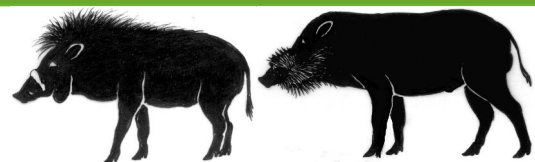
"This is a very special and important population because it's the only population in the world," says Rode-Margono. With less than 250 mature animals on the island, and none in captivity, "it's quite important to keep an eye on them."

Radioactive wild boar contaminated by the Fukushima disaster are causing havoc in Japanese communities after breeding unhindered in the exclusion zone





Articles in the news



<http://www.dailymail.co.uk/news/article-3524770/Radioactive-wild-boar-contaminated-Fukushima-disaster-causing-havoc-Japanese-communities-breeding-unhindered-exclusion-zone.html>

By Sara Malm for MailOnline

Published: 15:52 GMT, 5 April 2016 | Updated: 17:49 GMT, 5 April 2016

Radioactive wild boars are running rampage across northern Japan after being contaminated in the wake of the 2011 Fukushima nuclear disaster.

The animals are causing hundreds of thousands of pounds in damage to local farms, having been allowed to breed unhindered in the exclusion zone around the Fukushima Daiichi plant.

The number of boars in Fukushima has increased by more than 330 per cent in recent years, as local hunters cannot kill off the radioactive animals fast enough.

The Fukushima Daiichi plant was devastated by a massive earthquake and tsunami in 2011, and radioactive water has been flowing from the reactors ever since..

In the years after the nuclear disaster, the number of wild boars in Fukushima prefecture increased from 3,000 to 13,000, as they spread outside the exclusion zone.

During the same time period, the animals caused £620,000 worth of damage to agriculture in the area, The Times report.

Local authorities are calling in hunters to cull the boars, but the animals are breeding so quickly that mass graves are now filled to the brim and incinerators are running out of capacity.

The boars have been contaminated through eating everything from crops to berries, roots and small animals affected by radioactive fallout.

Normally one of the healthiest red meats - high in protein and leaner than domestic pork - the Fukushima wild boars are quite the opposite.

Tests carried out on the meat of the wild boars in the area found levels of the radioactive element caesium-137 which are 300 times higher than the legal limit for human consumption.

Meanwhile, the operator of Fukushima Daiichi has switched on a giant refrigeration system to create an unprecedented underground ice wall around its damaged reactors.

Tokyo Electric Power Co (Tepco) is starting the system in phases to allow close monitoring and adjustment.

It has started with the portion near the sea to prevent contaminated water from escaping into the Pacific Ocean before expanding it to the No.1 reactor.

The decontamination and decommissioning of the plant, damaged by a massive earthquake and tsunami in 2011, hinge of the success of the wall.

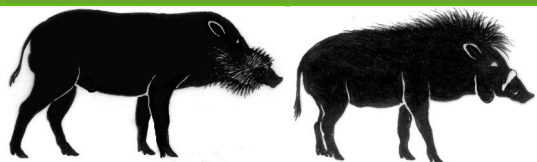
Woman left needing surgery after herd of wild JAVELINAS attack her as she is out walking her dogs

<http://www.dailymail.co.uk/news/article-3617120/Woman-left-needing-surgery-herd-wild-JAVELINAS-attack-walking-dogs.html>

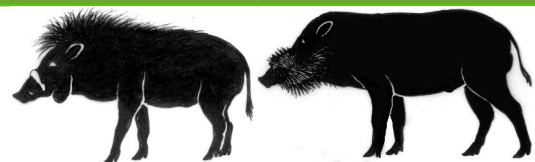
By Dailymail.com Reporter

Published: 01:16 GMT, 31 May 2016 | Updated: 07:04 GMT, 31 May 2016





Articles in the news



A woman is recovering after a herd of javelinas attacked while she was walking her dogs. The victim, who has not been identified, was out in Fountain Hills, Arizona, on Friday when the pack of wild pigs, also known as collared peccaries, ran at her. She lost her balance and fell. That's when the animals started biting her arms and neck. The woman's husband and a neighbor ran over and pulled the woman away, Tucson News Now reported.

The woman underwent surgery and remained hospitalized Friday night. One of the dogs also needed surgery.

She has since been released from hospital and is recovering.

Amy Burnett, a Game and Fish, told AZ Central: 'We are fortunate that the attack was not worse. 'Attacks by javelina on humans are rare, but when they happen, public safety is our main concern.

All six of the animals were put down after the horrifying incident.

Javelinas are becoming an increasing problem in the neighborhood as residents keep leaving out food.

Arizona's Game and Fish Department reports that javelinas can be very aggressive, and will even walk right up to someone's front door.

Namibia drills boreholes to save 100 hippos stranded in mud ponds

<http://www.news24.com/Africa/News/namibia-drills-boreholes-to-save-100-hippos-stranded-in-mud-ponds-20160818>

2016-08-18 14:36

News24 Correspondent

Linyati River - In a last-ditch attempt to save at least 100 hippos stranded in mud ponds in northern Namibia, authorities are drilling three boreholes to try to increase the water levels, a newspaper reported on Thursday.

The hippos were first reported trapped in fast-drying ponds in a tributary of the Linyanti River last month, sparking widespread concern. Hippos need to spend about 16 hours a day in water. There are also a number of crocodiles in the ponds.

Five hippos are already reported to have died. Namibia's environment ministry insists this is not because of the low water levels, but because of fights between hippo bulls.

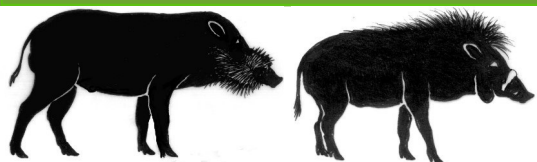
The ministry announced in a statement earlier this month that it would have to cull up to five bulls "to reduce fighting". The New Era newspaper suggested on Thursday that two had already been culled. Their deaths appear to be on top of the five which had already died.

Unusually low water levels in the river this year are being blamed on drought. The Kwando River did not flow into the Linyanti catchment this year, officials say. And there was no overflow of water from Lake Liambezi, as normally happens.

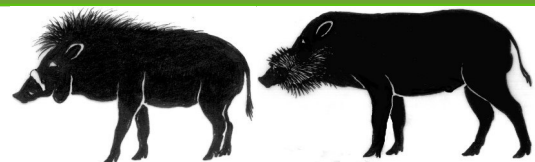
There had been calls for the animals to be urgently relocated (and fears the hippos might have to be shot by trophy hunters). But now, water is being pumped from two of three new boreholes into the drying ponds and hopes are high the animals can be saved, reports the New Era.

Environment Minister Pohamba Shifeta told the paper: "We started pumping water into the ponds. One borehole will be completed this week. One has been rehabilitated. We will have all ponds filled up with water to save the animals."





Articles in the news



The minister said the hippos were "fine" and fighting between the bulls "is also calmer". A number of hippos and crocodiles also got stuck in the mud in a stream of the Linyanti River in 2003.

Descendants of Pablo Escobar's hippos are castrated in Colombia, decades after animals escaped drugs lord's zoo and thrived in the wild

<http://www.dailymail.co.uk/news/article-3615381/Colombia-forced-castrate-Pablo-Escobar-s-hippos-animals-escaped-notorious-drugs-lord-s-private-zoo-thrive-wild.html>

By Hannah Parry For Dailymail.com

Published: 19:36 GMT, 29 May 2016 | Updated: 22:11 GMT, 29 May 2016

More than thirty years after notorious drugs baron Pablo Escobar smuggled them into Colombia, the hippo population is getting out of control.

The infamous gangster, who was on America's most wanted list for years and ran a drug trafficking cartel worth an estimated \$21 billion, had brought in rare and exotic creatures for a zoo he set up in his grand home Hacienda Napoles in the 1980s.

And while the rest of the animals were relocated to other zoos around the world when he was shot dead by Colombian police in 1993, the four African hippos escaped.

With plentiful food in the jungle and no competition, the population thrived and today there are believed to be as many as 40 hippos living in rivers and lakes around the Colombian landscape.

But while the animals may be 'sweet' they can also be incredibly dangerous.

Hippos are known for killing more people per year than lions, elephants, leopards, buffaloes and rhinos combined in Africa.

And they appear to be becoming a major problem in Colombia.

Locals have complained that the animals are becoming bolder, and are often seen wandering through city streets.

There have even been reports of them chasing people down.

San Diego University ecologist Rebecca Lewison told the BBC: 'It's just like this crazy wildlife experiment that we're left with. Gosh! I hope this goes well.'

Locals in rural Antioquia, first started reporting hippo sightings in 2007, and now it is estimated there are between 26 and 28 of the violent animals roaming around the park which was once Escobar's opulent home. While some small groups of hippos have also migrated through the Magdalena River to areas such as Puerto Berrio and Boyaca.

Some families even took in hippo calves and nursed them at home as pets, according to El Colombiano newspaper.

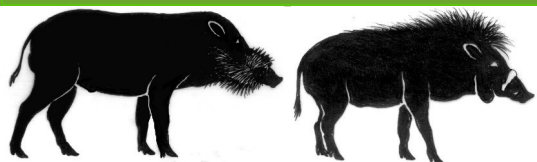
A young girl told the paper: 'My father brought a little one home once. I called him Luna (Moon) because he was very sweet — we fed him with just milk.'

Fishermen have called on the government to cull the growing population. While environmentalists are also concerned that the hippos may upset the natural ecosystem and displace indigenous species such as manatees and otters.

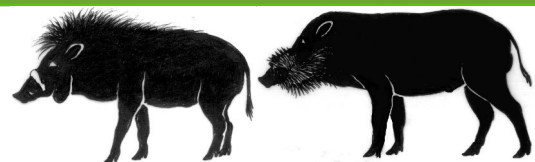
However, the wild animals are popular with most Colombians who don't want to see them killed.

Colombian officials have attempted to tackle the problem by introducing a castration program to curb the population.





Articles in the news



Escobar ran his drug empire from the eight-square-mile ranch in the South American country. At one point he supplied 80 per cent of the world's cocaine.

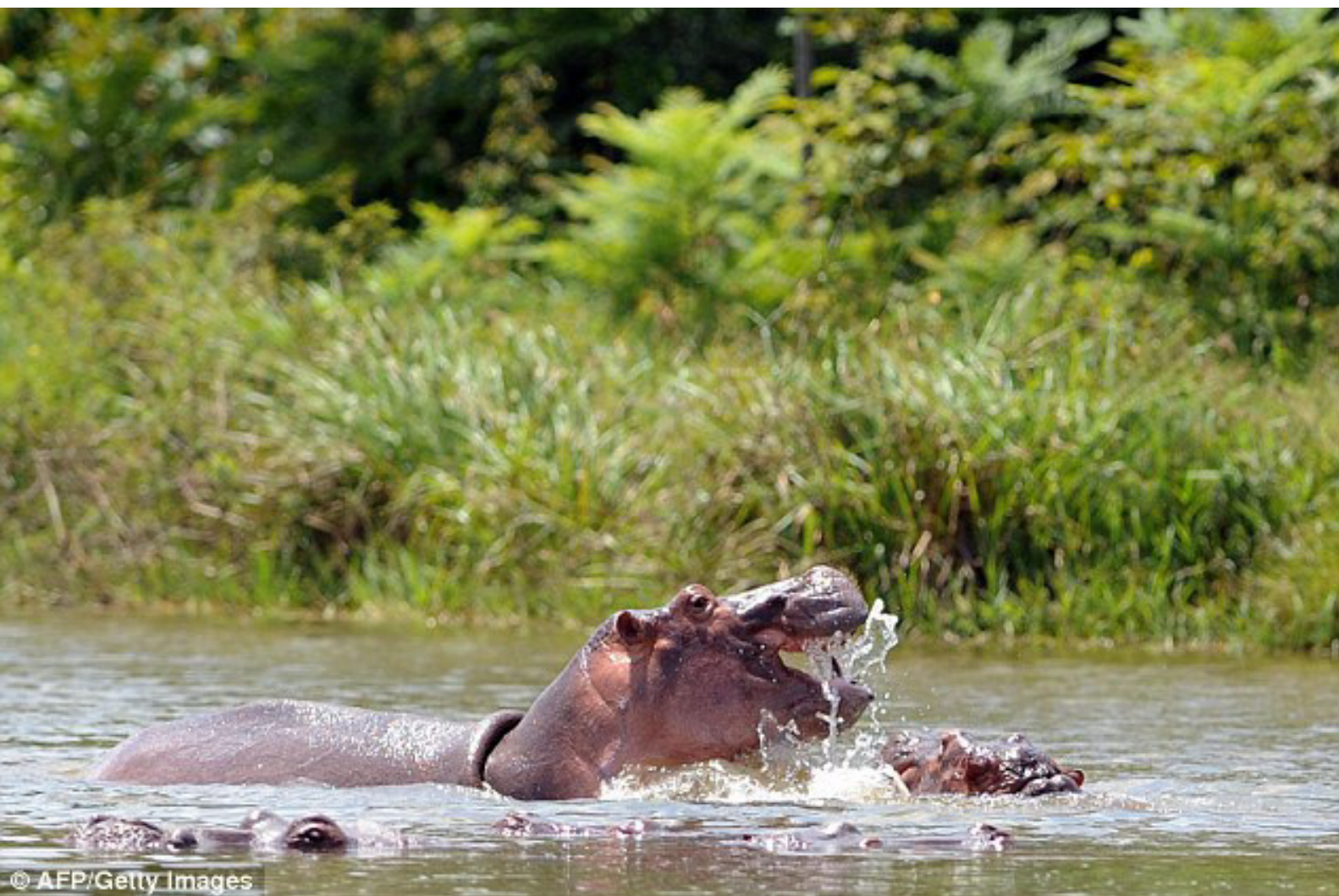
Despite his brutal reputation the drug baron spent much of his fortune converting his home into his very own fantasy land.

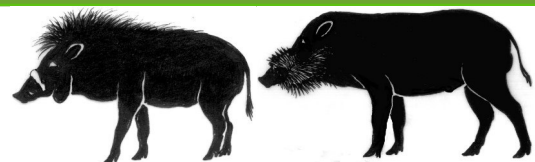
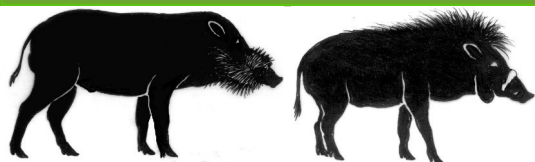
It was littered with giant concreted dinosaurs, a bullfighting ring, luxury cars, and a plane he used to smuggle drugs to the U.S.

It also featured a zoo featuring giraffes, elephants, kangaroos and - of course - hippos.

Escobar's interest in wild animals led to the biggest hippo population outside of Africa near his estate. He was cornered by Colombian police on December 2 in 1993 and gunned down.

Now, Hacienda Napoles has been turned into a Jurassic Park theme park.





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The IUCN/SSC Wild Pigs, Peccaries and Hippos Specialist Groups (WPSG, PSG and HSG) are three of several Specialist Groups of the Species Survival Commission (SSC) developed by the IUCN to foster conservation, research and dissemination of information for species of conservation concern.

These groups consist of technical experts focusing on the conservation and management of wild pigs, peccaries and hippos.

The broad aim of these groups is to promote the longterm conservation of wild pigs, peccaries and hippos and, where possible, the recovery of their populations to viable levels.

Pigs, peccaries and hippopotamuses are nonruminant ungulates belonging to the Suborder Suiformes of the Order Artiodactyla (the even-toed ungulates).

Within the Suborder Suiformes, pigs belong to the Family Suidae, peccaries to the Family Dicotylidae and hippopotamuses to the Family Hippopotamidae.

