Suiform Soundings

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

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Photo front page:

Borneo Bearded Pig (*Sus barbatus barbatus*). Photo: Wong Siew Te

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Table of Contents

Borneo Bearded Pig (*Sus barbatus barbatus*). Photo: W. Siew Te

Editorial

Dear readers,

One day I was sitting in a branch of a tree in the Maya Forest, a trinational forest shared by Mexico, Guatemala and Belize. We were there to see one of the rarest species of mammals in the Neotropical forests in this region, the white-lipped peccary. Four days later, a group appeared at the pond where we were waiting. They came in a single file, as many as 45 individuals that filled the forest with their vocalizations. They wallowed in the mud for 12 minutes and then left, also leaving us amazed by such a close encounter. Unfortunately, white-lipped peccary is an endangered species in all of Mesoamerica. Its range has diminished by 87% in the past 100 years.

All wild pigs, peccaries and hippos are amazing animals that play several ecological roles. They have a close relationship with ancient and modern humans, are smart animals, and have unique evolutionary histories. However, most of them are facing an uncertain future, one shared by the white-lipped peccary that we spotted in the Maya forest.

In this edition of Suiform Soundings, we, the editorial team, bring the most up-to-date information in all aspects of these interesting species with the aim of sharing knowledge and raising awareness of the problems that they face and the conservation actions needed. We present the latest scientific research and other relevant news that wild pigs, peccaries and hippos are facing. Unfortunately, the news is not always positive, like the fact that probably African Swine Fever is eradicating complete populations of the wild pigs species in Southeast Asia (see Abstract section), or that a species of peccary (Chacoan peccary) is predicted to go extinct within 30 years without remedial actions (see Abstract section) and if current rates of deforestation continue. We must work together to save the wild pigs, peccary and hippo species in their natural habitat, most of that work requires most accurate and up-to-date information and our newsletter helps to partly fill knowledge gap.

Therefore, here I describe the current issue of Suiform Soundigs the Newsletter of the Peccary, Wild Pigs and Hippos' IUCN Specialist Groups. This is another spectacular issue that, thank you to the effort of the editorial team, especially our general editor Thiemo Braasch, is here for you

In this issue you will find two articles on babirusas, that amazing-looking hairless pig with males and their protruding tusks that pierce through the top lip and arch backwards. One article

describes the movement of molar teeth in captive individuals and another analyses social behavior and dominance in a captive group. In another article, Ralf Lohe indicates possible morphological differences between populations of bearded pigs *Sus barbatus* (Bearded pigs) on the east coast of the Malaysian peninsula and encourages further research on this issue. Finally, we bring a comprehensive description of a workshop that the the Tapir and Suiform Taxon Advisory Group (TAG) of the European Association of Zoos and Aquaria (EAZA) conducted in 2020, and a plan to save the species in captive environments. It entitled, “One Plan Approach to save species — a new integrative Regional Collection Plan for hippos, pigs, peccaries, and tapirs”.

This issue includes four book reviews by our general editor. One is about a question I always have in my mind, and in the own words of the book’s author, Max D. Price, “Why were wild boars and domesticated pigs part of daily life in the ancient past and became a taboo in Judaism and Islam?”- In his book “Evolution of a Taboo – Pigs and People in the Ancient Near East”, Max D. Price analyzed evolution and history to respond to that question!

I invite you to read this amazing issue and to become interested to learn more about all aspects of the life of wild pigs, peccaries and hippos, being informed is one of the best tools we can use to win the race against extinction for all wildlife!

I hope you enjoy the readings!

Rafael Reyna

Think Pig

Indicating possible morphological differences in adult males of *Sus barbatus oi* vs. *Sus barbatus barbatus*

by Ralf Lohe*

*IUCN/SSC Wild Pig Specialist Group

In this article I will describe anecdotal observations from the east coast of the Malaysian peninsula of possibly specific morphological differences between different populations of bearded pigs *Sus barbatus* and encourage research on this issue. The morphological differences observed may indicate evolutionary differentiation, which is of interest for the taxonomic classification of populations, and could be of importance for the conservation of the species and its possibly distinct units.

Fig. 1: Large male piglet (~45kg) of *Sus barbatus oi*; the warts on the bridge of the nose are already visible. Photo. R. Lohe.

Wild pigs have a wide distribution on the Malaysian peninsula and the islands of Southeast Asia. It is not clear, how they reached these islands, but pigs are known to be strong swimmers and bearded pigs have been reported swimming in the ocean kilometres from the coast. The colonisation of even far away islands may have been assisted by people, maybe by island-hopping via some now vanished islands. Such events happened irregularly, and such colonisations would have led to the establishment of isolated populations and potentially finally to the formation of a number of subspecies and even species, the classification of which is not clear in all cases. For bearded pig, two subspecies are recognized: *S. b. barbatus* from Borneo and *S. b. oi* from the Malaysian peninsula and Sumatra.

On two trips (2003 and 2014), I visited the Kuala Rompin area on the east coast of the Malaysian peninsula. On seven occasions, I observed wild bearded pigs. I also had the opportunity to examine freshly killed animals (5x), older trophies (5x), talk to hunters and see photographs of hunted pigs from the area.

In the literature (Groves & Grubb 2011; Luskin & Ke, 2018), the warts of the species are not mentioned or are described as small or smaller than in other Southeast Asian warty pigs (*S. celebensis*, *S. verrucosus* and *S. blouchi*). This feature is supposed to be independent of the subspecies of *S. barbatus*. In fact, I could not find any remarkable warts on the *S. barbatus* I saw

Fig.2: Old male of *Sus barbatus oi* from Kuala Rompin. The dark colour of the tusks is caused by the food, as the hidden root-part of the tusks has the normal light colour. Photos. R. Lohe.

in zoos or on photographs. However, I found that, at least in the Kuala Rompin region of the Malaysian peninsula, the adult males of *S. b. oi*, especially the older ones, have large and very well-developed warts. There is one pair of upright standing, disc-shaped warts (bigger than 8 cm x 8 cm x 3 cm in old males) on the bridge of the nose above the tusks. The warts are densely covered with strong bristles, which appear to be worn down. There is a deep and narrow gap between the warts. A second pair of large warts is along the edge of the lower mandible (like in bush pig and warthog); these are 20 cm x 4 cm x 4 cm or larger. The roots of the bristles are deeply embedded in the tissue of the warts. According to the abrasion of the molars and the development of the tusks I observed, the bearded pigs seem to reach their maximum body size quite young (possibly between 3 and 5 years). The warts are already visible in large piglets, but the wart growth is obviously slower than the growth of the body, as large males with smaller warts were all determined as relatively young.

The big warts of *S. b. oi* are only visible at a closer look. At some distance, the longhaired "beard" of *S. b. barbatus* looks pretty much the same like the large, but covered with shorter hair, warts of *S. b.oi*. I could not find any records about *S. b. oi* in captivity. So it is possible that the warts are barely mentioned in the description of the species because they were simply overlooked on wild-living animals.

In the literature, the body size of adult males bearded pigs is indicated at 60 kg (average, with 145 kg maximum) without indicating differences between the two recognized subspecies (Caldecot 1991) or up to 200 kg for Borneo (Pfeffer 1959). I visually assessed the large males of *S. b. oi* (8x) being well over 200 kg, but this might be a consequence of the abundant food supply (oil palm fruit).

I was not able to verify, whether my observations are valid for the entire subspecies or just for the population around Kuala Rompin. Unfortunately, there might not be much time left to find out, as the ongoing heavy persecution may likely cause a collapse of the population in the nearest future.

It should be mentioned that in 2003 the hunting pressure on the species appeared to be moderate and almost entirely done by indigenous people or for crop protection. Since 2010 in Malaysia the bearded pig is formally a protected species (Wildlife Conservation Act 2010, Act 716; Laws of Malaysia 2010), but with exceptions for indigenous people and for crop protection. In 2014, I found that, despite its legal protection, the persecution of the species is now on the level of intensive pest control. Population numbers appear to be rapidly declining as result of this persecution. As the situation for the animals does not seem to be better in other areas across the range of the species, there should be a serious discussion about a change in the conservation management strategy. By my impression it would be effective to replace the current protection on the paper by a well-balanced concept that respects the traditions of the indigenous people, mitigates the damage in agriculture and recognizes the high potential of the bearded pig for sustainable use. Applying such a differentiated approach would provide benefits for local people and support the conservation of these unique pigs and their diverse local populations.

Fig. 3: Old male of *Sus barbatus barbatus*. Without warts on the bridge of the nose, the mandibular warts are just slightly indicated. Photo. R. Lohe.

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Fig. 4: Old male of *Sus b. barbatus* in Zoo Berlin, Germany. Photo: R. Lohe

Ecology and Conservation

One Plan Approach to save species — a new integrative Regional Collection Plan for hippos, pigs, peccaries, and tapirs

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Introduction

In November 2020, the Tapir and Suiform Taxon Advisory Group (TAG) of the European Association of Zoos and Aquaria (EAZA) conducted its Regional Collection Plan (RCP) online-workshop. EAZA RCPs follow the 'IUCN Guidelines on the Use of Ex situ Management for Species Conservation' (IUCN/SSC, 2014) to recommend which species should be managed under an EAZA Ex situ Programme and specify which direct and/or indirect conservation and/or non-conservation roles these Programmes aim to fulfil for each species. Twenty seven taxa from four families — Hippopotamidae, Suidae, Tayassuidae, and Tapiridae — were evaluated during the RCP workshop, despite the fact that only nine species are currently held (N > 3 individuals) in EAZA institutions (Figures 1–3).

This new and comprehensive RCP follows the One Plan Approach: 'the joint development of management strategies and conservation actions for all populations of a species by all


Fig. 1: The Vulnerable (IUCN Red List) Sulawesi babirusa (*Babyrousa babyrussa*) at Nuremberg Zoo. Photo: J. Beckmann


Fig. 2: The Critically Endangered (IUCN Red List) Visayan warty pig (*Sus cebifrons*) at Ostrava Zoo. Photo: J. Pluháček

Fig. 3: The Endangered (IUCN Red List) Pygmy hippopotamus (*Choeropsis liberiensis*) at Basel Zoo. Photo: J. Pluháček

responsible parties to produce a single, comprehensive conservation plan for a species' (Byers et al., 2013). Accordingly, in situ and ex situ experts jointly developed this RCP, bringing together in situ and ex situ knowledge and conservation efforts. For all of its activities, including this RCP, the TAG works closely with the relevant IUCN SSC specialist groups (SGs); several TAG members are indeed SG members. Finally, the RCP is closely linked to the RCP of the Cattle and Camelid TAG through the Global Species Management Plans (GSMPs) for banteng, anoa, and babirusa, which are collectively known as the 'Action Indonesia' initiative (https://www.actionindonesiagsmp.org/).

TAG mission and species threats

The TAG's mission is to ensure that diverse populations of wild pig, peccary, tapir, and hippo species in EAZA collections have the required characteristics to respond to the conservation needs of the taxa, as well as the supplementary roles and needs of the zoo community. Additionally, the TAG aims to promote and support in situ and ex situ conservation, research, and education efforts, as well as any conservation-related collaborations between relevant in and ex situ actors. For example, the conservation of many South American and Asian species, as well as the African pygmy hippo (*Choeropsis liberiensis*), can be positively impacted by educating EAZA zoo visitors about the negative impacts of imported deforestation and unsustainable agriculture (palm/vegetable oils, soy, cattle, etc.) and how consumer choices matter in mitigating these threats as visitors live in countries that import and trade these commodities in large quantities.

In general, habitat loss is a major issue facing all threatened species in the TAG, especially the Chacoan peccary (*Catagonus wagneri*) and pygmy hippo. In addition, the latter inhabits one of the poorest regions of the globe where the human population has increased dramatically, which places further pressure on this species. Exploitation (through unsustainable hunting and poaching) and diseases are also of great concern to a number of these taxa. A relatively new and significant threat to wild pigs in Asia is the current spread of African Swine Fever (ASF) in the region (e.g. Luskin et al., 2021). Several endemic pig species and sub-species that inhabit islands or have very small ranges are highly threatened by ASF. The TAG is therefore in close contact with the IUCN SSC Wild Pig Specialist Group, which is currently focusing on ASF in Asia. Unfortunately, this disease has also reached Europe and become a real threat for the ex situ populations of threatened wild pig species in EAZA zoos. Further, both species of hippo are very sensitive to anthrax outbreaks (Wafula et al., 2008; Hang'ombe, 2012; Dudley et al., 2016; Stears et al., 2021); however, this threat is extremely limited in captivity.

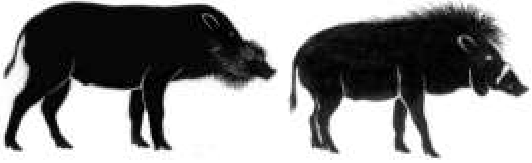
Managing the challenges of successful breeding

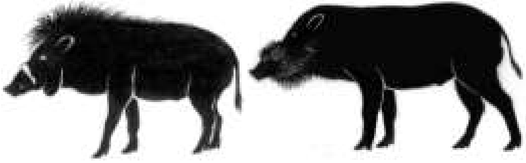
For biological and welfare reasons, the Tapir and Suiform TAG considers a breed and cull policy as an extremely important tool for sustaining viable, long-term populations and managing potential ‘surplus’ problems for the specific taxa under its remit. Full details of what is meant by culling and when this may be considered an appropriate management tool by EAZA institutions can be found in EAZA’s Culling Statement (https://bit.ly/35cHAHJ). One reason why breed and cull is recommended as a population management tool by this TAG is that a reproduction stop in wild pigs and peccaries may lead to permanent sterility of females, even if this stop is only short term, which in turn can incapacitate populations and leave no flexibility should the (conservation) need for future breeding arise. This ‘use it or lose it’ phenomenon (Penfold et al., 2014) is also exhibited in other species, such as the Indochinese sika deer (*Cervus nippon pseudaxis*) — a sub-species that is listed by the IUCN Red List as extinct in the wild — and other ungulates kept in zoos. Based on long-term experience in European zoos, tapirs and pygmy hippos also face the same problems if a breeding stop is applied for several seasons. The results of such a decision will become visible after several years in long-lived species, at which time it may be too late to start breeding again. The ability to maintain breeding potential while avoiding overpopulation is additionally important because some of the TAG species are large animals (i.e. tapirs and hippos) that require heated stables and heated water in most parts of Europe. Consequently, surplus individuals may be very difficult to place. Lastly, breeding is supported as a natural behaviour that animals need to be able to express.

Keeping all-male groups is another solution for the surplus challenge. While this will not work for all species, in cases where it is possible/appropriate all-male groups can be immensely helpful to facilitate genetic and demographic management as they allow coordinators to replace breeding males periodically with other genetically valuable males that grew up in the correct social setting. Thus, we can avoid losing the reproductive potential of females in the absence of regular breeding and avoid skewed sex ratios (Pluháček & Steck, 2015). Showing groups of mature males to visitors also allows zoos to educate the public about species-specific male characteristics, such as warts in warty pigs, and inter-male behaviours, such as ‘boxing’ by male babirusa (Macdonald et al., 1993).

Valuable and interesting species in captive facilities

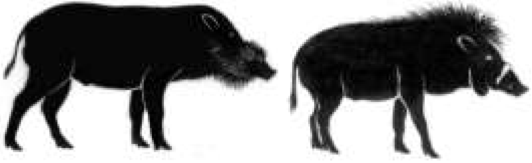
The new RCP of the EAZA Tapir and Suiform TAG identifies nine taxa (representing eleven species) that will be managed under an EAZA Ex situ Programme (EEP). EAZA will proactively manage these taxa to fulfil the ex situ roles assigned to it in the RCP (Table 1). Three additional species will be monitored by the TAG without specific management plans identified (Mon-T): white-lipped peccary (*Tayassu pecari*), Eurasian wild pig (*Sus scrofa*), and Javan warty pig (*Sus verrucosus*). For collared peccary (*Pecari tajacu*), the TAG recommends a partial/slow replacement with Chacoan peccary (Mon-T Repl). The western Sunda bearded pig (*Sus barbatus*) will be monitored in its range state institutions (Mon-T), but the TAG recommends that European institutions do not obtain this species (Mon-T DNO). The remaining eleven species are not held by EAZA members. The TAG recommends not to obtain these but will monitor this recommendation (Mon-T DNO). Nevertheless, as the situation for various species might change over time, the TAG will work closely with the relevant IUCN SSC SGs to carefully monitor all species in situ and ex situ, including in other regions, so that strategies can be adapted in due time if needed.

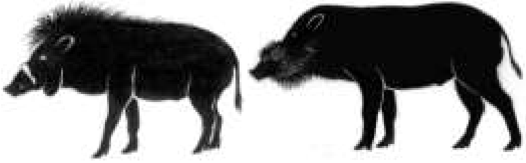




Tab. 1: EAZA Ex situ Programmes (EEP) of the tapir and Suiform EAZA Taxon Advisory Group, including the roles the programmes aim to fulfil.

Species **Target population size EAZA** **↑ increase** **≈ maintain** **↓decrease**	**Conservation roles**	**Non-conservation roles**
Malayan tapir *Tapirus indicus* ↑	DIRECT Become part of a global meta population for **insurance** purposes Support **conservation education (in range)** by providing and helping to develop materials/programmes aimed at local communities INDIRECT Support **research** identified by the IUCN SSC Tapir SG by providing data for Population Viability Analysis (PVA) modelling and samples for genetic and taxonomic research, as well as data on reproductive parameters and disease transfer; help test and develop field methods Deliver **conservation education** materials to EAZA region visitors on the negative impacts of unsustainable agriculture and how consumer choices matter	
Lowland tapir *Tapirus terrestris* ↑ slightly	DIRECT As **insurance** populations, keep the potential to reinforce *in situ* populations and **reintroduce** individuals in range Support **conservation education (in range)** by providing and helping to develop materials/programmes aimed at local communities INDIRECT Support **research** identified by the IUCN SSC Tapir SG by providing data for PVA modelling and samples for genetic and taxonomic research, as well as data on reproductive parameters and disease transfer; help test and develop field methods Deliver **conservation education** to EAZA region visitors on the negative impacts of unsustainable agriculture and how consumer choices matter	
Pygmy hippo *Choeropsis liberiensis* ↑	DIRECT Working towards becoming an **insurance** population and explore potential for supporting population restoration in the future INDIRECT Provide input into basic biology **research** upon request Provide **veterinary expertise and training** in range upon request **Fundraising** for IUCN SSC Hippo SG endorsed projects	Maintain a healthy population for **exhibit/display** purposes
Common hippo *Hippopotamus amphibius* ≈	INDIRECT Provide **veterinary expertise and training** to help mitigate human-wildlife conflicts Support **conservation education (in range)** by providing and helping to develop materials/programmes aimed at local communities Provide input into basic biology **research** upon request **Fundraising** for IUCN SSC Hippo SG endorsed projects	Maintain a healthy population for **exhibit/display** purposes; ambassador species





Tab 1 continued

Species **Target population size EAZA** **↑ increase** **≈ maintain** **↓decrease**	**Conservation roles**	**Non-conservation roles**
Chacoan peccary *Catagonus wagneri* ↑ slow	DIRECT **Insurance** and potentially global source population for the in range *ex situ* population managed by El Centro Chaqueño para la Conservación e Investigación (CCCI) Remain available to provide support and input for **research** INDIRECT Deliver **conservation education** to EAZA region visitors on the negative impacts of unsustainable agriculture and how consumer choices matter **Fundraising** for CCCI	
Visayan warty hog *Sus cebifrons* ↑ slighty	DIRECT Become part of a global **insurance and source population**, as guided by the West Visayas Conservation Workshop (2019) Upon request, the programme can support the development of **education** methods/materials/strategies for Talarak breeding centres (and potentially other centres) INDIRECT **Fundraising** for Talarak Foundation Provide *ex situ* **expertise** upon request	Deliver **education** materials on the concept of endemic/island species
Babirusa *Babyrousa* Sulawesi babirusa *Babyrousa celebensis* ↑ as guided by the GSMP Moluccan babirusa *(Babyrousa babyrussa)* Do not obtain Togian babirusa (*Babyrousa togeanensis*) Do not obtain.	DIRECT As part of the Global Species Management Plan (GSMP), a global **insurance** population is being developed for Sulawesi babirusa Deliver **training** on handling, feeding, and caring for rescued/confiscated individuals in range, as well as capacity building for **education** and husbandry training for in range zoological institutions (for Sulawesi babirusa) INDIRECT **Fundraising** for GSMP implementation and small-scale *in situ* projects for any of the three species **Raise awareness** of the GSMP's structure and efforts	
Common warthog *Phacochoerus africanus* ≈ balance with red river hog		Maintain a healthy population for African **exhibits/display** purposes
Red river hog *Potamochoerus porcus* ≈ balance with common warthog		Maintain a healthy population for African **exhibits/display** purposes and deliver **education** on the important role of prey; flagship for West African forest/African landscapes and the threat posed by wild meat

Acknowledgements

The RCP workshop would never have been this successful without the input, hard work, and cooperation of all programme coordinators, TAG members, IUCN SSC specialist groups for Tapirs, Wild Pigs, Peccaries, and Hippos, and especially the EAZA Executive Office team! We gratefully acknowledge everyone's important contributions.

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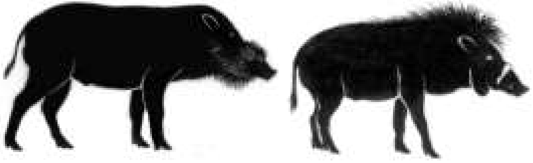
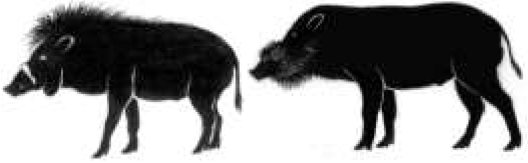


Physiology and Anatomy



Observation of mandibular yaw movement in the Sulawesi babirusa (*Babyrousa celebensis*)

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Abstract

Recent observations of babirusa skulls have found there are two types of wear patterns on the molar teeth, suggesting a relationship with the grinding of their specific diet in the wild. Yaw rotation, which is involved in the transverse grinding of food particles, has not been reported for the babirusa mandible. Therefore, we have sought a simple protocol to geometrically describe such a motion based on videos of a male babirusa. When observed in frontal view, the yaw movement of the babirusa mandible could be shown as a waveform with approximately three cycles per second on the position-time graph based on the measured x-coordinates of the mandibular canines.

Keywords: babirusa, canine teeth, mastication, video analysis, yaw rotation

Introduction

The Sulawesi babirusa (*Babyrousa celebensis*) inhabits the tropical rainforest on the banks of rivers and ponds on Sulawesi and some neighbouring islands in Indonesia (Macdonald, 2017a). Their natural habitat nurtures a wide variety of fruit-bearing trees, and fruit has been assessed as a particularly important component of the diet for the babirusa (Leus, 1996; Macdonald, 2017a). Detailed examination of the teeth in babirusa skull specimens described their surface structure as well as the progressive wear of the molar crowns, and pointed out the differences in wear from those of domestic pigs (Macdonald, 2019). More recent observations have revealed two types of erosive wear patterns on babirusa molar teeth, suggesting a relationship with the transverse grinding of their specific diet in the wild, such as seeds of certain fruits (Macdonald, 2021).

Mastication in mammals is a cyclic movement of the mandible, tongue and hyoid apparatus (Weijs, 1994). In domestic pigs, mandibular movements for mastication include 1) pitch rotation (i.e., straight up and down movements by rotation around the mediolaterally oriented axis through the condylar processes), 2) yaw rotation (i.e., transverse movements by rotation around the dorsoventrally oriented axis) and 3) rostrocaudal translation (i.e., protraction and retraction along the anteroposterior axis) (Menegaz et al., 2015; Grossnickle, 2017). The main mandibular movement in pigs and babirusa is pitch rotation, which is easily visible. On the other hand, the yaw rotation in pigs is not easy to observe. In previous studies, the yaw movement in domestic pigs was recognised by observing the mandibular incisor teeth moving from side to side across the midline (Herring & Scapino, 1973; Herring, 1976; Langenbach et al., 2002). However, when

the animal lowered its snout, it was easy to lose sight of the incisors. Our observations and video recordings of the feeding behaviour of the adult female babirusa failed to find any yaw rotation (Ito et al., 2020, 2021). The possible reasons for this included the following: 1) There was a low frequency of yaw rotation occurrence, depending on the physical properties of the food particles. 2) The yaw angle during mastication was small, unlike the yaw movement during yawning, where the rotation angle is large enough to be visible from afar (Figure 8 in Ito et al., 2020). 3) Except for the grimace (Figure 3 in Ito et al., in press), the lips of the female babirusa tend to cover the teeth, even during mastication, making it difficult to observe her mandibular dentition.

Menegaz et al. (2015) applied X-ray reconstruction of moving morphology (XROMM; Brainerd et al., 2010) to make accurate measurements of the three-dimensional movement of the pig mandible. This advanced method may be useful for future research on other animals, but its application to the captive babirusa under the current conservation breeding programme is not realistic. In long-term studies on the mandibular movement during mastication, there should be a simple and practical recording method to clarify the correspondence between food characteristics and the occurrence of mandibular yaw movements in the babirusa.

Against this background, we have sought a practical protocol suitable for recording the yaw movement of the mandible, focusing anew on the dentition of the adult male babirusa. The most distinctive characteristic of the adult male babirusa is the growth of the maxillary canine teeth through the skin covering the snout and to then curve caudally and extend towards the forehead (Macdonald, 2017b; Macdonald & Shaw, 2018). The mandibular canines are also well developed and are characterised by their deeply implanted roots (Figure 7 in Macdonald et al., 1993). In other words, the adult male babirusa has a pair of bared canine teeth on each of its upper and lower jaws, and these four canine teeth are always visible in frontal view, even when the animal looks down (Figure 3 in Macdonald, 2017b; Figure 3 in Macdonald & Shaw, 2018). Here, we report on 1) the validity of detecting the yaw movement of the mandible by tracking the movement of the four canines in the video footage of an adult male babirusa and 2) the characteristics of the yaw movement of the babirusa mandible during mastication.

Materials and methods

Study site, period and animals

Observations and video-recordings were made at Babirusa Park (8° 32' 42" S, 115° 15' 20" E), located in the agricultural area of Lodtunduh village, Bali, Indonesia. This facility had been set up for a five-year project of conservation breeding and behavioural research which started in January 2005. Of the nine Sulawesi babirusa, we focused on an adult male, Indro, with the most developed tusks (date of birth: 17 October 2001).

Enclosure and animal husbandry

The animal was kept in an outdoor enclosure of 480 m^2 with coconut palms and banana plants, and an undergrowth of cogongrass.

Fig. 1: A pair of Sulawesi babirusa exploring in the mud. An adult male, Indro, digging in the mud with the tip of his snout (left), and an adult female, Priska, immersing her snout in the water (right).

He had free access to the entire area including the pen, grassland, swimming pool and adjacent mud wallow (Figure 1). The water pool of this facility, the surrounding paddy fields and irrigation streams have long been inhabited by apple snails (*Pomacea canaliculata*), mosquitofish (*Gambusia affinis*), swamp eels (*Monopterus albus*) and frogs, and seasonally by aquatic plants such as water hyacinth (*Eichhornia crassipes*), sawah lettuce (*Limnocharis flava*) and water lettuce (*Pistia stratiotes*).

The keepers fed the animal twice a day, in the morning and late afternoon. The babirusa diet comprised sweet potatoes, fresh fruits such as papayas and bananas, green vegetables and commercial swine pellets. In addition, free foraging in the spacious outdoor areas accounted for an important proportion of his nutritional intake.

Observations and video recordings

Animal behaviours in the pool and mud were observed directly and recorded on the videotapes of a camcorder (DCR-TRV240K, Sony) placed at a distance of 3–4 m from the animal. The videos were later converted to digital format with a frame rate of 29.97 frames per second. The videos appropriate for this study met the following criteria: 1) the animal was facing the video camera spontaneously in an open space; 2) the animal's face, along with four canine teeth, was continuously on the screen; and 3) the continuous close-up shot remained at the same magnification. Approximately 43 min of video was recorded in December 2005. We present a 3.8-sec of the video, consisting of 114 frames as a representative example of his behaviour.

Measuring coordinates and lengths of the subject in the frame

The video footage was divided into the individual frames for analysis. To extract the yaw rotation of the mandible, the x- and y-coordinates of nine characteristic measurement points in each frame were determined using the Multi-point Tool in ImageJ software (v1.51j8, National Institutes of Health, USA). The measurement points included the middle of each of the bilateral maxillary canine teeth, the apex and middle of each of the bilateral mandibular canine teeth and three background points (see below). The criterion for selecting the measurement points was the centre of a small natural stain on the canine surface (i.e., a narrow area that could be identifiable by its distinctive pattern of colour and shape) when all the frames were viewed at 300% magnification. The length of the subject in the frame was also measured using ImageJ. Because the scale was not shot together with the subject during the video recording, the measured lengths were presented in pixels and relative to the width of the base of the maxillary canines seen in frontal view.

Trajectory plotting

To eliminate the negative effects of camera shake, the coordinates of all measurement points were corrected by parallel shift, in which the coordinates of a specific immovable background point were shifted to the all-frame average background point coordinates. A scatter plot was generated using the resulting coordinate data to represent the trajectory of the movements of the measurement points on the four canine teeth (i.e., tracking of measurement points). In addition, the change over time for the y-coordinates only was graphed.

Position-time graph based on the x-coordinates of canine teeth

Even if no movement of the temporomandibular joint occurs, a slight shaking of the head by the animal will be recorded as an apparent movement of the mandible. To assess the net horizontal movement of the mandible, we analysed the variation of the x-coordinate of the mandibular canines relative to the midpoint between the bilateral maxillary canines (hereafter, the maxillary midpoint). The x-coordinate data of the maxillary midpoint were shifted to the average x-coordinate of the maxillary midpoint for all the frames to obtain a perfect match. All the measurement points on the canines were accordingly corrected in the x-coordinates by a parallel shift. A scatter plot was generated to represent the temporal change in the resulting midpoint-corrected x-coordinate of the canines.

Temporal change in the distance between the x-coordinates of the maxillary and mandibular canine teeth

To examine the possibility of detecting the mandibular yaw movement without the above-mentioned correction processes of the background alignment and maxillary midpoint alignment, the raw data of the measured coordinates of each canine tooth were used to directly present the change over time of the distance between the x-coordinates of the maxillary and mandibular canines on the same side.

Statistical analyses

A Pearson's correlation coefficient was applied to measure the strength of a linear relationship (here, the degree of consistency) between the variables (the x-coordinate of the mandibular canine after the maxillary midpoint alignment vs. the distance between the x-coordinates of the maxillary and mandibular canines). The strength of the correlation was evaluated using Evans' (1996) guidelines. All analyses were carried out in R version 4.0.2 (R Core Team, 2020), with $p < 0.05$ indicating statistical significance.

Results

Trajectory of the movement of canine teeth

Figure 2 shows an example of the trajectory of the movement of the four canine teeth; the sequence shows the male babirusa inserting his snout into the mud, scooping up some mud and starting to chew. To avoid overlapping trajectories, we omitted the presentation of those movements for the apex of the mandibular canines, which had behaved very similarly to those in the middle of the mandibular canines. The values on both axes were given in pixels. For reference, the width at the base of the left maxillary canine in frontal view was 18.4 pixels (SD = 0.7, n = 114 frames).

As expected, the appearance of the two trajectories drawn by the bilateral canines was very similar. On the other hand, a comparison of the trajectories of the maxillary and mandibular canines showed two distinctive differences. Firstly, when his snout tip was inserted into the mud, the trajectory of the maxillary canines was confined to a relatively small area in the coordinate plane. However, the mandibular canines showed a clear vertical movement. The other difference was when his snout was pulled up and he began to chew; the trajectory of the maxillary canines was almost still, whereas that of the mandibular canines appeared to contain a horizontal component of motion.

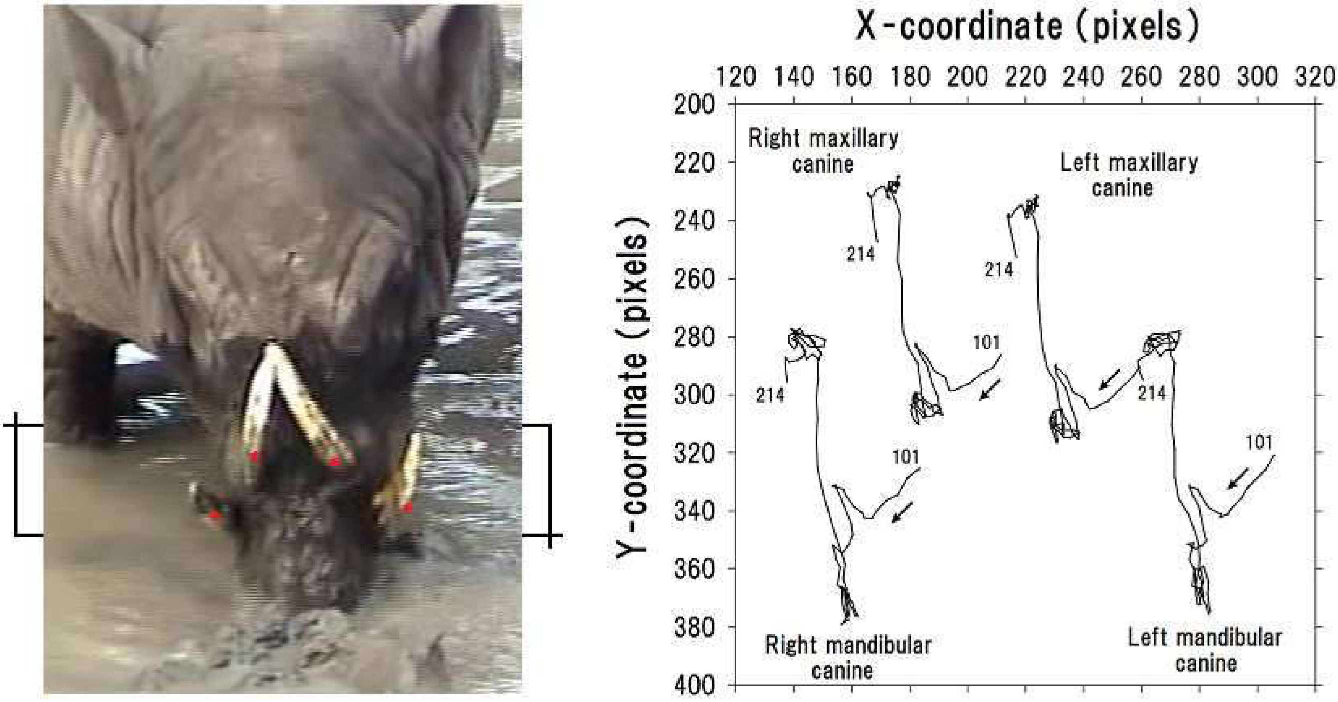

Fig. 2: Measurement points of the coordinates and trajectory of the movement of babirusa canine teeth observed in frontal view. The red dots on the image indicate the measurement points. The y-coordinates on the vertical axis of the trajectory increase from top to bottom, in accordance with the fact that the origin (0, 0) of the x- and y-coordinate system of ImageJ software is set at the top left of the image. The values in the coordinate plane, 101 and 214, indicate the first and last frame numbers, respectively. The arrows indicate the direction of movement. The box on the image indicates the crop area to be used in Figure 5.

Vertical component of motion

The vertical movements are shown in the position-time graph (Figure 3). The results are restricted to those of the left canines to avoid any overlapping of movements of the contralateral canines on the graph. The decisive differences between the movements of the maxillary and mandibular canines were shown in the shaded interval from Frames #123 to #133. The maxillary canines exhibited a small vertical change of approximately 7 pixels (equivalent to 38.0% of the width at the base of the left maxillary canine), whereas the mandibular canines showed a decrease of 24 pixels (equivalent to 130.4% of the left maxillary canine width). Given the limited movement of the maxillary canines, the difference between the two movements suggested a mouth-opening

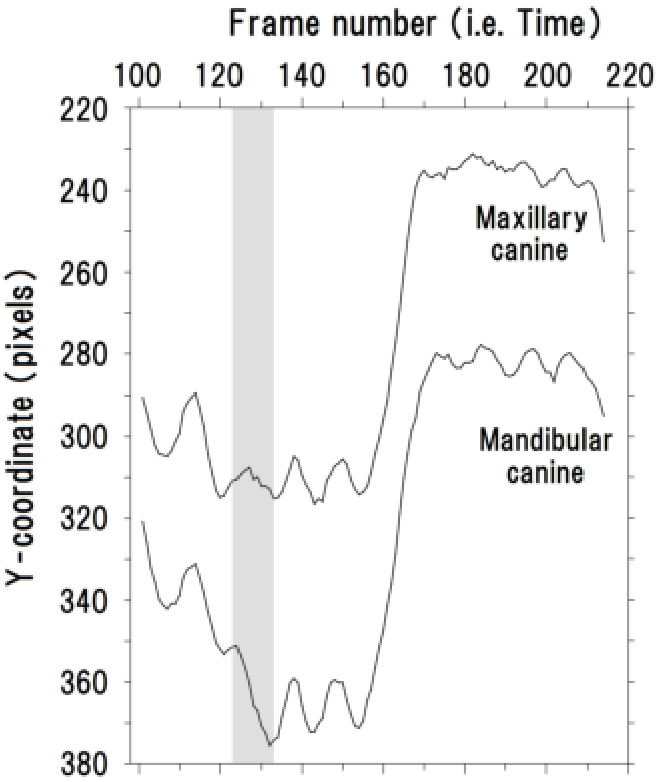

Fig. 3: Position-time graph based on the measured y-coordinates of the left canine teeth of the male babirusa. The values on the vertical axis increase from top to bottom. Note that in the shaded interval Frames #123–133, the maxillary canines show a small vertical variation, whereas the mandibular canines show a significant decrease.

movement (i.e., pitch rotation of the mandible) had occurred with the snout tip inserted into the mud.

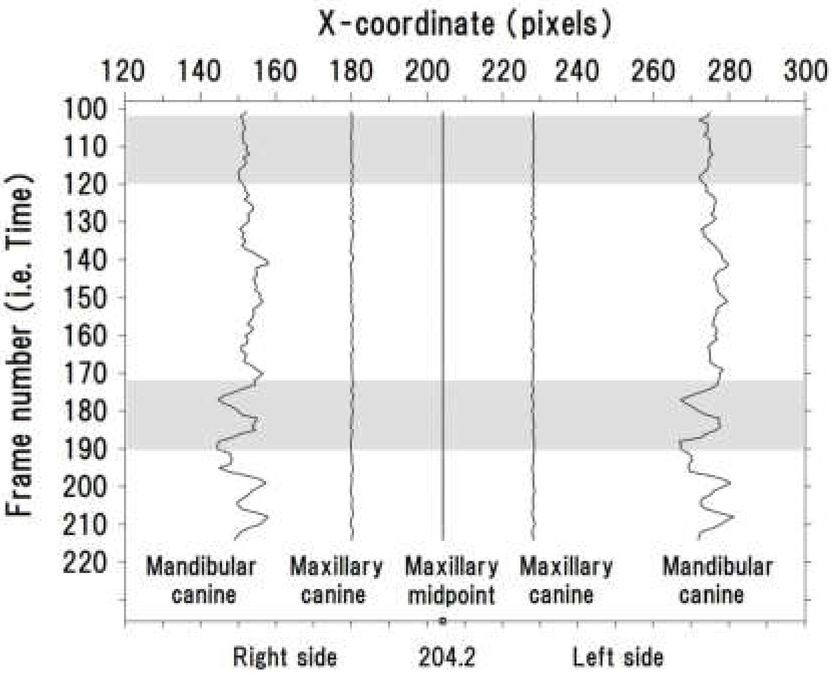

Fig. 4: Position-time graph based on the x-coordinates of the male babirusa canine teeth relative to the maxillary midpoint. The time (i.e., frame number) on the vertical axis runs from the top to bottom. The x-coordinates of the maxillary midpoint in each frame are consistently plotted at a mean value of 204.2. Note that from Frame #168 onwards, the mandibular canines repeat a clear horizontal movement, suggesting the yaw movement of the mandible. The two shaded intervals correspond to the photographic presentations in Figure 5.

Horizontal component of motion

A slight body swaying of the animal caused a range of values for the x-coordinate around the maxillary midpoint (M = 204.2, SD = 22.7, n = 114 frames). This was compensated for by bringing the x-coordinate of the maxillary midpoint to the mean value (204.2) (Figure 4). In the interval from Frame #101 to #167, the mandibular canines showed relatively little horizontal waveform variation. However, from Frame #168 onwards, waveforms with a mean horizontal displacement of 9.9 pixels (SD = 1.6, n = 7; equivalent to 53.8% of the left maxillary canine width) were recorded at a frequency of approximately three cycles per second. The difference in the horizontal movement of the mandibular canines between the two shaded intervals (Frames #102–120 and Frames #172–190) in Figure 4 was in agreement with the direct comparison of the still images (Figure 5). In the former, the four canines presented an almost straight alignment. This suggested no yaw movement of the mandible (Figure 5A). In the latter, the maxillary canines, in the centre of the images, presented an almost straight alignment, whereas the mandibular canines on either side of the image formed gentle waving curves. This clearly suggested mandibular yaw movement (Figure 5B).

Temporal change in the horizontal distance between the positions of the maxillary and mandibular canine teeth

Figure 6 shows the change over time of the difference between the actual measurements of the x-coordinates of maxillary and mandibular canines. In the interval from Frame #101 to #167, there was no clear waveform. However, from Frame #168 onwards, waveforms with a mean peak-to-peak amplitude (i.e., the change between highest and lowest values) of 9.8 pixels (SD = 1.5, n = 7; equivalent to 53.3% of the left maxillary canine width) were recorded at a frequency of approximately three cycles per second.

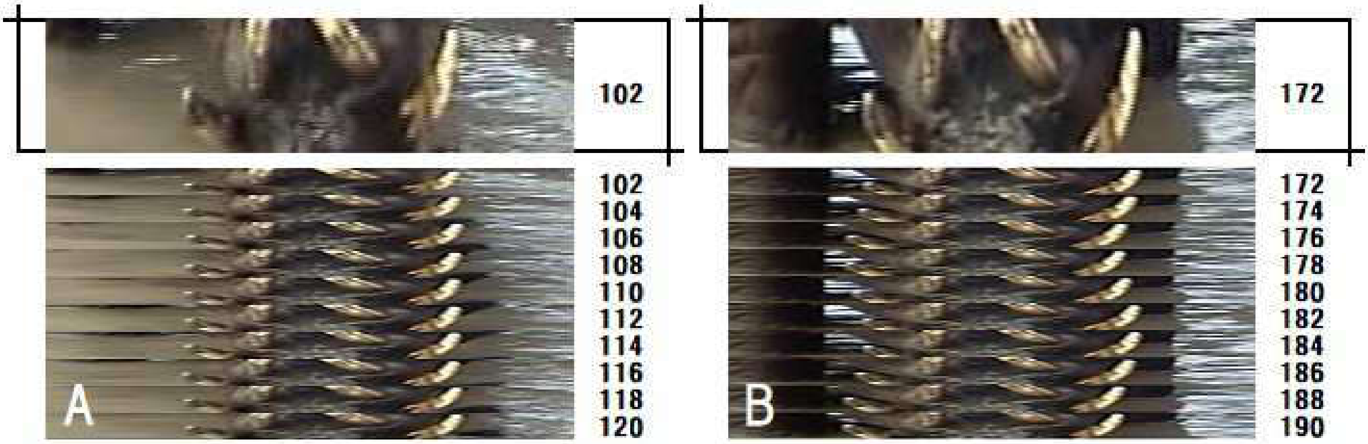

Fig. 5: A sequence of cropped images showing the dorsal part of the snout with the four canine teeth of an adult male babirusa. The number to the right of the image indicates the frame number. The top images #102 and #172 are the cropped images of the specified area in Figure 2. A: The 10 images of the identical area cropped from even-numbered Frames #102 to #120, corresponding to 0.6 sec of the video. The 10 images have been scaled down to 20% vertically compared with the cropped areas. Note that the four canines present an almost straight alignment, suggesting no mandibular yaw movement. B: The 10 cropped images from even-numbered Frames #172 to #190 created in the same way. Note that the mandibular canines in the image form a gentle wavy curve, clearly suggesting the yaw movement of the mandible.

Regarding the two variables, the x-coordinate of the mandibular canine after alignment at the maxillary midpoint in Figure 4 and the distance between the x-coordinates of the maxillary and mandibular canines as shown in Figure 6, there was a very strong, positive correlation, r (112) = 0.997, p < 0.001.

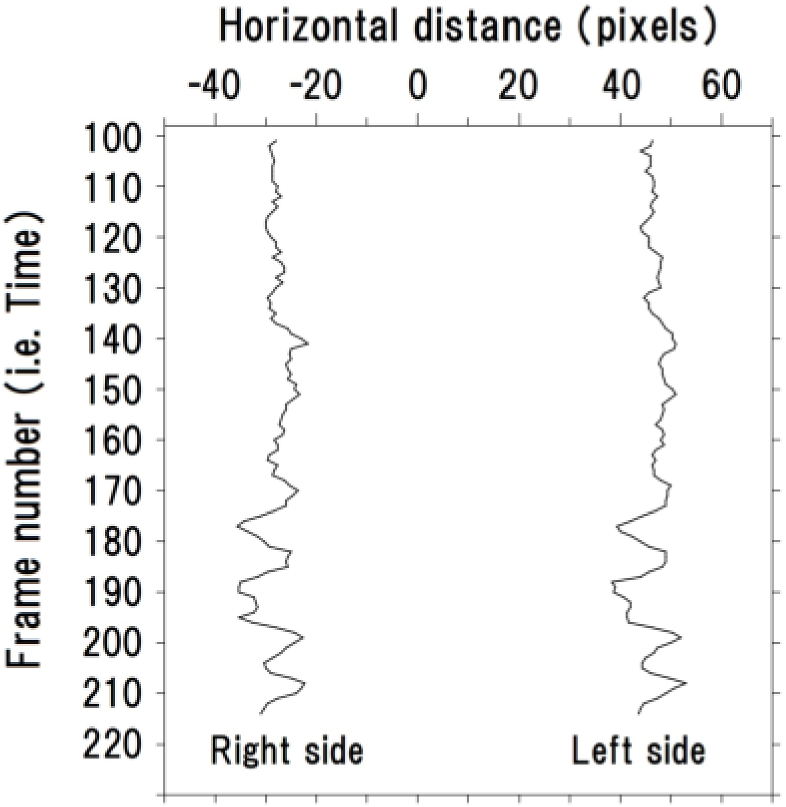

Fig. 6: Temporal change in the difference between the actual measurements of the x-coordinates of the maxillary and mandibular canine teeth on the same side of the male babirusa. The values on the horizontal axis are calculated as ‘the x-coordinate of the mandibular canine minus that of the maxillary canine’. Thus, the horizontal axis indicates the position of the mandibular canine when the maxillary canine is in the zero position. Note that these behaviours appear to be almost identical to those shown in Figure 4.

Discussion

Characteristics of the yaw movement of the babirusa mandible

We have demonstrated the mandibular yaw movement of the adult male babirusa geometrically (Figures 4 and 6) and photographically (Figure 5), based on videos of their usual behaviours.

In the initial 67 frames from Frame #101, a sequence of actions in which the animal inserted its snout into the shallow mud and dug up the mud (Figure

2) corresponded to the ‘ploughing behaviour’ with a scent-marking function observed in dry sand (Leus et al., 1996). During this period, the pitch rotation of the mandible was detected in the measured coordinate data. A clear yaw movement of the mandible was detected in the 47 frames following from Frame #168, immediately after the animal pulled his snout out of the mud to start chewing. The timing, direction and magnitude of the yaw movements represented in the waveform on the graph (Figures 4 and 6) were consistent with those of the actual movement of the animal (Figure 5B) and indicated that this simple method was suitable for reliably recording the yaw movements of the babirusa mandible as numerical data. The frequency of recorded babirusa yaw movements (approximately three cycles per second) was comparable to that of the transverse component of mastication in domestic pigs (Herring & Scapino, 1973).

Methodological validity

In the current study, we have succeeded in detecting the mandibular yaw movement of the babirusa using the coordinate data of the canine teeth. Measurement points on the lips or skin can be easily displaced by changes in facial expression, such as grimaces (Ito et al., in press) due to contraction of the facial muscles; these are independent of the movement of the temporomandibular joint. Therefore, the canines are the more appropriate measurement points for collecting positional data on the maxilla and mandible of the male babirusa. Note that this technique will not work for female animals or for male juveniles that do not have canine teeth outside the oral cavity.

Conclusion

Mandibular yaw movement of the male babirusa can be measured by evaluating the temporal change in the horizontal distance between the maxillary and mandibular canines in videos of the adult male animals viewed from the front. It is important to collect the coordinate data using strictly defined measurement points on the video frames at a magnification of at least 300%. The use of tracking markers attached to the canines could improve the efficiency of video analysis.

Acknowledgements

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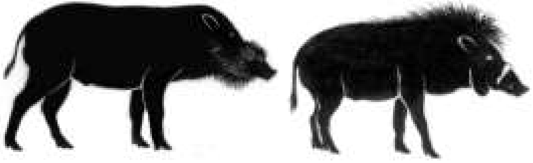

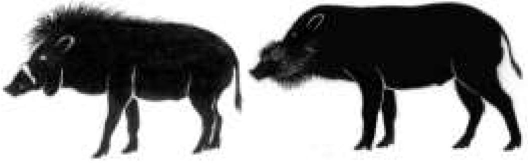

Notes on social grooming between adult female Sulawesi babirusa (*Babyrousa celebensis*)

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Abstract

Social interactions, including solicitations for nosing behaviour, between two unrelated adult female Sulawesi babirusa (*Babyrousa celebensis*) were observed in a zoo setting. When the dominant sow approached the already-lying-down subordinate sow, the dominant sow stood beside or over the snout of the subordinate sow. She then lay down, exposing her abdomen, and the subordinate sow responded with a gentle 'belly-nosing' behaviour by moving her snout vertically up and down on the abdomen of the dominant sow. We found no evidence to conclude that the gentle nosing behaviour by the subordinate babirusa sow towards the dominant animal constituted a harmful behaviour. Rather, the nosing behaviour of the babirusa sow appeared to be a form of social grooming.

Key words: belly nosing, inter-female interaction, social rank, soliciting behaviour, wild pig.

Introduction

The Sulawesi babirusa (*Babyrousa celebensis*) is a wild pig inhabiting Sulawesi, Indonesia (Macdonald, 2017a) and is a social animal that forms matriarchal groups (Patry et al., 1995; Clayton & MacDonald, 1999). Being a rare and wary species in the rainforests, the details of their behavioural patterns are still largely unknown.

In August 2016, when we were focusing on their feeding habits at Bali Zoo in Indonesia (Ito et al., 2017), we noticed previously undocumented interactions between babirusa sows. In video footage shot after the morning feeding of 27 August 2016, a babirusa sow named Priska approached a resting sow named Shela and lay down in front of her head. In response to this, Shela began to rub the udder area of Priska with her snout. The postures and motions of the two sows resembled those of a sow and piglet during suckling behaviour. At the same time, it was also reminiscent of the so-called 'belly nosing' behaviour, which is the most common abnormal behaviour in commercial pig production (e.g. Allison, 1976; Fraser, 1978). This persistent rooting behaviour with the pig snout against the abdomen of a pen-mate results in the development of abdominal skin lesions. Experiments with domestic pigs have shown that increasing the weaning age of piglets reduces the expression of abnormal 'belly-nosing' behaviour (e.g. Gonyou et al., 1998; Worobec et al., 1999; Main et al., 2005).

Thus, we questioned whether the babirusa inter-female interactions observed in August 2016 was a harmful behaviour or not. What did the social nosing of the abdomen in babirusa sows

represent? This is an observational case report detailing the behavioural aspects of the social interactions between babirusa sows during and following their lying-down behaviour.

Materials and methods

Study site, period and animals

Observations were carried out for 116 days between 21 August 2016 and 30 August 2018 at Bali Zoo in Indonesia. The subjects were two adult female Sulawesi babirusa, both born in Surabaya Zoo, Indonesia, without kinship to each other (Shela, born on 7 January 2003 and Priska, born on 10 October 2003). Both had a well-documented husbandry history, having been transferred to Babirusa Park, Indonesia, in December 2004 for five years of conservation breeding and behavioural research (Ito et al., 2019a,b, 2020, 2021a) before being transferred to the study site in April 2010. Each had experience of birth and good parenting. There were also records of intense conflicts between the two, particularly during the nursing period, but no records of belly nosing between them.

Enclosure and animal husbandry

Since 2015, when their male young were removed, the two solitary sows had been kept together in a 100 m^2 outdoor enclosure, because of babirusa being social animals. This meant that, in contrast the species' usual patterns of forming matriarchal groups (Patry et al., 1995; Clayton & MacDonald, 1999), a pair of unrelated sows was unwillingly created. Necessary equipment was installed in the enclosure, and the animals were fed twice a day, in the morning and late afternoon, with extra tree leaf fodder at midday (Ito et al., 2021b). Nesting material was provided. Animal handling was kept to a minimum. During the study period, neither animal had physical contact with males but exhibited normal oestrous cycles.

Observations of social rank and interaction

To ascertain the social rank, we routinely checked the following indications: 1) Food competition; 2) babirusa-specific agonistic behaviours, here where 'tossing the head' (i.e. thrusting the snout upwards while confronting an opponent) was regarded as a social dominance display, and in response to the signal, 'lowering the head' was regarded as a subordinate display (Macdonald et al., 1993); and 3) a facial expression showing a 'submissive grimace' (i.e. the raising of the corner of the upper lip) was also regarded as a signal by the subordinate sow.

Animal behaviour was observed live and also video-recorded for about two hours, including the morning feeding. Observations began when one sow was seen walking in the direction of the other sow, which had lain down beforehand, and ended when both sows either fell asleep or one of them stood up. We observed the following in detail:

1) The position of the approaching animal selected to lie down relative to the already recumbent partner, here as classified into four peripheral areas (cranial, caudal, ventral or dorsal sides; Fig. 1).

2) The postures and positions of the head and abdomen of both animals and the motions of the snout, abdomen and limbs during the belly nosing.

3) The time interval between when the approaching sow lay down and the already-lying-down animal started the belly nosing.

4) Whether the masseuse or recipient of the belly nosing was the subordinate or dominant sow.

The video-recording time for the analysis was about 28 hr 42 min. In cases when accurate

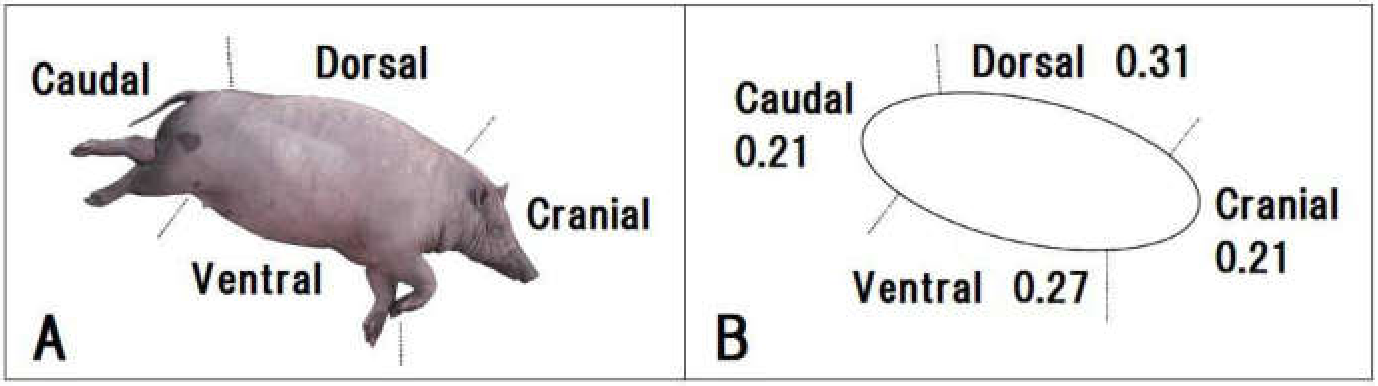

Fig. 1: The four peripheral areas around a babirusa sow lying in lateral recumbency to categorise the place where the approaching animal lay down.

A: The dominant sow, Priska, in the lying posture.

B: Approximate outline of the body trunk of a lying animal in Fig. 1A. As babirusa usually lie down close together, sometimes leaning on each other, a simple oval outline is sufficient to represent the place of the other animal. The values indicate the relative length of each arc. Assuming that babirusa will lie down randomly, the ratio of the four lengths is consistent with the theoretical ratio of the frequency of lying down in the four areas.

behavioural data could not be obtained because of the inconvenient position of the observer, such data were excluded from the analysis. Veterinary staff checked for the occurrence of skin lesions on both animals.

Results

Social rank

In every feeding time, Priska moved from her own feed trough to the other trough and drove Shela away so that Priska could eat more of her favourite foods. Shela was recorded lowering her head (Fig. 2) with a ‘submissive grimace’ (Fig. 3). Clearly, Priska was consistently dominant over Shela throughout the study period.

Frequency of one sow approaching the other

We recorded 408 occasions of their interactions (Fig. 4). The dominant sow, Priska, initiated the interaction by approaching the other sow more frequently (n = 295, or 72.3%) than Shela

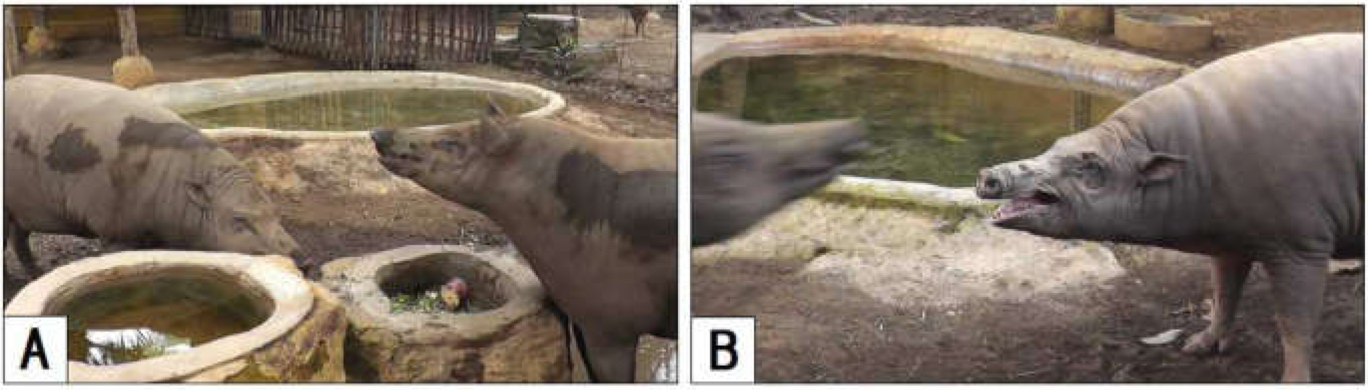

Fig. 2: Agonistic interactions between babirusa sows at the food trough.

A: The subordinate babirusa sow, Shela (left), lowering her head in submission to the dominant sow, Priska (right).

B: The dominant babirusa sow, Priska (left), thrusting her snout upwards, and the subordinate sow, Shela (right), lowering her head with a submissive grimace.

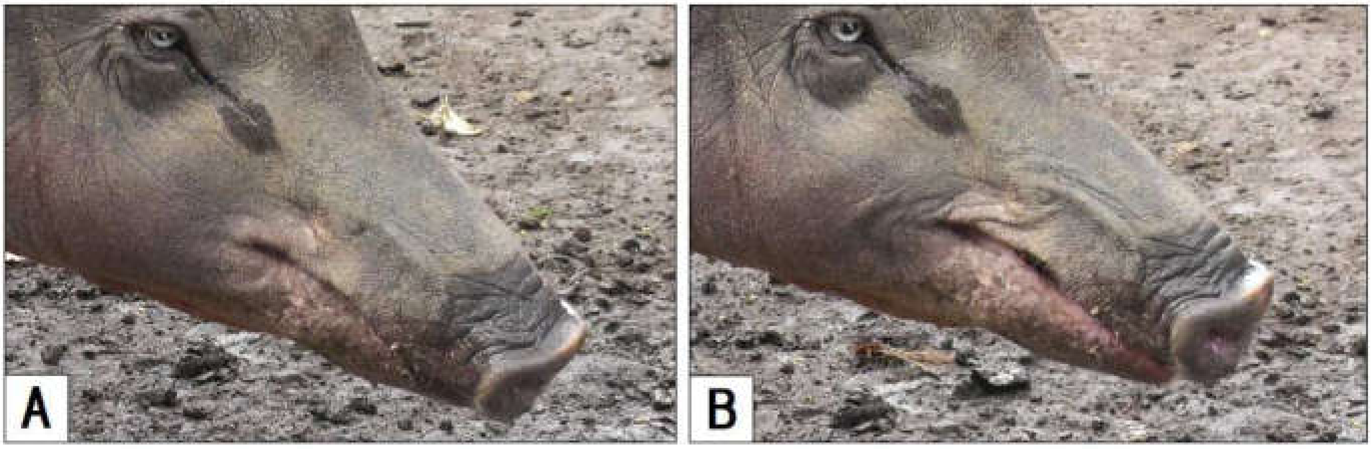

Fig. 3 Facial expressions of the babirusa sow.

A: Usual face of the subordinate babirusa sow, Shela.

B: Submissive grimace of Shela. Note the raised upper lip and raised corners of her mouth, which are characterised by the wrinkling of hairless skin.

approached Priska (n = 59, or 14.5%; binomial test, P < 0.001). The initiator on the remaining 54 occasions (13.2%) could not be identified, as each interaction had already started at the beginning of our observations.

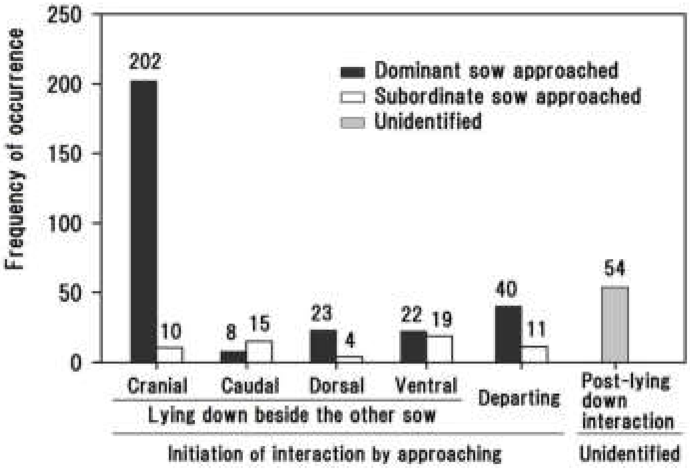

Fig. 4: A depiction of the 408 interactions observed.

Behavioural samples where the animal approached the other resting babirusa sow and then walked away without lying down or belly nosing were plotted in the category ‘Departing’. The 54 interactions (grey bar, categorised as ‘Unidentified’) had already started with both animals in their lying position at the beginning of the observation.

The dominant sow approached the already-lying-down subordinate sow

The 295 interactions initiated by the dominant sow consisted of 255 interactions when the dominant animal lay down beside the subordinate sow and 40 short interactions when the dominant sow walked away from the other after being approached.

The dominant sow selected the cranial area of the resting subordinate sow as the place to lie down (n = 202 of 255, or 79.2%) more frequently than the theoretically expected rate (Fig. 1B; binomial test, P < 0.001). In front of the subordinate sow’s head, the dominant sow exposed her abdomen at a significantly higher rate (n = 197 of 202, or 97.5%) than the theoretically expected rate (Fig. 1B; binomial test, P < 0.001). She never lay down with her dorsum or head in front of the subordinate sow’s head. Almost immediately after exposing her abdomen (M = 2.3 s, SD = 4.9, n = 104), the dominant sow began to receive ‘belly nosing’ from the subordinate sow (n = 126 of 202, or 62.4%; Fig. 6) at an average rate of 8.3 times per 10 seconds (SD = 1.4, n = 104). The motion of the snout in this behaviour was similar to the udder massage (i.e. massage of the udder area with up-and-down movements of the snout) by piglets just before suckling. The massage lasted for an average of 70.7 s (SD = 90.2, n = 104) with short intervals to pause (M = 1.2 times, SD = 1.9, n = 104). During the massaging, the

Fig. 5: Initiation of the social interaction between the dominant and subordinate babirusa sows in the resting place.

A: The dominant babirusa sow, Priska, approaching the resting subordinate sow, Shela.

B: Priska straddling the head of Shela.

C: Priska exposing her abdomen to the head of Shela.

dominant sow often stretched out her limbs and held them in the air. 'Belly sucking' was not exhibited by the subordinate sow. Even after the masseuse had terminated her nosing behaviour, the recipient did not walk away. The lower jaw of the subordinate sow was sometimes placed on the thigh of the dominant sow in lateral recumbency. Often, both animals fell asleep together, except when external stimuli caused them to stand up.

In five of the 202 occasions (2.5%), when the dominant sow exposed her tail to the subordinate sow's head, the subordinate sow did not exhibit any nosing behaviour.

In addition, seven occasions of a different pattern of nosing behaviours were recorded. After the dominant sow approached the recumbent subordinate sow, the still-standing dominant sow briefly massaged the abdomen of the subordinate sow at a slightly lower rate (M = 6.2 times per 10 seconds, SD = 1.4, n = 7) and for a shorter period (M = 9.1 s, SD = 2.5, n = 7).

No agonistic interaction was seen on any of these occasions during the resting period.

Fig. 6 Belly nosing by the subordinate babirusa sow, Shela, on the abdomen of the dominant sow, Priska.

A: Shela placing her snout under the abdomen of the resting Priska.

B: Shela rubbing Priska's abdomen upwards with the tip of her snout.

C: The tip of Shela's snout reaches a higher position than in Fig. 6B.

The subordinate sow approached the already-lying-down dominant sow

Of the 59 interactions initiated by the subordinate sow, the subordinate sow lay down beside her on 48 occasions and walked away without physical contact on the remaining eleven occasions. The position of the subordinate sow's lying down had no bias towards the cranial area of the dominant sow (n = 10 of 48, or 20.8%; Fig. 1B; binomial test, P = 1). Only once (n = 1 of 59, or 1.7%) did the subordinate sow perform belly nosing on the dominant sow. Belly nosing in the opposite direction was also observed on one occasion (1.7%). Once (1.7%), when approaching the head of the dominant sow, the subordinate animal was bitten on the forelimb.

When the approaching sow was not identified

The remaining 54 occasions when we failed to record the initiator consisted of 16 occasions of belly nosing performed by the subordinate sow in the lying posture, 16 occasions of resting side by side and 22 occasions of resting in other positions. The motion of the snout during belly nosing by the subordinate sow and the rate of nosing (M = 8.7 times per 10 seconds, SD = 2.0, n = 16) were similar to those of the 126 interactions initiated by the dominant sow.

Table 1 Frequency of belly nosing according to the animal approached

The arrows indicate the direction of belly nosing.

Animal approaching the other sow	Number of observation	Frequency of belly nosing		
Dominant	295	Dominant	→ 7 ← 126	Subordinate
Subordinate	59	Dominant	→ 1 ← 1	Subordinate
Unidentified	54	Dominant	→ 0 ← 16	Subordinate
Total	408		151	

Comparison of the frequency of belly nosing

In total, 151 occasions of belly nosing were recorded (Table 1). Reciprocal belly nosing was not observed on any of these occasions; it was always unidirectional. Adding the 16 occasions mentioned above, the frequency of belly nosing performed was extremely biased towards the subordinate sow (n = 143 of 151, or 94.7%; binomial test, P < 0.001). When compared the expression rate of belly nosing at which they approached each other, the dominant sow Priska showed no difference in the expression rate between when Priska herself approached the other sow (n = 7 of 295, or 2.4%) and when the subordinate sow, Shela, approached (n = 1 of 59, or 1.7%; Fisher's exact test, P = 1). In contrast, Shela showed a significantly higher expression rate when Priska approached (n = 126 of 295, or 42.7%) than when Shela herself approached (n = 1 of 59, or 1.7%; Fisher's exact test, P < 0.001).

Skin condition after nosing behaviour

During the study period, there were no skin lesions occurring on either animal that could be attributed to the nosing behaviour. There was no large difference in body condition, such as thinness and obesity, between them. There was no evidence of unusual rubbing behaviour against objects in the enclosure.

Discussion

Differences in individual behaviour

The majority (n = 295 of 408, or 72.3%) of the interactions were initiated by the dominant sow approaching the subordinate one. One possible explanation for this is that the subordinate sow, which had usually lost the food competition, started resting earlier. In addition, the dominant sow chose to lie down more often next to the head of the subordinate sow (n = 202 of 255, or 79.2%), than when the subordinate sow performed the same action (n = 10 of 48, or 20.8%; Fisher's exact test, P < 0.001). Such differences in the behavioural patterns between the babirusa sows may suggest that their behaviours were determined by their social rank rather than by opportunism or chance.

Characteristics of belly nosing in the babirusa sow

Although our observations were similar in appearance to abnormal belly nosing in domestic pigs, there were several fundamental differences between them. In the present study, 1) the recipient of the nosing behaviour approached the masseuse, who had already lain down (Fig. 5A) and exposed her abdomen towards the snout of the masseuse (Fig. 5C). 2) The recipient stretched her limbs during the nosing, much like the reaction of nursing sows during suckling. 3) After the nosing behaviour, the two animals did not leave the resting site but fell asleep in close physical contact. Moreover, a crucial difference was 4) the age of the masseuse. In pig studies, these were predominantly piglets that had been force-weaned at an early age, whereas in the current study, the animal was a babirusa sow having experienced giving birth and lactation.

Harmless belly nosing in the babirusa

The belly-nosing behaviour reported here occurred at a specific time, almost immediately after the recipient lay down (M = 2.3 s) and lasted a relatively short period of time (M = 70.7 s). Hence, it does not constitute stereotypic behaviour. Their interactions were not a series of coincidences but seemed to represent an orderly dialogue. There was no evidence of skin lesions in the babirusa caused by nosing. These findings indicate that the belly nosing of the babirusa in the present study could not be regarded as harmful behaviour. Rather, the observation of the recipient’s hind legs being stretched in the air and both animals falling asleep together can be judged as reflecting an affiliative relationship in these babirusa sows.

Structural characteristics of the babirusa snout

As is well known, Eurasian wild pigs (*Sus scrofa*) can dig up hard ground for foraging. In contrast, the babirusa can only plunge its snout into sandy, soft or muddy ground for scent marking (Leus et al., 1996). The difference in their digging ability has been explained by the fact that pigs have a distinct rostral bone (os rostrale) in the most rostral extension of the nasal septal cartilage (Hillmann, 1971), whereas babirusa lack the development of the bone; only a (1–2 mm) thin 1–3 cm^2 piece of calcified cartilage or bone is present (Macdonald, 2017a,b). We speculate, therefore, that the belly nosing between the adult babirusa may be just a gentle rubbing of the recipient.

Solicitations for belly nosing in the babirusa sow

Another notable observation was the apparent solicitation of belly nosing. When the dominant sow Priska approached Shela and exposed her abdomen to Shela’s snout, Shela began nosing her. However, when Shela spontaneously approached the dominant sow Priska, Shela rarely performed belly nosing towards Priska (Table 1). The difference in Shela’s positive attitude towards belly nosing could be attributed to the presence or absence of an intervention by the recipient.

The exposure of the abdomen exhibited by the babirusa sow was comparable to the soliciting behaviour observed in Japanese macaques (Macaca fuscata), which has been defined as ‘a gesture by presenting the neck, face, rump, dorsum, ventrum, or flank, or as lying down in front of the partner’ (Ueno et al., 2014). We interpreted the gesture of one babirusa sow exposing her abdomen to the snout of the other as a sign of soliciting behaviour, seeking gentle nosing of the abdomen.

Potential role of belly nosing in the babirusa

Studies indicate that gentle stimulation of the abdomen of domestic pigs can have positive effects on the recipient. According to Camerlink et al. (2012), pigs that received more social nosing gain more weight. Based on their neurobiological study, Rault et al. (2019) argue that stroking of the pig's abdomen offers an interesting model for the study of positive welfare. Perhaps, these effects could also be expected in the babirusa.

After the cohabitation of the two babirusa sows, they showed not only agonistic interactions (Fig. 2), but also developed affiliative interactions such as cooperative work to build sleeping nests (Ito et al., 2019a,b) and nosing behaviour reported herein. Taking into account the development of the affiliative relationship between the two sows in a dominant-subordinate relationship, we speculate that the soliciting behaviour and the resulting nosing behaviour may be social skills that contribute to post-competition reconciliation between babirusa sows. In line with research on domestic pigs (e.g. Camerlink & Turner, 2013; Camerlink et al., 2014), more studies on affiliative and agonistic interactions of the babirusa will help us better understand the social skills of the babirusa.

Limitations

Caution should be taken in the interpretation of our findings. The current study was initiated by an extremely rare opportunity to observe the social interactions between two unrelated babirusa sows. Fortunately for the health of the species yet unfortunately when it comes to collecting more data, there were no other babirusa sow–sow pairs kept in Indonesian zoos under the same conditions as these because keeping sow–sow pairs is not ideal for conservation breeding. Clearly, much more data on the social interactions between more subjects are required to generalise our findings to this animal species.

Acknowledgements

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Where Are All The Sabah Pigs?

https://www.macaranga.org/where-are-all-the-sabah-pigs/
by Kymberley Chu, SL Wong and Alven Chang, 16th February 2022

African Swine Fever has devastated wild pig populations in Sabah. To understand its impact on the animals, the forest, and people, data is needed. But counting pigs is tricky. This is Part 1 of a two-parter on the impact of the disease. IT IS December 2020 and in the Lower Kinabatangan Wildlife Sanctuary, Sabah, a dead Bornean bearded pig (*Sus barbatus*) lies on the ground. It was the first of 14 that would be found in the following weeks.

“We knew something was very wrong when more pig carcasses started to pop up,” says Dr Benoit Goossens, director of the Danau Girang Field Center, which is located there.

That discovery was the first report of African Swine Fever (ASF) in Sabah. ASF is a highly contagious viral disease affecting pigs and can kill them in as few as 6 days.

From media reports and interviews with scientists and locals, the disease is decimating wild pig populations in Sabah. Currently, the outbreak is on-going as there is no treatment for ASF.

To control its spread, the state instituted culling, suspended hunting of wild pigs and cautioned against wild pig consumption.

If so many wild pigs have died from the outbreak, how is this affecting the forest ecosystems? This worries one tropical forest ecologist.

Sui Peng Heon was reading the newspaper when she learned about the ASF outbreak in the Kinabatangan area in March last year. She is a research team lead with the Stability of Altered Forest Ecosystems (SAFE) Project, Sabah.Her team has been monitoring populations of medium sized mammals such as the bearded pig in the Kalabakan Forest Reserve since 2010.

Understudied

“There are severe gaps in our understanding of bearded pigs,” says Sui. Calling them the “gardeners of the forest”, she says wild pigs contribute to essential ecological services in maintaining forest biodiversity in Malaysia.

However, no thanks to the lack of scientific interest and dedicated funding for wild pigs, even the basic biology of wild pigs is “very poorly understood”.

A Borneon bearded pig suspected of having died of ASF. Photo: R. Kailoh

Goossens agrees. “There are not many studies on what they do, how they contribute to the forest and what would happen if they were not there.”

With ASF impacting these ‘gardeners’, what is happening to the forest? Sui and her team are determined to find out.

Barriers to counting

But getting information about the outbreak has been difficult. To begin with, nobody has counted wild pigs in Sabah, though there are estimates of where they live, says Sui.

Scientists could not run field surveys due to strict movement control orders (MCOs) implemented to curb the concurrent Covid-19 pandemic raging through Sabah.

So scientists turned to crowd-sourcing for information on the ASF impact. “Have you seen any dead pigs? How are the pigs doing in your area?” they asked on social media. They shared findings with colleagues and the government. That quickly formalised into the Babi Hutan Project Borneo, a citizen science project to track bearded pigs.

A collaborative project of Imperial College London, the Sabah Wildlife Department, and Sabah Department of Veterinary Services (DVS), the project invites the public to report details and submit photos of ASF-infected pigs. Despite their efforts, the project’s data could not conclude on the severity of ASF, says Sui. The data comprised primarily anecdotal evidence and had huge discrepancies in everything from timelines to numbers of dead pigs.

Macaranga has been contacting the DVS for data and comments since November last year but has had no response to questions. Macaranga is therefore referring to validated data by the Malaysian DVS available on the public platform, World Organisation for Animal Health (OIE).

OIE sent Macaranga data from the date of the first confirmed outbreak on 8 February 2021 to 22 October 2021.

Interestingly, the data does not reflect the scale of devastation of ASF as reported by the media, locals and researchers. There were 38 ASF outbreaks in that period but the total verified number of deaths was 1,454. This comprised 72 wild pigs and 1,382 commercial pigs (including culled animals).

On the contrary, mass culling was announced by the state in February 2021 when the first ASF cases were detected among farmed pigs in Pitas district. The Star reported that 2,000 commercial pigs and 1,000 wild bearded pigs would be culled to counter the outbreak in the Pitas district alone.

However, according to the OIE data, in Pitas, 315 commercial pigs succumbed to ASF and only 25 were culled. No infected wild pigs were recorded.

For commercial pigs, the data appears to suggest that not many farms have been affected. According to federal DVS estimates, there were 89,627 commercial pigs in Sabah in 2020. The OIE data indicates that only a small number of that has been verified as affected. Nonetheless, as of January 2022, the Star reported that 20 of Sabah’s 23 districts had been declared outbreak districts, 10 of which were by then ASF-free. Macaranga could not verify commercial pig data and reports with the DVS, pig farm associations or commercial pig farmers, except for one commercial pig farmer.

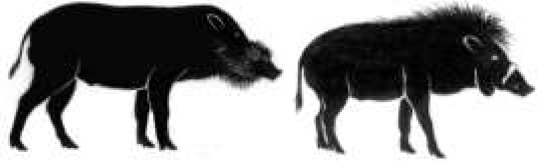
As for wild pigs, scientists aver that pig numbers have plunged. Goossens says his research centre’s camera traps in Kinabatangan show this.

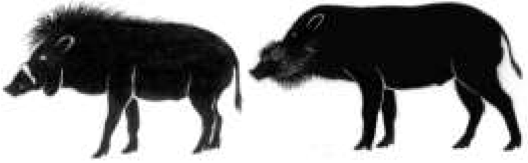
Before ASF, large families of wild pigs were regularly observed on camera traps and sighted along the Kinabatangan River. Tracks were observed in the forest.

But these sightings have plummeted since the outbreak. Goossens reckons that Kinabatangan has lost 90% of its pigs based on the impact of ASF as published in scientific findings elsewhere. “Usually what happens with ASF, about 90—95% of the wild pig populations are killed.”

The Covid factor

Collating data on wild pig deaths is extremely challenging, says Sui. The MCO meant rangers,





researchers and even recreational hikers could not enter pigs' forest habitats in protected areas. By nature, bearded pigs are already difficult to spot, with the males especially being solitary creatures unless it is breeding season, she says.

"They are widely distributed across a large spatial area, so it is unlikely you would notice many dead pigs or be alarmed [by them]."

Equally challenging is getting data from other wild pig habitats like oil palm estates and state forests near villages. Sui suggests that workers and villages did not understand the significance of dead pigs and did not trust authorities enough to report them.

Impact on forests

Sui hopes to bring the project to its next stage of investigating the ecological impacts of such a large drop in wild pig populations and recovery of the populations

"The bearded pigs are the most likely creatures you will encounter when you enter a forest. They're a very good indication generally of how the ecosystem is doing because they are resilient." Bearded pigs are also important for forest regeneration. When pigs consume seedlings and turn over the soil, they contribute to top-down control of how many seedlings tend to survive and become saplings.

Competition and diversity

Without them, Sui says "there could be uncontrollable sprouting of most seedlings into saplings and stiff competition in the understory. They [the seedlings] have to compete for more resources to grow into trees, which affects forest dynamics quite a bit."

What's more, wild boars shape tree diversity. Female pigs construct birthing nests using hundreds of tree saplings from different areas.

A 2021 scientific paper by Matthew Luskin and his colleagues suggests that the lack of wild pigs in "defaunated forests may be missing these wildlife disturbances that contribute to the maintenance of hyperdiverse (very diverse) plant communities".

Despite the gloomy backdrop of bloated pig carcasses across Sabah, both Sui and Goossens are optimistic that the wild pig populations will bounce back.

Says Goossens, "Pigs are really resilient. (ASF) hasn't wiped out the whole population; we still have evidence of pigs in our area. There have been photos taken of pigs and their piglets. They are a fast-reproducing species."

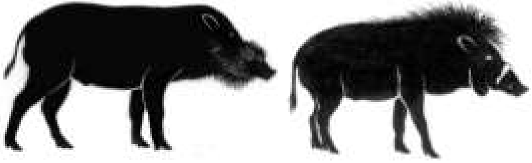
"It might take 2 to 3 years but I am pretty sure they will recover."

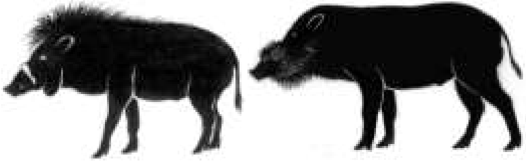
Hong Kong begins hunting wild boar amid public safety fears

https://www.theguardian.com/world/2021/nov/18/hong-kong-begins-hunting-wild-boar-amid-public-safety-fears
by Reuters, 18th Nov 2021

Penalties increased for feeding wild pigs as city struggles to control the animals, one of which bit a police officer last week.

Hong Kong authorities have captured and euthanised seven wild boars as they began a campaign to reduce their numbers in urban areas around the financial centre after one bit a policeman last week. The boar round-up on Wednesday in a district where authorities said some people were spotted feeding them marks a policy shift in controlling the most commonly seen wild animals in the city. "Veterinarians used dart guns to capture seven wild pigs for humane dispatch





through medicine injection," the Agriculture, Fisheries and Conservation Department (AFCD) said in a statement. It said boars in the residential area less than 30 minutes' drive from the heart of the financial district were "accustomed to wandering along the road and looking for food from passersby or even chasing vehicles."

Last week, a wild boar knocked down a police officer and bit his leg, causing a deep wound and prompting Hong Kong leader Carrie Lam to warn the government would increase penalties for those who feed them. That animal subsequently fell off the edge of a car park, plunging about 10 metres (33ft) to its death.

About 30 boar attacks have been reported in recent years, authorities said.

Hong Kong's policy had been to capture the animals, then sterilise and relocate them to remote, unpopulated areas. The city is home to about 3,000 wild boars, according to government data, and they are not a protected species. Boar have at times been seen on subway trains, or waiting for the traffic light to turn green at pedestrian crossings by the harbour. At the start of the coronavirus pandemic last year, when most Hong Kong people were working from home, a video of a boar family bathing in a fountain in between the financial district's skyscrapers went viral. The shift in policy has sparked criticism from animal rights groups.

Roni Wong, a spokesperson for the Hong Kong Wild Boar Concern Group, said the boar problem was caused by the government, which had failed to allocate resources to deal with the animals peacefully. "Now the animals have to pay for the cost," Wong said. Lam said this week she understood many in Hong Kong loved wild animals, but "ultimately, our society has to ensure the safety of residents". "As a responsible government, we need to take action," she said at her weekly news conference on Tuesday.

Feral hogs spotted in Canada national park for first time

https://www.theguardian.com/world/2021/oct/13/feral-hogs-canada-elk-island-national-park
by Leyland Cecco, 13th Oct 2021

Wild pigs seen in Alberta's Elk Island national park, raising fears they will cause damage to sensitive ecosystems.

Feral hogs have been spotted in a Canadian national park for the first time, raising fears that the wild pigs – which in recent years have rampaged across North America – will cause damage to sensitive ecosystems. Parks Canada has confirmed that wild pigs – a hybrid of domestic pigs and European wild boar – have been spotted in Alberta's Elk Island national park. Elk Island, a fenced-in park 40km (25 miles) east of Edmonton, is home to one of the country's largest wild bison herds.

The pigs – which can weigh more than 300lb and move in groups called "sounders" – are voracious eaters of roots, bulbs, tubers, bird eggs and small amphibians. They destroy wetlands and contaminate water sources. "Wild pigs are the worst invasive wild mammal on the planet," said Ryan Brook, head of the University of Saskatchewan's Canadian Wild Pig Research Project. "They're a global menace." "Public sightings and video sightings provided by landowners confirm that there is at least one sounder [a sow and piglets] in the region that is known to periodically come into the park," a Parks Canada spokesperson, Janelle Verbruggen, told the Canadian Press.

In Elk Island, where bison herds coexist with elk and deer, Brook said the hogs could upend the

delicate balance of the park. Both the grasses the ungulates graze on and the wetlands used by bison, could be destroyed. “They just rip through the ground, pulling up insect larvae and roots. They just tear everything apart so that it has a harder time growing back. They get into wetlands and they wallow around and they contaminate the water. They just do tremendous destruction,” he said.

The US Department of Agriculture estimates feral hogs cause more than $1.5bn in damage nationwide every year. Verbruggen said the Alberta government is working with Parks Canada to prevent the hogs from establishing a permanent presence in the area. The pigs were introduced to Canada’s Prairies in the 1990s by farmers, but have proved impossible to control once they escape the confines of a farm. Hogs are “extremely smart and elusive”, according to the the Canadian Wild Pig Research Project.

Ryan Brook, who heads up the project at the University of Saskatchewan, told the Canadian Press that while Elk Island is the first to have feral pigs, he suspects Prince Albert national park in Saskatchewan will probably be next.

Experts say trapping is the best method to deal with the hogs – but an entire sounder must be trapped at once, or else the pigs will startle easily and disperse quickly.

While hunting has become an increasingly popular option in the United States – and one that went viral on social media after one farmer asked how he should handle “30-50 feral hogs” suddenly appearing on his property – experts say firearms spook the animals and often make the problem worse. “While we fully support hunters and hunting, we also acknowledge that nowhere on Earth has hunting ever successfully controlled wild pig populations,” wrote Brook.

Hippo talk: study sheds light on purpose of call and response

https://www.theguardian.com/environment/2022/jan/24/hippo-talk-study-purpose-call-and-response
by Nicola Davis, 24th Jan 2022

Researchers say ‘wheeze honks’ are identity signals, with reactions ranging from calls to spraying dung linked to level of familiarity.

A call from a stranger may elicit myriad responses – panic, confusion, maybe even excitement – but it turns out that hippos have a rather more corporeal reaction: they spray dung.

Researchers studying hippopotamuses in Mozambique have revealed that the creatures not only react to the vocalisations of other hippos, but that the calls act as an identity signal. In other words, they allow hippos to tell the difference between a familiar individual and a stranger. “Hippos are quite talkative. They have a repertoire of different calls: wheeze honks, grunts, bellows, squeals,” said Prof Nicolas Mathevon, of the University of Saint-Etienne in France, a co-author of the study. “However, the function of these calls has not been studied experimentally. Our study is the first to test experimentally the function of a hippo call.”

Writing in the journal Current Biology, Mathevon and colleagues report how they studied the loud “wheeze honk” calls of hippos – a sound not unlike a growling laugh.

The team recorded calls from individual hippos within groups – or pods – living in the same or different lakes in the Maputo special reserve. Five pods were then played back calls from an individual in their own group, a neighbouring group at the same lake, and a distant group of hippos that were strangers to them, while two pods were played calls from their own group and a distant group. The team found that hippos responded to the calls by calling back, approaching the sound or by spraying dung. The latter, however, was more common when the call was from a stranger than from a hippo of the same or neighbouring group.

“When we played back familiar calls … the reaction was not aggressive. Basically, they just called back,” Mathevon told the Guardian.

The team add that the hippos’ responses were stronger for calls from individuals that were less familiar. “Our experiments suggest that in hippos, the arrival of a stranger individual is perceived as more threatening than that of a neighbour,” the team write.

While Mathevon said it was not a surprise that hippos use vocalisations to communicate – noting they are an excellent way to send information – he said the results show that hippo groups are territorial.

The team add that their experiments show wheeze honks can travel more than 1km (0.6 miles), suggesting hippos would be familiar with the calls of others living on the same lake.

“The most interesting thing to come out of this study is that hippos may have a fine-grained knowledge of the voices of all the individuals around them, and that this knowledge can help them navigate in their social network,” said Mathevon. The team said the findings could have implications for conservation, particularly when it comes to relocating individuals.

“It may be possible to get the local hippos used to the voice of the new ones before they arrive and vice versa,” said Mathevon. “Of course, we are not saying that this measure will be sufficient to suppress all aggression, since other sensory signals are certainly also involved, but it may help.”

Two hippos test positive for Covid at Antwerp zoo

https://www.theguardian.com/world/2021/dec/05/hippos-test-positive-covid-antwerp-zoo-belgium?CMP=fb_gu&utm_medium=Social&utm_source=Facebook
by Reuters, 5th Dec 2021

Staff at zoo in Belgium investigating cause of infections, which could be first reported cases in species.

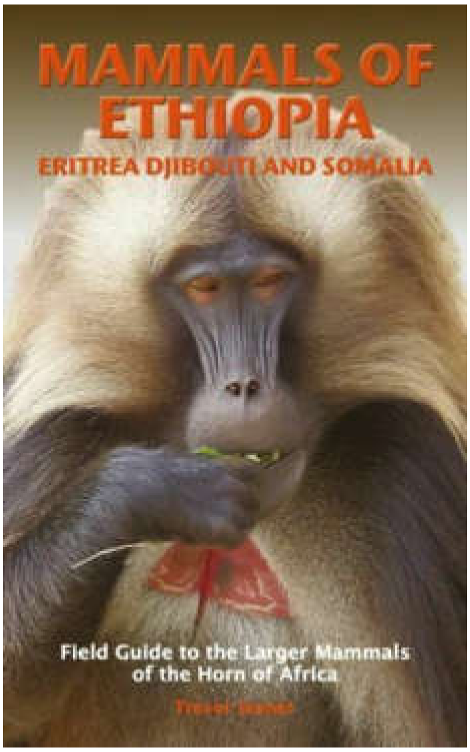
Two hippos at Antwerp zoo in Belgium have tested positive for Covid-19 in what could be the first reported cases in the species, staff said.

Imani, aged 14, and Hermien, 41, have no symptoms apart from runny noses, but the zoo said they had been put in quarantine as a precaution. “To my knowledge, this is the first time in this species. Worldwide, this virus has been reported mainly in great apes and felines,” the zoo’s vet, Francis Vercammen, said. The coronavirus is thought to have jumped from an animal to a human, and it is proved to have passed from humans to animals.

Pets including cats, dogs and ferrets have become infected following contact with their owners, and zoo cases have been reported in big cats, otters, primates and hyenas. The disease has also spread in mink farms and to wild animals such as deer. Antwerp zoo is investigating the causes of the outbreak. None of the zookeepers had recently shown Covid symptoms or tested positive for the virus, it said.

New books about Suiformes

Mammals of Ethiopia, Eritrea, Djibouti and Somalia



The Horn of Africa comprises Ethiopia, Eritrea, Djibouti and Somalia. It covers a large but highly unknown African region from the lowest point below sea level at Lake Assal to the Simien Mountains and from the hyper-arid Danakil Desert to the forests near to the Congo Basin and the Afroalpine moorlands, flooded grasslands and acacia savannas. This is a centre of mammalian biodiversity in Africa. From 281 mammal species found in this region 45 are endemic, most of them shrews and rodents but also some gazelles and antelopes. Regarding human population size Ethiopia is the second largest African country after Nigeria. Overall, about 125 million people live in this region. Unfortunately, it is also known for civil wars and political unrest in Somalia and most recently in Ethiopia. Travelling and scientific research is very restricted and there are huge security problems in many parts.

Nevertheless, the mammal species of the Horn of Africa are fascinating and very interesting and deserve more attention.

After a short introduction including the different vegetation zones and habitats, biomes, topography each of the mentioned countries is described in respect to climate and habitats. The book follows the taxonomy as used in The Kingdon Field Guide to African Mammals (Kingdon, 2012). As this is a field guide to larger mammals regarding rodents, only squirrels, porcupines and root-rats are presented in the species accounts. There are no species accounts of insectivore and bat species. The species accounts comprise a large photo of each species and often further photos, a distribution map, a short description of the the distribution in the covered region (including the mentioning of distinct subspecies living in the region), the IUCN Status, type locality, local names (if available), average sizes, morphological description, habitat, similar species and morphological differences to these similar species distinguishable in the field and a brief description of the species' behaviour.

Regarding Suiformes covered in this newsletter, the common hippo is patchily distributed in lakes and river systems in the southern and western part of the area. The bushpig (subspecies *Potamochoerus larvatus hassama*) can be found in Eritrea, Ethiopia and southern Somalia. There is a distinct subspecies of the Giant forest hog, *Hylochoerus meinertzhageni meinertzhageni* living in Ethiopia. Two subspecies of the common warthog can be found at the Horn of Africa, *Phacochoerus africanus africanus* in Ethiopia, northern Somalia and Djibouti and *P. a. aeliani* in Eritrea. The desert warthog and its subspecies *Phacochoerus aethiopicus delamerei* can be found in eastern and southern Ethiopia and Somalia.

Due to security issues, political unrest and civil war the knowledge of mammals and other animals is very poor in Somalia is very poor. Therefore, distribution maps of many species cover only parts of Somalia. The part following of the species accounts deals with descriptions of national parks in Ehtiopia and where to find mammals there and in Eritrea, Djibouti and Somalia. This part also includes a list of national parks reserves and sanctuaries in each of the countries including main features and main mammal species that can or could be found there. Unfortunately, no information are available for many of these reserves in Somalia due to armed conflicts (see above).

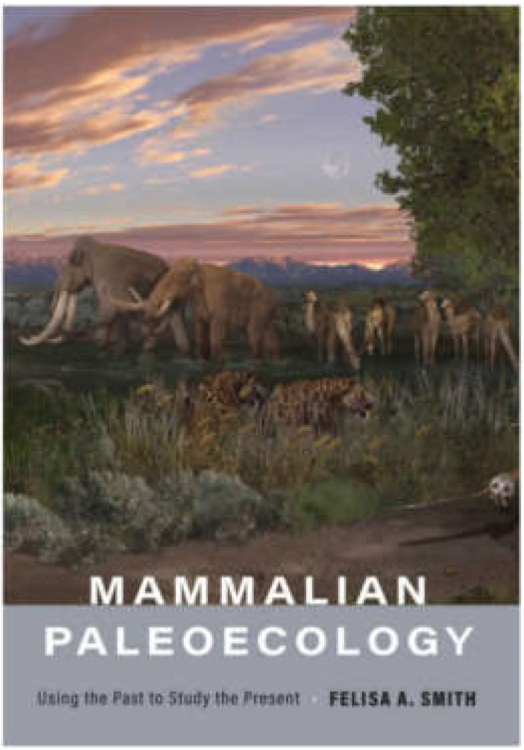
Finally, there is a checklist of mammals of the Horn of Africa (including insectivores and all known rodents and bats), a description of eponyms of larger mammals of the Horn of Africa and a brief note about species conservation in region as wells as organisations involved in the conservation and a map review.

This book fills a gap with all the 232 photos in high quality, distribution maps and up to date information on little known and endangered mammals like the dibatag and the beira. Hopefully, it will help to raise attention to the mammals of this area and will inspire more conservation efforts for the mammal species living at the Horn of Africa.

Mammals of Ethiopia, Eritrea, Djibouti and Somali – Field Guide to the Larger Mammals of the Horn of Africa
by Trevor Jenner
216 pages, paperback
Meru Publishing 2020
ISBN: 9780993416118

Reviewed by Thiemo Braasch

Mammalian Paleoecology – Using the Past to Study the Present



Paleoecology is the study of interactions between organisms and their environments across geological timescales. This book focuses on mammalian paeloecology. After a brief introduction the book is separated into three parts.

Part 1 deals with the general principles of paleoecology. It offers the history of the subject paleoecology, fossils and fossil types, taphonomy (the way animals become fossils, fossilization) and determing age and context.

Part 2 is about characterizing the ecology of fossil organisms including the size of fossils and the derived size of ancient mammals (including gigantism and dwarfism), the scientific investigation of fossil mammalian teeth and what these teeth teach us about the ecology of ancient mammals, how to use stable isotope analysis for the reconstruction of mammalian movement, diet and trophic relationships, nontraditional “fossils” like footprints, fossilized fecal pellets and mammal midden and finally a short chapter about reconstructing past climate.

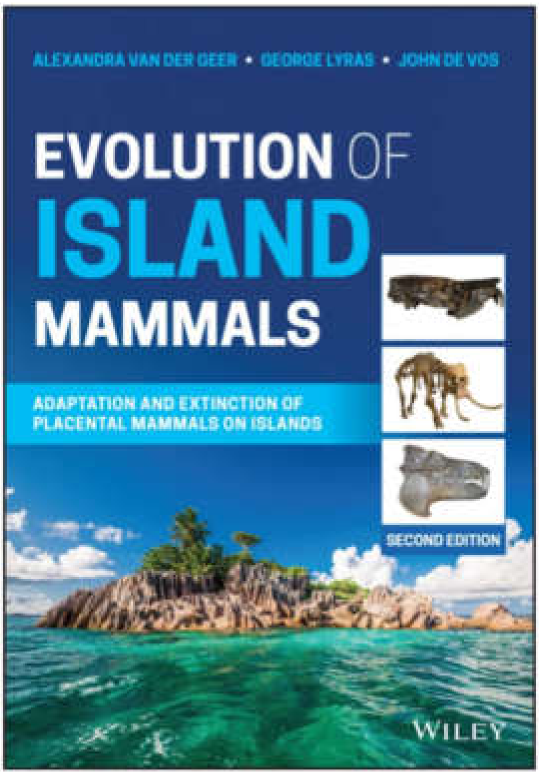
The last part 3 explains how to use paleoecology to understand the present. The past has been the prologue for the present. Therefore, understanding how mammals adapted to past climate changes can help us to understand how mammals will adapt to the ongoing human made global

climate change. How serious is the loss of biodiversity today? Is the current rate of biodiversity loss unusual in earth history? Are we the new driver of extinctions? This chapter answers important present questions and discusses the importance of megafauna for ecosystems.
Overall, this book offers a well written overview about mammalian paeloecology. There are 50 black and white photos, 90 black and white illustrations and tables to illustrate each chapter. A list of publication is provided at the end of each chapter for further reading and there is also a long list of references at the end of the book. This book is highly recommended to people who are interested in palaeontology of mammals and how this science can help us to understand us how organisms respond and adapt to environmental changes.

Mammalian Paleoecology – Using the Past to Study the Present
by Felisa A. Smith
260 pages
John Hopkins University Press 2021
ISBN: 9781421441405

Reviewed by Thiemo Braasch

Evolution of Island Mammals – Adaptation and Extinction of Placental Mammals on Islands



Islands are famous for endemic species like moas and kiwis on New Zealand or the Comodo Dragon in Indonesia as well as anoas and babirusas in the same country. Many exceptional and even bizarre mammals have evolved on islands like dwarf elephants or giant rats. This book is the most updated overview of the current knowledge on fossil island mammals around the world.
The first part of the book is about the history of island studies, island types, dispersals to islands, species that can become successful islanders and composition of island faunas.
The second part deals with some islands and their faunas. The mammalian faunas of Cyprus, Crete, Gargano, Sicily, Malta, Sardinia and Corsica, the Balearic Islands, Madagascar, Java, Flores, Sulawesi, the Philippines, Honshu, Shikoku and Kyushu, the southern and central Ryukyu Islands, the Californian Channel Islands, the Greater Antilles, and finally the Lesser Antilles are presented. These islands are described by their geology and palaeography, historical palaeontology, biozones and faunal units and peculiarities and evolution of endemic lineages. Regarding Suiformes, there are descriptions of the dwarf hippopotamus of Cyprus, dwarf hippos of Crete, dwarf hippos of Sicily, the dwarf hippopotamus of Malta, island pigs of Sardinia and Corsica, hippos of Madagascar, the extinct Sulawesi giant Pig and the extant babirusa on Sulawesi, extant warty pigs on the Philippines and

the extant Ryukyu Wild Pig on Ryukyu. In Suiformes there is one trend: All insular hippos were smaller than their mainland ancestors. Island pigs are also smaller than those living on mainlaind.

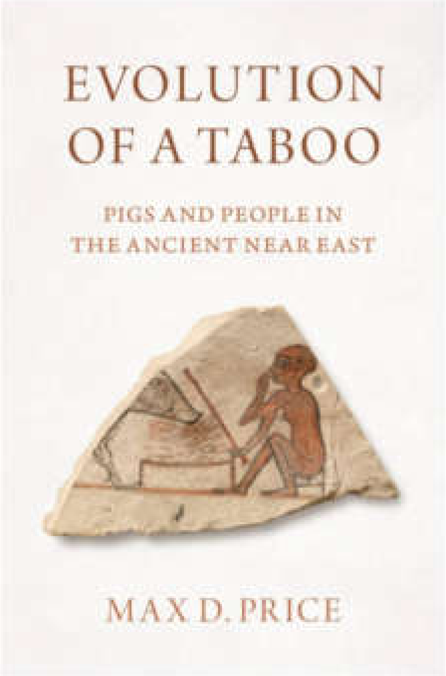
The final third part of the book deals with an overview of endemic species on islands summarising the chapters before, speciation processes in island environments, dwarfism and gigantism on islands, parallel patterns and trends and finally the extinction of island mammals.

There are few information available about ancient and extinct island mammals and the second part of the book offers an overwhelming cornucopia of information about unique and even bizarre pygmy and giant forms of different mammals. The book has many illustrations and photos of fossils and presents the extinct fauna of islands impressively. Although the reasons for the extinction of the many presented species in the book are not discussed for some of them the arrival of modern humans might have been the cause. Islands offer unique insights in the evolution of mammals. This book closes a gap by showing and describing the marvellous ancient mammal fauna as a compendium and with the analysis of the processes and mechanisms underlying mammalian island evolution. Everyone interested in mammalian evolution and palaeontology will be fascinated by the ancient fauna of even well known islands presented in this book.

Evolution of Island Mammals – Adaptation and Extinction of Placental Mammals on Islands
by Alexandra van der Geer, George Lyras and John De Vos
576 pages
Second Edition, Waley Blackwell 2011
ISBN: 9781119675730

Reviewed by Thiemo Braasch

Evolution of a Taboo – Pigs and People in the Ancient Near East



EVOLUTION
OF A TABOO

PIGS AND PEOPLE IN
THE ANCIENT NEAR EAST

MAX D. PRICE

Why are pigs “haram”, forbidden by Muslim dietary laws? Why are pigs not kosher in Judaism? Why are pigs uncomplicated animals in cultures around the world but not for people in the Near East? According to zooarchaeology pigs were domesticated in the Near East around 10,000 years ago. Why were wild boars and domesticated pigs part of daily life in the ancient past and became a taboo in Judaism and Islam? Why are there strong negative attitudes against these animals?

Max D. Price is a lecturer in archaeology at the Massachusetts Institute of Technology and answers these questions in this book.

The author first presents a geographical background of the Near East and a zoological background of wild pig species living there, pig domestication and pig husbandry. The next chapters deal with the different ages and pig-human relationships during these times starting in the Palaeolithic age and later going through the following ages. Max D. Price writes about ancient artefacts and art depicting pigs and wild boars in different ages and what they tell us about human attitudes towards pigs, pig husbandry and urbanism, theorizing the taboo and discussing religious, physiological, ecological and politic-economic or ethnic-politic explanations. The pig taboo is also discussed as an evolving cultural element. Pigs became also part of cultural war between Romans and Jews.

It would be far beyond the scope of this review to discuss all the different aspects and facts around the pig taboo. The author offers an interdisciplinary explanation for the most important taboo in the modern word in a well written way. This book helps to understand the history of this taboo. Understanding is an important step to accept and tolerate cultural cultural differences and attitudes. Therefore, this author has written an extraordinary book that will hopefully get a wide audience not only for people interested in ancient history or the history of domesticated pigs but generally those who want to understand the ancient differences between Christianity, Judaism and Islam.

Evolution of a Taboo – Pigs and People in the Ancient Near East
by Max D. Price
312 pages
Oxford University Press 2021
ISBN: 9780197543276

Reviewed by Thiemo Braasch

General articles about Suiformes

Spatial distribution modeling of the wild boar (*Sus scrofa*) under current and future climate conditions in Iraq
Khwarahm, N.R., Ararat, K., HamadAmin, B.A., Najmaddin, P.M., Rasul A. and S. Qader 2021
Biologia Volume 77: 369–383
Wild boar (*Sus scrofa* L., 1758), was once native to Eurasia, is currently one of the most widely distributed species in the world. Apart from its economic values, the species is considered as a pest (e.g., for rooting behavior, agricultural damages and influencing livestock) and vector for spreading diseases (e.g., swine fever) particularly by farmers, villagers, and epidemiologists. Global climate change has shown to influence population growth and geographical distributions in a wide range of species. Expanding our knowledge on the potential distribution of *S. scrofa* under current and future climate change conditions is useful for effective management strategies. For example, for managing human-wildlife conflicts, locating and controlling the spread of diseases, population control, and reducing ecological threats. Using the maximum entropy (MaxEnt) algorithm and geographic information system (GIS) techniques, we aimed at (i) modeling current known distribution and predict the potential distribution of *S. scrofa* in the northeast of Iraq; (ii) modeling potential future distribution of the species under climate change scenarios; and (iii) identifying the most relevant environmental predictors influencing the spatial distribution. *Sus scrofa* populations are mainly distributed in the mountainous areas, within the optimal altitude

range of 750 -1250 m a.s.l. The range of contraction would be larger than the expansion range. Future distribution of the species would be toward the mountain forests of the east (mainly) and southeast of the Zagros Mountains where the forests are denser. Mixed oak forests and mosaic landscapes of grassland, shrubland, and croplands provide hideout, shade and abundant food choices for *S. scrofa* populations. Management strategies should focus primarily on the mixed forests and croplands, for locating and controlling the possible spread of diseases, population control, reducing ecological threats, and controlling human-wildlife conflicts. Current and future distribution maps (categorized maps) generated from the study provide invaluable baseline information for further research on the forest and mountain ecosystems in Iraq and across the Zagros Mountains.

Contribution of Acorn Masting to Food Composition and Body Condition of and Crop Damage by Wild Boars (*Sus scrofa*) Inhabiting Evergreen Forests in Japan Akitaka Omori, Eiji Hosoi

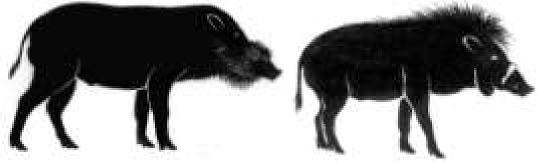
Omori, A. and E. Hosoi 2021
Mammal Study, 47(2): 1-11

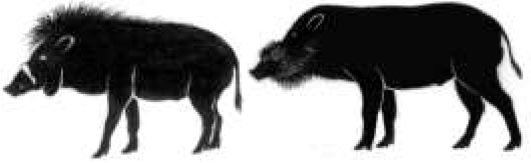
We analyzed the stomach contents of wild boars (*Sus scrofa*) inhabiting evergreen forests in western Japan and found that they were dependent on the masting of acorns of *Castanopsis cuspidata*. The increased availability of *C. cuspidata* acorns positively affected their consumption by wild boars. In the good mast years, wild boars consumed *C. cuspidata* acorns from November to June of the following year. No significant annual variation in body condition was detected, suggesting that alternative food resources (e.g., bamboo shoots) may have maintained the body condition of wild boars, even in poor mast years. A strong negative correlation was found between the consumption of *C. cuspidata* acorns and the amount of crop damage to vegetables. This study revealed the wild boar as a pulsed food resource feeder, which has not yet been identified in Japan, and emphasized the importance of considering *C. cuspidata* masting for designing effective strategies for mitigating crop damage.

The effect of hunter-wild boar interactions and landscape heterogeneity on wild boar population size: A simulation study

Lee, S.-H. and C.-M. Park 2022
Ecological Modelling 464, https://doi.org/10.1016/j.ecolmodel.2021.109847

In recent years, wild boar (*Sus scrofa*) populations have increased rapidly, causing serious problems such as crop damage and disease transmission. In the present study, we built an individual-based model to explore how heterogeneous landscapes and the interactions of wild boars and hunters affect wild boar population control. The simulated wild boars in the model move on a heterogeneous landscape. To make the movement more realistic, we included randomness in the simulated boar behavior. The simulated hunters either walk to move one site during a one-time step or jump to move multiple sites at once. Simulation results showed that the randomness positively contributed to the increase in population size, while the remaining variables contributed negatively. The randomness had the greatest impact on population size, followed by the landscape heterogeneity and the hunting success probability. On the other hand, the jumping movement probability had the least effect. Interestingly, the effect of jumping on the population size could be understood as a result of two effects cancelling one another; the hunters are trapped in the preferred area, and the hunters move to another area without removing all





simulated boars gathered in the preferred area. Furthermore, we briefly mentioned which ecological approaches can be used to control wild boar population growth with regard to our simulation results and proposed some ideas to improve the model and make it more realistic.

Spatio-temporal behaviour of female wild boar in an agro-forestry–pastoral landscape of Southern Italy

Gaudiano, L., Pucciarelli, L., Frassanito, A.G., Mori, E., Morimando, F., Silvestri, F.M., Sorino, R., Viviano, A. and G. Corriero 2022
Mammal Research, https://doi.org/10.1007/s13364-022-00617-7

Among large-sized mammals, the wild boar *Sus scrofa* is the main agricultural pest in Mediterranean countries. Despite being a widely studied species, its physiological adaptability requires a high number of research works assessing its ecology in different habitat types. Furthermore, little is known about ecology of the wild boar at the southernmost limits of its distribution range. We studied home range size, habitat selection and activity rhythms of female wild boar in a protected area of Southern Italy, at the limits of its distribution range. Population density was also assessed through drive counts. We monitored GPS collar-tagged, adult wild boar for at least 6 months. Female family groups selected deciduous woodland throughout the year, whereas scrubland and cultivations were selected only during the summer. Locations of wild boar were much closer to the forest edge than expected by chance alone. Throughout the year, female wild boar were mostly active between dusk and dawn with no significant inter-seasonal differences in the activity time; diurnal activity occurred principally in winter and spring. Wild boar were more active in the darkest nights, while their activity decreased in the full moon nights, possibly to limit encounters with the main predator, the grey wolf *Canis lupus*.

A review of the impacts of invasive wild pigs on native vertebrates

McDonough, M.T., Ditchkoff, S.S., Smith M.D. and K.C. Vercauteren 2022
Mammalian Biology, https://doi.org/10.1007/s42991-022-00234-6

The wild pig (*Sus scrofa*) is a successful invasive species that has become well established outside of its native range in Eurasia. The invasive wild pig is the result of released or escaped domesticated livestock becoming feral, or Eurasian boar introduced for hunting purposes. The global spread of wild pigs has recently been exacerbated in some areas, such as the USA, by anthropogenically assisted dispersal. Once established in novel ecosystems, wild pigs have the potential to have significant negative impacts on the ecosystem, and the scientific literature is replete with examples. It is generally accepted that wild pigs negatively impact native fauna where they have become established, yet the degree to which they impact faunal communities has not been well described. This paper serves as a review of the information to date on the implications of wild pig invasions and impacts they have on terrestrial vertebrates in their invasive range. In addition, the review highlights our need for more research in this area, particularly regarding declining species.

A Wild Boar Chase: Ecology of Harm and Half-Life Politics in Coastal Fukushima

Morimoto, R. 2022
Vol. 37 No. 1, https://doi.org/10.14506/ca37.1.08

This article explores how the Japanese state's radiation-centered approach to ecological redress in postfallout costal Fukushima impacts a local framework of relationality called en/By

ethnographically tracing encounters between humans and wild boars in the region through an ecosemiotic lens, the essay articulates the differences and tensions between en/ and the model of relationality that the government's decontamination policy enforces. In so doing, I decenter and unsettle the dominance of biomedically oriented, anxiety-driven toxic discourses of radiological threat. Against the narratives of anthropocentric exposure and nuclear victimhood that tend to encircle Fukushima since the nuclear accident, the article illuminates the multiscalar and semiotic issue that decontamination efforts catalyze. The essay argues that narrowly defining safety in terms of distancing radioisotopes from humans engages what I call a half-life politics of nuclear things, through which locals, wild boars, and the land itself are made complicit in the production of nuclear waste.

Habitat correlates of wild boar density and rooting along an environmental gradient

Ferretti, F., Lazzeri, L., Mori, E., Cesaretti, G., Calosi, M., Burrini, L. and N. Fattorini 2022
J. of Mammalogy, 102(6): 1536-1547
In wild ungulates, habitat choice usually is influenced by foraging constraints and predator avoidance, potentially leading to spatial variation of population density (e.g., greater densities in food rich or safer habitats). Assessing habitat-correlates of abundance and foraging activity in turn is important in understanding determinants of distribution. We assessed habitat correlates of presence, density, and rooting, for wild boar *Sus scrofa*, the most widespread ungulate in the world, in six protected areas of central Italy. We worked along an altitudinal gradient ranging from the coast to mountains, in late spring-summer 2019. We surveyed 617 sampling plots randomly placed onto study areas with tessellation stratified sampling, where we used fecal counts to estimate wild boar density and visually estimated the proportion of rooted area. Overall estimates of density and rooting (± standard error) varied from 3.5 ± 2.0 to 17.9 ± 5.4 individuals/km2 and from 1.4 ± 0.8% to 10.9 ± 1.1% of rooted ground. Density and rooting showed a moderate yet nonsignificant correlation across sites. Probability of presence, abundance, and rooting in sampling plots were higher in ecotone habitats (transition habitats between wooded and open areas). Topography did not influence boar presence or local abundance. Rooting increased with decreasing slope and rock cover, as well as increasing elevation, possibly due to soil supporting forage of higher nutritional quality. Our results support the importance of ecotone habitats for wild boar, emphasizing the role of these transitional areas in the period of nursing/weaning of offspring, as well as when crops are actively growing. Differences in overall estimates of rooting across study sites may depend on site-specific features (soil moisture and availability of alternative food resources). Future studies should test the correlation between inter-annual differences of rooting and changes in population density. Notwithstanding the latter, we identified significant ecological drivers of wild boar density and rooting activity.

Ethnozoological study of the wild pig (*Sus* spp.) hunting among Sundanese in Upper Citarum Watershed area, West Java, Indonesia

Mulyanto, D., Abdoellah, O.S., Iskandar, J. and B. Gunawan 2021
Biodiversitas 22(11): 4930-4939
In the past, wild pigs had a high population in the rural ecosystem of West Java. However, the population of wild pigs, particularly Javan warty pig, decreases due to forest destructions and intensive hunting. This study aimed to elucidate the local knowledge on wild pigs, the mode of hunting, and diverse aspects of wild pig hunting. We conducted qualitative methods with

ethnozoological approach, including participant observation and in-depth interview. The results showed that based on the local people the wild pig can be divided into four “races”, while based on zoology, two species of wild pig are documented in Java. During hunts all members get specific key roles. Thus, hunting success is increased by division of labor. Hunting wild pigs played an important role in socio-economic and cultural function for the village community. Due to intensive hunting of wild pigs, the population of these animals, particularly the Javan warty pig are decreased, and consequently the socio-economy of this animal in rural ecosystem may decrease or even disappear.

Pleistocene rock paintings of Sulawesi warty pigs

Brumm, A., Oktaviana, A.A., Burhan, B., Hakim, B., Lebe, R., Ririmasse, R., Sulistyarto, P.H., Macdonald, A.A. and M. Aubert
Archaeology in Oceania 56(3): 149-172
The Indonesian island of Sulawesi harbours numerous early rock paintings of the endemic Sulawesi warty pig (*Sus celebensis*). Several *S. celebensis* images, including one dated to at least 45,500 years ago (ka), portray these suids with an anatomical character not observed in the living species: a pair of teat-like protuberances in the neck area. This feature seems to be most consistent morphologically with neck “wattles”, cutaneous appendages only manifested in modern domestic swine (*Sus scrofa*) and some other domesticated ungulates (e.g. goats). The notion that the trait portrayed by the Late Pleistocene artists is a domestication character is clearly contentious. We therefore consider: (1) whether we have misidentified the trait – a common problem in rock art analysis; (2) whether wattles are a genuine domestication trait; and (3) if so, whether the notion that Pleistocene people domesticated S. celebensis is plausible. A clear resolution to all of these problems evades us; however, our investigation of this anomaly in the ancient rock art poses important questions about the nature and complexity of early human–pig relations in this island.

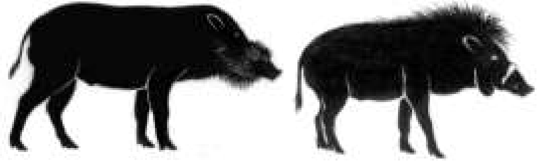
Predicting preferred prey of Sumatran tigers *Panthera tigris sumatrae* via spatio-temporal overlap

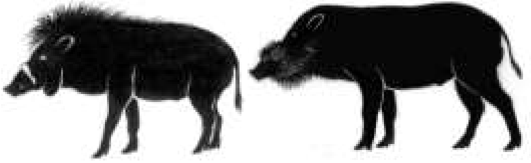
Allen, M. L., Sibarani, M. and M. Krofel 2021
Oryx 55(2): 197-203, https://doi.org/10.1017/S0030605319000577
Encounter rates of carnivores with prey are dependent on spatial and temporal overlap, and are often highest with their preferred prey. The Critically Endangered Sumatran tiger *Panthera tigris sumatrae* is dependent on prey populations, but little is known about its prey preferences. We collected camera-trap data for 7 years (2010-2016) in Bukit Barisan Selatan National Park, Sumatra, to investigate spatial and temporal overlap of tigers with potential prey species. We also developed a novel method to predict predator-prey encounter rates and potential prey preferences from camera-trap data. We documented at least 10 individual tigers, with an overall detection rate of 0.24 detections/100 trap nights. Tigers exhibited a diurnal activity pattern and had highest temporal overlap with wild boar *Sus scrofa* and pig-tailed macaques *Macaca nemestrina*, but highest spatial overlap with wild boar and sambar deer *Rusa unicolor*. We created a spatial and temporal composite score and three additional composite scores with adjustments for the spatial overlap and preferred prey mass. Wild boars ranked highest for all composite scores, followed by sambar deer, and both are known as preferred tiger prey in other areas. Spatial and temporal overlaps are often considered as separate indices, but a composite

score may facilitate better predictions of encounter rates and potential prey preferences. Our findings suggest that prey management efforts in this area should focus on wild boar and sambar deer, to ensure a robust prey base for this Critically Endangered tiger population.

Expansion of native wild boar populations is a new threat for semi-arid wetland areas
Barasona, J. A., Carpio, A., Boadella, M. et al. 2021
Ecological Indicators 125, https://doi.org/10.1016/j.ecolind.2021.107563
Wildlife management and conservation requires monitoring of species distribution and population indicators, especially when the unbalanced demographic changes of some species can affect the whole ecosystem functioning. The populations of wild boar (*Sus scrofa*) have, over the past few decades, undergone an expansion around the world, reaching situations of overabundance that can cause serious economic, ecological and health problems. This numerical increase of wild boar and its new spatial invasion can affect certain vulnerable species in sensitive ecological zones, such as the main inland wetland complex in SW Europe. In this context, we aim to (i) examine the association of wild boar abundance and that of lagomorphs, and waterbird productivity, controlling the possible effects of wild carnivores and other environmental predictors, and (ii) applying a survey method useful for managers to evaluate expected effect of wild boar abundance. Overall, the presence of wild boar has been detected in 80.8% of the monitored wetlands (n = 26), but a high variation of abundance rates was found. Wild boar abundance negatively associated with the productivity of the entire community of waterbirds, a priori highly vulnerable, breeding on shores or islands, both colonially (genus *Gelochelidon*, *Himantopus*, *Recurvirostra*, *Sternula*, *Glareola*, *Tringa* and *Phoenicopterus*) or solitary (genus *Anas*, *Spatula*, *Mareca*, *Charadrius*, *Vanellus*, *Anser*, *Ardea*, *Aythya*, *Fulica*, *Netta*, *Oxyura* and *Tadorna*). In addition, we evidenced a clear negative association of wild boar and wild rabbit (*Oryctolagus cuniculus*) population abundance in the monitored wetlands. Rabbits are a keystone species in the study area and represent stable prey for many endangered predators. Our results suggest that potential impacts caused by high wild boar abundance may be already reaching unsustainable levels for some wetlands. Inter-species integrated monitoring is key to address the population management plans of wild boar populations in wetlands and to preserve the most vulnerable species.

Impacts of a large invasive mammal on water quality in riparian ecosystems
Bolds, S. A., Lockaby, B., Ditchkoff, S.S. et al. 2021
Journal of Environmental Quality 50(2): 441-453, https://doi.org/10.1002/jeq2.20194
Wild pigs (*Sus scrofa*) are a highly invasive species in many regions of the world and can act as ecosystem engineers in areas where they are established. In riparian ecosystems, wild pigs may affect water quality parameters and introduce fecal bacteria, although previous studies have reported conflicting results. We propose four conditions that we believe are needed for an accurate assessment of wild pig impacts on water quality and address each one in our study. Water samples were collected between May 2018 and June 2019 in riparian watersheds on a privately owned property in Alabama that was densely populated by wild pigs (treatment) and in watersheds at a nearby national forest without an established population. Samples were analyzed for concentrations of water quality parameters, such as anions and cations, dissolved oxygen, total suspended solids, N, dissolved organic C, and *Escherichia coli* and other fecal coliforms. An additional 38 samples were analyzed using quantitative polymerase chain reaction for swine fecal





bacteroidetes. At treatment watersheds, specific conductivity and concentrations of organic N and C, SO42-, and Ca2+ were between 2 and 11 times that of reference watersheds. *Escherichia coli* values at treatment watersheds were 40 times reference watershed values. DNA from swine fecal bacteroidetes was detected in 70% of treatment samples and 0% of reference samples. Wild pigs are a threat to water quality in riparian areas, and our results indicate that it may be important to control populations upstream of major drinking water sources and recreational areas.

Capital-income breeding in wild boar: a comparison between two sexes
Brogi, R., Chirichella, R., Brivio, F. et al. 2021
Scientific Reports 11(1), https://doi.org/10.1038/s41598-021-84035-w
Organisms differ in the strategy adopted to fuel reproduction by using resources either previously acquired and stored in body reserves (capital breeding) or, conversely, acquired during their reproductive activity (income breeding). The choice of one or the other strategy is related to several internal and external factors which are counteractive in wild boar. Based on a large dataset of culled wild boar, we investigated individual body weight variability throughout the period of 1st September-31st January, which included the main part of the mating season, among different sex and age classes to determine their position along the capital-income breeding continuum. Though food resources were abundant during the rut, adult males lost body weight suggesting they adopted a predominantly capital breeding strategy, likely owing to the high intra-sexual competition entailed by the peculiar mating system of the species. On the contrary, subadult males seemed to behave as income breeders, likely enhancing the reproductive flexibility of wild boar populations. During the rut, females stored reserves, thus suggesting that they substantially relied on them to cover future reproductive costs.

The more you know: The equivocal effects of prior knowledge on preferences for hunted vs. farmed wild boar meat
Demartini, E., Vecchiato, D., Marescotti, M. et al. 2021
International Journal of Gastronomy and Food Science 24,
https://doi.org/10.1016/j.ijgfs.2021.100325
Much of the so-called 'wild' or 'game' meat bought these days is actually farmed (not hunted), and current legislation does not require marketers to reveal the production method. What would consumers make of this distinction if they knew? We explore the roles of objective and subjective prior knowledge in determining consumer preferences for wild boar (*Sus scrofa*) sausage produced using meat from hunting, farming or an unspecified production method. A discrete choice experiment that includes two tests and corresponding selfevaluations reveals that farmed meat is the most preferred type, closely followed by hunted meat, while meat from an unspecified production method is clearly the least preferred. Objective knowledge about hunting is positively related to preferences for hunted meat, while the opposite is true for the effect of prior knowledge about farming on preferences for farmed meat. Finally, subjective knowledge is not a reliable predictor of preferences for either hunted or farmed meat.

Effects of pulsed resources on the dynamics of seed consumer populations: a comparative demographic study in wild boar
Gamelon, M., Touzot, L., Baubet, E. et al. 2021
Ecosphere 12(5), https://doi.org/10.1002/ecs2.3395

Mast seeding is a well-known example of pulsed resources in terrestrial ecosystems. Despite the large literature available so far on the effects of mast seeding on the dynamics of seed consumer populations, it remains unknown whether heterogeneity in demographic responses to mast seeding exists both within a population of consumers and among consumer populations. Here, we fill this knowledge gap by assessing the effects of acorn production (i.e., oak mast) on all stage-specific demographic rates (i.e., survival, growth, reproduction) in several consumer populations. From long-term capture-mark-recapture data collected in three wild boar populations in Europe and detailed information on annual acorn production, we quantified the effects of acorn production on body mass-specific demographic rates in these populations. We then built a body mass-structured population model for each population and assessed the effect of acorn production on generation time-the mean age of mother at childbirth-and population growth rate using a combination of prospective and retrospective demographic analyses. Within populations, acorn production had a positive effect on reproduction (proportion of breeding females) and growth of small-sized females. Survival remained buffered against environmental variation, in accordance with the demographic buffering hypothesis. Thus, all stage-specific demographic rates were not influenced in the same way by acorn production. In turn, higher reproduction and growth probabilities involved higher population growth rates and shorter generation times. Despite these common demographic responses to mast seeding among populations, we highlighted marked among-population variation in the magnitude of these responses. Also, while populations inhabiting resource-rich environments took advantage of current acorn conditions, populations under resource-poor environments stored and allocated acorns produced the preceding year to reproduction indicating contrasting breeding tactics along the capital-income continuum. Our results suggest heterogeneity in demographic responses to mast seeding, within and among populations. This is an important finding for our understanding of the effects of mast seeding on the dynamics of seed consumer populations.

Wild boar (*Sus scrofa*) as bioindicator for environmental exposure to organic pollutants

Gonzalez-Gomez, X., Cambeiro-Perez, N., Figueiredo-Gonzalez, M. and E. Martinez-Carballo et
2021
Chemosphere 268, https://doi.org/10.1016/j.chemosphere.2020.128848

Organic pollutants (OPs) are widely distributed around the globe, their presence has become an issue of great concern in the last years due to their potential health effects. Wildlife biomonitoring of OPs has been nowadays a common approach to assess chemical exposure in wildlife and humans. In a sample of 60 wild boars (Sus scrofa) from NW Spain, we evaluated the suitability of using liver and hair samples for the assessment of exposure and bioaccumulation of polychlorinated biphenyls (PCBs) including dioxin and non-dioxin like PCBs (DLPCBs and NDLPCBs), organochlorine and organophosphate pesticides (OCPs and OPPs, respectively), polybromodiphenyl ethers (PBDEs), pyrethroids (PYRs) and polycyclic aromatic hydrocarbons (PAHs). Selective pressurized liquid extraction (SPLE) and liquid-liquid extraction (LLE) methodologies were used to determine the target OPs in liver and hair samples. Clean-up of extracts was performed by solid-phase extraction (SPE) using EZ-POP cartridges and detection by gas chromatography coupled to tandem mass spectrometry (GC-QqQ-MS/MS). We found a distribution pattern of Sigma PAHs > Sigma OCPs > Sigma PYRs > Sigma NDLPCBs > Sigma OPPs > Sigma DLPCBs > Sigma PBDEs in liver and of Sigma PAHs > Sigma OCPs > Sigma NDLPCBs > Sigma PYRs > Sigma OPPs > Sigma DLPCBs > Sigma PBDEs in hair. Significant correlations ($p < 0.050$) between the socio-demographic characteristics (gender, age and place) and OP concentrations of OCPs, PBDEs, PYRs, OPPs and PAHs were detected. Moderate correlation was found between HCB, PCB28, PCB157 and chlorpyrifos contents in both hair and liver samples. On the basis of these results, our data shows the correlation and complementary information given by both biological samples. (C) 2020 Elsevier Ltd. All rights reserved.

Spatial Genetic Structure and Demographic History of the Wild Boar in the Qinling Mountains, China

Hu, C., Yuan, S., Sun, W. et al. 2021

Animals 11(2), https://doi.org/10.3390/ani11020346

The wild boar is native to the temperate region of Eurasia, which is now one of the most widely distributed mammals worldwide. The recent expansion in the wild boar population has attracted a lot of attention, which may cause great damage to ecosystems. Elucidating the patterns of the population structure, genetic diversity, population origin, and colonization route of wild boar is very helpful in the conservation and management of wild populations. Phylogeographic analysis has proven to be a powerful tool. Here, 82 samples of wild boars in 16 sampling locations were collected in Qinling Mountains (QM). Genetic analysis was conducted based on the mitochondrial control region and nuclear genes. The level of genetic diversity of wild boars in QM was lower than the total population in East Asia, but higher than European population. No obvious phylogeographic pattern were found. The effective population size was under demographic equilibrium in the past. Species dispersal patterns and population genetic structure can be influenced by geographical features. Qinling Mountains (QM) provide an excellent area for phylogeographic study. The phylogeography of Asian-wide wild boars revealed the colonization route. However, the impact of the QM on genetic diversity, genetic structure and population origin is still poorly understood. In this study, genetic analysis of wild boar in the QM was conducted based on the mitochondrial control region (943 bp) and twelve microsatellite loci of 82 individuals in 16 sampling locations. Overall genetic haplotype diversity was 0.86, and the nucleotide diversity was 0.0079. A total of 17 new haplotypes were detected. The level of genetic diversity of wild boars in QM was lower than in East Asia, but higher than in Europe. Phylogenetic analysis showed the weak genetic divergence in QM. Mismatch analysis, neutrality tests, and Bayesian Skyline Plot (BSP) results revealed that the estimates of effective population size were under demographic equilibrium in the past. Spatial analysis of molecular variance indicated no obvious phylogeographic structure.

Multi-Scale Spatial Prediction of Wild Boar Damage Risk in Hunchun: A Key Tiger Range in China

Jin, Y., Kong, W., Yan, H. et al. 2021

Animals 11(4), https://doi.org/10.3390/ani11041012

Spatial distribution of wild boar damage risk is important and can be informative to wildlife habitat management. Hunchun is an important active area of Siberian tiger in China. The wild boar damage has brought barriers to the conservation and management of the Siberian tiger in this region. We predicted the spatial distribution of wild boar damage risk in Hunchun in terms of home range and feeding sites scales, and explored the spatial interaction between tiger habitats and the damage risk of wild boar. The results show the distance to the forest edge is an important factor affecting the wild boar damage, and 38.68% of the high-risk areas are overlapped with tiger habitats in Hunchun. Therefore, precise and differentiated management strategies should be adopted in the management of wild boar population. Hunchun, a typical area suffering wild boar (*Sus scrofa*) damage, is an important region for the Siberian Tiger (*Panthera tigris*) in China. By incorporating the maximum entropy model with 22 variables in the home range scale (12 variables) and in the feeding site scale (10 variables), we predicted wild boar damage risks in this area of China and analyzed how spatial factors influence damage risk. Damage risk was found to be high in areas close to the forest edge, areas with a higher forest cover and lower to medium deciduous forest proportion, low road density, and a medium river density and farmland proportion. The proportion of farmland which was identified as being in the high damage risk zone was 23.55%, of which 38.68% was within the habitat area of the Siberian Tiger. Finally, we propose wild boar damage prevention based on different management goals.

Spared from poaching and natural predation, wild boars are likely to play the role of dominant forest species in Peninsular Malaysia
Khalidah, K. N., Wahdaniyah, S., Kamarudin, N. et al. 2021
Forest Ecology and Management 496, https://doi.org/10.1016/j.foreco.2021.119458
Wild boar (*Sus scrofa*) populations have increased remarkably in many parts of the world. In predominantly Muslim regions such as Peninsular Malaysia, wild boars are native species that have thrived, in part, because Muslims do not hunt them, and also because apex predators such as Malayan tigers (*Panthera tigris jacksoni*) are declining rapidly. We examined the relationship between the number of wild boar detections, and both landscape metrics and on-site vegetation structure in forestry reserves of Peninsular Malaysia. Camera-trapping was used to record wild boar detections. At each camera trap location, we measured the characteristics of the surrounding landscape and site-level habitat attributes. Our analyses revealed that the number of wild boar detections was positively associated with the number of trees with DBH 45 cm, number of fallen trees, number of palms, number of saplings, and elevation. In contrast, the number of wild boar detections was negatively associated with the distance from nearest paved and unpaved roads, number of trees with DBH < 45 cm, and canopy cover. Surprisingly, we found that the number of wild boar detections was not associated with forest type, landscape type, and logging. The high detection of wild boars may indicate that large carnivores are disappearing in the forestry reserves. Generally, our findings suggest that wild boar can thrive in tropical fragmented landscapes with favourable site-level habitat characteristics, limited hunting pressure, and an absence of apex predators. In conclusion, wild boars are most likely to affect the ecological integrity of forest reserves.

Non-Invasive Reproductive Hormone Monitoring in the Endangered Pygmy Hog (*Porcula salvania*)
Kumar, V., Buragohain, S., Deka, P.J. et al. 2021
Animals 11(5), https://doi.org/10.3390/ani11051324
The pygmy hog is one of the world's rarest suids and classified as an endangered species. Efforts are being made to breed them in captivity and reintroduce them into the wild. In this study, we examined reproductive hormones in captive pygmy hogs using a non-invasive method by collecting 785 fecal samples from five females and two males for 12 months. High-pressure liquid chromatography was performed to examine the presence of immunoreactive progesterone and testosterone metabolites in the fecal samples. We standardized and validated enzyme

immunoassays (EIA) for fecal progesterone and testosterone metabolites. Using progesterone EIA, we were able to detect pregnancies in four females and estimate the relevant gestation period. We also recorded 172 births from the captive breeding center and found strong seasonality patterns in births. In males, fecal testosterone metabolite concentrations were higher in the breeding season than in the non-breeding season as evidenced by elevated testosterone concentrations during breeding season. A significant difference in fecal progesterone metabolites concentration was observed between non-pregnant and pregnant females. This study can directly help in monitoring the reproductive status of reintroduced hogs both in the wild and in conservation breeding programs in India and elsewhere. The pygmy hog (Porcula salvania), until recently was classified as a critically endangered suid facing the threat of extinction due to habitat degradation. Efforts are being made to protect the pygmy hog from extinction and breed them in captivity under the Pygmy Hog Conservation Programme (PHCP). However, very little information is available on the reproductive physiology of pygmy hogs. Therefore, the present study aims to standardize enzyme immunoassays (EIAs) for monitoring pregnancy and reproductive status using progesterone and testosterone metabolites. A total of 785 fecal samples were collected from five females and two males over a period of one year from the PHCP Research and Breeding Centre, Guwahati, Assam. High-pressure liquid chromatography (HPLC) analysis revealed the presence of immunoreactive progesterone and testosterone metabolites in feces. Mating was observed in all five females, and four of them gave birth successfully. We were able to detect pregnancy using fecal progesterone metabolites. The mean gestation period, based on mating and parturition, was estimated to be 153.25 days from the four females studied. The breeding center recorded 172 births between 1996 and 2000 and found strong seasonal patterns in the birth rate, with most of the births occurring between May and June. In the males, fecal testosterone metabolites were significantly higher in the breeding season than in the non-breeding season. This is the first study on the subject and will help with future breeding programs in other captive breeding centers and with reproductive monitoring of reintroduced populations.

Wildlife disturbances as a source of conspecific negative density-dependent mortality in tropical trees

Luskin, M. S., Johnson, M.S., Ickes, K. et al. 2021

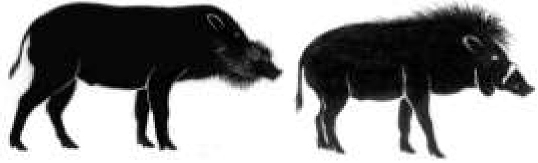
Proceedings of the Royal Society B-Biological Sciences 288(1946),

https://doi.org/10.1098/rspb.2021.0001

Large vertebrates are rarely considered important drivers of conspecific negative density-dependent mortality (CNDD) in plants because they are generalist consumers. However, disturbances like trampling and nesting also cause plant mortality, and their impact on plant diversity depends on the spatial overlap between wildlife habitat preferences and plant species composition. We studied the impact of native wildlife on a hyperdiverse tree community in Malaysia. Pigs (*Sus scrofa*) are abnormally abundant at the site due to food subsidies in nearby farmland and they construct birthing nests using hundreds of tree saplings. We tagged 34 950 tree saplings in a 25 ha plot during an initial census and assessed the source mortality by recovering tree tags from pig nests (n = 1672 pig-induced deaths). At the stand scale, pigs nested in flat dry habitats, and at the local neighbourhood scale, they nested within clumps of saplings, both of which are intuitive for safe and efficient nest building. At the stand scale, flat dry habitats contained higher sapling densities and higher proportions of common species, so pig nesting increased the weighted average species evenness across habitats. At the neighbourhood scale, pig-induced sapling mortality was associated with higher heterospecific and especially conspecific sapling densities. Tree species have clumped distributions due to dispersal limitation and habitat filtering, so pig disturbances in sapling clumps indirectly caused CNDD. As a result, Pielou species evenness in 400 m(2) quadrats increased 105% more in areas with pig-induced deaths than areas without disturbances. Wildlife induced CNDD and this supported tree species evenness, but they also drove a 62% decline in sapling densities from 1996 to 2010, which is unsustainable. We suspect pig nesting is an important feature shaping tree composition throughout the region.

Wild Boar Meat as a Sustainable Substitute for Pork: A Mixed Methods Approach
Machackova, K., Zeleny, J., Lang, D. and Z. Vins 2021
Sustainability 13(5), https://doi.org/10.3390/su13052490
Sensory analysis is unusual in sustainability research, although it can offer a neoteric aspect of nature and wild animals' perception. The study's objective was to identify consumers' attitudes towards plant and animal products from wild and conventional foods and put these findings into a broader social context. A blind sensory evaluation with 80 semi-trained assessors was used, segmented by gender, age, education, income, place of origin, family status, number of children, and willingness to pay. Wild boar (*Sus scrofa*) was chosen as an example of an overpopulated animal species occurring in the wild, which could be considered a partial substitute for pork. Statistical testing in these blind evaluations proved that wild boar meat is not considered less tasty. Therefore, wild boar meat could represent a partial substitute, complementing pork, on which consumers are willing to spend the same amount of money. Despite the mostly indifferent sensory evaluation, focus group responses showed considerable barriers to wild food. This paper concludes that possible educational and popularizing procedures are presented, including forest pedagogy, eliminating consumers' prejudices. A mixed-methods approach within quantitative and qualitative methodology was chosen.

Observation of rescue behaviour in wild boar (*Sus scrofa*)
Masilkova, M., Jezek, M., Silovsky, V. et al. 2021
Scientific Reports 11(1), https://doi.org/10.1038/s41598-021-95682-4
Here, we provide unique photo documentation and observational evidence of rescue behaviour described for the first time in wild boar. Rescue behaviour represents an extreme form of prosocial behaviour that has so far only been demonstrated in a few species. It refers to a situation when one individual acts to help another individual that finds itself in a dangerous or stressful situation and it is considered by some authors as a complex form of empathy. We documented a case in which an adult female wild boar manipulated wooden logs securing the door mechanism of a cage trap and released two entrapped young wild boars. The whole rescue was fast and particular behaviours were complex and precisely targeted, suggesting profound prosocial tendencies and exceptional problem-solving capacities in wild boar. The rescue behaviour might have been motivated by empathy because the rescuer female exhibited piloerection, a sign of distress, indicating an empathetic emotional state matching or understanding the victims. We discuss this rescue behaviour in the light of possible underlying motivators, including empathy, learning and social facilitation.



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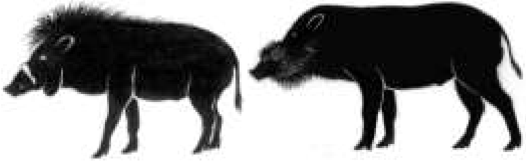


Sanitary Waste Landfill Effects on an Invasive Wild Pig Population
Mayer, J. J., Edwards, T.B., Garabedian, J.E. and J.C. Kilgo 2021
Journal of Wildlife Management 85(5): 868-879, https://doi.org/10.1002/jwmg.22042
Being opportunistic omnivores, wild pigs (*Sus scrofa*) readily feed on edible garbage. Given the presence of substantial volumes of edible food waste, large multi-county and regional municipal sanitary waste landfills constitute attractive forage resources for pigs, providing a year-round anthropogenic source of potentially high-quality forage. Our objective was to assess the effects that a large regional landfill has on the local pigs foraging in that facility's waste disposal cells. The landfill, located on the United States Department of Energy's Savannah River Site (SRS) in South Carolina, USA, became operational in 1998 and pigs began foraging there in 2001. By 2009 >100 pigs/night were observed foraging in the landfill, suggesting landfill establishment may have important consequences for population dynamics, public safety, and disease transmission. We evaluated changes in body mass, fetal litter size, numbers of pigs removed, and wild pig-vehicle collisions (WPVCs) before (1980-2000) and after (2001-2019) pigs began foraging in the landfill on SRS. Body mass during the after period increased to a greater extent for pigs in the vicinity of the landfill compared to pigs on the rest of SRS. Fetal litter size increased for pigs in the vicinity of the landfill, whereas it remained unchanged on the rest of SRS. Our density surrogate (number of pigs harvested) increased around the landfill during the after period by 2.9 times, whereas on the rest of the site it only increased by 53%. No WPVCs occurred adjacent to the landfill before 2001, but WPVCs increased along the 2 major roads bordering the landfill after 2001. Effects of sanitary waste landfills on wild pig populations scavenging there can present unique challenges to population management, control, public safety, and disease transmission. Potential approaches to address these challenges could be exclusion fencing to prevent access to the landfill's waste disposal cells or enhanced placement of waste cell covers to reduce access. (c) 2021 The Wildlife Society.

Social media as a window into human-wildlife interactions and zoonotic disease risk: an examination of wild pig hunting videos on YouTube
McLean, H. E., Jaebker, L.M., Anderson, A.M. et al. 2021
Human Dimensions of Wildlife, https://doi.org/10.1080/10871209.2021.1950240
Wild pigs (*Sus scrofa*) damage agriculture and the environment, as well as transmit diseases to animals and people. Hunters are particularly vulnerable to zoonotic disease risks when harvesting wild pigs. Management agencies have endeavored to inform the public about disease risks associated with wild pigs and best practices for mitigating such risks. However, the extent that this guidance has reached hunters and influenced their practices is unclear. We approached this topic through an analysis of wild pig hunting videos on YouTube. We found evidence of relatively few behaviors and communications regarding disease risks and best practices for personal safety. In contrast, many videos showed behaviors that could increase the risk of disease transmission to the subjects and other animals. We emphasize the importance of understanding the influence of social media on viewers and discuss implications for management agencies, including opportunities for strategic messaging in public health campaigns.

The wild boar *Sus scrofa* as a threat to ground-nesting bird species: an artificial nest experiment
Mori, E., Lazzeri, L., Ferretti, F. et al. 2021

Journal of Zoology 314(4): 311-320, https://doi.org/10.1111/jzo.12887
Nest predation is reported as a cause of reproductive failure of ground-nesting bird species whose populations in Europe are declining. Conversely, European populations of the wild boar Sus scrofa have been expanding, leading to increasing threats to habitats and ecological communities. The impacts of wild boar on ground-nesting bird species are poorly known and have never been explicitly assessed. We conducted an artificial ground-nest experiment in Mediterranean habitats of central Italy using camera traps to assess predator identities. Deployed nests contained quail or chicken eggs, and predation occurred within one week for 47/48 deployments carried out during March-July 2020. The wild boar was the most common predator (36% deployments), followed by the magpie *Pica pica* (18%), the red fox *Vulpes vulpes* (10%) and the pine marten *Martes martes* (10%). Predation by other species was occasionally observed. Egg type and deployment habitat did not significantly influence time to predation or the likelihood that a nest was preyed upon by wild boar, respectively. The presence of a stuffed gull close to the nests significantly delayed predation. Nests preyed by birds and mammals other than wild boar were often subsequently scavenged by wild boar, which consumed the remaining eggs or eggshells. Time to predation increased from spring to summer, suggesting a reduction of predation intensity during periods when the availability of natural eggs is lowest. The likelihood of a nest being preyed upon by the wild boar compared to other predators increased when wild boar frequency of occurrence in 1-week camera trap shootings was the highest, suggesting that higher abundance/activity of this species triggered increased egg predation. The wild boar might act as major predators of ground-nesting bird species in Mediterranean habitats and the large-scale population increase of this ungulate should be considered a significant threat to ground-nesting species of European conservation concern.

Predation on Translocated Burmese Star Tortoise (*Geochelone platynota*) by Asiatic Jackals (*Canis aureus*) and Wild Pigs (*Sus scrofa*) at a Wildlife Sanctuary in Myanmar
Platt, S. G., Aung, S.H.N., Soe, M.M. et al. 2021
Chelonian Conservation and Biology 20(1): 133-138, https://doi.org/10.2744/CCB-1461.1
Successful restoration of Geochelone platynota to Dry Zone ecosystems in Myanmar depends on the survival of translocated tortoises and, therefore, a knowledge of predators and predation is important. We here report the loss of 28 and approximately 200 translocated *G. platynota* to Eurasian golden jackals (*Canis aureus*) and wild pigs (*Sus scrofa*), respectively, at Shwe Settaw Wildlife Sanctuary in central Myanmar. Measures to reduce the risk of future predation include structural reinforcement of acclimation pens to deter wild pigs and the experimental use of large cat (e.g., tiger [*Panthera tigris*] and leopard [*Panthera pardus*]) odors to repel jackals and wild pigs from the translocation area.

Density dependence of daily activity in three ungulate species
Ramirez, J. I., Zwerts, J.A., van Kuijk, M. et al. 2021
Ecology and Evolution 11(12): 7390-7398, https://doi.org/10.1002/ece3.7570
Daily activity in herbivores reflects a balance between finding food and safety. The safety-in-numbers theory predicts that living in higher population densities increases safety, which should affect this balance. High-density populations are thus expected to show a more even distribution of activity-that is, spread-and higher activity levels across the day. We tested these predictions for three ungulate species; red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), and wild boar

(*Sus scrofa*). We used camera traps to measure the level and spread of activity across ten forest sites at the Veluwe, the Netherlands, that widely range in ungulate density. Food availability and hunting levels were included as covariates. Daily activity was more evenly distributed when population density was higher for all three species. Both deer species showed relatively more feeding activity in broad daylight and wild boar during dusk. Activity level increased with population density only for wild boar. Food availability and hunting showed no correlation with activity patterns. These findings indicate that ungulate activity is to some degree density dependent. However, while these patterns might result from larger populations feeling safer as the safety-in-numbers theory states, we cannot rule out that they are the outcome of greater intraspecific competition for food, forcing animals to forage during suboptimal times of the day. Overall, this study demonstrates that wild ungulates adjust their activity spread and level based on their population size.

Improving Hunted Wild Boar Carcass Hygiene: Roles of Different Factors Involved in the Harvest Phase

Ranucci, D., Roila, R., Onofri, A. et al. 2021

Foods 10(7), https://doi.org/10.3390/foods10071548

Game meat production strongly differs from that of other meats, as peculiar factors present in the field and in the steps prior to transfer to a game-handling establishment can influence the hygiene of the carcasses and, therefore, of the meat. The effects of such factors were considered in hunted wild boars based on the main hygienic criteria adopted in meat processing. Environmental, animal, and hunting conditions were studied during two selective hunting seasons in Central Italy. A total of 120 hunted wild boar carcasses were sampled after the skinning process and analyzed for aerobic colony count, Enterobacteriaceae count, and *Salmonella* spp. isolation. The calculated mean values for aerobic colony and Enterobacteriaceae counts were 3.66 and 2.05 CFU/cm(2), respectively, in line with the limits set for the meat of other ungulates by EU legislation. Salmonella spp. showed a prevalence of 2.5% (IC 95%: 1.72-3.27%). Statistical analysis of the data performed with the AIC criterion showed that the main parameter to consider for improving the hygienic level of carcasses is to reduce the time in the refrigerator before skinning, followed by hunting on cold days (<10 degrees C) without rain, hunting animals <60 kg, and reducing the time between shooting and evisceration.

The global impact of wild pigs (*Sus scrofa*) on terrestrial biodiversity

Risch, D. R., Ringma, J. and M.R. Price 2021

Scientific Reports 11(1), https://doi.org/10.1038/s41598-021-92691-1

The International Union for the Conservation of Nature's (IUCN) Red List of Threatened Species is a comprehensive database of over 120,000 species and is a powerful tool to evaluate the threat of invasive species to global biodiversity. Several problematic species have gained global recognition due to comprehensive threat assessments quantifying the threat these species pose to biodiversity using large datasets like the IUCN Red List of Threatened Species. However, the global threat of wild pigs (*Sus scrofa*) to biodiversity is still poorly understood despite well-documented ecosystem level impacts. In this study, we utilized the IUCN Red List to quantify the impacts of this globally distributed species throughout its native and non-native range. Here we show that wild pigs threaten 672 taxa in 54 different countries across the globe. Most of these taxa are listed as critically endangered or endangered and 14 species have been driven to extinction as a direct result of impacts from wild pigs. Our results show that threats from wild pigs are pervasive across taxonomic groups and that island endemics and taxa throughout the non-native range of wild pigs are particularly vulnerable.

Impact of wild boar (*Sus scrofa*) rooting on a soil seed bank of oak-linden-hornbeam forest in the Bialowieza Forest
Sondej, I. 2020
Sylwan 164(8): 676-682, https://doi.org/10.26202/sylwan.2020033
The wild boar is an omnivorous animal that disturbs the top soil layer by foraging (rooting). In some regions of Europe seasonal fluctuations in rooting have been observed. Wild boars not only eat plants, but also strongly modify their habitat. In the Bialowieza Forest wild boar most frequently visit oak-hornbeam forests growing on fertile soil. On sites where the forest floor is covered with dense vegetation germination of seeds is difficult, and wild boar rooting can promote the removal of diaspores from deeper layers of the soil seed bank. The aim of this study was to assess the impact of wild boar rooting on the soil seed bank in a natural oak-linden-hornbeam forest. Observations were carried out on permanent plots in the strictly protected zone of the Bialowieza National Park. Samples of the soil seed bank were taken from plots which showed varying intensities of wild boar rooting (frequency and average percentage of exposed ground surface). Areas to be sampled were selected on the basis of archival data. Research was conducted by the seedling emergence method during two vegetation seasons. Altogether, 7985 seedlings of 67 taxa germinated from 240 soil samples. The highest number of germinated seedlings and species were found in the highly rooted plots. In all the series dominant species was Urtica dioica. In the soil seed bank 19 species of anemochory germinated, and accounted for 27.5% of all species present in the seed bank of all series. Permanent wild boar rooting increased the species richness in the soil seed bank and increased the amount of species with higher light requirements.

Priority areas identified through spatial habitat suitability index and network analysis: Wild boar populations as proxies for tigers in and around the Hupingshan and Houhe National
Nature Reserves
Tang, T., Li, J. Sun, H. and C. Deng 2021
Science of the Total Environment 774, https://doi.org/10.1016/j.scitotenv.2021.145067
The decline and fragmentation of habitats areas are two main factors that lead to the reduction of biodiversity in landscape ecosystems. As a kind of large carnivores, South China tiger (*Panthera tigris amoyensis*) is one of the most endangered tiger subspecies and considered to be extinct in the wild. The Chinese government has intended to release a certain number of tigers into two of their historically habitats areas, Hupingshan-Houhe national nature reserves (NNR) in central-south China that provides suitable habitats for *P. tigris*. Because wild boar (*Sus scrofa*) is a prey of *P. tigris*, spatially characterizing the populations of the prey and its habitats is critical for the success of habituating the tigers to the areas. Although there has been effort made to protect the habitats of wild boar, there have been no report that deal with investigation and analysis of the habitat suitability and potential forwild boar, especially in terms of landscape connectivity. Herewe present the novel integration of the habitat suitability index (HSI) and graph-based network to identify the priority areas for wild boar dispersal in and around the NNR. In addition, a novel method to identify the proper connectivity distance to avoid excessive connectivity when the field

data are essentially non-existent. Results showed that in summer and winter, the potential habitat areas were 6848-10,245 and 5984-10,152km(2), respectively. The total area of the priority patches was 1590 km(2), approximately occupying 16% of the suitable habitat area. Our study indicated that the novel integration of the HSI and network analysis led to an effective approach to spatially characterize priority patches to support decision-making for landscape planning. The results shown here also have implications for future efforts for habituating large carnivores into their historical habitat regions.

Catch-effort model used as a management tool in exploited populations: Wild boar as a case study

Vajas, P., Calenge, C. Gamelon, M. et al. 2021

Ecological Indicators 124. https://doi.org/10.1016/j.ecolind.2021.107442

For sustainable management of exploited populations, it is required to have good knowledge on temporal trends in population density to adapt the harvest. In this regard, hunting statistics are often collected routinely by government agencies and associations. These data are used to assess demographic trends through the development of indices, which are in turn used to manage exploited populations in a sustainable way. However, these population indices depend on features of the hunting process (e.g. hunting effort, hunting conditions, probability of catch). In this study, we show how to use hunting logs to assess demographic trends in exploited populations while accounting for the components of the hunting process. In particular, we developed a catch-effort model to study how the hunting effort leads to mortality rate - hunting pressure - within a given habitat type and during a given period. We illustrated the usefulness of this approach using exploited wild boar (*Sus scrofa*) populations as a case study. We used a large hunting logs dataset to perform our study, with several hundreds of thousands hunting events for more than 10 years in two French departments in France, including information about the number of hunters, of wild boars culled and the date of the hunt. We showed that catchability is a key parameter to assess hunting pressure at a given time and place. This parameter varies both within the hunting season and between habitat types. Once this variation in catchability was accounted for, our catch-effort model allowed us to obtain estimates of relative densities of wild boar populations over the study period at the management unit scale. Thus, catch-effort models are powerful tools to assess population density and to understand the underlying hunting process. Our study offers straightforward and reproducible conceptual framework that can be applied routinely by wildlife managers on exploited populations and practitioners from hunting statistics logs.

Diet preferences of common warthogs (*Phacochoerus africanus*) in Gassi and Haro Aba Diko controlled hunting areas, Western Ethiopia

Edossa, A., Bekele, A. and H. JebessaDebella 2021

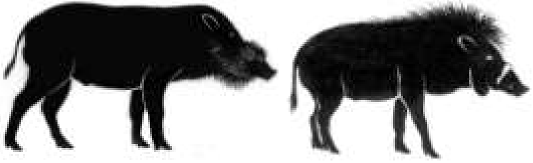
Global Ecology and Conservation 29: e01722

To assess feeding ecology and diet preferences of common warthogs *Phacochoerus africanus* (Gmelin, 1788), the study was conducted in Gassi Controlled Area (GCHA) and in Haro Aba Diko Controlled Hunting Area (HADCHA) from May 2017 to June 2018. Diet composition of common warthog was determined using feeding quadrat and microhistological methods. From the leaf cuticle fragments observed of feces, 41 and 45 plant species were recognized as annual dietary components of common warthog in GCHA and HADCHA, respectively. Uncertainty of epidermal fragments and fine digestion, led certain forage species consumed by warthogs to be unidentified. In Gassi Controlled Hunting Area, *Cynodon nlemfuensis* (75.5%), *Cynodon dactylon* (69%), and *Cyperus fischerianus* (47%) had the higher relative frequency occurrence (RFO) in the feces of the animal during the wet season. In Haro Aba Diko Controlled Hunting Area, *C. nlemfuensis* (76.5%), *C. dactylon* (73.5%) and *H. rufa* (57.5%) were the top three forage species with higher RFO in the feces of the warthog during the dry season. During the wet season in GCHA, *C. fischerianus*, *D. abyssinica*, *C. dactylon*, *C. nlemfuensis*, *Hyparrhenia rufa*, *A. abyssinicus*, *Sesbania sesban* and *Diplolophium africanum* were identified as the staple forage species of common warthogs. In HADCHA, *C. fischerianus*, *D. abyssinica*, *C. dactylon*, *C. nlemfuensis*, *H. rufa*, *H. hirta*, *S. poiretiana*, *A. abyssinicus*, and *S. sesban* were identified as the staple forage species of warthogs during the wet season. In GCHA *C. dactylon*, *C. nlemfuensis* and *A. abyssinicus* were the top three species which showed high acceptability during the wet and dry seasons. *Hyparrhenia hirta*, was high acceptability during the wet season which was less acceptability during the dry season but the difference was not significant. In HADCHA *C. fischerianus*, *D. abyssinica*, *C. dactylon*, and *C. nlemfuensis*, showed high acceptability during both seasons. Therefore, common warthogs foraged on wide range of food resources of graminoids, forbs, and shrubs in the study areas. Certain staple forage species were frequently preferred, because of their compatibility with the physiology of warthogs.

Conservation Status and Habitat Preferences of Common Warthog (*Phacochoerus africanus*) in Old Oyo National Park, Nigeria

Adeola, A.J., Adeyemo, A.I., Ejidike, B.N. Olaniyi, O.E., Akande, O.A., Ajayi, S.R. And O.K. Azeez
2021
Journal of Applied Sciences and Environmental Management 25(1)

This study assessed the conservation status and habitat preference of Common warthog in Old Oyo National Park, Nigeria using direct sighting and line transect method. The abundance estimate and encounter rate of common Warthog in the study area from 2018-2019 showed that year 2018 recorded 213 individuals at an encounter rate of 0.38/km while year 2019 recorded 184 individuals at an encounter rate of 0.32/km while the mean abundance estimate of common Warthog are 4.65±0.64 and 1.71±0.48 which represents 156 and 58 individuals at encounter rate of 0.55/km and 0.20/km in the wet season and dry season of year 2018 compared to year 2019 with average abundance estimate value of 4.00±0.85 and 1.41±0.61 which represents 135 and 48 individuals at an encounter rate of 0.47/km and 0.17/km for wet and dry season respectively. The mean age structure and sex ratio of the observed warthog population during dry and wet seasons revealed that juveniles had highest mean of age structures among the populations observed across the seasons. The habitat preference of common warthog revealed that they are mostly found in mixed woodland and open savanna with 112 observation and the lowest was recorded in the outcrop vegetation and open savanna with 21 individuals.in the wet season. During the dry season, mixed woodland/open savanna and Riparian grassland had the highest sightings of 45 and 33 individuals each. The outcrop vegetation/open savanna had the lowest observation of 1 individuals only. The study also recommends that more aspect of the ecology of the animal should be studied in details and emphasis should be placed on the habitat requirements.



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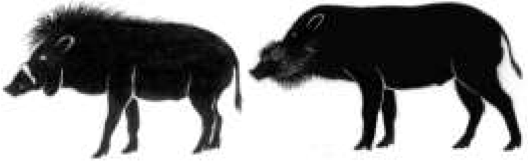


A Late Pleistocene third molar of *Hylochoerus* (Suidae, Mammalia) from Rusinga Island, Kenya: paleoenvironmental implications and a note on the hypsodonty of African forest hogs
Lazagabaster, I.A., Cerling, T.E. and J. T. Faith 2021
Historical Biology 3673-3685
African forest hogs (genus *Hylochoerus*) are extant Afro-tropical suids that inhabit a variety of forest environments and thick bushlands and are predominantly herbivores. *Hylochoerus* likely evolved from a Pleistocene *Kolpochoerus majus*-like ancestor, but its recent evolutionary history is virtually unknown. Here, we describe a partial right lower third molar from the Late Pleistocene Wasiriya Beds of Rusinga Island (~50-36 ka). The crowns are mesiodistally compressed in a bunolophodont fashion and arranged in columnar pillars that resemble those of extant *Hylochoerus*. We provide accurate data derived from computed tomography on the hypsodonty index (HI) of extant *Hylochoerus* and show that the Rusinga third molar crown was as tall as those of its modern counterpart (HI = 1.8–2.0). Stable carbon isotope analyses suggest that the diet of the Rusinga specimen (δ13C = −17.0 ‰) was also like that of extant forest hogs (δ13C average = −17.6 ‰). This extremely negative value contrasts strikingly with those of other fossil large herbivores at Rusinga (δ13C average = −0.7 ‰.). Among the potential explanations for this anomaly, the most likely is that the Late Pleistocene paleoenvironments were more heterogeneous than previously considered and may have included closed-canopy woodland in the highlands of Rusinga.

Tracing the Domestic Pigs in Africa
Weka, R., Bwala, D., Adedeji, Y., Ifende, I., Davou, A., Ogo, N. and P. Luka 2021
IntechOpen, DOI: 10.5772/intechopen.95077
Pigs are vital to the economy and critical in meeting the ever increasing demand for livestock and livestock products in most parts of the world. Pig is one of the oldest domesticated animals, though their ancestory is still shrouded in controversy due to lack of sufficient archaeological and genetic information. However, most of the breeds are thought to have descended from the Eurasian Wild Boar (*Sus scrofa*). This chapter will therefore look at the African pig under the following headings: Introduction, origin of pigs – genetic and historical/archaeological evidences, pig breeds in Africa, economic importance of pig production in Africa, marketing of pigs in Africa, herd health management of pigs in Africa, and challenges affecting pig production in Africa.

Less than six generations to save the chacoan peccary
Camino, M., Thompson, J., Velasco-Aceves, P.A., Cirignoli, S., Tiddi, R., Cortez, S., Matteucci, S.D. and M. Altrichter 2022
Biodiversity and Conservation, https://doi.org/10.1007/s10531-021-02337-x
The Dry Chaco has one of the highest deforestation rates of the world. The chacoan peccary (*Catagonus wagneri*; ChP) is endemic to the forests of this region and faces a high risk of extinction. However, we lack sufficient information about this species to develop effective conservation actions. This is the first study to determine the relevance of primary and secondary forest as habitat for the species and to address opportunities for conservation. We used occupancy modelling to study habitat selection. Using additional information on the species and the region, we then estimated the time left before the ChP's habitat outside of protected areas is completely lost, and the number of ChP generations likely to exist before this happens. Finally, we

identified protected areas that can sustain viable populations, and estimated the number of individuals that can survive within them. We found that the ChP occupies both primary forests and secondary forests. Also, that if deforestation rates remain consistent, the habitat for the ChP outside protected areas will have disappeared before 2051 (< 6 peccary generations). Furthermore, we found that most protected areas are too small and isolated to sustain viable populations. Our results have great management implications. Well-managed forests may allow the conservation of the ChP. Initiatives focused on forest conservation should increase, alongside the restoration of degraded and deforested areas. We also recommend the creation of new protected areas and wildlife corridors, and working horizontally with local communities.

Personality and plasticity of defensive behavior in collared peccary (*Dicotyles tajacu*)
Bonnemaison, A., Altino, V.S., Nogueira-Filho, S.L.G. and S.S.C.Nogueira 2021 Behavioural Processes 193: 104537
Inter-individual differences in behavior, together with phenotypic plasticity, may play a key role in the reintroduction success of captive-born individuals. Therefore, we aimed to investigate whether and how personality traits affect the plasticity of defensive behavior in collared peccary (*Dicotyles tajacu*). Twenty-six adult captive-born collared peccaries (12 males and 14 females) were submitted to three short-term challenges for personality assessment. Thereafter, each individual was submitted to four sequential tests, with different degrees of risk, allowing us to assess temporal/context consistencies in personality traits as well as the plasticity of defensive behavior. We noted a pronounced variability among the individuals' boldness trait, while males and females did not differ in their behavioral responses in all tests. Additionally, collared peccaries show behavioral plasticity of defensive behavior across risk conditions. We also verified an association between boldness and defensive behavior in this species: the higher the boldness score, the less time collared peccaries spent on wariness behaviors in the higher risk condition. The link between personality traits and behavioral plasticity of collared peccaries across risk conditions warrants further investigation to understand the impact of this association on the post-release success of this and other species.

Dominance hierarchy and social network in a captive group of white-lipped peccary males: what happens after the alpha male leaves?
Grossel,L.A., Javorouski, M.L., Moreira, N. and E.L. de Araujo Monteiro-Filho 2021
Acta Ethologica, https://doi.org/10.1007/s10211-021-00386-7
Dominance hierarchies are typically stable, with dominants occupying central positions in social interaction networks. However, system perturbations, such as the removal of individuals, may cause instability, which varies according to the group's resilience. If the hierarchy undergoes a restructuring, this can occur through a dynamic process of self-organization (Social Dynamics hypothesis) or through the influence of individuals' attributes (Previous Attributes hypothesis). We analyzed the resilience of the white-lipped peccary hierarchy after the alpha's death and observed how the rise of a new dominant occurred. Additionally, we evaluated the validity of these two hypotheses in the restructuring of the system. We observed the group of white-lipped peccary males of the Municipal Zoo of Curitiba, PR, Brazil, from May to October 2018. We recorded and analyzed the agonistic and affiliative interactions, and we collected data from the attributes: weight, testicle size, testosterone serum and age, before and after the dominant's death (August). Due to this perturbation, the hierarchy started to show instability, but proved to be

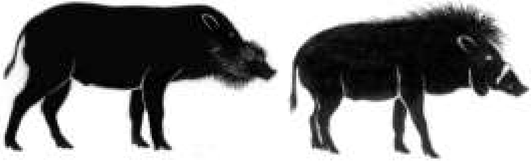
resilient. There was an increase in agonism and more than one individual pleading for the new dominant position, which was occupied by a subordinate male. Affiliative interactions were also important in the rise of the new alpha. The hierarchy was well ordered by the social dynamics among individuals, but weight and testicular volume were also correlated with the status of the individuals before, and with the serum testosterone after the alpha’s death. Thus, both hypotheses affected the restructuring of this system.

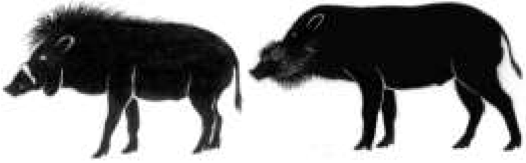
New record of the Chacoan Peccary, *Catagonus wagneri* (Rusconi, 1930) (Artiodactyla, Tayassuidae), in Santiago del Estero, Argentina

Nettie, A.M., Ochoa,A.C., Rueda, C.V., Palomo, L., Rueda, M.P. and O.B. Quiroga 2021
Check List 17(5)
New records of the Endangered *Catagonus wagneri* (Rusconi, 1930) are reported in Campo Grande Community of peasants, northwestern Santiago del Estero, Argentina. The new records were obtained through camera traps as well as the finding of a skull and footprints. We conducted interviews confirmed the historical presence of the species. The records indicate the presence of *C. wagneri* in the North Biological Corridor, expanding this species' distribution in Santiago del Estero province, providing initial evidence of potential connection between northern and southern populations.

Areas for the connectivity of Chaco peccary (*Catagonus wagneri*) populations at the southern limit of their distribution in the Argentine Chaco

Rivas, F.F., Brassiolo, M.M and I.C. Silva 2021
Brazilian Journal of Animal and Environmental Research 4(2)
The area of geographical distribution of mammal populations in the Argentine Chaco ecoregion is being increasingly reduced and this is mainly due to the progressive destruction of habitats. In this context, several species have been affected, among which is the endemic *Catagonus wagneri* (Tayassuidae), currently classified as "endangered" and with a trend of population decline. In this work, the predictions estimated by three algorithms were compared to establish the potential geographic distribution of this species at the southern limit of its natural distribution. Priority locations for landscape connectivity were identified by comparing intrinsic variations in the PC index based on data classification methods. With the use of foot transects, trap cameras and surveys with the local population, the presence of chacoan peccary was recorded on 25 occasions. From the GLM, Random Forest and Maxent algorithms (mean AUC 0.74), a reference model was obtained. Using it as an input and the PC index, the variation in the importance of the connectivity surfaces of the landscape was evaluated using three classification methods: quantile, equal interval and natural breaks. The consensus model (SDM) occupies 55,674 km2 of Argentina, representing 10% of the Chaco Seco ecoregion. The distribution occupies not only forest ecosystems, but also environments with less tree coverage. Coefficients of variation of 170% were recorded between the classification methods for the number of patches of classes 9 and 10 of the priority habitat for landscape connectivity. The SDM shows a fragmented distribution in line with the Chaco's land use change process.The results suggest a great variability of the PC index depending on the method of classifying data in class intervals, an aspect that was not discussed in previous studies.





A Behavioral Study of Chacoan Peccaries (*Catagonus wagneri*) in a Zoo Environment

Kurowski, D. and F. Logiudice 2021

The Pegasus Review: UCF Undergraduate Research Journal Vol. 14(1)

Found in the highly specialized area of the Gran Chaco, the Chacoan peccary (*Catagonis wagneri*) is an endangered animal threatened by industrial agriculture. In an attempt to save this species, three C. wagneri were brought to Central Florida Zoo where their health is monitored with great care in an attempt to possibly breed them in the future. While taking care of the other hooved animals, zookeepers are not able to give the peccaries their uninterrupted attention and have turned to help from the University of Central Florida to closely track if their behavior is indicative of a healthy, properly enriched captive peccary. By observing the activity patterns, type of encounters, and signs of stressful behavior in this aggregate of peccaries, it was hoped to be determined how well these peccaries have adapted to captivity with a newly introduced member, and how often they exhibit stressful behavior. Following the installation of the dividing fence, there was a decrease in aggressive behavior between the new and established peccaries, and an increase in the number of positive encounters such as mutual scenting and body rubbing. The eventual decline of aggressive behavior can be attributed to the increased exposure the fence created which allowed for agonistic behavior, such as charging and teeth chattering, to be executed in a safe manner. Socialization was progressively improved between the three as a new hierarchy was developed, eventually leading to group scenting and days where all members of the aggregate rested near each other.

Temporal and spatial patterns of common hippopotamus populations in the Okavango Delta, Botswana

Inman, V.L., Bino, G., Kingsford, R.T., Chase, M.J. and K.E.A. Leggett 2021

Freshwater Biology, https://doi.org/10.1111/fwb.13868

Conservation requires reliable estimates of a species' population and their spatial distribution. Knowledge of large-scale habitat use and population trends in common hippopotamus (*Hippopotamus amphibius*; hereafter hippo) in wetland ecosystems is limited, with no studies of hippo populations in the Okavango Delta (the Delta), Botswana.

1. We examined the drivers of long-term trends and spatial patterns in the Delta's hippo population, using 13 years of aerial surveys (1996–2018) informing on the potential impacts of changes in inflow, flooding patterns and rainfall on hippo populations.
2. We estimated temporal changes in hippo populations and relationships with rainfall and inflow. We also examined how spatially explicit hippo counts related to flood and surface water extent and vegetation class at different scales.
3. The Delta's hippo population has increased, probably due to increasing long-term rainfall and inflow, following a period of severe drought/low flooding. Hippos were positively associated with areas with high variation in flooding and negatively associated with broad-scale surface water extent, indicating hippos avoided permanent swamps and main channels, probably due to water depth, lack of nearby grazing, and thick riparian vegetation. At a fine scale, hippos relied on large lagoons for daytime refuge.
4. The most recent population estimate indicates that Botswana has the third highest hippo population in Africa, reflecting the importance of the Delta. Reductions in inflow and rainfall from climate change and water resource development would threaten these hippo populations by reducing grazing availability, lagoon sizes, and seasonal swamps. Ongoing monitoring of hippos

should continue as they represent a good indicator for the entire floodplain ecosystem.

The Quaternary Hippopotamus records from Italy

Martino, R. and L. Pandolfi 2021
Historical Biology, https://doi.org/10.1080/08912963.2021.1965138

The genus Hippopotamus dispersed from Africa to Europe during the Pleistocene and the taxon is testified from different Italian localities. Despite the large number of available specimens, Hippopotamus is mainly documented by fragmentary remains and detailed stratigraphic and/or geographic data are often absent or uncertain. In Italy, hippopotamuses are recorded in at least 100 fossiliferous localities spanning from the late Early Pleistocene to the Late Pleistocene. At present, three different Pleistocene species are recognised: *H. antiquus* from Early to Middle Pleistocene, H. amphibius from Middle to Late Pleistocene and H. pentlandi from late Middle-early Late Pleistocene Sicilian localities. Upper Valdarno basin (Tuscany), Chiusi basin (Tuscany), Colfiorito basin (Umbria), Sant'Oreste (Latium), Puntali Cave (Sicily) and Acquedolci (Sicily) are just a few fossiliferous Italian sites where significative findings of Hippopotamus were collected during the 19th and 20th centuries.

The Fossil Record of Continental Hippopotamids (Mammalia: Artiodactyla: Hippopotamidae) in Greece

Athanassiou, A. 2021
Fossil Vertebrates of Greece Vol. 2: 281-299

Hippopotamidae, an artiodactyl family of African origin, flourished in Europe during the Pleistocene. In Greece, it is reported from more than 20 continental localities, geographically dispersed from the northern to the southernmost part of the country and geochronologically dated from the earliest to the latest Pleistocene. Two species are recognized: the Early–Middle Pleistocene *Hippopotamus antiquus* and the Late Pleistocene *Hippopotamus amphibius*, the latter being the less common in the fossil record. Particularly rich or important material has been found in various sites within the Megalopolis Basin and the localities Ravin Voulgarákis, Kalamotó, and Dyrós Cave. Besides their definite presence in the Pleistocene of Greece, representatives of Hippopotamidae might also have been present during the late Miocene as well. This would imply the presence of a Hexaprotodon-like taxon in Greece, as is the case in other European Mediterranean regions.

Mitochondrial sequences of the extinct Cypriot pygmy hippopotamus confirm its phylogenetic placement

Psonis, N., Vassou, D., Nicolaou, L., Roussiakis, S., Iliopoulos, G., Poulakakis, N. and S. Sfenthourakis 2021
Zoological Journal of the Linnean Society, https://doi.org/10.1093/zoolinnean/zlab089

The Cypriot pygmy hippopotamus is an extinct Mediterranean species that inhabited the island of Cyprus during the Late Pleistocene. This iconic species last appears at the archaeological site of Akrotiri Aetokremnos, dated to ~12 500 cal. BP. Taxonomically, the Cypriot pygmy hippopotamus has been assigned to *Hippopotamus minor*, which, based on morphology, is more closely related to the common hippopotamus (*Hippopotamus amphibius*; today present only in Sub-Saharan Africa) than to the West African pygmy hippopotamus (*Choeropsis liberiensis*). Despite adverse conditions for preservation that greatly reduce the likelihood of DNA preservation in subfossil samples from hot environments, we recovered and analysed ancient DNA from petrous bones excavated from Akrotiri Aetokremnos. By whole mitogenome hybridization capture and exhaustive high-throughput sequencing, we were able to investigate the molecular phylogeny and taxonomic status of the Cypriot pygmy hippopotamus. The results of our low-coverage ancient mitogenomic analyses support the close phylogenetic affinity of *H. minor* to *H. amphibius*, with their divergence estimated at ~1.36 or 1.58 Mya, depending on the molecular dating method. To our knowledge, this study constitutes the first step towards reconstruction of the molecular phylogeny of Mediterranean Hippopotaminae.

The Population Dynamics of the Luangwa (Zambia) Common Hippopotamus (*Hippopotamus amphibius*) during the Period 1952 – 2015

Chomba, C., Simpamba, T. and V. Nyirenda 2021
International Research in Environment, Geography and Earth Science 9: 74-91
The population size of hippopotamus (*Hippopotamus amphibius* Linnaeus 1758) in Luangwa valley, Zambia was earlier assessed for the period 1976 -2008 and repeated 2009 -2015 and found to have reached and maintained carrying capacity K of 6000 individuals over a 165 km river stretch. This study covered the period 2009-2015 and used riverbank count method as in previous studies. In 1976, a stretch of 165 km was demarcated for intensive population monitoring using the same survey methods. Results of this monitoring showed that the population recorded high densities of up to 42 hippopotami/km during the period 1976 - 2008. The method involved counting individuals and taking GPS locations of hippopotamus schools. During the period 2009 -2015 the population had maintained irregular cycles oscillating above and below K of 6000 and was still within carrying capacity band of 3000 individuals. The highest population size was 7,862 hippopotami and density of 48/km reached in 2015, and the lowest was 4501 hippopotami and density of 27/km recorded in 1978. Between 1976-2008, and 2009-2015 the population still oscillated between 5000 - 8000 individuals, which is symptomatic of a population that had reached its asymptote. Plot of population size for the period 1976-2015 assumed a population model which was a hybrid between less accurate regulation and stable limit cycle. The slow-down in population growth at K and oscillations were attributed to environmental resistance. More studies are required to identify the impact of climate change on the population size and density fluctuations to determine whether K will rise or drop.

Diseases

A Review of Environmental Risk Factors for African Swine Fever in European Wild Boar

Bergmann, H., Schulz, K., Conraths, F.J. and C. Sauter-Louis 2021
Animals 2021, 11(9), 2692; https://doi.org/10.3390/ani11092692
A detailed understanding of environmental risk factors for African swine fever (ASF) in wild boar will be not only essential for risk assessments but also for timely and spatially informed allocation of resources in order to manage wild boar-targeted ASF control measures efficiently. Here, we review currently known environmental risk factors that can influence the occurrence of ASF virus infection in wild boar when compared to disease occurrence in wild boar of a non-exposed reference scenario. Accordingly, the exposure of wild boar to environmental risk factors related to (1) climate, (2) land cover, (3) human activity, (4) wild boar and (5) ASF were evaluated. As key environmental risk factors in this review, increased ASF occurrence in wild boar was associated

with seasonal patterns, forest coverage, presence of water, human presence, farming activities, wild boar density and ASF nearness. The review highlights inconsistencies in some of these risk factor associations with disease detection in space and time and may provide valuable insights for the investigation of ASF transmission dynamics. The examined risk information was applied to consider potential improvements of the ASF control strategy in wild boar regarding disease surveillance, hunting, wild boar carcass searches and ASF barrier implementation.

The effects of habitat fragmentation on the genetic structure of wild boar (*Sus scrofa*) population in Lithuania

Griciuvienė, L., Janeliūnas, Z., Jurgelevičius, V. and A. Paulauskas 2021
BMC Genomic Data 22: 53

Background

Wild boar (*Sus scrofa*) is a widely distributed ungulate whose success can be attributed to a variety of ecological features. The genetic variation and population structure of Lithuania's wild boar population have not yet been thoroughly studied. The purposes of this study were to investigate the genetic diversity of S. scrofa and assess the effects of habitat fragmentation on the population structure of wild boar in Lithuania. A total of 96 S. scrofa individuals collected from different regions of Lithuania were genotyped using fifteen microsatellite loci.

Results

The microsatellite analysis of the wild boars indicated high levels of genetic diversity within the population. Microsatellite markers showed evidence of a single panmictic wild boar population in Lithuania according to STRUCTURE's highest average likelihood, which was K = 1. This was supported by pairwise Fst values and AMOVA, which indicated no differentiation between the four sampling areas. The results of the Mantel test revealed a weak isolation by distance and geographic diversity gradients that persisted between locations. Motorway fencing and heavy traffic were not an effective barrier to wild boar movement.

Conclusions

There was limited evidence of population genetic structure among the wild boar, supporting the presence of a single population across the study area and indicating that there may be no barriers hindering wild boar dispersal across the landscape. The widespread wild boar population in Lithuania, the high level of genetic variation observed within subpopulations, and the low level of variation identified between subpopulations suggest migration and gene flow between locations. The results of this study should provide valuable information in future for understanding and comparing the detailed structure of wild boar population in Lithuania following the outbreak of African swine fever.

African Swine Fever Survey in a European Context

de la Torre, A., Bosch, J., Sánchez-Vizcaíno, J. M., Ito, S., Muñoz, C., Iglesias, I. and M. Martínez-Avilés 2022
Pathogens 11(2): 137, https://doi.org/10.3390/pathogens11020137

African swine fever (ASF) is currently the most threatening disease for domestic and wild pigs worldwide. Wild boar has been the main affected species in all EU countries except for Romania, where most notifications occur in domestic pigs. The spread of ASF in wild boar is challenging to control; risk factors are harder to identify and establish than in domestic pigs, which, together with an underestimation of the disease and the lack of treatment or an effective vaccine, are hindering control and eradication efforts. We distributed two online questionnaires, one for domestic pigs and one for wild boar, to experts of different background and countries in Europe, to explore risk factors in relation to ASF control connected to farming, hunting, trade, the environment, and domestic pig and wild boar populations. Overall, wild boar movements were estimated to pose the highest risk of ASF introduction and spread. The movement of pork and pork products for own consumption also ranked high. Here we explored, in addition to the assessment of risk pathways, the identification of risks of transmission at the domestic/wild boar interface, the importance of biosecurity practices and improved control efforts, and controversial opinions that require further attention.

One hundred years of African swine fever in Africa: Where have we been, where are we now, where are we going?

Penrith, M.L. and F.M. Kivaria 2022
Transboundary and Emerging Diseases, https://doi.org/10.1111/tbed.14466
One hundred years have passed since the first paper on African swine fever (ASF) was published by Montgomery in 1921. With no vaccine, ineffectiveness of prevention and control measures and lack of common interest in eradicating the disease, ASF has proven to be one of the most devastating diseases because of its significant sanitary and socioeconomic consequences. The rapid spread of the disease on the European and Asian continents and its recent appearance in the Caribbean puts all countries at great risk because of global trade. The incidence of ASF has also increased on the African continent over the last few decades, extending its distribution far beyond the area in which the ancient sylvatic cycle is present with its complex epidemiological transmission pathways involving virus reservoirs in ticks and wild African Suidae. Both in that area and elsewhere, efficient transmission by infected domestic pigs and virus resistance in infected animal products and fomites mean that human driven factors along the pig value chain are the dominant impediments for its prevention, control and eradication. Control efforts in Africa are furthermore hampered by the lack of information about the size and location of the fast-growing pig population, particularly in the dynamic smallholder sector that constitutes up to 90% of pig production in the region. A vaccine that will be both affordable and effective against multiple genotypes of the virus is not a short-term reality. Therefore, a strategy for management of ASF in sub-Saharan Africa is needed to provide a roadmap for the way forward for the continent. This review explores the progression of ASF and our knowledge of it through research over a century in Africa, our current understanding of ASF and what must be done going forward to improve the African situation and contribute to global prevention and control.

African swine fever endemic persistence in wild boar populations: Key mechanisms explored through modelling

Gervasi, V. and V. Guberti 2021
Transboundary and Emerging Diseases, https://doi.org/10.1111/tbed.14194
African swine fever (ASF) is a serious global concern from an ecological and economic point of view. While it is well established that its main transmission routes comprise contact between infected and susceptible animals and transmission through contaminated carcasses, the specific mechanism leading to its long-term persistence is still not clear. Among others, a proposed mechanism involves the potential role of convalescent individuals, which would be able to shed the virus after the end of the acute infection. Using a spatially explicit, stochastic, individual-based

model, we tested: (1) if ASF can persist when transmission occurs only through infected wild boars and infected carcasses; (2) if the animals that survive ASF can play a relevant role in increasing ASF persistence chances; (3) how hunting pressure can affect the ASF probability to persist. The scenario in which only direct and carcass-mediated transmission were contemplated had 52% probability of virus persistence 10 years after the initial outbreak. The inclusion of survivor-mediated transmission corresponded to slightly higher persistence probabilities (57%). ASF prevalence during the endemic phase was generally low, ranging 0.1-0.2%. The proportion of seropositive individuals gradually decreased with time and ranged 4.5-6.6%. Our results indicate that direct and carcass-mediated infection routes are sufficient to explain and justify the long-term persistence of ASF at low wild boar density and the ongoing geographic expansion of the disease front in the continent. During the initial years of an ASF outbreak, hunting should be carefully evaluated as a management tool, in terms of potential benefits and negative side-effects, and combined with an intensive effort for the detection and removal of wild boar carcasses. During the endemic phase, further increasing hunting effort should not be considered as an effective strategy. Additional effort should be dedicated to finding and removing as many wild boar carcasses as possible.

The impact of African swine fever virus on smallholder village pig production: An outbreak investigation in Lao PDR

Matsumoto, N., Siengsanan-Lamont, J., Halasa, T. et al. 2021

Transboundary and Emerging Diseases, https://doi.org/10.1111/tbed.14193

African swine fever virus (ASFV) causes a deadly disease of pigs which spread through southeast Asia in 2019. We investigated one of the first outbreaks of ASFV in Lao People's Democratic Republic amongst smallholder villages of Thapangtong District, Savannakhet Province. In this study, two ASFV affected villages were compared to two unaffected villages. Evidence of ASFV-like clinical signs appeared in pig herds as early as May 2019, with median epidemic days on 1 and 18 June in the two villages, respectively. Using participatory epidemiology mapping techniques, we found statistically significant spatial clustering in both outbreaks ($p < 0.001$). Villagers reported known risk factors for ASFV transmission - such as free-ranging management systems and wild boar access - in all four villages. The villagers reported increased pig trader activity from Vietnam before the outbreaks; however, the survey did not determine a single outbreak source. The outbreak caused substantial household financial losses with an average of nine pigs lost to the disease, and Monte Carlo analysis estimated this to be USD 215 per household. ASFV poses a significant threat to food and financial security in smallholder communities such as Thapangtong, where 40.6% of the district's population are affected by poverty. This study shows ASFV management in the region will require increased local government resources, knowledge of informal trader activity and wild boar monitoring alongside education and support to address intra-village risk factors such as free-ranging, incorrect waste disposal and swill feeding.

ESBL/AmpC-Producing Escherichia coli in Wild Boar: Epidemiology and Risk Factors

Formenti, N., Calo, S., Parisio, G., et al. 2021

Animals 11(7), https://doi.org/10.3390/ani11071855

The complex health problem of antimicrobial resistance (AMR) involves many host species, numerous bacteria and several routes of transmission. Extended-spectrum β-lactamase and

AmpC (ESBL/AmpC)-producing *Escherichia coli* are among the most important strains. Moreover, wildlife hosts are of interest as they are likely antibiotics free and are assumed as environmental indicators of AMR contamination. Particularly, wild boar (*Sus scrofa*) deserves attention because of its increased population densities, with consequent health risks at the wildlife-domestic-human interface, and the limited data available on AMR. Here, 1504 wild boar fecal samples were microbiologically and molecularly analyzed to investigate ESBL/AmpC-producing *E. coli* and, through generalized linear models, the effects of host-related factors and of human population density on their spread. A prevalence of 15.96% of ESBL/AmpC-producing *E. coli*, supported by blaCTX-M (12.3%), blaTEM (6.98%), blaCMY (0.86%) and blaSHV (0.47%) gene detection, emerged. Young animals were more colonized by ESBL/AmpC strains than older subjects, as observed in domestic animals. Increased human population density leads to increased blaTEM prevalence in wild boar, suggesting that spatial overlap may favor this transmission. Our results show a high level of AMR contamination in the study area that should be further investigated. However, a role of wild boar as a maintenance host of AMR strains emerged.

Detection and molecular characterization of *Babesia* sp. in wild boar (*Sus scrofa*) from western Japan

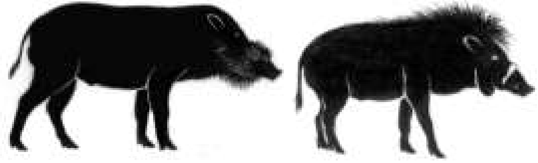
Morikawa, M., Mitarai, S., Kojima, I., et al. 2021
Ticks and Tick-Borne Diseases 12(4), https://doi.org/10.1016/j.ttbdis.2021.101695

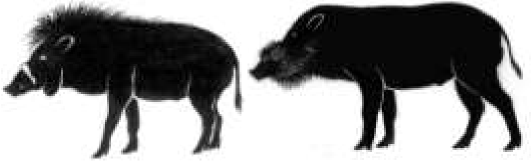
Wild animals often act as reservoirs of tick-borne *Babesia* and *Theileria* spp., which cause piroplasmosis. Therefore, epidemiological investigations about the distribution of these parasites in wild animals are important for evaluating the transmission risk to humans and livestock. In this study, we surveyed *Babesia* and *Theileria* spp. infecting wild boar (*Sus scrofa*) in Kagoshima and Yamaguchi prefectures and Tsushima island, which are all in western Japan, and performed molecular genetic analyses on the samples. DNA was extracted from either blood or liver samples of wild boar captured in Kagoshima prefecture in 2015, 2016, and 2018 and from blood samples from wild boar captured in Yamaguchi prefecture in 2013-2015 and Tsushima island in 2018. PCR screening for the partial 18S ribosomal RNA gene (18S rRNA) of both *Babesia* and *Theileria* spp. in wild boar revealed that 63.9 % (140 of 219 samples) were positive. Sequencing of all positive samples revealed that they were all the same *Babesia* species. Subsequent phylogenetic analyses showed that the parasite is closely related to *Babesia* sp. previously detected in the hard tick, *Amblyomma testudinarium* in Kagoshima, and further analyses suggested that this species is genetically related to *Babesia gibsoni*. On the other hand, no Theileria were detected in any of the samples. In summary, we observed a high prevalence of *B. gibsoni*-like *Babesia* sp. in wild boar in western regions of Japan. The host range, distribution, pathogenicity, and life cycle of this protozoan should be further evaluated.

Long-Term Determinants of the Seroprevalence of the Hepatitis E Virus in Wild Boar (*Sus scrofa*)

Barroso, P. Risalde, M.A., Garcia-Bocanegra, I. et al. 2021
Animals 11(6), https://doi.org/10.3390/ani11061805

The hepatitis E virus (HEV) is an emerging zoonotic pathogen whose main reservoir is suids. Most of the ecological and epidemiological aspects of its sylvatic cycle remain unknown. Thus, in this work, we study the drivers of HEV exposure in the wild boar population of Doñana National Park (DNP, southwest Spain) operating in the medium and long-term (2005–2018). Anti-HEV





antibodies are widely distributed throughout the wild boar (46.7 ± 3.8%, 327 out of 700 sampled), showing a statistically significant age-increasing pattern. The temporal pattern displayed important interannual fluctuations. This could be mediated by marked variations in the population control of the wild boar, and subsequent changes in abundance rates, and its interplay with climatic conditions; as wet years together with a low abundance of wild boar led to the lowest seroprevalence. The fact that seroprevalence is high during conditions of high abundance, and not affected by rainfall level, is probably due to the increased interactions among the animals, and possibly, the subsequent higher environmental contamination with HEV particles. The proximity to the marshland (the main water body of the study area) is associated with a higher risk of testing positive, which is probably mediated by the preferential use of this area during the dry season and the favourable environmental conditions for the survival of HEV particles. A deeper understanding of the epidemiology of HEV in host communities deserves future research concerning other susceptible species. Most importantly, wild boar population control remains a challenge at the international level, and an increase of shared pathogen-related conflicts associated with this species is expected, as exemplified by HEV. Therefore, surveillance of wild boar diseases, including integrated population monitoring and sustainable population control programmes, will be essential to control the associated risks.

The Role of Interleukine-10 and Interferon-gamma as Potential Markers of the Evolution of African Swine Fever Virus Infection in Wild Boar

Barroso-Arevalo, S., Barasona, J.A., Cadenas-Fernandez, E. and J.M. Sanchez-Vizcaino 2021

Pathogens 10(6), https://doi.org/10.3390/pathogens10060757

African swine fever virus (ASFv) is one of the most challenging pathogens to affect both domestic and wild pigs. The disease has now spread to Europe and Asia, causing great damage to the pig industry. Although no commercial vaccine with which to control the disease is, as yet, available, some potential vaccine candidates have shown good results in terms of protection. However, little is known about the host immune mechanisms underlying that protection, especially in wild boar, which is the main reservoir of the disease in Europe. Here, we study the role played by two cytokines (IL-10 and IFN-γ) in wild boar orally inoculated with the attenuated vaccine candidate Lv17/WB/Rie1 and challenged with a virulent ASFv genotype II isolate. A group of naïve wild boar challenged with the latter isolate was also established as a control group. Our results showed that both cytokines play a key role in protecting the host against the challenge virus. While high levels of IL-10 in serum may trigger an immune system malfunctioning in challenged animals, the provision of stable levels of this cytokine over time may help to control the disease. This, together with high and timely induction of IFN-γ by the vaccine candidate, could help protect animals from fatal outcomes. Further studies should be conducted in order to support these preliminary results and confirm the role of these two cytokines as potential markers of the evolution of ASFV infection.

Mechanistic modelling of African swine fever: A systematic review

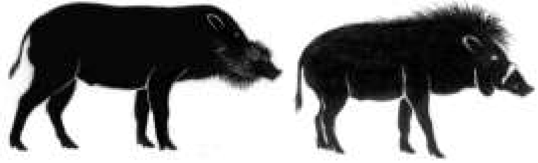
Hayes, B.H., Andraud, M., Salazar, L.G. et al. 2021

Preventive Veterinary Medicine 191, https://doi.org/10.1016/j.prevetmed.2021.105358

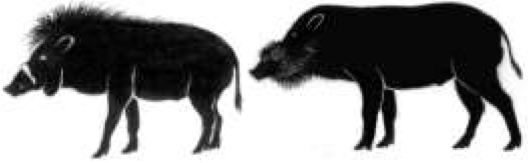
The spread of African swine fever (ASF) poses a grave threat to the global swine industry. Without an available vaccine, understanding transmission dynamics is essential for designing effective prevention, surveillance, and intervention strategies. These dynamics can often be

unraveled through mechanistic modelling. To examine the assumptions on transmission and objectives of the mechanistic models of ASF, a systematic review of the scientific literature was conducted. Articles were examined across multiple epidemiological and model characteristics, with filiation between models determined through the creation of a neighbor-joined tree using phylogenetic software. Thirty-four articles qualified for inclusion, with four main modelling objectives identified: estimating transmission parameters (11 studies), assessing determinants of transmission (7), examining consequences of hypothetical outbreaks (5), assessing alternative control strategies (11). Population-based (17), metapopulation (5), and individual-based (12) model frameworks were represented, with population-based and metapopulation models predominantly used among domestic pigs, and individual-based models predominantly represented among wild boar. The majority of models (25) were parameterized to the genotype II isolates currently circulating in Europe and Asia. Estimated transmission parameters varied widely among ASFV strains, locations, and transmission scale. Similarly, parameter assumptions between models varied extensively. Uncertainties on epidemiological and ecological parameters were usually accounted for to assess the impact of parameter values on the modelled infection trajectory. To date, almost all models are host specific, being developed for either domestic pigs or wild boar despite the fact that spillover events between domestic pigs and wild boar are evidenced to play an important role in ASF outbreaks. Consequently, the development of more models incorporating such transmission routes is crucial. A variety of codified and hypothetical control strategies were compared however they were all a priori defined interventions. Future models, built to identify the optimal contributions across many control methods for achieving specific outcomes should provide more useful information for policy-makers. Further, control strategies were examined in competition with each other, which is opposed to how they would actually be synergistically implemented. While comparing strategies is beneficial for identifying a rank-order efficacy of control methods, this structure does not necessarily determine the most effective combination of all available strategies. In order for ASFV models to effectively support decision-making in controlling ASFV globally, these modelling limitations need to be addressed.

Detection of Porcine circovirus 3 from captured wild boars in Korea
Dhandapani, G., Yoon, S., Noh, J. et al. 2021
Veterinary Medicine and Science, https://doi.org/10.1002/vms3.518
Porcine circovirus 3 (PCV3) is a newly discovered ssDNA virus. The virus was first reported in pigs suffering from several clinical syndromes, including porcine dermatitis and nephropathy syndrome, reproductive disorders, respiratory disease and myocarditis. PCV3 was recently reported in wild boars with high prevalence as well. In this study, 266 wild boar anal swab, feces, nasal swab and whole blood samples were collected from three mainland provinces and one island province (Chungbuk, Gangwon, Gyeonggi, Jeju) of South Korea between 2019 and 2020 including 119 from male, 142 from female and 5 undetermined. PCV3 was diagnosed targeting conserved rep (replication associated protein) gene region using Direct PCR and sequencing. Out of 266 tested samples, 15 were positive for PCV3 with detection frequency at 5.6%. Among 266 samples tested, we obtained 14 partial rep gene sequences and one complete genome sequence of PCV3 with a genome size of 2000nt. Here we present the evidence of PCV3 circulation in Korean wild boars.



New scientific articles



Epidemiological analysis of classical swine fever in wild boars in Japan

Shimizu, Y., Hayama, Y., Murato, Y. et al. 2021
BMC Veterinary Research 17(1), https://doi.org/10.1186/s12917-021-02891-0

This study describes the epidemiological characteristics of classical swine fever (CSF) outbreaks in Japan. The first case was confirmed in September 2018, 26 years after the last known case. Outbreaks occurred on 39 farms, 34 commercial farms, and 5 non-commercial farms, between September 2018 and August 2019. In this study, a descriptive analysis was conducted of the epidemiological data on the characteristics of the affected farms, clinical manifestations, intra-farm transmission, association with infected wild boars, and control measures implemented on the farms. Twenty-eight of the 34 affected commercial farms were farrow-to-finish farms. It was assumed that the major risk factors were frequent human-pig interactions and the movement of pigs between farms. Fever and leukopenia were commonly observed in infected pigs. In 12 out of 18 farms where clinical manifestations among fattening pigs was the reason for notification, death was the most frequent clinical manifestation, but the proportion of dead animals did not exceed 0.5% of the total number of animals at most of the affected farms. Therefore, the clinical form of CSF in Japan was considered to be sub-acute. Twenty-three of the 29 farms (79%) with pigs at multiple stages (i.e., piglets, fattening pigs, and sows), had infection across the multiple stages. Many of these farms were within 5 km of the site where the first infected wild boars had been discovered, suggesting that infected wild boars were the source of infection. Infections still occurred at farms that had implemented measures at their farm boundaries to prevent the introduction of the virus into their farms, such as disinfection of vehicles and people, changing boots of the workers, and installation of perimeter fences. It is necessary to continue to strengthen biosecurity measures for farms located in areas with infected wild boars and to continue monitoring the distribution of infected wild boars so that any abnormalities can be reported and inspected at an early stage.

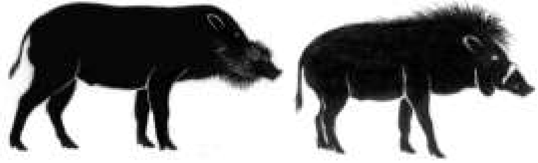
Presence of *Helicobacter pylori* and *H. suis* DNA in Free-Range Wild Boars

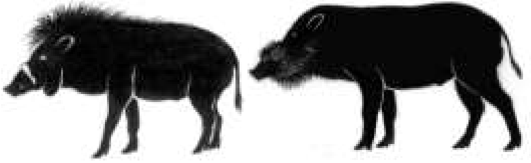
Cortez Nunes, F., Letra Mateus, T., Teixeira, S. et al. 2021
Animals 11(5), https://doi.org/10.3390/ani11051269

Helicobacter pylori (*H. pylori*) is a Gram-negative bacterium that infects half of the human population worldwide, causing gastric disorders, such as chronic gastritis, gastric or duodenal ulcers, and gastric malignancies. *Helicobacter suis* (*H. suis*) is mainly associated with pigs, but can also colonize the stomach of humans, resulting in gastric pathologies. In pigs, *H. suis* can induce gastritis and seems to play a role in gastric ulcer disease, seriously affecting animal production and welfare. Since close interactions between domestic animals, wildlife, and humans can increase bacterial transmission risk between species, samples of gastric tissue of 14 free range wild boars (*Sus scrofa*) were evaluated for the presence of *H. pylori* and *H. suis* using PCR. Samples from the antral gastric mucosa from two animals were PCR-positive for *H. pylori* and another one for *H. suis*. These findings indicate that these microorganisms were able to colonize the stomach of wild boars and raise awareness for their putative intervention in Helicobacter spp. transmission cycle.

The potential negative impacts of the classical swine fever virus on wild boar population in Gifu prefecture, Japan

Ikeda, T., Asano, M. and M. Suzuki 2021





Journal of Veterinary Medical Science 83(5): 846-849, https://doi.org/10.1292/jvms.20-0675

There is a possibility that classical swine fever (CSF) virus outbreak has negative impacts on wild boar. To adequately manage native wild boar populations, wildlife managers need to gather the field data on wild boar and implement population management practices. We aimed to report the relative abundance index of wild boar before and after this outbreak. Our results showed that relative abundance index declined from 2017 (8.88 wild boars/100 trap days) to 2019 (2.03 wild boars/100 trap days), because of the negative impact of this virus and continuous culling programs. Although the eradication risk from the synergistic effect is low, wildlife managers need to consider the relationship between the trade-off between the risk of CSF and the conservation ecology risk of native species eradication.

Modelling the Spatial Distribution of ASF-Positive Wild Boar Carcasses in South Korea Using 2019-2020 National Surveillance Data

Lim, J., Vergne, T., Pak, S. and E. Kim 2021

Animals 11(5), https://doi.org/10.3390/ani11051208

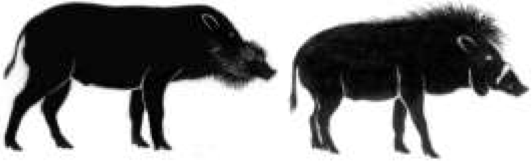
In September 2019, African swine fever (ASF) was reported in South Korea for the first time. Since then, more than 651 ASF cases in wild boars and 14 farm outbreaks have been notified in the country. Despite the efforts to eradicate ASF among wild boar populations, the number of reported ASF-positive wild boar carcasses have increased recently. The purpose of this study was to characterize the spatial distribution of ASF-positive wild boar carcasses to identify the risk factors associated with the presence and number of ASF-positive wild boar carcasses in the affected areas. Because surveillance efforts have substantially increased in early 2020, we divided the study into two periods (2 October 2019 to 19 January 2020, and 19 January to 28 April 2020) based on the number of reported cases and aggregated the number of reported ASF-positive carcasses into a regular grid of hexagons of 3-km diameter. To account for imperfect detection of positive carcasses, we adjusted spatial zero-inflated Poisson regression models to the number of ASF-positive wild boar carcasses per hexagon. During the first study period, proximity to North Korea was identified as the major risk factor for the presence of African swine fever virus. In addition, there were more positive carcasses reported in affected hexagons with high habitat suitability for wild boars, low heat load index (HLI), and high human density. During the second study period, proximity to an ASF-positive carcass reported during the first period was the only significant risk factor for the presence of ASF-positive carcasses. Additionally, low HLI and elevation were associated with an increased number of ASF-positive carcasses reported in the affected hexagons. Although the proportion of ASF-affected hexagons increased from 0.06 (95% credible interval (CrI): 0.05–0.07) to 0.09 (95% CrI: 0.08–0.10), the probability of reporting at least one positive carcass in ASF-affected hexagons increased from 0.49 (95% CrI: 0.41–0.57) to 0.73 (95% CrI: 0.66–0.81) between the two study periods. These results can be used to further advance risk-based surveillance strategies in the Republic of Korea

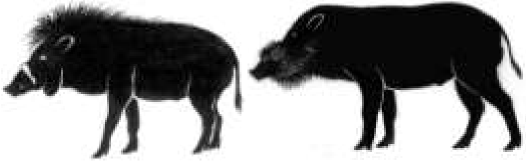
Evaluation of Three Medetomidine-Based Anesthetic Protocols in Free-Ranging Wild Boars (*Sus scrofa*)

Morelli, J., Rossi, S., Fuchs, B. et al. 2021

Frontiers in Veterinary Science 8, https://doi.org/10.3389/fvets.2021.693925

Three medetomidine-based drug protocols were compared by evaluating time courses, reliability and physiological effects in wild boars. A total of 21 cage-trapped wild boars (Sus scrofa) were





immobilized using one of the following drug combinations; MTZ: medetomidine (0.2 mg/kg) + tiletamine-zolazepam (2.0 mg/kg), MK: medetomidine (0.15 mg/kg) + ketamine (5 mg/kg), and MKB: medetomidine (0.1 mg/kg) + ketamine (5.0 mg/kg) + butorphanol (0.2 mg/kg). Induction time, recovery time, and physiological variables were recorded and arterial blood gas analysis measured twice, before and after 15 min of oxygen supplementation (0.5–1.0 L/min). For reversal, 4 mg of atipamezole per mg of medetomidine was administered intramuscularly. The boars recovered in the cage and were released once ataxia resolved. The MK group had significantly longer recovery times (mean 164 min ± 79 SD) compared to the other groups. MKB elicited longer and incomplete induction compared to the other groups (mean induction time 20 min ± 10 SD), decreasing the efficiency of the capture and increasing the risk of hyperthermia. Both ketamine-based protocols required additional ketamine intramuscularly to prolong the anesthesia after 20–40 min from induction. Agreement between the pulse oximeter and the blood gas analyzer was low, with the pulse oximeter underestimating the real values of arterial oxyhemoglobin saturation, particularly at higher readings. Mild acute respiratory acidosis (PaCO2 45–60 mmHg) and mild to moderate hypoxemia (PaO2 69–80 mmHg) occurred in most boars, regardless of the treatment group but especially in the MKB group. The acid-base status improved and hypoxemia resolved in all boars during oxygen supplementation, with the PaO2 rising above the physiological reference range (81.6–107.7 mmHg) in many individuals. MK and MKB induced safe and reliable immobilization of wild boars for at least 20 min. Supplemental oxygen delivery is recommended in order to prevent hypoxemia in wild boars immobilized with the protocols used in the present study. Long and ataxic recoveries occurred in most animals, regardless of the protocol, but especially in the MKB group.

African Swine Fever in wild boar: Assessing interventions in South Korea

Jo, Y. and C. Gortazar 2021

Transboundary and Emerging Diseases, https://doi.org/10.1111/tbed.14106

African Swine Fever (ASF) was detected in South Korean pig farms in September 2019. Currently, ASF occurs mostly in wild boar (*Sus scrofa*). We describe the ASF dynamics in wild boar in South Korea from October 2019 to October 2020 and use case studies to evidence the advantages and limitations of the control measures applied. During 2019, ASF remained confined in fenced areas of three counties. Since January 2020 however, the ASF management policy changed from fencing with limited disturbance to culling (with more disturbance), and ASF spread east and south. Until 31 October 2020, a total of 775 wild boar ASF cases have been confirmed, affecting 9 counties. Interventions for ASF control in wild boar included silent (trapping) and non-silent (shooting) population control, local and large-scale fencing, and carcass destruction. Pre-ASF wild boar densities were closed to 10 per km2. Biosafety risks arose from the movements of people and vehicles, swill feeding of wild boar, destroying pig herds, handling wild boar during trapping and hunting, and searching for and disposing of carcasses. Despite training efforts, biosafety regulations were sometimes ignored. We observed differences between counties regarding disease control. While interventions apparently succeeded in controlling ASF in one site where geographical features and fast decision making facilitated an early and efficient fencing, and culling was performed silently, biosafety problems and habitat- and management-related delays hindered ASF control in other situations. Given that carcass, destruction faces specific limitations in South Korea, fencing and trapping (under appropriate biosafety conditions) might represent the most effective intervention option.

African Swine Fever spread across Asia, 2018-2019

Mighell, E. and M.P. Ward 2021

Transboundary and Emerging Diseases, https://doi.org/10.1111/tbed.14039

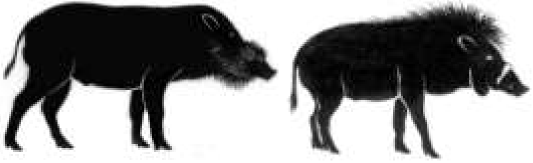
African Swine Fever Virus (ASFV) is a highly contagious pathogen that causes disease in pigs, commonly characterized by acute haemorrhagic fever. Prior to August 2018, African Swine Fever (ASF) had not been reported in Asia, but has since spread throughout China, Mongolia, Korea, Vietnam, Laos, Cambodia, Myanmar, the Philippines, Hong Kong, Indonesia, Timor-Leste and Papua New Guinea. Using data collated from reports of confirmed cases, we applied spatio-temporal analysis to describe ASFV spread throughout Asia during its early phase-from 1 August 2018 (reported start date) to 31 December 2019-to provide an overview and comparative analysis. Analysis revealed a propagating epidemic of ASFV throughout Asia, with peaks corresponding to increased reports from China, Vietnam and Laos. Two clusters of reported outbreaks were found. During the epidemic, ASFV primarily spread from the North-East to the South-East: A larger, secondary cluster in the North-East represented earlier reports, while the smaller, primary cluster in the South-East was characterized by later reports. Significant differences in country-specific epidemics, morbidity, mortality and unit types were discovered. The initial number of outbreaks and enterprise size are likely predictors of the speed of spread and the effectiveness of ASFV stamping out procedures. Biosecurity methods, wild boar populations and the transportation of pigs and movement of infected fomites are discussed as likely risk factors for facilitating ASFV spread across Asia.

The impact of an African swine fever outbreak on endemic tuberculosis in wild boar populations: A model analysis

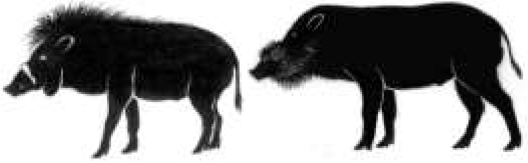
O'Neill, X., White, A., Ruiz-Fons, F. and C. Gortazar 2021

Transboundary and Emerging Diseases, https://doi.org/10.1111/tbed.14052

A mathematical model is developed and analysed to examine the impacts of African swine fever (ASF) introduction into a wild boar population that supports endemic animal tuberculosis (TB). TB is a widespread infectious disease caused by the *Mycobacterium tuberculosis* bacteria belonging to the Mycobacterium tuberculosis complex (MTC) that can persist in reservoir wildlife hosts. Wild boar (*Sus scrofa*) are a key reservoir for MTC, and an increasing trend in wild boar density is expected to lead to an increase in TB prevalence with spill-over to livestock. MTC infection is presently controlled through a variety of strategies, including culling. African swine fever (ASF) is a virulent, viral infection which affects wild boar and is spreading across Eurasia and Oceania. ASF infection leads to near 100% mortality at the individual level, can cause a dramatic decrease in population density and may therefore lead to TB control. We extend an established model that captures the key demographic and infection processes for TB in wild boar to consider the impact of ASF introduction on wild boar populations that support different levels of endemic TB. Our model results indicate that an ASF infection will reduce wild boar population density and lead to a decrease in the prevalence of TB. If ASF persists in the local host population the model predicts the long-term decline of TB prevalence in wild boar. If ASF is eradicated, or fades-out in the local host population, the model predicts a slower recovery of TB prevalence in comparison to wild boar density after an ASF epidemic. This may open a window of opportunity to apply TB management to maintain low TB prevalence.



New scientific articles



Evidence-Based African Swine Fever Policies: Do We Address Virus and Host Adequately?

Busch, F., Haumont, C., Penrith, M. et al. 2021

Frontiers in Veterinary Science 8, https://doi.org/10.3389/fvets.2021.637487

African swine fever (ASF) is one of the most threatening diseases for the pig farming sector worldwide. Prevention, control and eradication remain a challenge, especially in the absence of an effective vaccine or cure and despite the relatively low contagiousness of this pathogen in contrast to Classical Swine Fever or Foot and Mouth disease, for example. Usually lethal in pigs and wild boar, this viral transboundary animal disease has the potential to significantly disrupt global trade and threaten food security. This paper outlines the importance of a disease-specific legal framework, based on the latest scientific evidence in order to improve ASF control. It compares the legal basis for ASF control in a number of pig-producing regions globally, considering diverse production systems, taking into account current scientific evidence in relation to ASF spread and control. We argue that blanket policies that do not take into account disease-relevant characteristics of a biological agent, nor the specifics under which the host species are kept, can hamper disease control efforts and may prove disproportionate.

Identification of African swine fever virus genomic DNAs in wild boar habitats within outbreak regions in South Korea

Lee, K., Choi, Y., Yoo, J. et al. 2021

Journal of Veterinary Science 22(2), https://doi.org/10.4142/jvs.2021.22.e28

An African swine fever (ASF) outbreak in wild boars was first reported on October 2, 2019, in South Korea. Since then, additional cases were reported in South Korea's border areas. We here report the identification of ASF virus (ASFV) DNAs from two out of eight environmental abiotic matter samples collected from areas where ASF-positive wild boar carcasses were found. Comparative genomic investigations suggested that the contaminating ASFV DNAs originated from the wild boar whose carcass had been found near the positive sample sites. This is the first report on the identification of ASF viral material in wild boar habitats.

Kobuvirus detection in the critically endangered pygmy hog (*Porcula salvania*), India

Malik, Y., Bhat, S., Sircar, S. et al. 2021

Journal of Zoo and Wildlife Medicine 52(1): 343-347

Pygmy hogs (*Porcula salvania*) are the smallest and rarest wild suid. It is categorized as a Critically Endangered species as per the Red List of the International Union for Conservation of Nature. This study reports the first detection of a single-stranded RNA virus species, Aichivirus C, belonging to the genus Kobuvirus (KobV) and the family Picornaviridae, in pygmy hogs. KobV species are identified as a cause of acute gastroenteritis among children in India. As of now, there exists no report on the detection of KobV in animals from India. We used a detection assay based on reverse transcription–polymerase chain reaction for KobV screening in pygmy hogs from a conservation center in India. The 3D polymerase gene–based molecular analysis revealed KobV presence in the Indian wild suid, pygmy hogs. Of the 15 samples tested, three were found positive for picornaviruses and were negative for rotavirus A, rotavirus C, astrovirus, picobirnavirus and caliciviruses. Nucleotide-based sequence analysis of the partial 3D polymerase gene revealed close identity with porcine KobV from the Czech Republic (JX232619, 90.6%–91.6%) and Hungary (NC_011829, 89.8%–91.6%), wherein one of the current study strains clustered with the Czech Republic JX232619 strain in the phylogenetic tree. Further

investigation of the role of KobV in health and disease of pygmy hogs is warranted.

A framework for surveillance of emerging pathogens at the human-animal interface: Pigs and coronaviruses as a case study

Pepin, K.M., Miller, R. and M.Q. Wilber 2021

Preventive Veterinary Medicine 188, https://doi.org/10.1016/j.prevetmed.2021.105281

Pigs (*Sus scrofa*) may be important surveillance targets for risk assessment and risk-based control planning against emerging zoonoses. Pigs have high contact rates with humans and other animals, transmit similar pathogens as humans including CoVs, and serve as reservoirs and intermediate hosts for notable human pandemics. Wild and domestic pigs both interface with humans and each other but have unique ecologies that demand different surveillance strategies. Three fundamental questions shape any surveillance program: where, when, and how can surveillance be conducted to optimize the surveillance objective? Using theory of mechanisms of zoonotic spillover and data on risk factors, we propose a framework for determining where surveillance might begin initially to maximize a detection in each host species at their interface. We illustrate the utility of the framework using data from the United States. We then discuss variables to consider in refining when and how to conduct surveillance. Recent advances in accounting for opportunistic sampling designs and in translating serology samples into infection times provide promising directions for extracting spatio-temporal estimates of disease risk from typical surveillance data. Such robust estimates of population-level disease risk allow surveillance plans to be updated in space and time based on new information (adaptive surveillance) thus optimizing allocation of surveillance resources to maximize the quality of risk assessment insight.

African Swine Fever Laboratory Diagnosis-Lessons Learned from Recent Animal Trials

Pikalo, J., Deutschmann, P., Fischer, M. et al. 2021

Pathogens 10(2), https://doi.org/10.3390/pathogens10020177

African swine fever virus (ASFV) causes a hemorrhagic disease in pigs with high socio-economic consequences. To lower the impact of disease incursions, early detection is crucial. In the context of experimental animal trials, we evaluated diagnostic workflows for a high sample throughput in active surveillance, alternative sample matrices for passive surveillance, and lateral flow devices (LFD) for rapid testing. We could demonstrate that EDTA blood is significantly better suited for early ASFV detection than serum. Tissues recommended by the respective diagnostic manuals were in general comparable in their performance, with spleen samples giving best results. Superficial lymph nodes, ear punches, and different blood swabs were also evaluated as potential alternatives. In summary, all matrices yielded positive results at the peak of clinical signs and could be fit for purpose in passive surveillance. However, weaknesses were discovered for some matrices when it comes to the early phase of infection or recovery. The antigen LFD showed variable results with best performance in the clinical phase. The antibody LFD was quite comparable with ELISA systems. Concluding, alternative approaches are feasible but have to be embedded in control strategies selecting test methods and sample materials following a "fit-for-purpose" approach.

With or without a Vaccine-A Review of Complementary and Alternative Approaches to Managing African Swine Fever in Resource-Constrained Smallholder Settings

Penrith, M., Bastos, A. and E. Chenais 2021

Vaccines 9(2), https://doi.org/10.3390/vaccines9020116

The spectacular recent spread of African swine fever (ASF) in Eastern Europe and Asia has been strongly associated, as it is in the endemic areas in Africa, with free-ranging pig populations and low-biosecurity backyard pig farming. Managing the disease in wild boar populations and in circumstances where the disease in domestic pigs is largely driven by poverty is particularly challenging and may remain so even in the presence of effective vaccines. The only option currently available to prevent ASF is strict biosecurity. Among small-scale pig farmers biosecurity measures are often considered unaffordable or impossible to implement. However, as outbreaks of ASF are also unaffordable, the adoption of basic biosecurity measures is imperative to achieve control and prevent losses. Biosecurity measures can be adapted to fit smallholder contexts, culture and costs. A longer-term approach that could prove valuable particularly for free-ranging pig populations would be exploitation of innate resistance to the virus, which is fully effective in wild African suids and has been observed in some domestic pig populations in areas of prolonged endemicity. We explore available options for preventing ASF in terms of feasibility, practicality and affordability among domestic pig populations that are at greatest risk of exposure to ASF.

Efficacy of Oral Vaccine against Classical Swine Fever in Wild Boar and Estimation of the Disease Dynamics in the Quantitative Approach

Bazarragchaa, E., Isoda, N., Kim, T. et al. 2021

Viruses-Basel 13(2), https://doi.org/10.3390/v13020319

Classical swine fever virus (CSFV) in the wild boar population has been spreading in Japan, alongside outbreaks on pigs, since classical swine fever (CSF) reemerged in September 2018. The vaccination using oral bait vaccine was initially implemented in Gifu prefecture in March 2019. In the present study, antibodies against CSFV in wild boar were assessed in 1443 captured and dead wild boars in Gifu prefecture. After the implementation of oral vaccination, the increase of the proportion of seropositive animals and their titer in wild boars were confirmed. Quantitative analysis of antigen and antibodies against CSFV in wild boar implies potential disease diversity in the wild boar population. Animals with status in high virus replication (Ct < 30) and non- or low-immune response were confirmed and were sustained at a certain level after initial oral vaccination. Through continuous vaccination periods, the increase of seroprevalence among wild boar and the decrease of CSFV-positive animals were observed. The epidemiological analysis based on the quantitative virological outcomes could provide more information on the efficacy of oral vaccination and dynamics of CSF in the wild boar population, which will help to improve the implementation of control measures for CSF in countries such as Japan and neighboring countries.

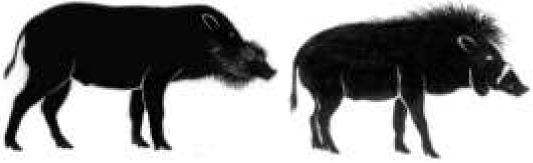
Typical intracranial myiasis in Nigerian red river hogs (*Potamochoerus porcus*) caused by an unknown bot fly (Diptera: Oestridae)

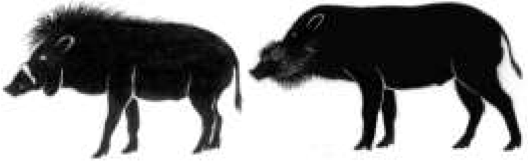
Friant, S., Young, D.K. and T.L.Goldberg 2022

International Journal for Parasitology: Parasites and Wildlife

Volume 17: 14-19

We report an unknown taxon of bot fly (Diptera: Oestridae: Oestrinae) in red river hogs (*Potamochoerus porcus* Linnaeus, 1758) in Cross River State, Nigeria. From direct observation and interviews with local hunters, we document that, remarkably, the parasite typically occurs within the intracranial supra-meningeal space – i.e., between the inner wall of the skull and the





brain – but without causing visible inflammation or clinical signs. The parasite is most similar (up to 87.9%) to *Rhinoestrususbekistanicus* based on cytochrome oxidase subunit 1 DNA sequencing but is sufficiently divergent phylogenetically to represent a new or previously un-sequenced taxon. Morphologically, the parasite shares some, but not all, features with *R. nivarleti*. Local cultural belief systems attribute aspects of red river hog behavior (e.g. intelligence, elusiveness) to the parasite, suggesting a prolonged presence in the red river hog population. The parasite's unusual anatomic location may be aberrant, or it may be a protective adaptation to life in red river hogs, which forage vigorously with their snouts.

Do wild suids from Ndumo Game Reserve, South Africa, play a role in the maintenance and transmission of African swine fever to domestic pigs?

Mapendere, C., Jori, F., Etter, E.M.C. and J. H.W. Ferguson 2021
Transboundary and Emerging Diseases 68(5): 2774-2786
Warthogs (*Phacochoerus africanus*) and bushpigs (*Potamochoerus larvatus*) are considered as the wild reservoirs of ASF. They are both present in Ndumo Game Reserve (NGR), located in the Northern South African Province of KwaZulu on the border with Mozambique. In that area, the occurrence of tick-warthog sylvatic cycle of ASF has been suspected for years. To assess if wild suids represent a risk of ASF virus spillover to domestic pigs, wild suid abundance and incursions outside NGR boundaries were estimated using transect counts, fence patrols and camera traps. Also, the presence of Ornithodoros ticks was explored in 35 warthog burrows within NGR. In addition, blood samples were taken from 67 domestic pig farms located outside NGR to be tested for ASF antibodies. Information on interactions between domestic and wild suids and ASF occurrence was gathered using interviews with pig farmers (n = 254) in the study area. In conclusion, the bushpigs and warthog's population estimates in NGR are 5 and 3–5 individuals/km2, respectively. Both species move out of the reserve regularly (15.4 warthogs/day and 6.35 bushpigs/day), with movements significantly increasing in the dry season. Some farmers observed warthogs and bushpigs as far as 8 and 19 km from NGR, respectively, but no reports of direct wild-domestic suids interactions or ASF outbreaks. Also, no soft ticks were detected in all warthog burrows and all the pig blood samples were negative for ASF antibodies. The absence of ticks in warthog burrows, the absence of antibodies in pigs sampled, the absence of reported outbreaks, and no familiarity with ASF in the study area, suggest that a sylvatic cycle of ASF is, at present, unlikely in NGR. This conclusion must be confirmed by a larger survey of warthog burrows and monitoring potential antibodies in warthogs from NGR.

The first genotype II African swine fever virus isolated in Africa provides insight into the current Eurasian pandemic

Njau, E.P. Entfellner, J.-B.D., Machuka, E.M., Bochere, E.N., Cleaveland, S., Shirima, G.M., Kusiluka, L.J., Upton,C., Bishop, R.P., Pelle, R. and E.A. Okoth 2022
Scientific Reports, 11: 13081
African swine fever (ASF) caused by the African swine fever virus (ASFV) is ranked by OIE as the most important source of mortality in domestic pigs globally and is indigenous to African wild suids and soft ticks. Despite two ASFV genotypes causing economically devastating epidemics outside the continent since 1961, there have been no genome-level analyses of virus evolution in Africa. The virus was recently transported from south-eastern Africa to Georgia in 2007 and has subsequently spread to Russia, eastern Europe, China, and south-east Asia with devastating

socioeconomic consequences. To date, two of the 24 currently described ASFV genotypes defined by sequencing of the p72 gene, namely genotype I and II, have been reported outside Africa, with genotype II being responsible for the ongoing pig pandemic. Multiple complete genotype II genome sequences have been reported from European, Russian and Chinese virus isolates but no complete genome sequences have yet been reported from Africa. We report herein the complete genome of a Tanzanian genotype II isolate, Tanzania/Rukwa/2017/1, collected in 2017 and determined using an Illumina short read strategy. The Tanzania/Rukwa/2017/1 sequence is 183,186 bp in length (in a single contig) and contains 188 open reading frames. Considering only un-gapped sites in the pairwise alignments, the new sequence has 99.961% identity with the updated Georgia 2007/1 reference isolate (FR682468.2), 99.960% identity with Polish isolate Pol16_29413_o23 (MG939586) and 99.957% identity with Chinese isolate ASFV-wbBS01 (MK645909.1). This represents 73 single nucleotide polymorphisms (SNPs) relative to the Polish isolate and 78 SNPs with the Chinese genome. Phylogenetic analysis indicated that Tanzania/Rukwa/2017/1 clusters most closely with Georgia 2007/1. The majority of the differences between Tanzania/Rukwa/2017/1 and Georgia 2007/1 genotype II genomes are insertions/deletions (indels) as is typical for ASFV. The indels included differences in the length and copy number of the terminal multicopy gene families, MGF 360 and 110. The Rukwa2017/1 sequence is the first complete genotype II genome from a precisely mapped locality in Africa, since the exact origin of Georgia2007/1 is unknown. It therefore provides baseline information for future analyses of the diversity and phylogeography of this globally important genetic sub-group of ASF viruses.

Tsetse Bloodmeal Analyses Incriminate the Common Warthog *Phacochoerus africanus* as an Important Cryptic Host of Animal Trypanosomes in Smallholder Cattle Farming
Communities in Shimba Hills, Kenya
Ebhodadghe, F.I., Okal, M.N., Kalayou, S., Bastos, A.D.S. and D. K. Masiga 2021
Pathogens 11(1): 1501
Trypanosomes are endemic and retard cattle health in Shimba Hills, Kenya. Wildlife in the area act as reservoirs of the parasites. However, wild animal species that harbor and expose cattle to tsetse-borne trypanosomes are not well known in Shimba Hills. Using xeno-monitoring surveillance to investigate wild animal reservoirs and sources of trypanosomes in Shimba Hills, we screened 696 trypanosome-infected and uninfected tsetse flies for vertebrate DNA using multiple-gene PCR-High Resolution Melting analysis and amplicon sequencing. Results revealed that tsetse flies fed on 13 mammalian species, preferentially *Phacochoerus africanus* (warthogs) (17.39%, 95% CI: 14.56–20.21) and *Bos taurus* (cattle) (11.35%, 95% CI: 8.99–13.71). Some tsetse flies showed positive cases of bloodmeals from multiple hosts (3.45%, 95% CI: 2.09–4.81), including warthog and cattle (0.57%, 95% CI: 0.01–1.14). Importantly, tsetse flies that took bloodmeals from warthog had significant risk of infections with *Trypanosoma vivax* (5.79%, 95% CI: 1.57–10.00), *T. congolense* (7.44%, 95% CI: 2.70–12.18), and *T. brucei* sl (2.48%, 95% CI: −0.33–5.29). These findings implicate warthogs as important reservoirs of tsetse-borne trypanosomes affecting cattle in Shimba Hills and provide valuable epidemiological insights to underpin the parasites targeted management in Nagana vector control programs in the area.

New scientific articles

Individual differences in behaviour and gut bacteria are associated in collared peccary (Mammalia, Tayassuidae)

P.L.G. Cairo,S.S.C. Nogueira,V.S. Altino,M. Vandenheede,M. Schroyen,B. Taminiau,G. Daube,E. Gross…et al. 2021Journal of Applied Microbiology, https://doi.org/10.1111/jam.15133

Aims

We tested the hypothesis that the behaviour of an individual is associated with the diversity of its gut bacteria, using the collared peccary (*Pecari tajacu*) as a model.

Methods and Results

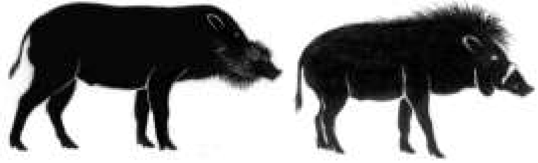
In all, 24 adult male collared peccaries received either low- (n = 12) or high-fibre diet (n = 12) to induce contrasting gut fermentation profiles. They were submitted to three short-term challenges, allowing us to rate the animals in a coping-style dimension named ‘calmness’. At the end of the experimental period, we collected samples of peccaries’ forestomach contents to characterize bacterial diversity. We found a significant positive association between individual ‘calmness’ z-scores and the bacterial evenness index in gut bacteria (and a similar trend with the Simpson’s diversity index), suggesting a more homogeneous bacterial community of calmer individuals. We also found a positive association between fibres digestibility and gut bacterial diversity in the peccaries’ forestomach, but no effect of the dietary fibre level.

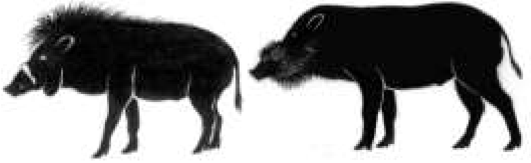
Conclusions

Gut bacteria evenness increases with ‘calmness’ z-scores, suggesting a more homogeneous bacterial community of calmer individuals, compared with the more heterogeneous of the most distressed ones. Our results also suggest associations between the digestibility of ADF with the gut bacterial diversity indices and with the relative abundance of the *Actinobacteria phylum*.

Significance and Impact of the Study

Our data showed that the hosts’ individual behavioural differences are potentially aligned with gut bacterial diversity. The behaviour–microbiota link is correlated with host feed efficiency and, ultimately, may have implications for animal health and welfare of farm animals.





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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 the 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 eventoed ungulates). Within the Suborder Suiformes, pigs belong to the Family Suidae, peccaries to the Family Dicotylidae and hippopotamuses to the Family Hippopotamidae.