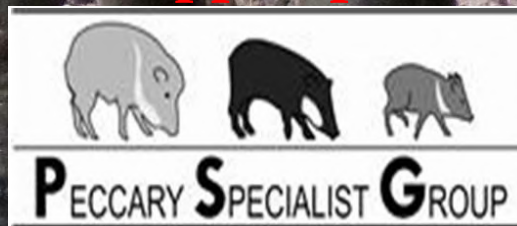


Suiform Soundings

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

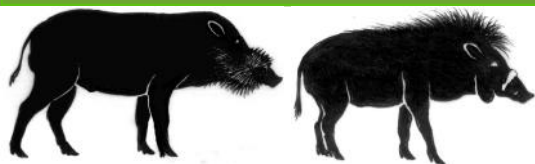


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Female North Sulawesi Babirusa (*Babyrusa celebensis*). Photo: Thiemo Braasch

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



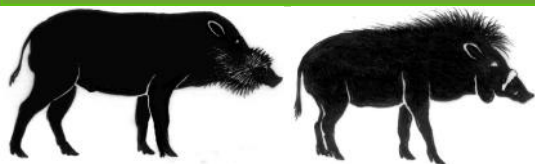


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Dear fellow reader,

I am glad to present you this issue of Suiform Soundings. Its publication has been delayed for a while but now you see the results of the work by the editorial team. The global Covid-19 pandemic is still affecting everybody's life. There has been some progress with vaccinations but this progress is still very moderate in most countries. How this pandemic will affect species and nature conservation remains an open question. Looking on the number of scientific abstracts you can see in this newsletter that scientific field work is limited due to travel restrictions and regulations limiting the number of people working together. Furthermore, there are less news about wild pigs, peccaries and hippos.

I hope that the next issue of Suiform Soundings will contain more scientific abstracts of investigations done in the field. Thanks to all the authors who have contributed to this issue!

With warm regards,

Thiemo Braasch
Chief Editor Suiform Soundings



Postponement statement of the 13th International Wild Boar and Other Suids Symposium, Barcelona.

The Organizing and Scientific Committees have decided to postpone the 13th International Symposium on Wild Boar and other Suids until 2022.

This difficult decision was taken in light of the development of the COVID-19 pandemic and the travel restrictions in place over the coming months and in order to guarantee the health and safety of all participants and staff involved.

While there has been great innovation in virtual events over the last few months, the aim and structure of the conference were developed to ensure optimum interaction between participants, to bring together diverse experiences and expertise and enhance collaboration between teams. The organizing committee felt this would not be possible virtually, and strongly believes that holding the symposium in person is a great opportunity to exchange knowledge and expertise, build new networks, and enhance interaction and collaboration among participants.

Therefore, it has been decided to privilege the option of celebrating the symposium in its classical format, if possible. Further information about options relating to the postponement, and all news as it develops will be available on this website. The exact dates in 2022 will be announced as soon as possible.

Registration

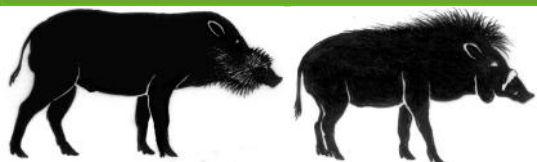
The new dates will be confirmed as soon as possible and new registration period will be opened in 2021.

Abstracts

All abstracts received will be kept and considered by the scientific committee. In addition, a new abstract submission period will be opened in the course of the second semester 2021.

New information will be published in Suiform Soundings and available on our webpage (<https://wildboarsymposium.com> in the second half of 2021!





Think Pig



Savory's Holistic Management – a tool for species conservation?

Thiemo Braasch

Chief Editor Suiform Soundings

What is the best way to protect wild animals?

The history of successful species conservation shows examples of very different strategies. After farmers in Australia were allowed to use 10% of the eggs of each saltwater crocodile nest to raise crocodiles for leather and meat production, the species recovered and is no longer endangered. Alternatively, humpback whales and grey whales recovered with the help of strict hunting bans. American bison previously persisted only in small populations in Yellowstone National Park in the United States and Wood Buffalo National Park in Canada, but there are now thousands of them kept semi-wild for meat production and the maintenance of grassland habitats.

There are many more examples of different ways to protect species, and sometimes different conservation strategies may even be applied for the same species in different populations. In all cases, the acceptance and assistance of local people is key to success. In the semi-desert areas of Namibia and South Africa, farmers turned their semi-desert cattle ranches into hunting reserves, keeping wild antelopes, giraffes, or even rhinos and elephants. In some areas the conservation success may be questionable due to either predation conflicts and persecution or isolated patches of herbivores that are unconnected to wild populations but these cases do not contradict the idea lying behind.

A holistic management approach is one strategy that could be applied to effectively manage lands and wild animal populations, in which landowners not only consider characteristics such as soil, water availability, or population densities, but all these different aspects together, alongside short- and long-term economic, social, and environmental realities. Allan Savory has written several books about holistic management, and describes how to use it as a tool for managing complex ecosystems. This management is derived from observations of savannah ecosystems and considers the movements of ungulates, their selective grazing and browsing, their role in fertilising the soil, and the role of predators. Savory also analyses the role of nutrients, energy flows, mineral cycles, and many other aspects and discusses how to consider all of these in specific situations.

Many conservation measures for endangered species address actions against direct threats to species. However, these direct threats may only be symptoms of fundamental causes. Therefore, if the fundamental cause(s) is/are not targeted, the symptoms may remain or even bounce back. Holistic management, as described by Savory, helps to ask new questions and identify the underlying causes of a problem. To cite Savory: “Going straight to the basic question of what is causing the problem demands courage, perseverance, and willingness to entertain new ideas, ... In general, the cause and effect check dictates that you not implement any action unless you feel sure that it addresses the cause of a problem, rather than its effects or symptoms. In an emergency you may proceed, but only in full knowledge of the dangers and only to buy time to rectify the cause.” (Savory, 2016).





Anatomy



At first glance, Savory's holistic management approach looks like a management tool for agriculture, and his books on this topic are found in book stores under 'agriculture', 'agronomy', and 'soil science'. While this categorisation is correct, the idea of holistic management goes far beyond these subjects. His ideas are used for successful conservation and wildlife management in Southern Africa and elsewhere. Holistic management helps to raise new questions, provides a broader view of the issues, and helps to identify new and unconsidered ideas for species conservation.

For further reading:

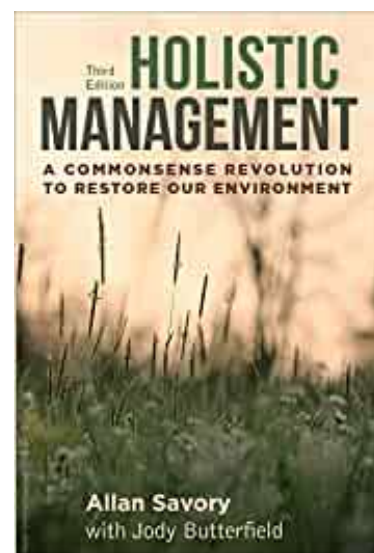
Holistic Management – A commonsense revolution to restore our environment.

By Allan Savory and Jody Butterfield

3rd Edition, 2016, Island Press

ISBN-10 : 9781610917438

Price: ~ 50 US\$



A rare 'unicorn' warthog in Langata, Kenya

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Langata is a very green suburb of Nairobi (Kenya) where a few gardens are contiguous with protected areas like the Giraffe Sanctuary or with the famous Nairobi National Park. The lucky owners of one of those plots are true nature lovers, professional naturalists and passionate warthog fans. They named their place *Hog Haven*.

For many years, they've experienced exploratory visits or long term residents of several wild species including bushbuck, duiker, dikdik, suni, hyena, leopard, sykes monkey, mongoose, hedgehog, hare, tortoise, tree hyrax and greater and lesser bush babies, as well as groups of common warthogs. Over the years the *pater familias* had to make sure that their dogs accept and respect those wild, warty visitors, and he patiently habituated the



Fig. 1: Hogs and dogs on Haven's patio. Photo: K. Hillman-Smith





Anatomy



Fig. 2-5: the Langata 'unicorn warthog'. Photos: F. Smith

hogs to accept both human and canine presence. He encouraged their regular visits and strengthened bonds by offering them small snacks. With time, the warthogs increasingly enjoyed the treat and became more and more relax and regular. The habit to stop by the *Haven* and get their tasty treat was passed from generation to the next.

In September 2020 and in the following months a group of common warthogs visited the garden with a strange newcomer, a healthy subadult male adorned with an **additional wart**! This odd wart is situated on the central axis of the face just below the eyes...like a 'unicorn' warthog!

To our knowledge, this exceptional facial morphology has never been reported in warthogs. After a thorough search on internet for other pictures of individuals with a similar facial wart, we only found one photo³ of an animal in an unknown zoo.

³https://www.animalspal.com/wp-content/uploads/2016/11/interesting_facts_about_warthogs1.jpg





Anatomy

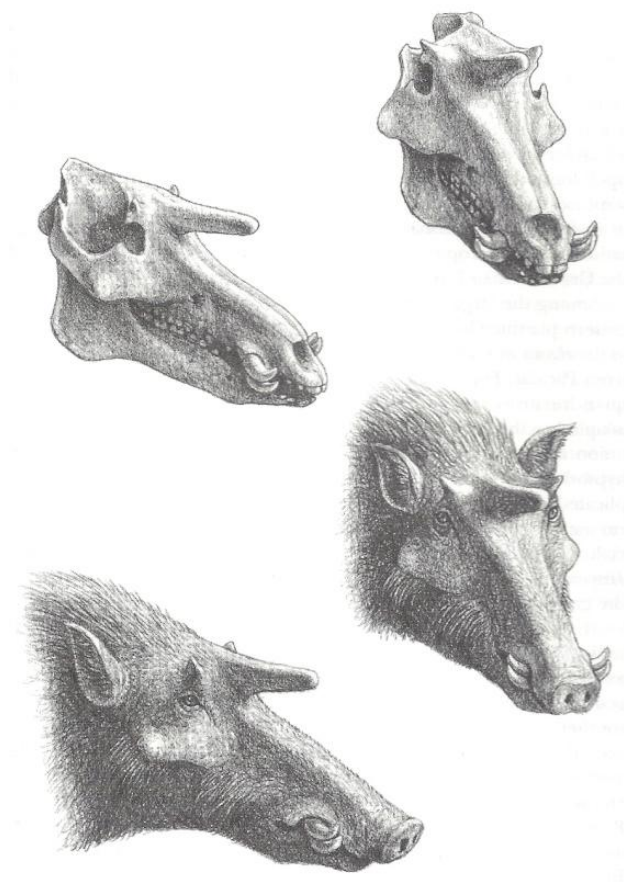


Fig. 6: Skull and fleshed out reconstruction of *Kubanochoerus gigas*. Source: Agustí and Antón (2002)

Paleontologists report that *Kubanochoerus*, a large and hefty suid fossil who lived in the Early Miocene (18 to 11 Ma) in Africa and Eurasia, did present a similar facial feature (Pickford & Tsujikawa 2019). The axial wart of *Kubanochoerus* however, was in fact a large frontal horn with a distinct underlying bone.

Other wild pigs' ancestors are known to have been equipped with various bony protuberances or horn-like structures. Some variations on the theme include: *Nyanzachoerus* with a horn on the zygomatic arch pointing laterally, *Lybicochoerus* with a short horn above each eye, or *Listriodon* with a frontal ossicone. It is presumed that these warts and horns are related to typical suid head-butting and head side-swiping during male-on-male dominance bouts (M. Pickford, pers. comm.).

The frontal wart on our 'unicorn' warthog is situated lower on the face and it is much smaller than its ancestors' adornments. If there is an underlying bony process, it must be limited to a slightly raised roughed bone. Indeed, in the first evolutionary phases of *Kubanochoerus* it may have started with very slight but quickly selected manifestations (A. Souron, pers. comm.).

We think that the strange Langata specimen is just a 'one-off', but if there is some underlying genetic control, it might be passed on to the next generation. In that case, Hog Haven may well be the cradle of a new *Phacochoerus* (*unicornis*?) lineage... As Martin Pickford put it: "Wait and see, I suppose?"

Acknowledgments

The authors wish to thank Tom Butynski, Martin Pickford, Kes Hillman-Smith and Antoine Souron for their kind contribution to this note.

References

- Agustí, J. and M. Antón 2002. *Mammoths, Sabertooths, and Hominids. 65 Million Years of Mammalian Evolution in Europe*. Columbia University Press. New York.
- Pickford, M. and H. Tsujikawa 2019: Revision of African *Kubanochoerinae* (Suidae: Mammalia) with descriptions of new fossils from the Middle Miocene Aka Aiteputh Formation, Nachola, Kenya. *Münchener Geowissenschaftliche Abhandlungen. Reihe A: Geologie und Paläontologie*. Band 46.





Behaviour



Vocalisation by babirusa (*Babyrousa* spp.)

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²Royal (Dick) School of Veterinary Studies, The University of Edinburgh, Easter Bush Campus, Midlothian EH25 9RG, Scotland

Abstract

The sounds made by babirusa (*Babyrousa* spp.) have been commented upon for many years, but until relatively recently have not been examined in detail. The relatively large number of babirusa (eleven animals) at Zoo Antwerpen, Belgium offered the opportunity to collect and sonographically analyse the variety of sounds made. Additional studies were then carried out on the videotape recorded material that had earlier been collected in North Sulawesi and in Surabaya Zoo. The sounds emitted by the babirusa could be categorized into 23 identities: bark, cluck, clucky grunt, common grunt, contact grunt, groan, growl, grumble, grunty cluck, grunty squeak, long grunt, mating cluck, mating rattle, peep, purr, rattle, scream, short grunt, shriek, snarl, squeak, squeaky grunt, startled grunt. These were converted into frequency-time spectrograms and recorded in association with the behaviour expressed. The major types of babirusa sounds taped in the zoo environment were groans, grunts, snarls, grumbles, squeaks, shrieks, clucks, rattles, growls and screams. Very much less vocalized sound was recorded from the babirusa in the wild. However, the behaviours associated with these vocalizations were comparable to those observed in the zoo environment. The extent to which babirusa also use visual clues, such as abrupt body movements, and vibrational cues derived from infrasonic vocalizations (< 20 Hz) or percussion, needs further exploration.

Introduction

Despite very early Chinese accounts that babirusa utter cries (Macdonald, 2017), in more recent times it had been reported that babirusa (*Babyrousa* spp.) do not make much sound (Krumbiegel, 1954). Indeed, a few grunts coming from a running female babirusa were the only vocalisation heard by Hodgen (1985) at the Jersey Wildlife Preservation Trust. However, Guillemard (1886) had earlier reported hearing a 'barking grunt' from adult female and male babirusa on Lembeh Island, North Sulawesi. When a group of babirusa entered an unknown area in the Togian Islands, rolling grumbles could be heard, which were described by Selmier (1983) as 'Erkundungslaute' (exploring noises). This was one item in a list of seventeen types of sound that she was able to identify from both her experience on the Togian Islands and following attendance at Ragunan and Surabaya Zoos, Indonesia. Ten years later, an in-depth study of the agonistic behaviour of babirusa in Surabaya Zoo confirmed that the species had indeed a much larger repertoire of sounds (Macdonald et al, 1993). This understanding was further extended by Maurice Patry who commented upon a number of vocalisations associated with agonistic behaviour video-recorded over several years in the forests of north Sulawesi (Patry et al, 1995). The study of the North Sulawesi babirusa (*B. celebensis*) in zoological collections has been very helpful to the gaining of insight into, and understanding of, the various behaviours of this wild pig genus. Daily access to the animals has allowed patterns of behaviour to be seen and heard repeatedly, and thus described. For example, early observations (Macdonald et al, 1989) in Surabaya Zoo revealed that when kept in a large group, the animals would often sleep together





Behaviour



Fig. 1a: Sleeping babirusa in Surabaya Zoo, Indonesia. Approximately twenty years ago the animals were kept together in a large group and had no access to nesting materials. Photo: A.A. Macdonald.

b. Sleeping babirusa in Ragunan Zoo, Indonesia. Approximately twenty years ago the animals were enclosed in an area with access to trees, bushes and other vegetation from which they could construct a nest enclosure. Photo: A.A. Macdonald.

(Figure 1a). At about the same time, observations were carried out on the group of babirusa in Ragunan Zoo that were housed in a large enclosure with access to trees and other vegetation (Macdonald, 2008). The latter animals undertook nest-building activity (Figure 1b). Reports by Selmier (1978, 1983) of observations she had made on the Togian islands implied that some sort of solitary nesting behaviour was normally undertaken there. This added to earlier observations made of nesting behaviour in North Sulawesi (Guillemard, 1886) and on Buru (Deninger, 1909). However, the growing awareness of the communal aspects of some babirusa behaviour stimulated further research activity and this has enabled the nest-building topic to be explored more systematically and to be understood in much more detail (Ito et al, 2019a,b).

As a consequence of these early communal behaviour observations, and a greater awareness of the sounds being produced by babirusa in zoological garden settings, it was decided to undertake the collection and sonographic analysis of the sounds made by the relatively large number of babirusa at Zoo Antwerpen, Belgium (Van Moeffaert, 1994). Additional studies were then carried out on the videotape recorded material that had been collected in North Sulawesi (Patry et al, 1995). These were supplemented by personal experience at the two Indonesian zoos over a number of years and observations made of digitally recorded material from Surabaya Zoo (Kartiko, 2006).

Materials and Methods

Zoo Antwerpen

Eleven babirusa (*B. celebensis*), three adult males, one juvenile male, five adult females and two juvenile females were observed in the period between the 20th of May 1993 and the 20th of February 1994. Two infant male and one infant female babirusa were also available for study. Acoustic communication was possible between the different indoor pens.

Random observation sessions were chosen at all times during the day, from 7.30 onwards until 18.00, and in all weather conditions. A total of twenty-four hours of vocalisations were recorded on music tape. The sound recordings were mostly made either outdoors early in the morning or indoors to avoid unwanted noises from the public, other zoo animals and street traffic. Some of





Behaviour



the sound recordings were made with an Uher Professional Cassette Recorder CR1601, a Sony Parabolic Reflector PBR-330 and an Uher Microphone M646. Other sound recordings were made with a Sony Professional Walkman WM-D6C and a Sennheiser Elektret Kondensator-Mikrofon ME80.

The sounds were converted into frequency-time spectrograms which were produced with the software HYPERSIGNAL (Hyperception Inc.), using the data sampled from a cassette at 44,1 kHz, then subjected to an FFT (Fast Fourier Transform) of order 12, frame size of 4096 samples, overlap of 2048 and using Hamming Window. The frequencies of the sounds were displayed in a log2 scale and the time in seconds. In total, 83 spectrograms were analysed using the following parameters:

Duration (D): time in seconds of one distinguishable sound.

Dominant frequency (Fd): frequency in Hertz of the component of the sound with the highest intensity as manifested by the lightest colouration on the spectrogram; the measurements were taken at the midpoint of the lighter colouration; the dominant frequency was responsible for the pitch that was heard.

Lowest frequency (Fl): frequency in Hertz of the lowest component of the sound, manifested by light colouration; the measurements were taken at the midpoint.

Highest frequency (Fh): frequency in Hertz of the highest component of the sound; the highest component of the sound displayed on the spectrogram depended on the vocal organ of the animal as well as on the intensity of the vocalisation and was therefore not highly relevant.

Noise (N): the proportion of the sound which had no discrete energy bands on the spectrogram; it was described on the arbitrary scale of low (L), medium (M) and high (H).

Harmonicity (H): the proportion of the sound with distinctive energy bands or harmonics displayed on the spectrogram; harmonics are components of the sound whose frequencies are harmonically related to the fundamental frequency (Campbell and Greated 1987); it was described on the arbitrary scale of low (L) when no energy bands were seen, medium (M) when energy bands were seen and high (H) when harmonics were present.

Shape (S): the appearance of the sound on the spectrogram; the leading edge could be right angled (LR) or have a slope (LS), the trailing edge could be right angled (TR) or have a slope (TS), both edges could have a slope (T) or both edges could be right angled (R); a right angled leading or trailing edge meant that the amplitude of the sound was concentrated on that side.

Intensity (I): the relative loudness of the sound was described in the arbitrary scale of low (L), medium (M) and high (H); because of the recording conditions, it was not possible to use decibels, as the intensity of recordings depended on the distance between the animals and the microphone and the level at which the tape recorder was recording.

North Sulawesi

The study area in North Sulawesi was situated south of the Paleleh mountain range in the northern watershed draining into the Paguyaman river on the Minahasa peninsula (Patry et al, 1995). The observations were carried out at two 'salt-lick' sites about 15 km apart, named 'Marisa' and 'Lantolo'. Both sites were located in dense lowland tropical forest. Observations were made in March and October 1988, May 1989, July 1990, and from August until November 1990. This represented a total of 60 days and approximately 600 hours of observation. Videotape recordings were started when one or more babirusa (*B. celebensis*) was seen to enter the study site and continued for the duration of the time that it/they were in view. A total of 8h 37min of tape containing recordings of babirusa were obtained in this manner.





Behaviour

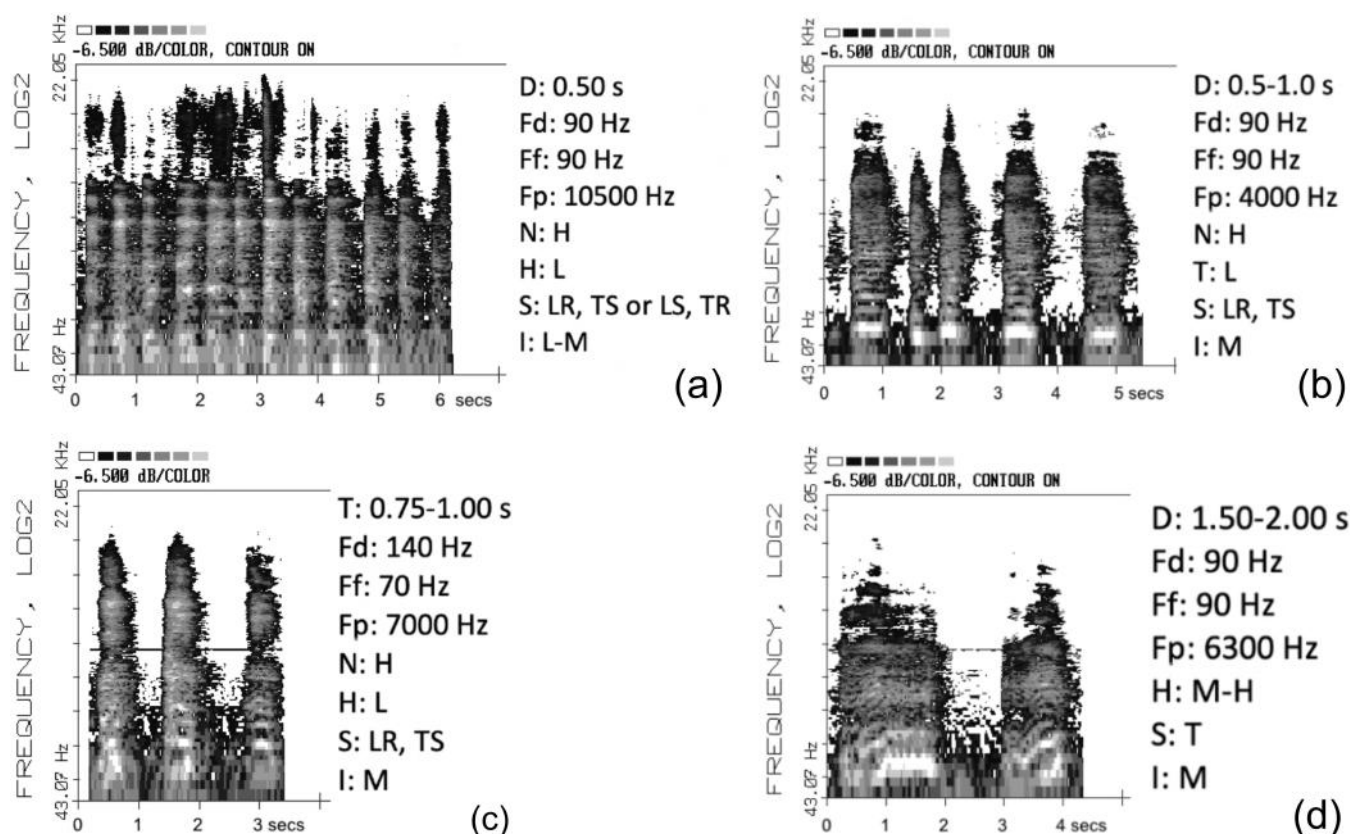


Fig. 2: Frequency-time spectrogram and analyses, as indicated in Materials and Methods, of (a) the common 'grunt'; (b) the contact 'grunt'; (c) the 'startled grunt'; and (d) the 'long grunt'.

Results

The sounds emitted by the babirusa could be categorised into 23 identities: bark, cluck, clucky grunt, common grunt, contact grunt, groan, growl, grumble, grunty cluck, grunty squeak, long grunt, mating cluck, mating rattle, peep, purr, rattle, scream, short grunt, shriek, snarl, squeak, squeaky grunt, startled grunt. It was obvious that these classifications were not completely discrete. The common grunt sound (Figure 2a) was frequently heard when the babirusa was standing, wandering around or foraging. This grunt varied from pig to pig. Different grunts could be produced by the same animal. It was also recorded from juvenile babirusa and adults in the forest. Zoo babirusa that had been separated from one another for a while, such as litter mates and mothers and young, appeared to be able to recognise each other from their grunts. As soon as one was aware of the other animal being near, short grunts are uttered in a repetitive way. When this was responded to, the grunts became louder and faster.

The contact grunt was different and much louder; it is expressed in a repetitive way in the zoo (Figure 2b). The babirusa repeated the grunts until it was answered by a conspecific. When these grunts were answered, the 'vocalisations' could continue for a very long time. These calls were heard throughout the day. In Antwerp Zoo, the contact calls were almost exclusively heard where no visual contact between the animals was possible. In zoos where the babirusa were penned together or in sight of one another, not many of these calls were heard. In the forest the sound was heard on only two occasions; the first when two adult males came into visual contact, and secondly, by a young adult male who appeared to be seeking a response from somewhere behind the 'hide' housing the cameraman (Figure 3).





Behaviour



Fig. 3: The contact grunt being given by a young adult male *B. celebensis* in North Sulawesi. Photo from video by M. Party.

The behaviour that was accompanied by a startled grunt (Figure 2c) was a fast movement backwards. The babirusa then stayed motionless for a moment facing the direction of the apparent danger, its body lowered and usually one leg was lifted. This sound was more often heard from those babirusa that were penned alone. The behaviour, but not the sounds, was identified in the forest. The long grunts (Figure 2d) were not heard in the forest.

When an adult male of higher rank approached an animal of lower rank, the latter lowered his head and often utter a

submissive peep (Figure 4a). When the submissive animal felt more threatened, the peep became elongated, and could turn from a peep into a squeak and then a rattle and growl (Figure 4b). In the zoo a babirusa would utter a rattle to protest against the approach of another animal. The noise was made with mouth opened and head slightly lowered in the direction of the perceived threatener. This sound was also recorded in the forest, and on one occasion, six short protestations came from a group of babirusa, but it was not possible to identify the cause.

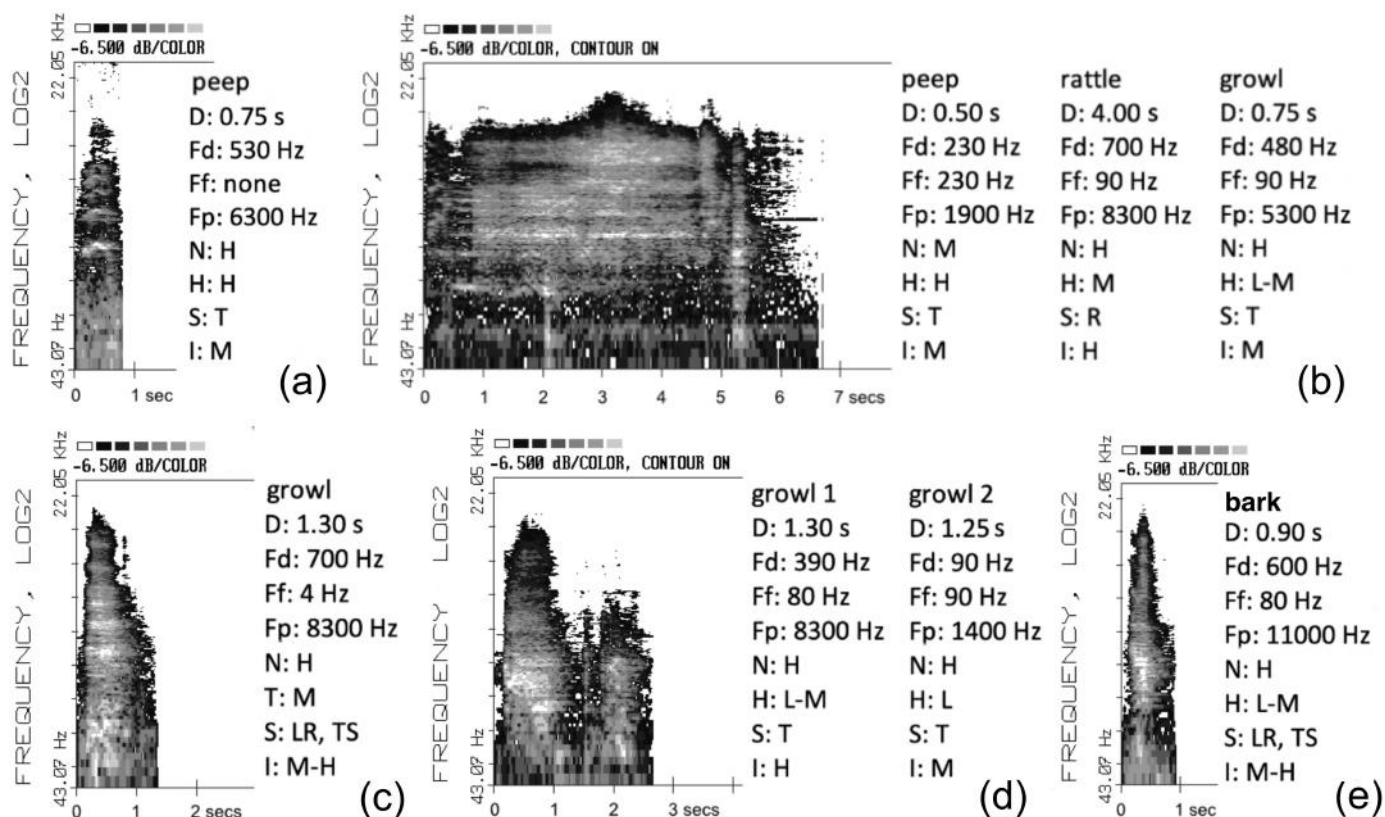


Fig. 4. Frequency-time spectrogram and analyses, as indicated in Materials and Methods, of (a) the short 'peep'; (b) the 'peep, rattle & growl'; (c) the 'growl'; (d) the 'growl'; and (e) the 'bark'.





Fig. 5: A pair of sub-adult male babirusa facing one another, with the one closest to the camera lowering its head and submitting to the other. Photo from video by M. Party.

Rattles were found to have various lengths, intensities and frequencies. They could be very long and followed by an inhaling growl; they could also be broken up into short segments or could be interrupted by a squeak. Loud rattles often had a higher dominant frequency. A weak variant of the rattle was a harsh peep.

Several examples of submissive behaviour were observed in the forest (Figure 5). During climax agonistic behaviour between two adult males, referred to as 'boxing', the animals often fought with their mouths open making the sounds of heavy breathing (Macdonald et al, 1993). Towards the conclusion of the contest the superior male sometimes uttered a rolling, deep-

throated, low pitched growl. The inferior male meantime made an oscillating rattling call that increased in frequency and turned into a deep-throated rattle sound overlaid with a final rising then falling scream of submission.

Both in the zoo and in North Sulawesi, female babirusa, when threatening each other, uttered deep-throated growls (Figures 4c,d). These growls were often accompanied by clicking sounds, probably produced by the tongue. Threatening behaviour by a higher female animal of another female could turn into a fight, in which the animals tried to bite each other's legs.

The warning sound used by the babirusa was a bark (Figure 4e). Other babirusa upon hearing this reacted with complete immobility. When after a few seconds no danger was detected, the animals continued their previous activities. Similar behaviour was seen in North Sulawesi, but no associated sound was recorded.

When piglets were removed from a zoo pen to be placed elsewhere, they shrieked (Figure 6a). In Surabaya zoo, a male babirusa lying in a pen was sometimes seen to swing his head up and round towards an approaching animal which appeared to be about to lie down beside him. A loud shriek of short duration (< 1 sec) was usually uttered by the approaching submissive pig. In the forest a short shriek was produced somewhere off camera view and the adult female and two juvenile babirusa in camera view reacted to the noise by standing still and looking left and right.

Fighting between females was always accompanied by loud screaming (Figure 6b). This was noted both in the zoos and in the wild. A deep throated growling was recorded during one fight between two females, and a short 'woh' sound was heard at the end. The loud screaming was also recorded in zoos if the female was trapped in a confined space with an amorous male when she not ready to be mated.

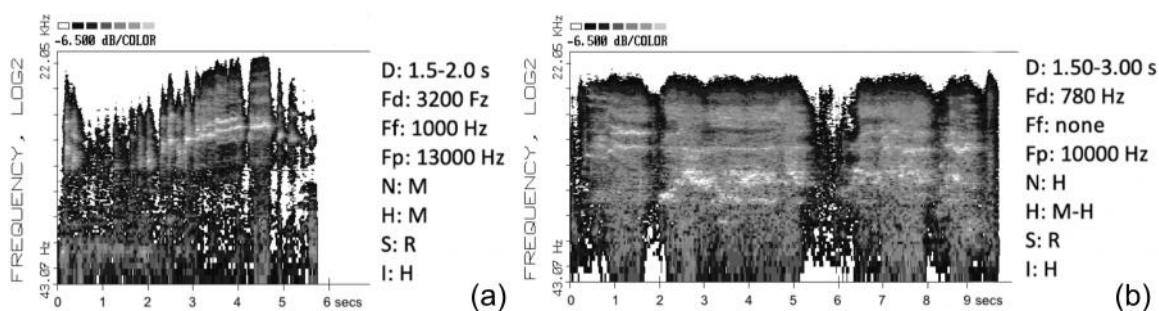


Fig. 6: Frequency-time spectrogram and analyses, as indicated in Materials and Methods, of (a) the 'shriek' and (b) the 'scream'.





Behaviour

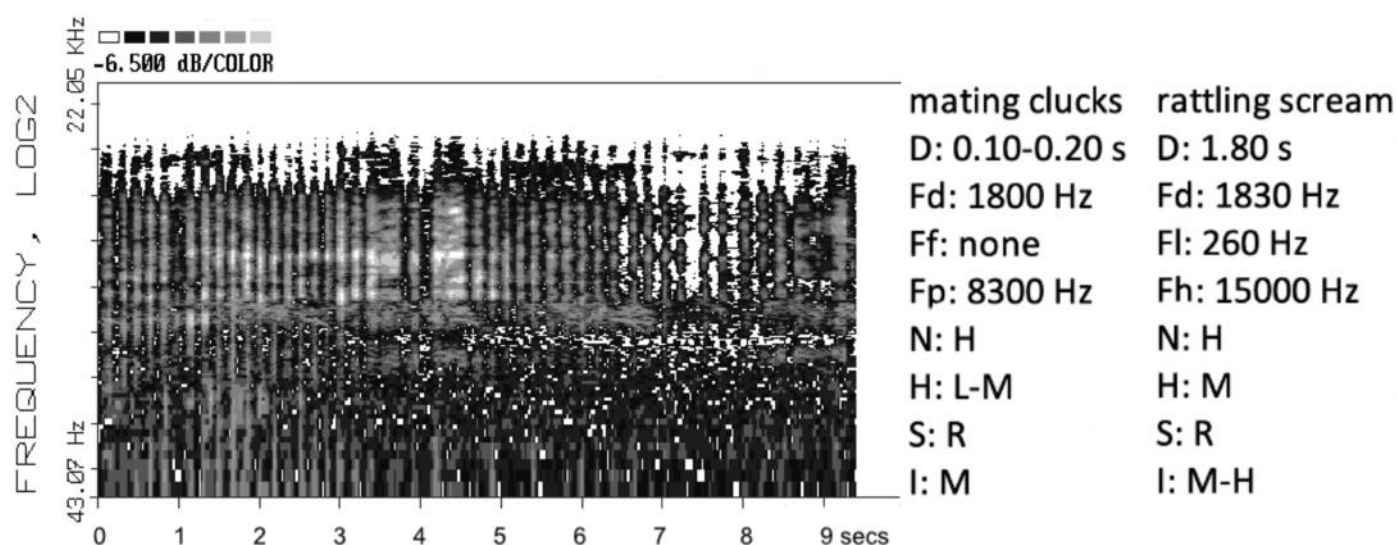


Fig. 7: Frequency-time spectrogram and analyses, as indicated in Materials and Methods, of 'mating clucks' and 'rattling scream'.

Sexual behaviour was shown as soon as an oestrus female babirusa was in the vicinity of a male. The male started to follow the female while uttering a stream of mating clucks (Figure 7). When the female stopped or looked behind her, the male clucks changed into a mating rattle. In Surabaya and Ragunan zoos, when an oestrus female was detected in a large pen, the boar started to chase her while producing a stream of deep clucks (Leus et al. 1992). In those instances when the female that came into oestrus was penned adjacent to a male, the male detected it and started clucking at her. The female responded by clucking back and was seen to keep close to the fence that separated them. During courting behaviour, the level of excitement of the boar appeared to determine the duration of each mating cluck. The more he became excited, the more rapidly the clucks were uttered. These were described by Selmier (1983) as 'Stakkato-Laute'.

During mounting and copulation (Figure 8) both male and female made clucking noises, the male louder than the female (Leus et al. 1992). Sometimes the clucking rate of the male babirusa decreased to 1-3 per second and the female became silent. While she stood still his clucking rate was largely stable. When she moved, the rate of his clucking increased slightly, and then slowed when she became still again. He continued to make clucking sounds while he dismounted, and then stopped.

No instances of oestrus behaviour or sounds were recorded in the forest. Similarly, as almost all the video material was collected at the open salt-lick areas, no evidence of nest building at the end of pregnancy was recorded. In the zoo, the female defended her nest very aggressively for the first few days after parturition. She uttered a stream of clucks and rattles for as long as she felt threatened (Figure 9a). When these nest-defending rhythmical clucks were played back to her, she started vocalising the same clucks and showed more excited behaviour, although she had previously been in a calm emotional state. It was also remarkable that there was a response to the clucks even when they were played through the closed earphones of a Walkman. This might suggest that specific (possibly low) frequencies

within the sounds were responsible for her reaction.



Fig. 8: Mating in Surabaya Zoo. Photo from video by L.G.T. Kartiko.





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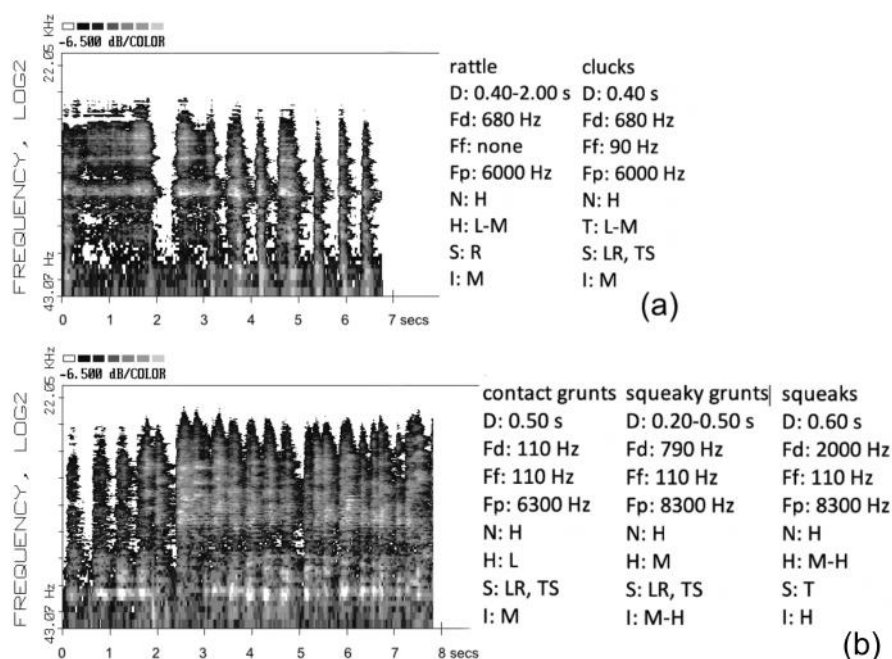


Fig. 9: Frequency-time spectrogram and analyses, as indicated in Materials and Methods, of (a) 'rattle & clucks'; and (b) 'contact grunts, squeaky grunts and squeaks'.

sound in order to keep in contact with the mother (Figure 10). When left alone, this sound became shorter, higher and louder. The sow answered these calls with common grunts. When the shrieks of her piglets were played back to the sow, she uttered defensive clucks after she had nosed each of her young. Three rapid grunts were uttered by an adult female in the forest as she turned to flee the site followed rapidly by a juvenile babirusa. It had earlier been reported that rhythmic grunting noises accompany nursing (Selmier, 1983). However, these sounds were not recorded from either the lactating sow or the suckling piglets in either Antwerp zoo or in the wild (Figure 11). Only one sow in Antwerp uttered soft groans while nursing.

Squeaky grunts might imply that the vocalising babirusa was getting more excited. These grunts were only heard when the babirusa was calling for contact with

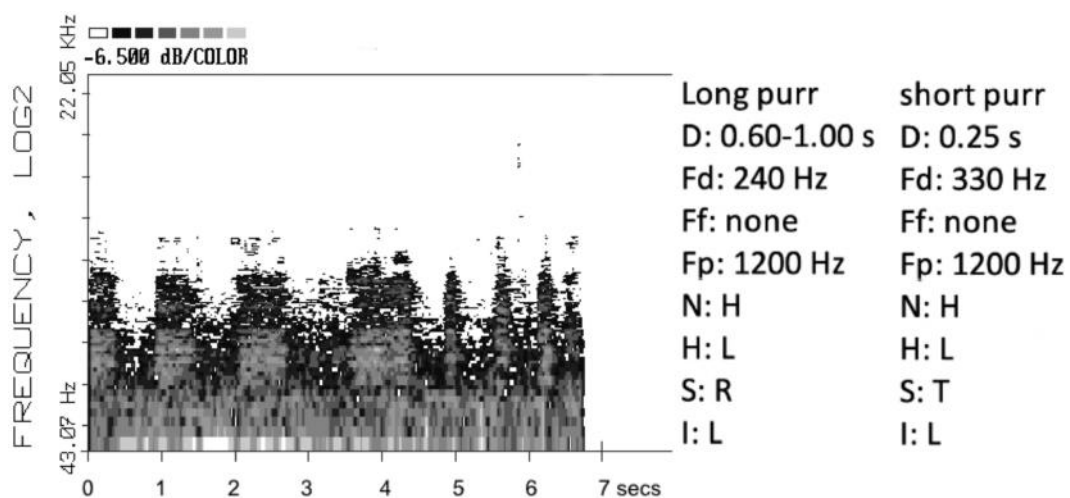


Fig. 10: Frequency-time spectrogram and analyses, as indicated in Materials and Methods, of 'long and short purrs'.



Fig. 11: Two lactating babirusa with twin suckling piglets in Sulawesi.

Photos from video by M. Party.





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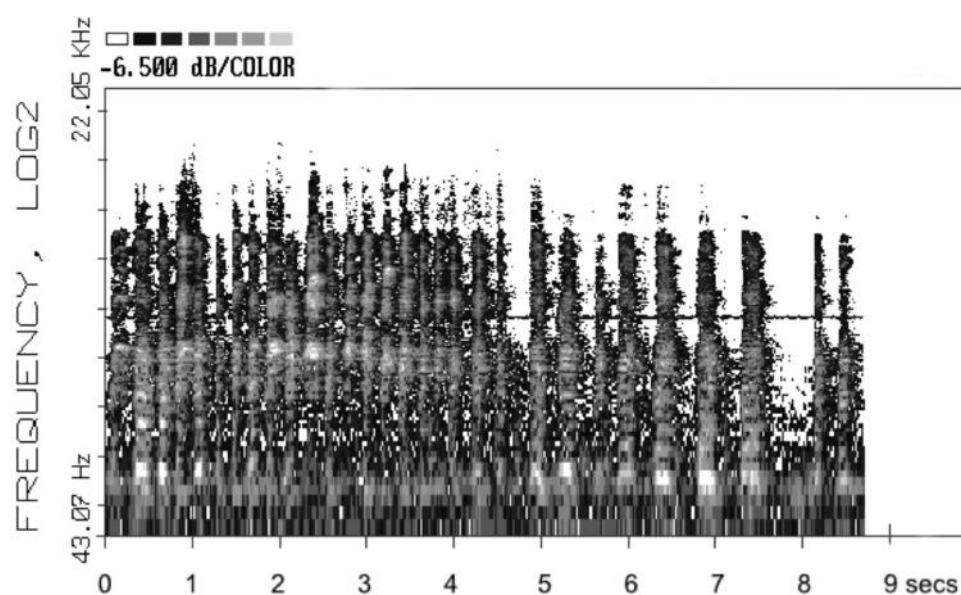


Fig. 12: Frequency-time spectrogram of highly emotional grunts as described in the text.

followed by contact grunts of different intensities and frequencies, then squeaky grunts and grunty squeaks, and finally squeaks characteristic of the highest emotional state. An example of how grunts became higher and were uttered more rapidly when the animal became more excited, is shown in Figure 12 (note that the scale of this spectrogram is two seconds for one unit). In the beginning of the spectrogram, three contact grunts, a squeak and another contact grunt are uttered in a total time of 2.40 seconds. Then a series of much faster calls followed: a total of sixteen calls in 6.60 seconds, eleven squeaky grunts and five squeaks, were uttered. These were then followed by nine contact grunts in 7.60 seconds. On one occasion when a juvenile Buru babirusa (*B. babyrussa*) was confined on Taliabu island (Macdonald et al, 2018) the rattling sound it made was locally described as 'ikaka ... ikakaka ... ikakaka' (E. Kailuhu, personal communication).

Discussion

The current spectrographic study represented another step towards a better understanding of the sounds produced by babirusa. It has presented a quantified depiction of a number of the vocalisation descriptors listed earlier (Selmier, 1983; Leus et al, 1992; Macdonald et al, 1993; Patry et al, 1995). In so doing it has created a foundation for further studies seeking to analyse the sounds made by babirusa in more detail. These could examine in a statistical fashion any differences that may exist between the different sounds produced, between different animals according to age and sex, and perhaps also differences according to species and geographical region (e.g. *B. babyrussa* vs. *B. celebensis*).

The major types of babirusa sounds expressed in the zoo environment were groans, grunts, snarls, grumbles, squeaks, shrieks, clucks, rattles, growls and screams. Typical for the groan was its low intensity and pitch, and its harmonicity. The characteristic of the grunt was the lack of distinctive energy bands and the low dominant frequency. Long grunts, however, did have distinctive energy bands. The bark, snarl and grumble could be categorised with the grunts but had more amplitude and higher dominant frequencies. Squeaks had a high dominant frequency and lacked distinctive bands of low frequency. Shrieks could have been ranked in the same category as squeaks, but their dominant frequency was even higher. What was typical of the

conspecifics, or in running games and when chasing piglets. Grunty squeaks and squeaks represented the highest excitement and were heard when the animal was scared or was trapped. Thus, the contact calls formed a continuum between the common grunt and the squeak, which related to the excitement of the animal. The common grunt was characteristic of the calm state,





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clucks was their shortness and their dominant frequency being condensed into a very narrow zone. Rattles had horizontal as well as vertical energy bands; they were often long, the intensity and pitch varied considerably, and low frequencies were often lacking. Growls were low pitched and long. The characteristics of the scream were its high amplitude and the duration of the sound. Based on the findings of earlier work on acoustic communication between wild *Sus scrofa* by Klingholz et al (1979), studies were carried out by Garcia et al (2016) on semi-free ranging wild *Sus scrofa*. They were able to categorise 616 of the calls from the wild pigs' vocal repertoire into four types: grunts, which were pulsatile, low-frequency sounds, the main spectral energy being below 2 kHz; squeals, which contained energy in a broader frequency range, but lacking in a pulsed structure; grunt-squeals, which contained elements of both the previous types of sound; and trumpets, that were harmonic calls with a high frequency, ranging from 200 to 400kHz. Grunts and squeals were the most common call types. Contact and threat situations were the most common contexts for vocalisation. However, it was accepted that a number of specific call types had been missed by this otherwise very detailed study. As with the study of the babirusa vocalisations, it was possible that both species used acoustic parameters that were not easily perceived by humans, or indeed measured. Very low intensity contact calls were noted in both species.

Analyses of 1513 vocalisations made by domestic *Sus scrofa* piglets showed that they emitted a wide variety of sounds (Tallet et al, 2013). These could be assembled into either two or five clusters, the former encapsulating long high-frequency calls as opposed to shorter low-frequency calls, the latter five types being much less distinct than the former. Although very few babirusa piglet sounds were recorded in the present study, the concept of blurring of call types was also clearly seen in adult babirusa vocalisations.

The vocal repertoire of the babirusa as described in this study indicated that the sounds made were generally non-discreet and that, at times, they formed something of a continuum. Some sounds had mixed characteristics. For example, grunty squeaks, squeaky grunts and grunty clucks had characteristics of two types of sounds, with one type more dominant than the other. This meant that next to the easily recognisable types of sounds, there were also sounds which lay in between them. The vocalisations were used in different situations and probably corresponded to the emotional state of the animal at the moment that it was vocalising. Sounds like these contributed to the continuum in the vocalisation of the babirusa.

Many investigations have been carried out on the vocalisations of domestic animals (Green et al, 2018). These have provided a basis from which to determine in what ways vocalisation patterns are linked to arousal and emotional valence in domestic *Sus scrofa* (Linhart et al, 2015). In domestic pigs, positive valence was associated with a reduced vocal rate and negative valence was associated with longer calls (Leliveld et al., 2016). The structure of the call type has been shown to impact the acoustical encoding of the pig's emotions (Linhart et al., 2015). Although arousal led to an increase in central frequency and calling rate in the grunts and screams of pigs, the increases in intensity linked with arousal were only apparent in the screams emitted.

In the wild very much less vocalised sound from the babirusa was recorded. Indeed, during most of the time that the babirusa (*B. celebensis*) were filmed on Sulawesi, very few sounds were recorded from them at all. In addition, no sounds were recorded by a trail camera filming babirusa (*B. babirusa*) walking through the forest in east Buru (Macdonald et al, 2018). The suggestion that these observations may have been because of the intensity of other sounds in the forest, such as those made by cicadas (genus *Dilobopyga*), was countered by the clear capture of soft





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grunts when they did occur in Sulawesi. The observation of quietness of forest babirusa corresponded to the relative quietness noted among zoo babirusa that were within sight of one another. Groups of babirusa in the Sulawesi forest appeared to make more use of abrupt body-movement signals between conspecifics to indicate heightened awareness and the need to flee. It was also noted that when in small groups, these babirusa seemed to react in a co-ordinated fashion to unrecognised signals from conspecifics. The extent to which large mammals, and indeed birds, use vibrational cues either derived from infrasonic vocalizations (< 20 Hz) or percussion needs further exploration (Narins et al, 2015; Zeyl et al, 2020).

Acknowledgements

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Ecology and Conservation



African Swine Fever Adds to Global Disease and Sustainability Woes

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*Borneo Futures

African Swine Fever (ASF), a disease causing near to 100% case fatality among pigs, poses a great threat to both endemic pig species and the ecosystems of which they are a part in the Asian region. As discussed in a recent study by Luskin et al. in the journal *Conservation Letters*, the current ASF epidemic, first recognized in Asia in late 2018, has caused the death of over one hundred million domestic pigs, instigating unprecedented economic impacts on the global pork industry. While the economic downturn instigated by the other global epidemic – SARS-CoV-2 – remains at the forefront of national agendas, the researchers urge governments to acknowledge the potentially catastrophic cascade that could occur if the ASF epidemic is not appropriately managed in due time.

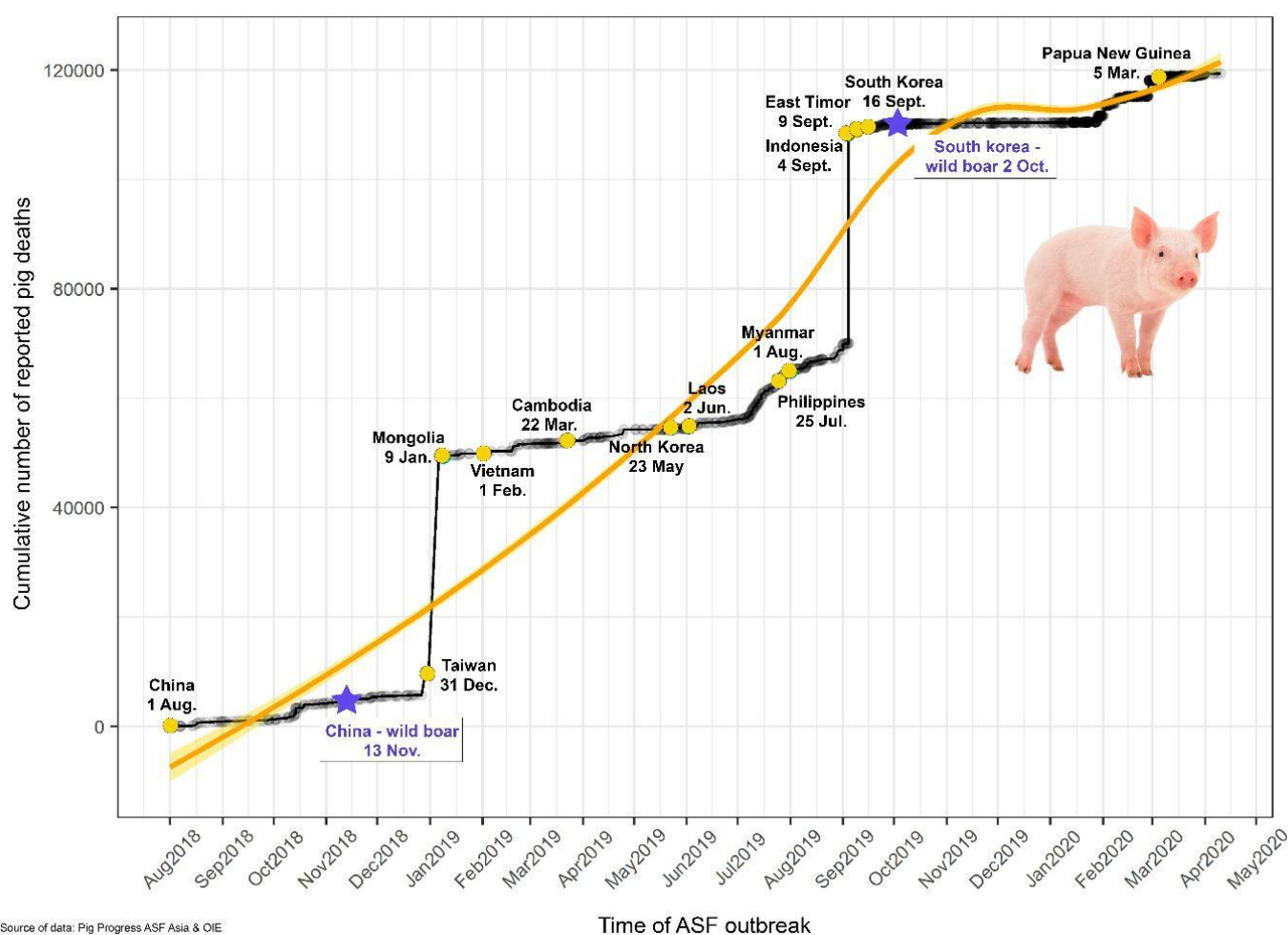


Fig. 1: Timeline of African Swine Fever spread in Asia and domestic pig deaths (not culled).

To mitigate irreversible impacts on endangered carnivores, plant communities, and the livelihoods of millions of people, caused by the prolific loss of pig species, the new study recommends the immediate implementation of time-critical research themes, improved emerging infectious





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disease detection through site-based monitoring, and surveillance paired with online reporting and proper carcass disposal. African Swine Flu is now wide-spread throughout mainland Asia, and large outbreaks in various parts of insular South-East Asia, including Sumatra, Bali, West Timor, and Java, clearly demonstrate the urgency of such action. This is an issue that can no longer be ignored.

The threat of ASF has caused producers to resort to culling mindboggling millions of domestic pigs reared for slaughter. These pigs can neither be sold nor kept, and are unceremoniously disposed of. This is a huge concern for regions such as the Philippines, Timor-Leste, and parts of Indonesia, where over 100 million people rely on pork as their primary source of protein and income.

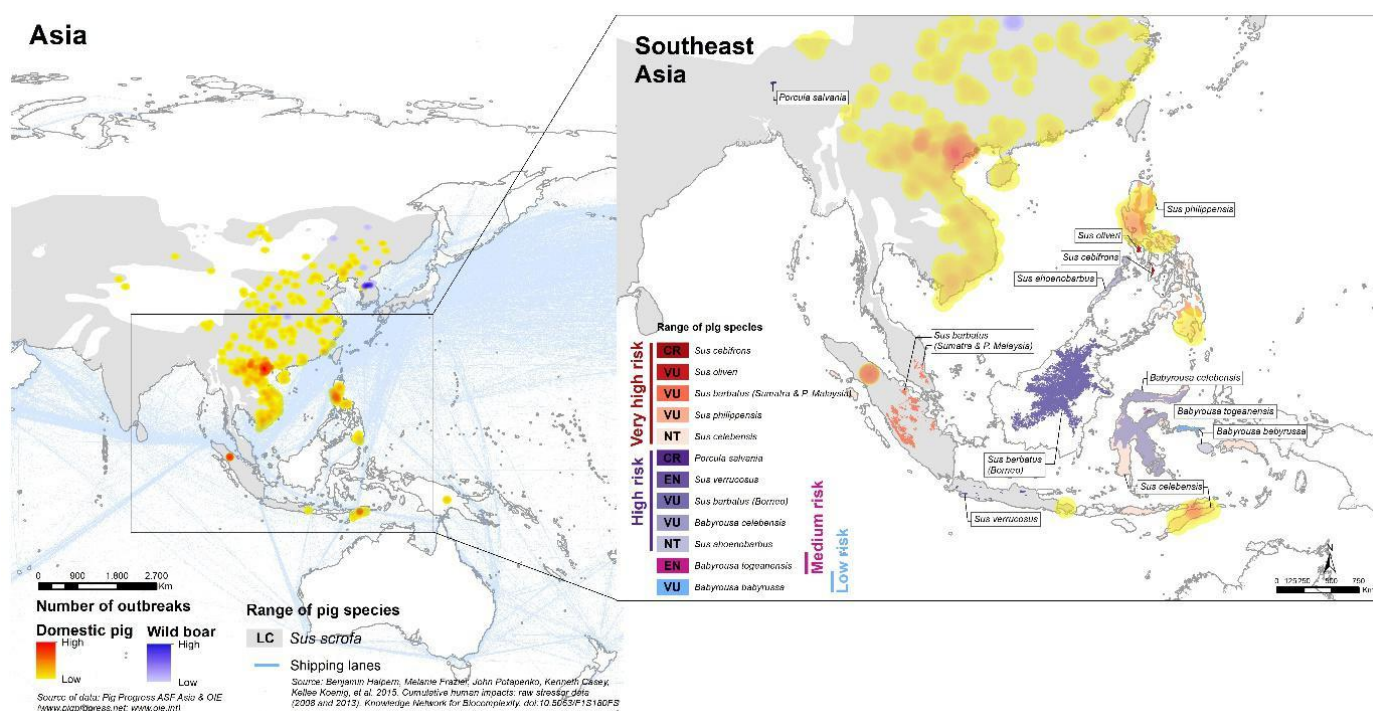


Fig. 2 The spread of African Swine Fever threatens Southeast Asia's 11 wild pig species.

African Swine Fever is a highly infectious, and easily transmitted disease. Once within a population, the disease can spread uncontrollably, particularly among the confined conditions in which domestic pigs are often found. Spreading through nose-to-nose contact, as well as contaminated fields, pastures, feed and water sources, means an outbreak is almost unavoidable when one individual becomes infected. These outbreaks can then rapidly spread to wild pig populations, posing a massive threat to the regions endangered pig species and the ecosystems that rely on them, while these wild pigs can also pass the disease on further to domestic pigs, as is thought to happen in Europe.

The real problem lies with the lack of interventions, research, and effective control. The marked lack of research into past and present outbreaks, has rendered ASF a disease of the unknown. Insufficient research efforts, and resulting uncertainty about the characteristics of the disease, raise issues in mobilization and facilitation of the development of interventions and control methods.





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With insufficient control among domestic populations, this infectious disease readily jumps to wild populations, many of which are already endangered – think the highly endangered Pygmy Hog of India, the charismatic Babirusa of Sulawesi, or the wild-maned Visayan Warty Pig of the Philippines. The spread of ASF among wild boar would cause irreversible damage to food-chains and ecosystems. Being a primary prey species in many areas, the loss of wild boar could precipitate the extinction of the Critically Endangered Sumatran tiger (*Panthera tigris sumatrae*) and Javan leopard (*Panthera pardus melas*) in Indonesia, and the Siberian tiger (*Panthera tigris altaica*) and Amur leopard (*Panthera pardus orientalis*) of Russia and China.

En route on the fast track to extinction, these big cats, suffering from a shortage in primary prey, would be forced to seek alternative food sources – preying upon forest-edge livestock and increasing human-wildlife conflict. The presence of wild boars, as ecosystem engineers, is also essential for maintaining terrestrial habitat structure and plant communities. Some species, such as bearded pigs (*Sus barbatus*), are seen to be the dominant force shaping tree seedling recruitment. The impacts of their loss could be devastating, at a time where conserving biodiversity is already a priority on the global agenda.

Luskin et al.'s study concludes that, if left uncontrolled, the current ASF outbreak could cause multiple mammal extinctions in the near future. While the disease is not known to undergo transmission between pigs and humans, and is therefore not an immediate threat to us, the consequences of large-scale species loss have the potential to induce massive impacts on food security as both animals and plants that rely on at-risk ecosystems cascade into extinction.

As of present, the global response is inadequate. The shortfalls in testing, research and interventions must be addressed, particularly by developed countries with whom the capacity lies. Governments must refrain from regarding ASF as a disease causing insignificant local deaths of pigs, and acknowledge it for what it is – a silent killer, lurking in the shadows, chipping away at food supplies, whittling down populations of endangered species, and threatening the progress of nations in achieving the Sustainable Development Goals of ending hunger and conserving biodiversity.

Reference

Luskin, M. S., Meijaard, E., Surya, S., Sheherazade, Walzer, C., & Linkie, M. 2020. African swine fever threatens Southeast Asia's 11 endemic wild pig species. Conservation Letters. doi:10.1111/conl.12784





Wild pig and local livelihoods in West Papua

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Abstract

Introduced species, such as wild boar were mostly sold and locally consumed for their meat. This study aims to have a better understanding on the contribution of wild pig, as a hunted species, to local livelihoods in eleven villages located along the coast of West Papua Province. On average, the actual hunting returns were two animals on each hunting trip. Wild pig is one of the major animals harvested, ($20.83 \pm SD 4.53$) individuals during seven month period of observations. The hunting catch was valued at IDR 84,375,000 (or US\$8,437.5), assuming an exchange rate of US\$1 equals IDR 14,000. Wild pigs are the most commonly hunted, because they are widely distributed, and provide a large amount of meat for both subsistence and sale purposes. Wild pigs contribute significantly to traditional economies across New Guinea, including Indonesian New Guinea.

Key words: wild pig, hunting, local livelihoods, West Papua

Introduction

Wildlife products are valuable commodities, and wild meat is considered as premium value because it has a high value per unit weight compared with other forest products (Williamson, 2002). The preferences for different wildlife species are usually influenced by economic activity, access to domestic meat, ethnic origin, geographical isolation, local wildlife availability and the biological attributes of species that are hunted (Naranjo et al., 2004).

Terrestrial vertebrate species including wild pigs, are hunted for both subsistence and the bushmeat market in the North Sulawesi province of Indonesia (Lee et al., 2005). Data from a 1990–1991 survey revealed that 50–60 pigs were sold in Langowan market, and that increases in the consumption of wild pig meat triggered hunters to hunt more to meet the demand (Clayton & Milner-Gulland, 2000). A survey at a single market showed that approximately 3,848 wild pigs were sent to market each year between 1993 and 1995; a third to half of the pigs were the endangered and legally protected babirusa (Clayton & Milner-Gulland, 2000).

In India, meat from adult wild pigs sells at around Indian rupees 2500 (USD 34) per kilogram, and represents approximately 50% of the average annual per capita income of the hunters in the large towns of Dakshina Kannada district (Madhusudan & Karanth, 2002). In Papua New Guinea, many different species are hunted by a variety of ethnic groups in different areas. For example, in the Southern Highland Province a wide range of mammal, bird and other edible fauna “acha” species are hunted (Dwyer, 1983; Sillitoe, 2001). In the Crater Mountain Wildlife Management Area of the Eastern Highlands Province, several species of mammals and birds are hunted (Mack and West, 2005). More than 80% of animals hunted in these areas included wild boar, cuscus, tree kangaroo, echidna and cassowary (Johnson et al., 2004). In Indonesian New Guinea, both introduced and native species are hunted (Petocz 1994; Flannery, 1995; Pattiselanno, 2006; Pangau-Adam et al, 2012). Introduced species, such as wild boar and rusa deer, were mostly sold and locally consumed for their meat (Pattiselanno, 2006; Pangau-Adam et al., 2012) and native species, such as common spotted cuscus and Grizzled Tree-kangaroo, were locally





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consumed (Pattiselanno and Koibur, 2008) and sold as pets (Pangau-Adam et al., 2012; Lyons & Natsuch, 2012). In this study, we aim to better understand the contribution of wild pig, as a hunted species, to local livelihoods in eleven villages located along the coast of West Papua Province.

Study area and methods

The study site is located on the Bird's Head Peninsula of Papua in Tamberau Regency approximately 200 km north-east of Sorong, the largest city in West Papua Province (Fig. 1).

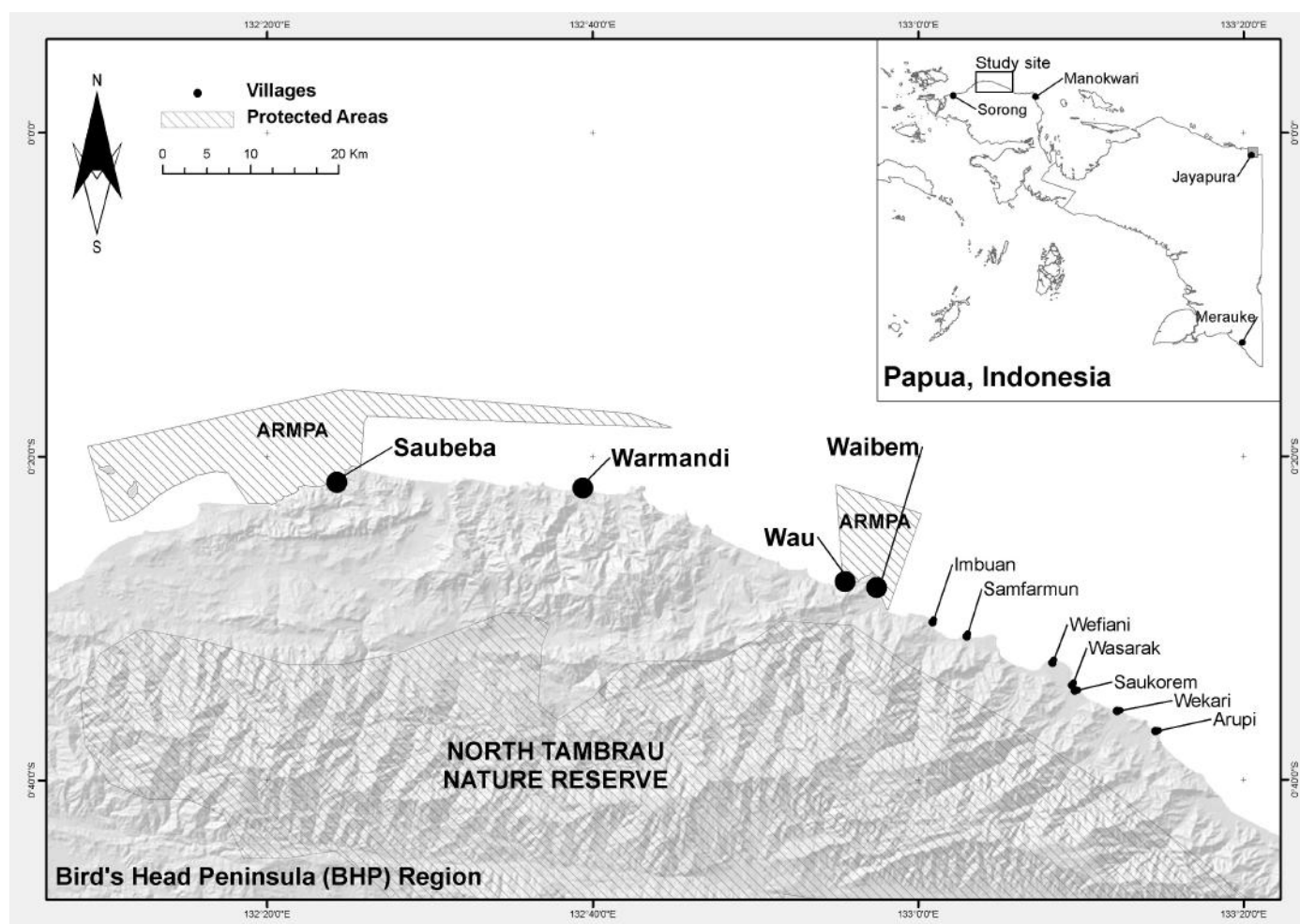


Fig. 1: Map showing the location of the study sites on the Bird's Head Peninsula. Large dots represent four villages in Abun District, also designated as Abun Regional Marine Protected Area (ARMPA) in a collaboration between the WWF Papua Program and the Sorong Regency Government. Small dots represent seven villages in Amberbaken District. The land areas in both districts are part of North Tamberau Nature Reserve.

Data collection was done through general village surveys and hunting surveys in two locations: Abun and Amberbaken. We studied four villages in Abun - Subeba, Warmandi, Wau and Waibem - mainly consisting of the Karon ethnic group. Whilst seven villages in Amberbaken - Arupi, Wekari, Saukorem, Wasarak, Wefiani, Samfarmun and Imbuan - were dominated by the Mpur ethnic group. This study received human research ethics approval from the James Cook University (JCU) Human Research Ethics Committee H4203.





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Although the study sites are located along the coast, people hunt inland to support their livelihoods, while fishing is done by a small number of the households (Gjertsen, 2011). Therefore, this study is important to investigate how importance hunting to people along the coast of the Bird's Head Peninsula.

Results

From 33 hunters interviewed, they reported catching nine species during excursions that occurred two to three weeks prior to being interviewed (Table 1). Of these, only five species were brought home during the seven month observations. Rusa deer (*Cervus timorensis*) and wild pig (*Sus scrofa*) are introduced and the other species are native.

Tab. 1: Species hunted in the coastal villages of West Papua.

Scientific name	Common name	IUCN Status ¹	Protected status under Indonesian Law ²
<i>Rusa timorensis</i>	Timor deer	Vulnerable	Protected
<i>Sus scrofa</i>	Wild pig	Least concern	
<i>Thylogale brunii</i>	Dusky pademelon	Vulnerable	
<i>Dendrolagus inustus</i>	Grizzled tree kangaroo	Vulnerable	Protected
<i>Spilocuscus maculatus</i>	Common spotted cuscus	Least concern	Protected
<i>Echymipera kalubu</i>	Spiny bandicoots	Least concern	
<i>Casuaris unappendiculatus</i>	Northern cassowary	Vulnerable	Protected
<i>Rhyticeros plicatus</i>	Papuan hornbill	Least concern	
<i>Ducula pinon</i>	Pinon imperial-pigeon	Least concern	

¹<http://www.iucnredlist.org/>

²Indonesian Law for Natural Resource and Ecosystem (Government Regulation PP No. 7/1999)

During interviews, hunters stated that catch results per hunting trip varied between one and five animals. On average, the actual hunting returns were two animals on each hunting trip ($2.42 \pm \text{SD } 1.93$) individual. The majority of the animals harvested were deer and pig (Fig. 2), with a total harvest of 301 animals from 371trips over ($210 \pm \text{SD } 60.76$ days). Animals harvested during the seven month period consisted of deer (25 individuals $\pm \text{SD } 9.46$); wild pig ($20.83 \pm \text{SD } 4.53$) and native species (4 ± 3.33).

During our survey across 11 villages along the coastal of the Bird's Head Peninsula of Papua, we recorded hunting results from 210 hunting trip. Data collected over seven months found that 5,625 kg of dressed weight of wild pig were harvested (Table 2), with the local price per kilogram being 15,000 IDR (or US\$1.13). The hunting catch was valued at IDR 84,375,000 (or US\$8,437.5), assuming an exchange rate of US\$1 equals IDR 14,000.



Fig. 2: Wild boar hunted at the Imbuan village of Amberbakh district in Tambrau Regency.

Photo: F. Pattiselanno





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Tab. 2: Seven month hunting yield reported by 33 collaborating hunters in the study villages.

Scientific name	Common name	Average weight (kg) ¹	Total individual	Annual offtake ²	Dressed weight ³	Average price/kg (IDR)
<i>Sus scrofa</i> ⁴	Wild pig	75	125	214	5625	15,000

¹Data provided by hunters and from published source (Flannery, 1995)

²Average catch per month is extrapolated to obtain annual offtake

³Dressed weights harvested (the weight of an animal after eviscerating, weight loss of 40%, see Auzel and Wilkie, 2000; Albrechtsen et al., 2006)

⁴Hunting take during seven month survey period

Discussion

Our study shows that wild pig meat plays an important role in supporting local livelihoods in West Papua. Meat of wild pig is not only used for consumptive purposes, but is also sold for obtaining extra household income. This finding concurs with other studies in Asia (Alvard, 2000; Bennett et al., 2000; Griffin & Griffin, 2000; Luskin et al., 2014) where subsistence hunting for ungulates is very important in developing nations because many people depend on wild pig meat for a dietary protein source. The overall range of species taken is determined by the hunter's assessment of profitability. Wild pigs are targeted because they provide a large amount of meat for both subsistence and sale purposes (Fig. 3).



Fig. 3: Wild boar transported from the hunting ground the near village at the coastal lowland forest of Tambrau Regency. Photo: F. Pattiselanno

Other studies also supported the findings in our study, with ungulates, such as wild pig being the most important source of income where trade has been documented (Fa & Brown, 2009; Robinson & Bennett, 2000). For example, in the Langowan market of Minahasa, North Sulawesi Province, wild pigs accounted for 67% of animals sold each week in a 1993-1995 market survey (Milner-Gulland & Clayton, 2002). Pigs also provided 58% of the total large game harvest by weight in traditional hunting by the Wana of upland Central Sulawesi (Alvard,

2000). In Sabah, 54% of the dressed weight of animals hunted consisted of bearded pig and 42% of deer (Bennett et al., 2000). Luskin et al. (2014) found that in 2011 over 7,500 wild boars were sold in Jambi city, Sumatra. Wild pig meat was transported to the city and sold at the local markets. In northeast Papua, an individual wild pig was sold for US\$30–50, equivalent to the monthly salary of a locally employed permanent worker (Pangau-Adam et al., 2012).





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In West Papua, although the hunting target varies from one site to another, wild pig and deer are the most commonly hunted species in all study sites because they are widely distributed (Pattiselanno, 2006). Likewise, in the Jayapura region of northeast Papua the main hunting targets were introduced wild pig and rusa deer, apparently because of the large amount of meat each individual provides (Pangau-Adam et al., 2012). Pigs are an extremely important source of hunted meat for traditional groups in Southeast Asia (Caldecott, 1988) and contribute significantly to traditional economies across the island of New Guinea, including Indonesian New Guinea (Dwyer, 1983).

Our study found that hunting may be a part of traditional farming activity in gardens and fallows. Not surprisingly, as most of the respondents are actively involved in agriculture, the percentage of farmers is 10-fold higher (70%) than those who fish (7%). They engaged in hunting during lean agriculture seasons for an alternative income. In this study, we found that 7% of respondents (N=1020) hunted for other purposes including festivals, to protect crops from this pest species and for a trophy.

Semiadi and Meijaard (2006), explained that hunting on Java and Bawean Island, Indonesia, is mostly performed to kill wild pig because the individual economic losses suffered from crop raiding are high and farmers are poor and rarely compensated for their losses. This is particularly true in developing countries (Linkie et al., 2007; Smith, 2005). Similarly, Fa and Brown (2009) argue that abundance of non-game or crop raiding species may rise if their competitors or predators are harvested or decrease if their prey is hunted. Human-wildlife conflicts commonly occur in tropical landscapes due to competition for space (Madhusudan & Karanth, 2000; Linkie et al., 2007). In Indonesia, this situation has led to the commercial harvesting of wildlife from plantations in addition to the construction of fencing systems to reduce crop damage from wild pigs and elephants (Alfred et al., 2012). In Papua, commercial hunting for wild pigs is positive for the environment because it reduces crop damage.

For many of the rural households along the coast of the Bird's Head Peninsula wild meat is not a luxury or something that they only turn to in times of hardship. Introduced species like wild pig (Fig. 4), also acknowledged as larger herbivores in Papua, are a vital source of animal protein and as a commodity that can be sold. Our study parallels with different studies across Asia (Alvard, 2000; Bennett et al., 2000; Griffin & Griffin, 2000; Luskin et al., 2014) where subsistence hunting for ungulates is very important in developing nations because many people depend on



Fig. 4: Meat from wild boar further processed for consumption purposes. Photo: F. Pattiselanno





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wild meat for protein. These species especially wild pig was hunted in secondary forest and crop land to protect crop damages.

Conclusion

Wild pigs are the most commonly hunted species in all study sites because they are widely distributed. Wild pigs are targeted because they provide a large amount of meat for both subsistence and sale purposes. Wild pigs are also an extremely important source of hunted meat for traditional groups and contribute significantly to traditional economies across New Guinea, including Indonesian New Guinea.

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IV Seminario Internacional del Jabalí – Edición Frontera

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Resumen

El jabalí europeo fue introducido en Uruguay a mediados de la década de 1920, luego se difundió al resto del país y llegó a la frontera con Brasil. La hibridación con ejemplares de cerdos domésticos asilvestrados aumentó su tamaño y agresividad. Por los perjuicios ocasionados fue declarado Plaga Nacional en 1982 y Plaga de la Agricultura en 2004. La complejidad y antigüedad de esta problemática hace que deba abordarse en forma interinstitucional, interdisciplinaria y transfronteriza, si quiere avanzarse en el control de la especie. Desde 2010 se desarrolla sistemáticamente la vigilancia sanitaria y en 2016 comenzaron a realizarse Jornadas en la frontera Uruguay-Brasil, primero de carácter regional y luego internacional. En 2019 se creó en la UDELAR (Universidad de la República Oriental del Uruguay) el grupo PROJAB, integrado por las Facultades de Ciencias y Veterinaria, que mantiene vínculos permanentes con organismos de gobierno, instituciones de enseñanza e investigación y Asociaciones de cazadores y productores.

Este año se realizaron las cuartas jornadas mediante plataforma zoom, debido a la situación sanitaria generada por el COVID-19. Llevaron por nombre "IV Seminario Internacional del Jabalí – Edición Frontera" y se fijó la sede virtual en la ciudad de Rivera (Uruguay), limítrofe con Brasil, para mantener la dinámica de los eventos antecesores. Disertaron técnicos y profesionales de Alemania, Argentina, Brasil, España y Uruguay, pertenecientes a distintas instituciones.

Abstract

The European wild boar was introduced in Uruguay in the mid-1920s, then spread to the rest of the country and reached the border with Brazil. Hybridization with specimens of feral domestic pigs increased their size and aggressiveness. Due to the damages they cause, wild boar and feral pigs were declared a National Plague in 1982 and Plague of Agriculture in 2004. The negative impact of wild boars is an old and complex problem and if progress is to be made in the control of this invasive species, it must be addressed in an inter-institutional, interdisciplinary and necessarily involving border countries. Since 2010, sanitary surveillance has been systematically performed and in 2016 conferences began to be held on the Uruguay-Brazil border. First from a regional perspective and then it was opened to international academic forums and health agencies.

In 2019 the proJAB, a research group involving professionals from Facultad de Ciencias y Facultad de Veterinaria, was established at the Universidad de la República in Uruguay (UdelarR). proJAB maintains permanent links with government agencies, teaching and research institutions, and hunters and producers associations. This year, the 4th conference was held in December 3-4, in a webinar format due to the sanitary emergency generated by COVID-19. The conference was named "IV International Wild Boar Seminar - Border Edition" and the virtual headquarters were set in the city of Rivera (Uruguay), bordering Brazil, in order to continue the





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dynamics of the predecessor events. Lecturers were technicians and professionals from Germany, Argentina, Brazil, Spain and Uruguay.

Introducción

El jabalí europeo (*Sus scrofa*) fue introducido en Uruguay a mediados de la década de 1920 por el productor agropecuario argentino Aarón de Anchorena en su establecimiento del departamento de Colonia (suroeste del país). A consecuencia de sueltas o escapes se difundieron al resto del país y llegaron a Brasil a fines de la década de 1980, favorecidos por las condiciones ambientales, la ausencia de depredadores naturales y su capacidad de adaptación (García et al., 2011; Lombardi et al., 2015). Actualmente se distribuyen en todo el territorio nacional. La hibridación con ejemplares de cerdos domésticos (que fueron introducidos por los españoles en 1541) hace que a nivel poblacional convivan estas cruzas, las variedades puras del jabalí y ejemplares de cerdos domésticos asilvestrados (García et al., 2011; Lombardi et al., 2015).

Por los diversos perjuicios que ocasiona el jabalí fue declarado plaga nacional en 1982 y plaga de la agricultura en 2004.

La complejidad y antigüedad de esta problemática hace que deba abordarse en forma interinstitucional, interdisciplinaria y transfronteriza, si quiere avanzarse en el control de la especie. En este marco de situación es que se realizaron en Artigas (Uruguay) en 2016 las I Jornadas Regionales del Jabalí del Cono Sur de América, que fueron seguidas en 2017 por las II (en Santana do Livramento, Brasil) y en 2018 por las III (en Salto, Uruguay). Todas fueron organizadas por un grupo de trabajo interinstitucional e interdisciplinario integrado por técnicos e instituciones de Brasil y Uruguay (Castro et al., 2017; Dos Reis et al., 2018; Comité organizador, 2019).

En 2019 se formalizó en la UDELAR (Universidad de la República Oriental del Uruguay) el grupo PROJAB (PROyecto JABalí), integrado por las Facultades de Ciencias y Veterinaria, que en la práctica viene realizando la vigilancia sanitaria sistemática de jabalíes y cerdos asilvestrados desde 2011. PROJAB mantiene vínculos permanentes con organismos de gobierno, instituciones de enseñanza e investigación y Asociaciones de cazadores y productores (PROJAB, 2020)

Metodología

Las cuartas jornadas se desarrollaron los días 3 y 4 de diciembre de 2020 mediante plataforma zoom, debido a la situación sanitaria generada por el COVID-19. Llevaron por nombre “IV Seminario Internacional del Jabalí – Edición Frontera” y se fijó la sede virtual en la ciudad de Rivera (Uruguay), limítrofe con Brasil (fig. 1), para mantener la dinámica de los eventos antecesores. Fue organizado por PROJAB y CENUR Noreste (Centro Universitario Rivera), ambos pertenecientes a la UDELAR (fig. 2).

Su objetivo fue generar un espacio de intercambio de información y experiencias entre los diversos actores e instituciones vinculados a la vigilancia sanitaria y el control y aprovechamiento productivo de los jabalíes y cerdos asilvestrados.

Disertaron profesionales de Alemania, Argentina, Brasil, España y Uruguay, pertenecientes a distintas instituciones como el Departamento de Defensa Agropecuaria de la Secretaría de Agricultura Pecuaria y Desenvolvimiento Rural (Brasil), el Instituto Friedrich Loeffler (Alemania), las Facultades de Ciencias y Veterinaria de la UDELAR (Uruguay), la Empresa Brasileira de Pesquisa Agropecuária (Brasil), el Ministério da Agricultura, Pecuária e Abastecimento (Brasil), el





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Fig. 1: Ubicación geográfica de la ciudad de Rivera (Uruguay) (fuente: <http://viajandoporuruguay.blogspot.com>).

Parque Nacional El Palmar (Argentina), la Empresa mUUcontrol (Uruguay), las Fundaciones Artemisan (España) y Oswaldo Cruz (Brasil), el Instituto de Investigación en Recursos Cinegéticos (España) y el Equipe Javali no Pampa (Brasil).

Participaron más de 100 personas (de 10 países) pertenecientes a distintas áreas: profesionales (médicos, veterinarios, biólogos, ingenieros, licenciados), productores, cazadores y estudiantes.

Se abordaron temas de actualidad como el concepto de One Health, vigilancia sanitaria, situación de Europa con respecto a la Peste Porcina Africana (en particular Alemania), experiencias de control en Parques Nacionales, alternativas de manejo en áreas de riesgo, investigaciones recientes sobre genética y ecología, bioseguridad en la caza y uso de aplicaciones tecnológicas (Apps) para las actividades cinegéticas, investigaciones y vigilancia sanitaria (cuadro 1).

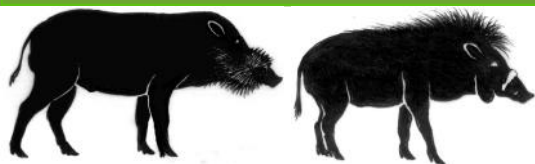
Finalizado el seminario se efectuó una reunión de evaluación y planificación de actividades entre los organizadores del evento y técnicos del Ministério da Agricultura, Pecuária e Abastecimento y el Departamento de Defensa Agropecuaria de la Secretaria de Agricultura Pecuaria y Desenvolvimento Rural de Brasil, acordándose emitir una declaración con recomendaciones para las autoridades de las distintas instituciones públicas y privadas que de una manera u otra tienen relación a la problemática que causan los jabalíes y cerdos asilvestrados.

Conclusiones

Los jabalíes y cerdos asilvestrados deben considerarse una plaga por los amplios impactos negativos que produce en diversos sectores. Sus poblaciones se encuentran en franca expansión geográfica y demográfica, lo que hace temer mayores impactos en el futuro.

En consecuencia, es necesario implementar y/o profundizar las siguientes acciones:





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Cuadro 1. Expositores y ponencias del IV Seminario (en orden cronológico).

Expositor	Institución y país	Ponencia (*)
Paul Raad	Veterinario privado, Uruguay	Introducción a Una Salud
Virginia Santiago	EMBRAPA, Brasil	Monitoreo sanitario de jabalíes y cerdos asilvestrados y sus implicancias en la salud animal y pública
Juliane Webster	Secretaria da Agricultura, Pecuária e Desenvolvimento Rural, Brasil	Experiencia da vigilância sanitária de Peste Porcina Clásica en cerdos asilvestrados en Rio Grande do Sul, Brasil
Klaas Dietze	Friedrich Loeffler Institute, Alemania	Situación de la Peste Porcina Africana en Alemania
La Hire Mendina Filho	Equipe Javali no Pampa, Brasil	Producción ovina: manejo adaptativo en áreas de alto riesgo
Diego Queirolo y Arley Camargo	CENUR Noreste, Uruguay	Avances en el estudio de la genética y ecología del jabalí
Cristian Sosa	Parque Nacional El Palmar, Argentina	Técnicas, alianza y evolución del control de mamíferos exóticos
Santiago Mirazo	PROJAB, Uruguay	Medidas y hábitos bioseguros en la caza
Luis Villanueva	Fundación ARTEMISAN, España	Observatorio Cinegético: un proyecto de Ciencia Ciudadana en España
Ricardo Lima	mUUcontrol, Uruguay	Uso de dispositivos IoT para rastreo de animales
Joaquín Vicente	IREC, España	Monitorización integrada de poblaciones silvestres: una iniciativa europea
Marcia Chame	Fundación Oswaldo Cruz, Brasil	SISS Geo - Sistema de información en salud silvestre

(*): Todas las ponencias estarán disponibles en breve en el blog y twitter de PROJAB.

- Establecer trabajos entre países de la región, con la participación de las distintas instituciones involucradas, para un correcto manejo poblacional de esta plaga, fomentando y apoyando a estudios poblacionales (densidad, uso de hábitat, comportamiento) para que sean la base de las estrategias de control y vigilancia sanitaria.
- Implementar un registro de cazadores asociados responsables capacitados.
- Formalizar programas de vigilancia sanitaria integrada en todos los países de la región. monitoreando las poblaciones animales y sus principales enfermedades (sean zoonóticas o de impacto económico) e intercambiar información sobre los diagnósticos realizados.
- Diseñar planes de contingencia para eventos sanitarios que involucren directa o indirectamente a los jabalíes y cerdos asilvestrados.
- Establecer y difundir procedimientos de bioseguridad en las acciones de control poblacional y vigilancia sanitaria.
- Fomentar y apoyar a los distintos grupos de investigación de la región para aumentar su capacidad de innovación respecto al seguimiento y control de los daños causados por los jabalíes y cerdos asilvestrados.
- Impulsar la creación grupo de cazadores capacitados para la respuesta rápida ante un insuceso sanitario en la fauna silvestre, formándolos con la figura de agentes sanitarios.
- Realizar simulacros en frontera con la participación de las Instituciones e individuos que están involucradas en la interfaz animal-humano-ecosistema ante la aparición de un brote de enfermedad.
- Promover la participación e intercambio de conocimientos y experiencias técnicas con Organismos Internacionales de reconocimiento, tales como la OIE, OMS, CVP, IICA, y FAO, entre otras, así como con las Agencias Gubernamentales y las Instituciones de Enseñanza e Investigación de otras regiones, que cuentan con una amplia experiencia en la atención de la problemática asociada a la presencia del jabalí y cerdos asilvestrados.
- Implementar una correcta comunicación y difusión de la problemática a todos los sectores, integrando a especialistas de las ciencias de la comunicación y educación para el desarrollo de actividades de difusión y educación comunitaria.





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IV Seminario Internacional del Jabalí Edición Frontera

3 – 4 de diciembre 2020



Expositores de:



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Fig. 2. Poster de las Jornadas.

- Incorporar a las herramientas oficiales existentes de relevamientos de datos (Declaración Jurada) la obtención de información sobre jabalíes y cerdos asilvestrados, así como también de otras especies exóticas invasoras (como por ejemplo el ciervo Axis).
- Crear una aplicación que brinde información para las distintas instituciones que trabajan en terreno (Ganadería y Agricultura, Medio Ambiente, Universidades, Institutos de investigación, Asociaciones de productores y cazadores) o implementar alguna ya existente.
- Establecer un cronograma de reuniones periódicas en frontera, previa conformación de un grupo de trabajo formal entre las instituciones involucradas de ambos países.

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Habitat selection and using local perception to estimate diet of *Phacochoerus africanus* (Gmelin 1788) and *Potamochoerus porcus* (Linnaeus 1758) in the different semi-natural and natural ecosystems of Benin

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Abstract

Diet plays an important role in satisfying the vital needs of most animal species, including *Phacochoerus africanus* and *Potamochoerus porcus*, two suids found in Benin. It is also a determining factor in the habitats selection in protected areas. We identify the preferred habitats and detect the diet of the red river hog and the common warthog through the local population perception in this study. Structured interviews were carried out with 139 people, followed by a prospection step in nine protected areas for practical identification of the species involved in the consumption by these suids and the presence points recording through direct and indirect clues. Citation frequencies (FL) were calculated to determine the contribution of the species cited in their diets, as well as a barplot to obtain the species consumed in common. The different species life forms consumed were summarised in a pie chart. Two Correspondence Analyses enabled us to identify the families of the most consumed species on the one hand and the nature of the species consumed on the other. The Manly alpha index is used to identify preferred habitats. In addition to certain specific wild and cultivated/introduced plant species (root of *Manihot esculenta* (16%), *Zea mays*, *Dioscorea praeheensis*), cow bones were eaten by the common warthog and *Archachatina* spp, earthworms, *Cardiosoma* spp, carcasses of *Tragelaphus spekei*, raptors by the red river hog. In contrast to the latter, the common warthog had a much greater preference for wild species and the least consumed plant species belonged to the family Anacardiaceae, Rubiaceae, Verbenaceae and Sapotaceae. Swamps, dense forests, fields/ fallow to a lesser extent on the one hand, and shrubby/tree savannas, fields/ fallow, open forests and wooded savannas on the other hand were the habitats where *Potamochoerus porcus* and *Phacochoerus africanus* have a preference respectively. We suggest the use of isotope approaches to assess possible overlaps in the suids trophic spectrum, to review land use policy and above all to raise awareness of the cohabiting importance with animal species.

Key words: feeding, knowledge, selected habitats, suids.

Introduction

Most terrestrial ecosystems have undergone significant changes as a result of human activities and therefore remain highly vulnerable (Vitousek et al., 1997). Pollution of natural habitats, land conversion, overexploitation and climate change are putting strong pressure on species (Wich, 2014; Brncic et al., 2015; Alves et al., 2018). The hunting of wildlife, whether for food, medicine or other purposes, causes significant damage to wildlife (Alves et al., 2018). Global biodiversity has





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been in extreme decline for decades, a decline confirmed by an evolving trend in the number of species threatened with extinction (Barnosky et al., 2011). The wild suids are not spared. Known since the Eocene era in Asia (Ducrocq et al., 1998), they were present in the wild (Souron et al., 2015). Suids provide a wide range of economic, social and ecological benefits to people (Larson et al., 2016). They contribute to household incomes (Balmford et al., 2002; Larson et al., 2016). However, they can cause damage to humans (Macdonald & Sillero-Zubiri, 2002) and crops (Granados & Weladji, 2012). They are found in different habitats depending on the species and are well known as seed dispersers (Beaune et al., 2012), which gives them a major interest in terms of floristic structuring of tropical forests and savannas. Several forest habitats are still subject to major anthropogenic pressure causing fragmentation of areas (Ouattara et al., 2019). Suids are a favourite target of local hunters (Yasuoka, 2006). As a result, since 1995 some species of wild pigs have become critically endangered (Oliver, 1995) and their population is currently in decline (Breuer et al., 2009; Vliet et al., 2007). Several research studies have been carried out on suid species, in particular on common warthog and red river hog, which are suid species highly appreciated for their meat. They are also quite prolific and very little data exist on the red river hog very little known in Benin, hence the need for investigations. Compared to exotic pigs, they are very prolific and resistant like the local domestic pig with enormous potential for use in game ranching (Codjia et al., 2020a) in Benin. It is then essential to determine the diet of these suids. While waiting for one of the most efficient techniques for diet determining like isotope approaches (Bibi et al., 2013; Yang et al., 2020) to be used, we proposed in this work to evaluate the common warthog and red river hog diet through the local populations perception study. In addition, the preferred habitats of the common warthog and red river hog will also be analysed. The following hypothesis are analyzed here, there is a particular overlap between the trophic spectrum of food consumed by the common warthog and red river hog. The common warthog and red river hog diet depends of the species nature consumed mainly. There is not much variability in preferred habitats specific to the common warthog and red river hog. The common warthog and red river hog diet depends of the species life forms consumed. We will try to answer these four hypotheses through this study results.

Materials and methods

Study area

The study sites extend between latitudes 8°00' and 7°12' N and longitudes 1°36'

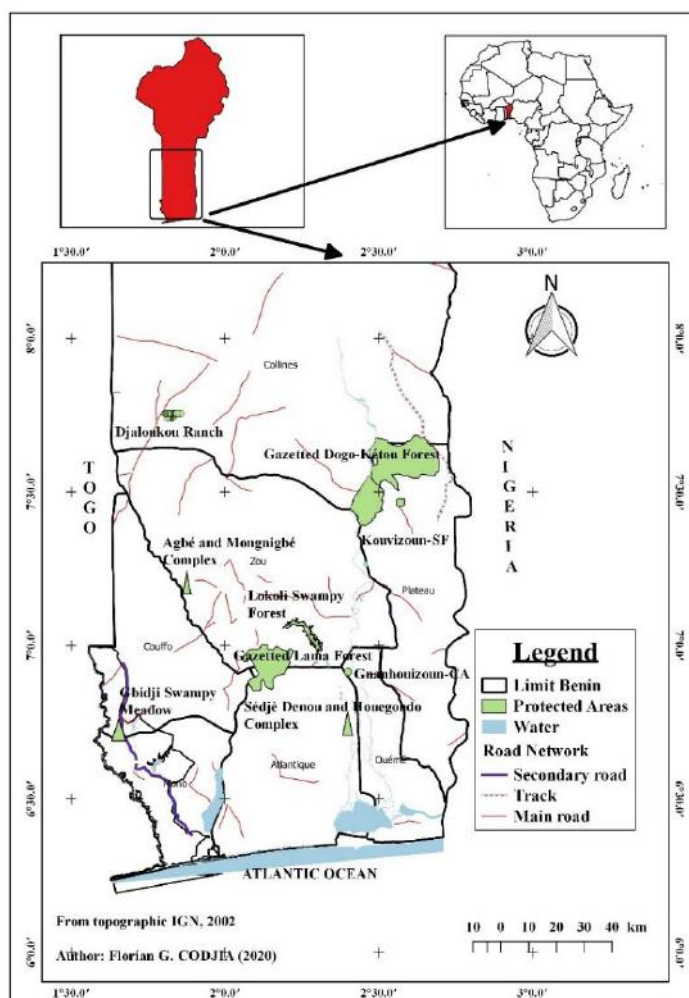


Fig. 1: Study area.





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and 2°48' E (Fig. 1) with an average of 2.250.000 ha. This is characterized by two climatic zones: the Sudano-Guinean transition zone and the Guinean zone. The first is characterized by shrubby/wooded savannah, forest galleries and fallow fields. Semi-deciduous dense forests, swampy formations, and thickets are often found in the Guinean zone in addition to fields. The choice of sites inventoried was based on the various results of our surveys and previous work where the presence of these suids was confirmed in Benin. Among these works we are those of Agassounon, (2005); Codjia et al., (2007); Adjin et al., (2011); Houehounha, (2011). The work of Codjia et al., (2020a) show that in addition to the low representativeness of the Guinean zone, the transition zone of Benin, on the other hand, is a determining factor in the explanation of these two sympatric species. Also from the works of INSAE, (2016), a severe degradation of the vegetation cover is noted in the Benin southern part due to a high concentration of more than half of the population.

The Lokoli swamp forest is located in the district of Koussoukpa, (commune of Zogbodomey) between 7°03' N and 2°15' E on an area of about 3000 ha. The average annual temperature is between 26 and 28°C. In the Guinean zone, the gazetted Lama forest extends between latitudes 6°55' to 7°00' N and longitudes 2°04' to 2°12' E halfway between Allada and Bohicon. The southern part of this forest is accessible by the Ouègbo-Toffo trail while to the north, an Agrimey-Koto trail leads to the edge of the forest. The climate in southern Benin is sub-equatorial with four seasons unevenly distributed. The Gbidji swamp meadow is located in the commune of Dédé within the Mono Biosphere Reserve which is between latitudes 6° 11 '14.2" and 6° 59 '58.7" N and between longitudes 1° 35 '47.1" E and 1° 59' 28.1" E. It is an integral part of the RAMSAR 1017 site. The main habitats types found in the study area are: Dense semi-deciduous forests, swampy formations, open forests, wooded savannas, wooded savannas, mosaics of fields and fallows, swampy meadows, plantations. The Gnanhouizoun Community Area is found in the village Gnanhouizounmè located in Damè-Wogon district (Bonou commune) with an area of 25.33651 ha. The commune of Bonou is located in the Department of Ouémé between 6°72' and 6°95' north latitude and between 2°15' and 2°40' east longitude. The Agbé and Mongnigbé Complex is located in the Zou department while the Djaloukou Ranch in the hills. The Sédjè Denou and Houegoudo Complex is located in the Atlantic Department, more precisely in the Zé commune. We finally have the Gazetted Dogo-Kétou Forest and the Sacred Forest of Kouvizoun which are located in the Plateau department. The main soils encountered in this study area are hydromorphic, ferruginous, ferralitic, sandy loam, colluvial, alluvial and vertisol.

Method of data collection

Different socio-professional categories were considered during the preliminary stage among 30 people found below eight degrees of latitude in Benin where the presence of *Phacochoerus africanus* and *Potamocheirus porcus* are reported. The different socio-professional categories included: ecological guide, breeder, farmer, forest operator, hunter, processor of agricultural products, shopkeeper, veterinarian. The number 30 (binomial distribution) has been used to approximate the normal distribution. It was then determined the proportion of people who have knowledge of these two species and have had at least one direct contact with them. The information was used to calculate the sample size (n) to be surveyed according to the equation of the normal approximation of the binomial distribution (Dagnelie, 1998):

$$n = \frac{U_{1-\alpha/2}^2 \times p(1-p)}{d^2}$$





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where n is the sample size per selected village, $p = 0.7$ is proportion of residents aware of the current presence of these suids, $U_{1-\alpha} / 2$ is the standardized value with a probability p equals $1-\alpha / 2$ for a probability of 0.95 (with $\alpha = 0.05$, $U_{1-\alpha} / 2 \approx 1.64$) and d is the margin of error of the

Tab. 1: Socio-demographic characteristics of respondents of six studied communities in Benin.

Ethnic group	Gender		Age		
	Men	Women	≤ 30 years	$30 < \text{years} \leq 60$	> 60 years
Adja	2	0	0	2	0
Aïzo	18	5	10	11	2
Fon	38	9	8	33	6
Mahi	4	1	1	2	2
Nagot	41	8	6	34	9
Wéménou	6	6	1	10	1

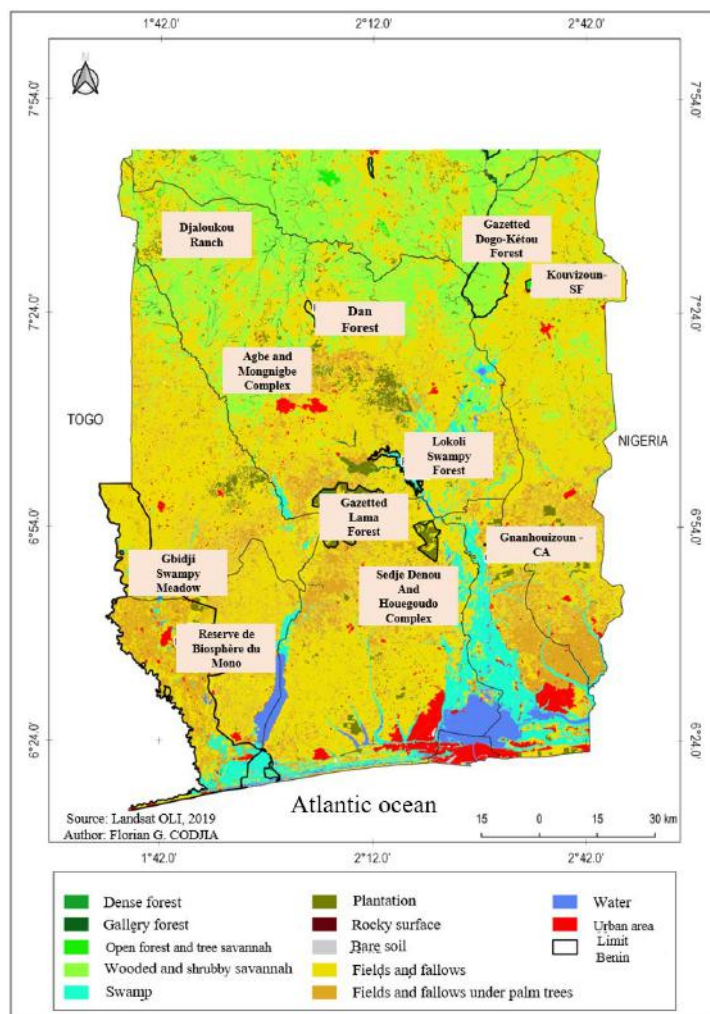


Fig. 2: Land cover map.

far as possible. About data contributing to the occupation of the species, a determination of their preferred habitats consisted of superimposing the direct/indirect occurrence points of each of them on the land-use map (Fig. 2) for the year 2019 of the study area. For this purpose footprints, lodgings, droppings, swill digging and food remains (Codjia et al., 2009) were therefore taken into account during our field investigations to collect the *Phacochoerus africanus* and *Potamocheorus porcus* presence points (Codjia et al., 2020b).

Data analysis method

Perception on the common warthog and the red river hog diet

To study the perception of local populations on the food consumed by the two species (common

measured parameters however a standard error of 6% will be considered for this study.

A total of $n=139$ people from these different socio-professional categories and ethnic groups were interviewed. The stratified method was used among the probability sampling methods, considering the districts and localities of each study site. Table 1 summarises some of the characteristics of the respondents. The surveys were carried out from 15 December 2019 to 29 March 2020 around 9 sites. Questions on the diet composition of these suid species were asked to all socioprofessional groups considered without distinction of sex and age. Data collection was carried out with semi-structured interviews using a questionnaire developed for this purpose. These were open and closed questions relating mainly to the plant species consumed, their origins (wild, cultivated or introduced), the animal species consumed, and nature (raptors, carcasses, bones). These surveys were conducted in french as well as in local languages with the help of an interpreter when necessary and as





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warthog and red river hog), citation frequencies were calculated and presented in table using Fidelity Level (FL). This index is calculated following the formula (Friedman et al., 1986):

$$FL = (n/N) * 100$$

n: number of people that provided an answer in relation to a given consumed species; N: total number of people surveyed for the given species (common warthog, red river hog). In addition, the life forms of these different species consumed by the common warthog and the red river hog were presented in a pie chart. The overlapping and the dependence of the both species by nature/type, the life forms were checked with Pearson chi-square test in R software using `chisq.test` function. At last, two correspondence analyses carried out with the FactoMineR package made it possible to describe these two suids, identify the families of the most consumed species on the one hand and the nature of the species consumed on the other.

Occupation of the common warthog and red river hog

The preferred habitat of *Phacochoerus africanus* and *Potamochoerus porcus* was determined here on the basis of the Manly alpha habitat selection indices by considering several types of formations such as: open forest and wooded savannah; gallery forest; fields and fallows land; swamp; dense forest; shrubby and wooded savannah etc. This was made possible by using the study area land cover map and following the Manly et al., (1972) method based on the formula below:

$$\alpha_i = \frac{r_i}{n_i} * \frac{1}{\sum r_i / n_i}$$

with α_i : Manly index for habitat i; r_i : the proportion for habitat type used by a given species ($i = 1, 2, 3, \dots, m$). The was obtained by type of habitat or land-use class. So it corresponded to the number of times the suid presence coordinates was recorded in a given type of formation; n_i : the habitat proportion i available in the study and m: the largest number of habitat types.

- when there is no preference in habitat selection $\alpha_i = 1/m$;
- when $\alpha_i > 1/m$, type i habitat is preferred;
- when $\alpha_i < 1/m$, habitat i is avoided.

Results

Red river hog and common warthog feeding

About species consumed, 86.66% were from the plant kingdom. It should be pointed out that 12% of the species from the animal kingdom involved in the diet were consumed by the red river hog (*Archachatina* spp, earth worms, *Cardiosoma* spp, carcass of *Tragelaphus spekei*, raptors) and 1.33% by the common warthog (cow's bone) in the Djaloukou Ranch. The cultivated or introduced species consumed by these suids are presented according to citation frequencies in Table 2. According to the respondents, both species consume *Zea mays* and *Manihot esculenta* much more. *Elaeis guineensis*, *Dioscorea rotundata*, *Ipomoea batatas* and *Vigna unguiculata* are specifically consumed by the red river hog, while the common warthog consumes more specifically *Arachis hypogea*, *Musa* sp. and *Mangifera indica* L.. The wild species consumed by these suids are presented according to citation frequencies in Table 3. It should be noted that 35% of the plant species consumed by these suids are wild in the study area. The respondents found with regard to wild species, common warthogs have a preference for *Pterocarpus erinaceus* Poir, *Vitellaria paradoxa* and *Dioscorea praehensilis*, while red river hogs





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Tab. 2: Cultivated or introduced species consumed by these suids.

Species	Cultived and introduced species	FL (%)
Common warthog	<i>Zea mays</i>	100
	<i>Manihot esculenta</i>	90.9090909
	<i>Musa sp</i>	18.1818182
	<i>Arachis hypogea</i>	18.1818182
	<i>Dioscorea rotundata</i>	9.09090909
	<i>Mangifera indica L.</i>	9.09090909
Red river hog	<i>Manihot esculenta</i>	43.442623
	<i>Zea mays</i>	32.7868852
	<i>Elaeis guineensis</i>	27.0491803
	<i>Ipomoea batatas</i>	8.19672131
	<i>Dioscorea rotundata</i>	6.55737705
	<i>Musa sp</i>	5.73770492
	<i>Vigna unguiculata</i>	2.45901639

Tab. 3: Wild species consumed by suids

Species	Wild species	FL(%)
Common warthog	<i>Pterocarpus erinaceus Poir.</i>	54.5454545
	<i>Vitellaria paradoxa</i>	45.4545455
	<i>Dioscorea praehensilis</i>	36.3636364
	<i>Dioscorea sagittifolia Pax</i>	27.2727273
Red river hog	<i>Dioscorea praehensilis</i>	17.2131148
	<i>Sarcocephalus latifolius</i>	15.5737705
	<i>Dioscorea sagittifolia Pax</i>	11.4754098
	<i>Pterocarpus erinaceus Poir.</i>	3.27868852
	<i>Adansonia digitata</i>	1.63934426
	<i>Vitellaria paradoxa</i>	1.63934426
	<i>Borassus aethiopum</i>	0.81967213

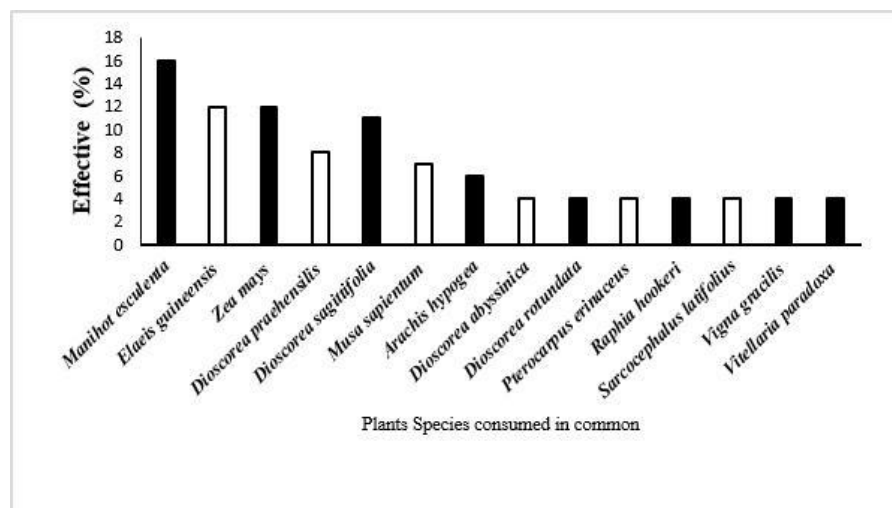


Fig. 3: Plant species eaten in common by common warthog and red river hog.

especially like *Dioscorea praehensilis*, *Sarcocephalus latifolius* and *Dioscorea sagittifolia* Pax..

The result of Pearson chi-square test showed that the both species diet didn't depend of the species consumed nature/type ($P=0.3718 >0.05$ at 5% threshold). These species seem having the same trophic spectrum. The plant species consumed in common by the two suids around the sites are shown in Fig. 3.

Whether red river hog or common warthog, the species of the plant kingdom consumed in common on the nine sites were mainly: *Manihot esculenta* root (16%), *Elaeis guineensis* Jacq nuts. (12%), *Zea mays* L. (12%), *Dioscorea sagittifolia* Pax (11%) and *Dioscorea praehensilis* (8%). The result of Pearson chi-square test showed there isn't a particular overlap between the trophic spectrum of food consumed by the common warthog and red river hog ($P=0.09435 >0.05$ at 5% threshold).

The different life forms reporting on for the plant species consumed by the two suids are illustrated in Fig. 4.

Mesophanerophytes (32%), Geophytes (20%), Therophytes (17%) and Nanophanerophytes (14%) were the most predominant life forms in their diets. At last, it should be noted that 12% of the plant species consumed were fruit species, including *Musa sp. L.* (5.33%), *Adansonia digitata*, *Ananas comosus*, *Borassus aethiopum*, *Citrus maxima* and *Mangifera indica L.* (1.33% each). The result of Pearson chi-square test showed that the both species diet didn't depend of species consumed life forms ($P=0.3921 >0.05$ at 5% threshold). *Azadirachta indica*, *Paullinia pinnata* and





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Vitellaria paradoxa were species under which the common warthogs took a rest around Agbé and Mongnigbé complex (Fig. 5).

Among the 19 families listed, the Dioscoraceae (57.89%), the Arecaceae (52.63%), the Euphorbiaceae (47.36%), the Poaceae (47.36%) and the Leguminosae. Papilionoideae. (21.05%) were respectively the most represented. The correspondence analyses results presented in Fig. 6 and Fig. 7 showed that the two factorial axes allow for 100% of the information to be summarised. Common warthogs had a much greater preference for wild species and the least consumed plant species belonged to the family Anacardiaceae, Rubiaceae, Verbenaceae and Sapotaceae. Red river hogs consume much more introduced or cultivated species of the family Dioscoraceae, Arecaceae, Euphorbiaceae and Poaceae.

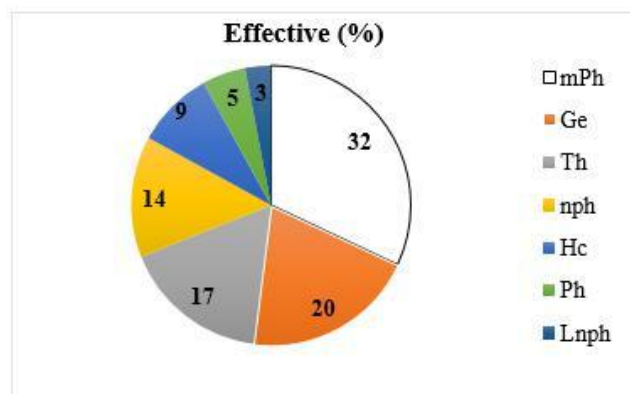


Fig. 4: Life forms identified.



Fig. 5: (a) Remaining *Raphia hookeri* nuts consumed by the red river hogs in Gbidji Swampy Meadow; (b) Fragment of *Ipomoea aquatica* plants commonly known as Viviman consumed by the red river hogs in Gbidji Swampy Meadow; (c) Tuber from thorny plants to the root of *Dioscorea praehensilis* commonly known as Dôhoun in the sacred forest of Kouvizoun and also cited in the consumption of the common warthog in other forests; (d) rhizomes and leaves of *Stylochaeton hypogeum* consumed by the red river hog in the Gazetted Lama Forest; (e) Resting sites of the common warthog in Agbé and Mongnigbé Complex where species such as *Azadirachta indica*, *Paullinia pinnata* and *Vitellaria paradoxa* are found.

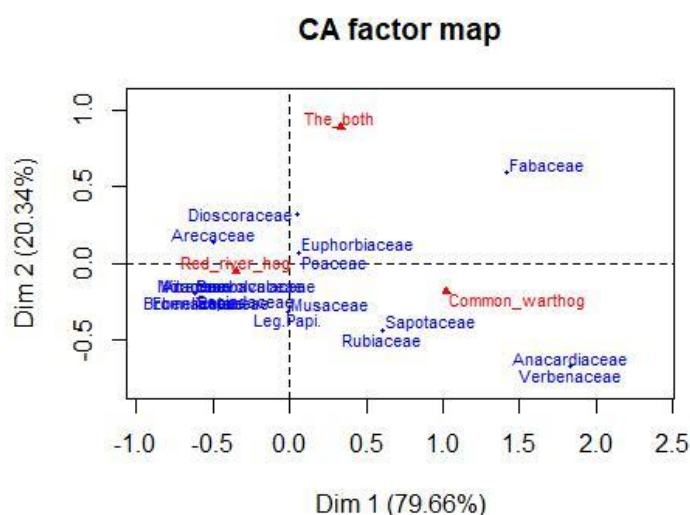


Fig. 6: Projection of correspondence analysis results for the species families consumed and suids on the first two factor axes.

Preferred habitats

Manly's alpha index values (α_i) for *Potamocheirus porcus* and *Phacochoerus africanus* are presented by the Fig. 8 (a and b respectively). On the basis of presence points superimposed on the study area land cover map, a total seven ($m=7$) habitats most used by these two suids were identified.

To a lesser extent, swamps, dense forests on the one hand and shrubby/tree savannas, fields/fallows, open forests and wooded savannas on the other hand are





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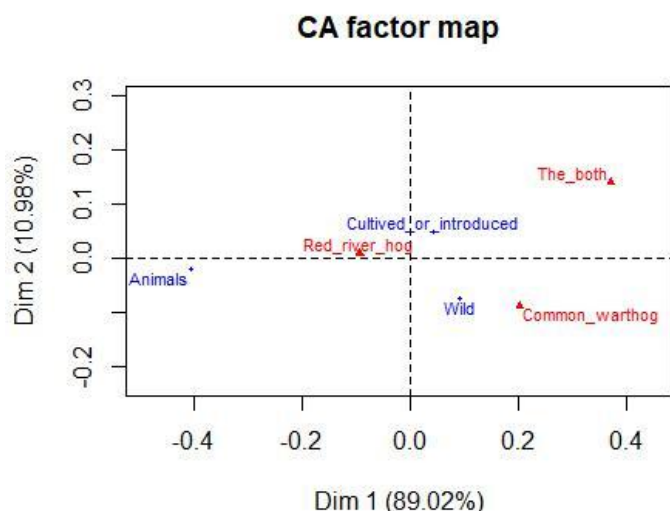


Fig. 7: Projection of correspondence analysis results for the types of species consumed and suids on the first two factor axes.

portion of wild origin was the most mobilised by the common warthog. This situation is closely linked to the reduced knowledge of the local population represented here by the respondents of the wild plant species consumed by the two suids. This trend is all the more contradictory with regard to species produced in the fields or introduced by man, which are easy to identify when

the habitats where *Potamocheorus porcus* and *Phacochoerus africanus* have a preference respectively ($\alpha_i > 1/m = 0.142$). Consequently, the red river hogs avoid gallery forests as well as open forests and wooded savannah quite well. Common warthogs, on the other hand, only avoid gallery forests ($\alpha_i < 1/m$). These two suids prefer field/fallow habitats and avoid gallery forests as much as possible.

Discussion

Under the strong contribution of the red river hogs, most of the elements from the plant kingdom consumed by the suids involved in the study came from the fields or introduced by men, while the smaller

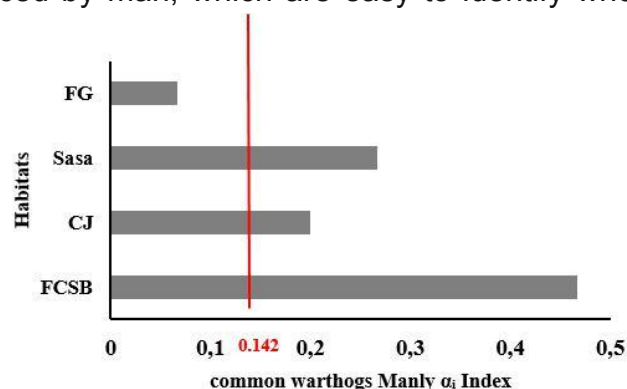
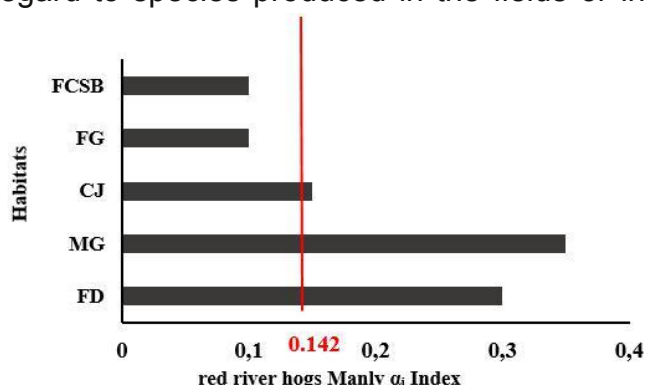


Fig. 8: Manly's α index values for red river hogs and common warthogs. FCSB=open forest and wooded savannah; FG=gallery forest; CJ=fields and fallow land; MG=swamp; FD=dense forest; Sasa=shrubby savannah.

these suids are caught in the fields or in the conservation area or even after damage has been observed. Following the example of the common hippopotamus (Dunham et al., 2010), it is therefore not surprising that strong depredations have been orchestrated by other types of suid such as the European wild boar (Blouch, 1988). It should also be noted that these two suids are still in the wild state at the investigation sites and therefore, unlike other domestic herbivores, a grazing follow-up cannot be carried out to obtain reliable results. Hence we will have to complete this work with further studies using isotopes. Regarding the state of occupied habitats, the high level of plant species consumption from the fields or introduced by men is evidence not only of the degradation of their habitats but also of the occupation of land by man illustrated by Codjia et al., (2020b).





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However, farming requiring the presence of humans is disturbing the peace and encroaching on the ecology of the red river hog and common warthog. It is above all essential to limit the expansion of agricultural land in these areas where these suids are prone to the long-term loss of their preferred habitats.

Furthermore, no wildlife work has yet mentioned the existence of these suids in more than half places investigated including Gnanhouizounmé forest-CA, Sédjè Denou and Houegoudo Complex, Gbidji Swampy Meadow, Djaloukou Ranch, Agbé and Mongnigbé Complex in Benin. It is therefore fundamental not only to continue research on this taxonomic group but also to propose sustainable conservation strategies. In this study, the most represented in the family of the most consumed species by these two suids were Dioscoraceae, Arecaceae, Euphorbiaceae, Poaceae and Leguminosae.-Papilionoideae. Several other families including the Balanophoraceae, Curcubitaceae, Sapotaceae, Vitaceae, Zingiberaceae were cited in the work of Adjin et al., (2011) as part of the plant species consumed by the common warthog in two southern Benin areas included in this study. We could thus deduce the great advance degradation in these forests, then reducing the species richness. Although among all the studies carried out up to now, this study reveals enough information at the same time on the two suids about their food ecologies. *Archachatina* spp, earthworms, *Cardiosoma* spp, carcasses of *Tragelaphus spekei*, raptors are the main animal species consumed by the red river hog, as well as cow bones by the common warthog. Thus the predation behaviour observed in common warthogs on young gazelles (*Gazella thomsonii*) especially in East Africa (Blair, 2012) is better justified. The diet of the common warthog and red river hog is therefore not only made up of species from the plant kingdom. Thus, the both suids diet didn't depend of the species nature consumed with the high contribution of red river hog which seem to be an omnivorous species. We know that life forms or biological forms provide information on the type of plant formation, its origin and transformations. They also refer to the adaptive behaviour of the species (Sirvent, 2020; Raunkiaer, 1934). Closely related to the species, therefore it's quite normal to find also that the both suids diet did not depend of species consumed life forms.

The results of this study had shown that among the plant species consumed, 12% were fruit species. Their frugivory was also confirmed in the work of Clauss et al., (2008). Several species, mainly *Manihot esculenta*, nuts of *Elaeis guineensis* Jacq., *Zea mays* L., *Dioscorea praehensilis* and *Dioscorea sagittifolia* Pax were preferred and consumed in common by both suids in the study area. Pending a diet study of these two suids using isotope approaches, the hypothesis that a particular overlap exists in the species diversity of the items consumed by the two suids species is not verified. The reasons are the low level of species consumed in common by the both species and the almost sympatric sites absence in our study area as translated by Codjia & Loubegnon, (in press) work. We also had to check the different habitats commonly selected by the two suids under study. On the basis of the occurrence points obtained for each of them, we note that this habitat selection takes into account many factors including water, vegetation and the human activities level. The work of Djaoun et al., (2018) had also taken this into account by insisting in addition to these three factors on the density of trees in relation to certain species including *P. porcus*. It is therefore not surprising to see the avoidance of gallery forests by common warthogs and red river hogs. The open forests and wooded savannas were also avoided by the red river hogs. These results are also reflected in the phyto-ecological characterisation of the habitat carried out in the same study area by Codjia et al., (2020b) where each elementary grouping was represented by plant species characteristic of the habitats they





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belonged to. It is quite normal to observe that the diet composition reflected by the local population in this study is closely linked to the preferred habitat types selected by each of these suids. To this end, this study showed that fields/fallows to a lesser extent, swamps and dense forests were the preferred habitats of *Potamochoerus porcus*, confirming Houehounha, (2011); Leus & Vercammen, (2013) work. As translated in the work of Codjia et al., (2007), shrubby/tree savannahs, fields/fallows, open forests and wooded savannahs were the main habitats where *Phacochoerus africanus* had a preference. The assumption that there is a large variability in preferred habitats specific to the common warthog and red river hog is verified. The avoidance observed by both species in gallery forests through this study is in contrast to the results of Leus & Vercammen, (2013) on the red river hog. This raises questions that call for further studies to be carried out to see the impact of water depth and extent on the activity budget of the two suids in Benin. This work complements the existing database on these suids of interest for possible reintroduction and breeding programmes in past and present distribution areas.

Conclusion

The diet composition of *Potamochoerus porcus* and *Phacochoerus africanus* according to the local population perception as well as their different preferred habitats were addressed in this study. In the light of the results, the diet of both suids consists of species from the plant kingdom. Regarding the species of the animal kingdom, further investigations are necessary, especially in the common warthog, which in the present study consumes as a priority the species of the plant kingdom. It was recognised in this study that these two suids consumed both cultivated/introduced and wild species, which better explains the cases of depredation, their slaughter and the human disturbance of habitats. The plant species least consumed by the common warthog belonged to the Anacardiaceae, Rubiaceae, Verbenaceae and Sapotaceae families and they have a greater preference for wild species than cultivated/introduced species, unlike the red river hogs in southern Benin. The most predominant life forms in their diets are Mesophanerophytes, Geophytes, Therophytes. About preferred habitats, shrubby/arboreal savannas, fields/fallows, open forests and wooded savannas on the one hand and swamps, fields/fallows to a lesser extent, dense forests on the other hand are respectively the habitats used by *Phacochoerus africanus* and *Potamochoerus porcus*. We suggest extending the diet study towards the use of isotope approaches to assess possible overlaps in the two suids trophic spectrum, review land use policy and, above all, raise public awareness of the cohabiting importance with wildlife species. It will also be good to carry out studies on protected areas in nature.

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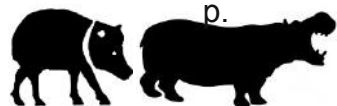




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Queixadas (*Tayassu pecari*) presos pelo fogo do Pantanal, a história de Benta e seu bando contada por um equipe de resgate de veterinários voluntários

White-lipped Peccaries (*Tayassu pecari*) trapped in the Pantanal fires – the story of Benta and her herd as told by veterinarians volunteering on a rescue team

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Summary

Fires have consumed nearly 4.5 million hectares across the Pantanal, totaling about 30% of the biome (Libonati et al 2020). The uncontrolled fires resulted in many fatalities and injuries to wildlife. In the northern Pantanal, a team of veterinarians described their experiences rescuing a herd of white-lipped peccaries trapped in a mudhole surrounded by smoldering soil and vegetation after the fire had passed (Fig. 1). The rescue team encountered approximately 30 white-lipped peccaries that were dehydrated and malnourished and some with severe burn injuries. Surviving animals were huddled near others that were dying, and some of the adults close to death were still trying to protect their young and other members of the herd (Fig. 1). The team's first visit occurred October 3rd 2020 when they rescued a young female peccary (Benta) a little over a month old, and 2 adults. They were taken to a rehabilitation base for more intense treatment. Both adults had severe injuries (bone exposure on both limbs and with loss of muscle tissue and nerves), which made rehabilitation impossible. Thus, the technical team opted for euthanasia. The care and rehabilitation process was initiated for the young peccary (Benta), and integrative techniques were applied, such as ozone and laser therapy. They also cleaned and dressed the injuries with ozonized oils and repellent to prevent further clinical deterioration (Fig. 2).

The team returned daily to the site for the next 10 days, encountering at least 7 carcasses and another 4 still alive (Fig. 3). The surviving individuals sustained injuries so severe that they had to be euthanized at the location or at the base. Local observations from the region over the years have shown that the herd usually begins to move to other areas at the onset of the rainy season. During the last field observations, peccaries with offspring that may have been part of the injured herd and escaped the fire were observed by the veterinarians near the mudhole. Camera traps were placed at feeding stations to monitor the well-being of the herd. By December 10th, Benta, fully recuperated, was released close to where a herd of peccaries was active, and based on camera trap pictures, appeared to have rejoined the herd (Fig. 4).

Até agora, os incêndios consumiram quase 4,5 milhões de hectares em todo o Pantanal, totalizando cerca de 30% do Bioma (Libonati et al 2020). Os incêndios fora de controle causou muita morte e ferimentos nos animais silvestres. Uma equipe de veterinários voluntários relata a experiência no resgate de um bando de queixadas encontrada num pogo de lama usado para se





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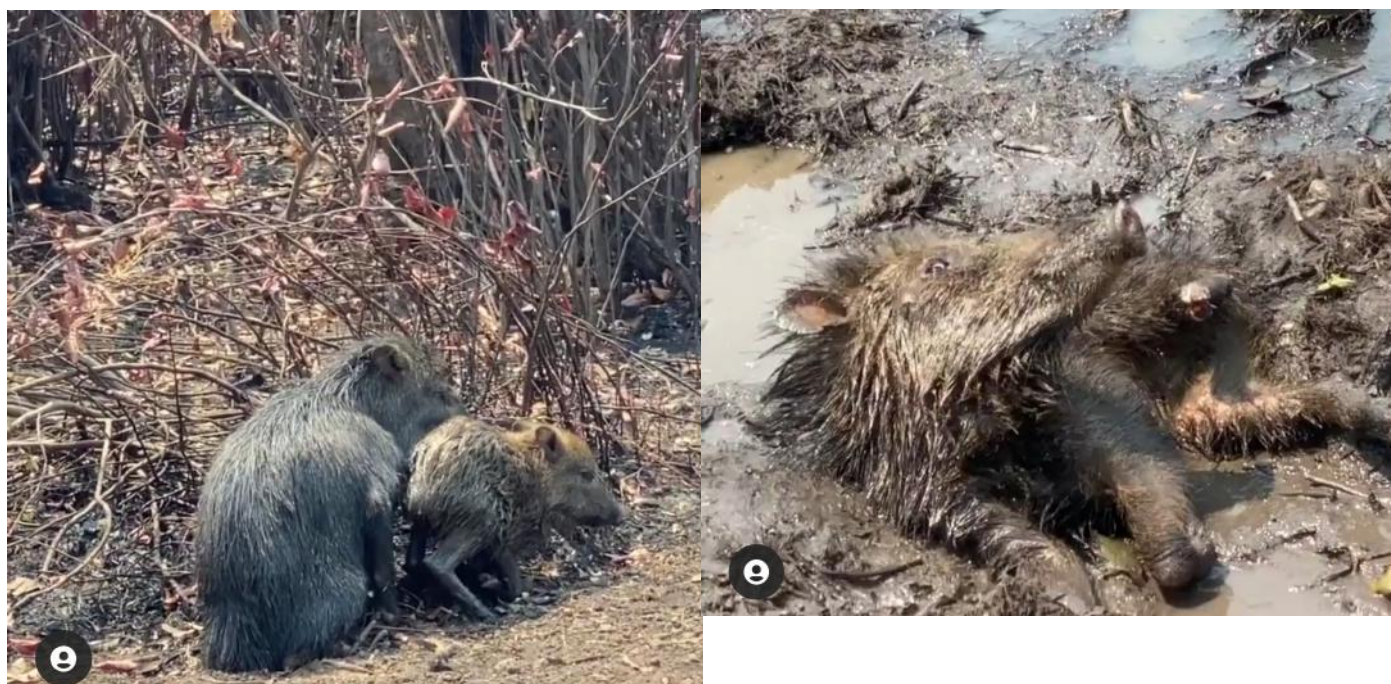


Fig. 1: Queixadas encontrados se protegendo num poço de lama no Pantanal.

Surviving white-lipped peccaries huddled in a mudhole. Photos: Instituto Vida Livre

proteger do fogo (Fig. 1). O objetivo da avaliação era identificar e resgatar os animais silvestres vítimas das queimadas e que apresentavam lesões e/ou necessidade de remanejamento em virtude da ausência de abrigo, água e alimento.

No dia 30 de setembro, a equipe do Projeto Lontra fazia reconhecimento terrestre das áreas atingidas pelas queimadas, a fim de identificar possíveis vítimas do local, quando avistaram um grupo de queixadas (*Tayassu pecari*) possivelmente lesionados, mas em local de difícil acesso e monitoramento, na região do Barão de Melgaco, Pantanal Norte. Nos dias posteriores, a equipe procurou formas de acesso até a área para o reconhecimento e tratamento veterinário. Devido ao grande número de animais lesionados, foi necessário fazer o tratamento de urgência no próprio local.

No dia 03 de outubro a equipe retornou de barco até o local, onde identificou um novo acesso, que facilitava o contato com os animais, o que resultou no resgate de 3 indivíduos, sendo dois adultos e um filhote (Benta), que foram levados até a base onde tiveram uma melhor avaliação clínica.

Os dois indivíduos adultos apresentavam lesões graves, (exposição óssea em ambos os membros, com perda de tecido muscular e nervos), o que impossibilitava a reabilitação. Sendo assim optado pela equipe técnica a eutanásia.

O filhote apresentava lesões moderadas com perda parcial dos cascos, porém seu quadro possibilitava o tratamento. Iniciado o processo de cuidados e reabilitação, foi aplicado técnicas integrativas como a ozônio-terapia e laser-terapia, assim como a limpeza e curativos com óleo ozonizado e repelentes, evitando uma piora no quadro clínico (Fig.2).

Simultaneamente ao tratamento na base, outra parte da equipe inicial se deslocava todos os dias até o local do resgate, a fim de monitorar o grupo e identificar outros possíveis animais feridos, além de levar alimentação, visto que toda área estava devastada e sem insumos.

Nos dez primeiros dias subsequentes foram identificadas 7 carcaças de queixadas, sendo uma da genitora de Benta e mais 3 indivíduos adultos impossibilitados de reabilitação, optamos pela





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Fig. 2: Cuidados e reabilitação usando técnicas integrativas como a ozônio-terapia e laser-terapia.

Care and rehabilitation using integrative techniques were applied, such as ozone and laser therapy. Photos: Instituto Vida Livre

eutanásia a campo, a fins de neutralizar o desgaste dos mesmos (Fig 3). Após mais alguns dias (+/- treze dias) resgatamos mais um indivíduo macho, com os mesmos sinais clínicos, porém optamos por levá-lo, pois, o mesmo apresentava lesões subjetivamente mais brandas, mas durante avaliação minuciosa constatou exposição óssea com quadro irreversível, optamos novamente pela eutanásia. Posteriormente as idas eram feitas em dias alternados e observamos que os intervalos entre os avistamentos estavam aumentando.



Fig. 3: Carcaças de queixadas, e indivíduos adultos impossibilitados de reabilitação.

White-lipped peccary carcasses and surviving individuals with injuries too severe for rehabilitation. Photos: Instituto Vida Livre

Após alguns dias o pantaneiro Jamilson da Silva, que nos acompanhava como guia e piloto, fez a observação que após aquelas duas primeiras chuvas, era comum que os grupos de queixadas saíssem daquele local, a fim de evitar locais que possivelmente seriam inundados, o que veio a coincidir com um intervalo maior no avistamento do grupo.

Com aproximadamente mais uma semana avistamos novamente o grupo no mesmo local e já





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Fig. 4: Benta quase recuperada.

Benta almost recuperated.

Photo: Instituto Vida Livre

apresentavam fêmeas no terço final da gestação e recém paridas, o que nos leva a suspeitar que o grupo poderia ter se agregado a outros ou que a visualização anterior do grupo não se deu de forma completa, devido a alguns fatores subjetivos como, a maior movimentação no Rio Mutum que fica próximo ao local, a identificação de pegadas de cão doméstico próximo ao ambiente e ao possível início das chuvas, que não se estabeleceu.

Com o tempo, o bando não estava mais sendo avistado pela equipe, assim foi instalado câmeras trap próximas dos pontos de alimentação, que identificou o grupo pela última vez. Através da utilização de camera-trap, identificou-se a movimentação de animais em pontos estratégicos, que eram abastecidos diariamente com água e alimento de forma a garantir a sobrevivência desses animais. Essas informações contribuem para o monitoramento e identificação das espécies locais sobreviventes.

Benta terminou seu tratamento e retornou à natureza após a equipe localizarem um local segura, onde já havia um grupo de queixadas que poderia acolhê-la novamente.

Video clips of the peccaries at the mudhole: Videos dos queixadas encontrado no lameiro

<https://www.instagram.com/p/CF64wTOFPP0/?igshid=1jpw9uqijj3qb>

<https://www.instagram.com/p/CGCfC-rsWyV/?igshid=1oqr10ho6yb9>

Entrevista com Rogerio Leonel Vieira:

<https://www.instagram.com/tv/Clgwx97pYgW/?igshid=ld95pkr4l6ow>

Soltura da Benta (Benta's release back to nature after 1 month of treatment)

<https://www.instagram.com/tv/CljCuxhpBnv/?igshid=10x8b5s485x60>

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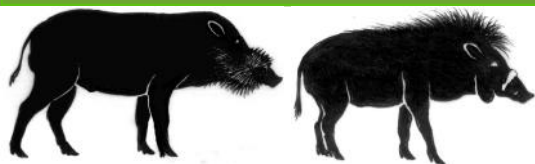
Vida Selvagem- Assistência Médico Veterinária; IEB - Projeto Lontra, Aquaplan, Dna. Alice e a equipe da Pousada Mutum, Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA), Projeto Queixada/Peccary Project.

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Preliminary protocol on capture and immobilization techniques for *Tayassu pecari* and *Pecari tajacu* - experiences learned from the Atlantic Forest, Pantanal and Cerrado of Brazil

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In Brazil, there are two species that belong to the Tayassuidae family, the collared peccary (*Pecari tajacu*) and the white-lipped peccary (*Tayassu pecari*). White-lipped and collared peccaries play multiple ecological roles in tropical ecosystems, and both species impact forest biodiversity through their ecological roles as fruit dispersers, ecosystem engineers, and prey for large carnivores (Keuroghlian and Eaton 2008,2009; Beck et al 2018). The larger white-lipped peccary's IUCN species status is vulnerable for their full geographic range, but it varies across Brazilian biomes from endangered in the Cerrado to critically endangered in the highly-fragmented Atlantic Forest (Keuroghlian et al 2012; Keuroghlian et al. 2013). Peccary populations continue to decline throughout their biogeographical range (Keuroghlian et al 2018). Here we present a preliminary protocol for capturing and handling individuals of both species for management and conservation purposes. The main purpose of this document is to help future researchers with information that will guarantee the well-being of the peccaries and the researcher/managers.

Capture

Trap box: 120 cm length x 90 height x 60 cm width with 2.5 cm x 2.5 cm width of the mesh of the grid not to hurt the snout. A type of portable corral trap (2.5m x 2.5m wire



Fig. 1: Examples of the trap, grid mesh size, corral traps, and example of canvas/plastic cover for capturing white-lipped and collared peccaries. Photos: M. Schiavo Nardi and A. Keuroghlian



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Fig. 1 continued.

mesh size) can also be used. Wire mesh trap boxes or corals require using a canvas/plastic cover for traps to minimized stress and injuries for the captured animals. When humans approach the trap they will bang against the sides. It is best to cover them immediately (Fig. 1).



Guillotine or drop-style doors are called "single-catch", baited with salt, corn, manioc and native fruits (Fig. 2).



Hand nets: interesting to use on young individuals and / or when the animal is weak and bruised and cannot run much. Length handle: 120 cm; Diameter: 60cm; Net depth: 100 cm



Fig. 2: Guillotine or drop-style technique. Photos: M. Schiavo Nardi and A. Keuroghlian





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Fig. 3: Showing the animal in the nylon net and how it could be transported. In this case we use this technique to weigh the captured animals, but it can be used to carry the animal. Photo: M. Schiavo Nardi and A. Keuroghlian

We have also used **nylon-type nets** to throw on the very sick or injured animal because it cannot run much, and then we carry them to a location so it can receive medical attention, as shown in Fig. 3.

Gediendson Araújo DMV, MSc, PhD et al (2020) uses a modified foot snare to capture jaguars and once caught a white-lipped peccary. The capture went smoothly; however, this was an isolated incident.

Anesthetic Dart Shooting may also be a possibility, but the authors do not have experience with this methodology. Anesthetic rifles take some time to take make the animal run quite a distance before the effect of anesthesia.

The advantages and disadvantages of each method are described in Table 1.

Chemical restraint

There is no evidence of sexual dimorphism in relation to size and weight between males and females for these two species. Therefore treatment between sexes for adults are the same (Keuroghlian and Desbiez 2010; Reyna-Hurtado et al 2018). The main risk when handling animals in this family are bites, given that their canines have great potential for injury and skin perforation.

In the cage, corral or other form of capture, it is recommended to cover the cage completely with a sheet, or dark plastic (the noise of the researchers scares the animals), before anesthetizing the animals, so that it does not keep banging against the cage (Fig. 1). **ATTENTION!** Collared peccaries, *P. tajacu*, are skittish, and will bang much more against the cage. It is important to cover the cage immediately. Pig pens made out of boards helps reduce the stress because there is less visibility for the animal.

The anesthetic should be applied as soon as possible, and this will vary according to the capture method; however,

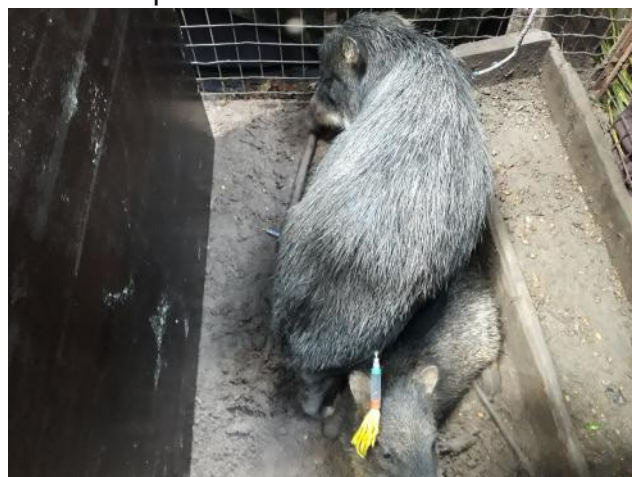


Fig. 4: The neck musculature and / or the posterior thigh muscle are the most used locations to inject the tranquilizer dart. Photos: M. Schiavo Nardi and A. Keuroghlian





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Tab. 1: Advantages and disadvantages for different capture methods.

Advantages	Disadvantages
Box traps	
Safe for staff and animal.	Catching a low number of animals at the same time
Allows you to carry out a capture management plan, with tranquility, maintaining the animals in a calm and safe environment.	The snout may get injured from hitting against the fence when trying to escape.
Traps are mobile, allowing rapid assembly and disassembly in different locations.	Need for animals to temporarily adapt to cages, a smaller space
Disarming of trap door can be done automatically and with the use of a trap site transmitters. Or by waiting to release the door when animals seen in the cage.	To select a trap location, prior knowledge of the area and peccary use facilitates selecting ideal locations.
	Despite traps allowing for more mobility and installation in a variety of locations, the material, usually made of iron, is quite heavy.
Corral traps	
Safe for staff and animal.	The construction demands a lot of material, which may be infeasible in situations where the displacement must be done on foot.
Enables the capture of several individuals of the herd at the same time	Little or no mobility of setting up the corral trap in different locations. The seasonal use of their home range, may lead to unsuccessful captures. However, if placed in an area of seasonal overlap, then success can be all year long. Or the researcher can set up corral traps in key locations for each season. This involves prior research.
When planned, the design of the corral trap allows separating individuals if necessary during handling, providing greater tranquility and safety for staff and animals.	Need for animals to temporarily adapt to corral.
Disarming of trap door can be done automatically and with the use of trap site transmitters. Or by waiting at a hideout to release the door when animals seen in the corral.	Larger area to ensure covering the corral to reduce animal stress (Fig. 1)
Nets	
Enables the capture of several individuals of the herd at the same time	Higher risk of injuries for animal and staff.
No adaptation period necessary for the animals.	Need to have someone waiting for the herd to arrive.
	There is no time for team planning and transportation to the location
	Management is more stressful for the animals and staff.
Anesthetic Dart Shooting	
No adaptation period necessary for the animals.	Need to be an experienced shooter.
Little material needed to transport in the field.	May cause injury to animal.
High mobility in the landscape.	Possibility of losing the animal after it is shot.
	Need for anesthetic drugs with a short latency period (limitation of the drug spectrum).
	Capture only one individual at a time.





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the use of an injection applicator to apply tranquilizer darts at a short range while the animal is in the cage or corral, is the most effective way of anesthetize the animals. This can be done with a blowgun, pneumatic pistol or rifle. The darts must be 3 or 5 ml, and can be charged with CO₂, butane or air. The neck musculature and / or the posterior thigh muscle are the most used sites (Fig. 4) for inserting the dart. The main venous access routes include the medial and cephalic saphenous veins (Fig. 5).



Fig. 5: The main venous access routes include the medial and cephalic saphenous veins. Photos: M. Schiavo Nardi and A. Keuroghlian

Tayassuidae are very susceptible animals to hyperthermia, and there are reports of capture myopathy for collared peccaries (Batista et al., 2008; Paula, et al., 2001). In this case, it is recommended to avoid the hottest hours of the day and avoid stressful activities during the capture and management of these animals. Such behaviors include excessive and unnecessary noises, such as talking loudly and manipulating the equipment loudly, not applying the visual barrier of the trap, mishandling the animals because of an inadequate anesthetic plan, or even poor physical restraint methods, among others factors.



Fig. 6: Monitoring physiological parameters during the anesthetic procedure of an adult white-lipped peccary (*Tayassu pecari*). Photo: M. Schiavo Nardi and A. Keuroghlian

Monitoring the physiological parameters is extremely important, and allows for identifying irregularities and reversing the problem quickly (Fig. 6). The basic parameters that we must measure are temperature, heart rate, respiratory rate, oxygen saturation, and blood pressure. These parameters may change according to the anesthetic protocol used, and the responsible veterinarian must be aware of the changes that the protocol may generate.

In general, the rectal temperature of an adult white-lipped peccary varies between 36 to 38.5°C. Temperatures above 40°C





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should receive treatment to reverse this high temperature. This can be done with a rectal enema and room temperature water, intravenous infusion of saline or Ringer's Lactate, and keep the animal wet, and place cold thermal bags on the inner thigh, neck, among other locations. Temperatures below 35°C should be treated for hypothermia; we used some of the same procedures described above; however, with heated liquids, use of covers and / or thermal blankets and never wet the animal.

As mentioned above, heart rate and respiratory rate vary according to the anesthetic protocol used and the age of the animal, and the responsible veterinarian must consider this when measuring the parameters. In general, for an adult white-lipped peccary, heartbeats should be around 60 to 100 bpm, regardless of the protocol. The respiratory rate should vary between 12 to 40 breaths per minute. Young animals tend to have both higher heart and respiratory frequencies than adults.

**** Always keep the eyes covered** with a cloth so as not to stress the animal during manipulation. When the animal is in the cage, it is always recommended to use a visual barrier, such as a sheet or dark plastic, before anesthetizing and when the animal is waking up after the procedure.

The anesthetic protocol that will be used varies according to the form of capture and the objective of the procedure. Protocols of animals contained in traps may differ from animals captured using dart shooting, and consideration must be observed for the latency period of the drug. Some anesthetic protocols used include: tiletamine hydrochloride and zolazepam (Zoletil® or Telazol®), the combination of ketamine, midazolam and xylazine, the combination of ketamine, midazolam, detomidine and butorphanol, and others.

Chemical restraint for white-lipped peccary (*T. pecari*): Tiletamine and zolazepam hydrochloride (@Zoletil) with a dosage of 4-5 mg/kg has the advantage of a short-latency, and it is relatively safe regarding cardiorespiratory depression. However, it has prolonged recovery, recovery and agitated induction, as well as elevated blood pressure and heart and respiratory rates which can cause hyperthermia on hot days. Our experience with the association of ketamine (5mg / kg), detomidine (0.02mg / kg), midazolam (0.5mg / kg) and butorphanol (0.1 mg / kg), showed positive results, with stability of the parameters, induction and a smooth recovery. Repeated supplementation of the anesthetic with ketamine can lead to seizures.

In captive animals, Selmi et al. (2013) evaluated the association of tiletamine-zolazepam / butorphanol (1.46 / 0.14 mg/kg) and tiletamine-zolazepam / xylazine (1.23 / 1.23 mg/kg), with satisfactory results for a simple procedure lasting an hour.

Chemical restraint for collared peccaries (*P. tajacu*)

In general collared peccaries take longer to recuperate from anesthetic compared to white-lipped peccary when using the association of tiletamine and zolazepam hydrochloride (@Zoletil), the dosage of 2.75 mg/kg is adequate to perform management procedures involving weighing, biometrics, gps/vhf collar placement, and blood collection. Our experience with captive animals has shown that the use of 5 mg/kg of ketamine, 0.5 mg/kg of midazolam and 0.5 mg/kg of xylazine, enabled the clinical evaluation of the animal and collection of biological material for approximately 30 minutes.





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The combination of tiletamine and zolazepam hydrochloride (@Zoletil), associated with xylazine has already been described in the literature with satisfactory effects with dosages of 2.35 mg/kg and 2.35 mg/kg, respectively (Gabor, 1997).

For collared peccaries in captivity, the combination of tiletamine-zolazepam/butorphanol (1.68 / 0.17 mg/kg) and tiletamine-zolazepam/xylazine (1.51 / 1.51 mg/kg) did not show satisfactory results for sedation (Selmi et al. 2013).

For both white-lipped and collared peccaries: it takes about 10 to 12 minutes (this can vary depending on ambient temperature, animal age, etc.) for the anesthetic to take effect, and allows for 30 to 40 minutes to work with the animals.

To help estimate anesthetic dose, data on head-body length and weight of animals in different age classifications are presented in Figures 7 and 8, Table 2 presents age classification based on tooth wear (Keuroghlian and Desbiez 2010).

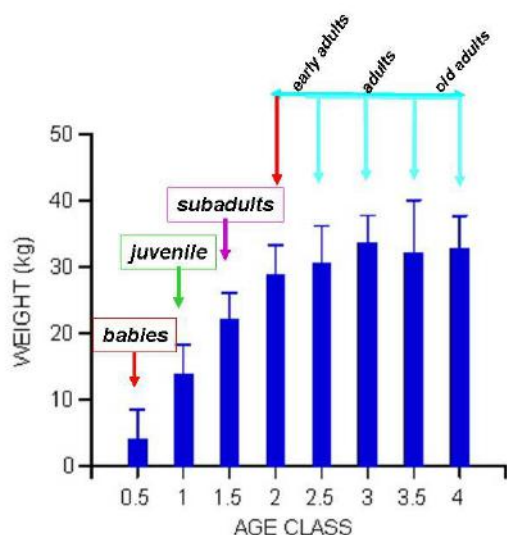


Fig. 7: Mean and SD for weights of white-lipped peccaries (*Tayassu pecari*) at Fazenda Rio Negro, Aquidauana, Mato Grosso do Sul, Brazil (2001 – 2005).

Source Keuroghlian and Desbiez 2010.

Vehicle transportation: should be inside a wooden box completely closed and with ventilation holes (Fig. 9).

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Data on head-body length and weight of adult wild collared peccaries captured in the Pantanal can be found in Table 3.

After the procedure, the animal should be placed back in the trap, covered with a sheet or cloth and kept in silence, being released only after complete recovery from anesthesia. The animal should not be released when it is still wobbly or unstable. It could take 4 to 6 hours. We know from experience from radio tracked animals that they are able to locate other members of the herd within a day.

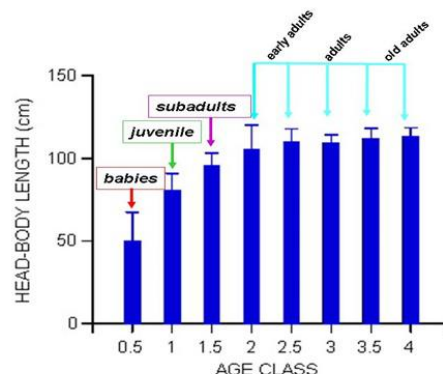


Fig. 8.: Mean and SD for head-body measurements of white-lipped peccaries at Fazenda Rio Negro, Aquidauana, Mato Grosso do Sul, Brazil (2001 – 2005). Source: Keuroghlian and Desbiez 2010.





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Tab. 2: Modified age classification from Bodmer et al., (1997) and Maffei (2003) for peccaries source: Keuroghlian e Desbiez 2010).

Age class	Age in years	Class description
0.5	≤ 5 months	baby
1	6-10 months	juvenile
1.5	1 - 2	subadult
2	2 - 3	young adult
2.5	3 - 5.5	young adult
3	5.5 - 8	adult
3.5 - 4.0	7 - 9+	old adult

Body measurements	Mean	Max.	Min.
Head-body (cm)	92	99	87
weight (kg)	18	24	12

<https://doi.org/10.1111/2041-210X.13516>

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Tab. 3: Biometric data of collared peccaries, *Pecari tajacu*, from adults (N=21); captures from the southern Pantanal, Mato Grosso do Sul, Brazil; source: Alexine Keuroghlian (unpublished data).

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Fig. 9: An example of wooden box completely closed and with ventilation holes for vehicle transportation. Photo: M. Schiavo Nardi and A. Keuroghlian





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Protocolo preliminar para técnicas de captura e imobilização a campo de *Tayassu pecari* e *Pecari tajacu*; experiências da Mata Atlântica, Pantanal e Cerrado do Brasil

No Brasil, ocorrem duas espécies da família Tayassuidae, o cateto, também conhecido como caititu/cateto (*Pecari tajacu*) e o queixada (*Tayassu pecari*). Os pecarídeos desempenham vários papéis ecológicos em ecossistemas tropicais, e ambas as espécies impactam a biodiversidade da floresta por meio de seus papéis ecológicos como dispersores de frutas, engenheiros de ecossistemas e presas para grandes carnívoros (Keuroghlian e Eaton 2008,2009; Beck et al 2018). O status de espécie IUCN dos queixadas é vulnerável em toda a sua distribuição geográfica, mas varia entre os biomas brasileiros: ameaçado de extinção no Cerrado a criticamente ameaçado na altamente fragmentada Floresta Atlântica (Keuroghlian et al 2012; Keuroghlian et al. 2013) . As populações de pecarídeos continuam diminuindo em toda sua região biogeográfica (Keuroghlian et al 2018). Aqui apresentamos um protocolo para captura e manusear indivíduos de ambas as espécies para fins de manejo e conservação. O principal objetivo deste documento é apresentar informações que garantam o bem-estar dos pecarídeos e do pesquisador / veterinário / zootecnista.

Captura: Ao capturar com armadilhas, currais ou armadilhas, eles devem ser visitados duas vezes ao dia para garantir que outros animais não tenham sido capturados e para evitar que os animais capturados fiquem presos por longos períodos de tempo. Os transmissores do local de armadilha podem falhar, por isso é necessária uma verificação pessoal.





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Caixa-armadilhas: 120 cm comprimento x 90 altura x 60 cm largura com 2,5cm x 2,5cm largura da malha da grade para não machucar o focinho. Também pode se usar um tipo de chiqueiro portáteis/brete (malha 2,5m x 2,5m). Armadilhas tipo gaiola e brete devem possuir alguma barreira visual, em virtude dos animais investirem contra a grade em situações de estresse, ao nos aproximarmos. A barreira visual pode ser de algum tecido, plástico ou de madeira (Fig. 1). Sistema da porta é guilhotina, iscados com sal, milho, mandioca e frutos nativos (Fig. 2).

Puçás: interessantes usar em filhotes e/ou quando o animal está fraco e machucado e não consegue correr muito. Extensão do cabo: 120 cm fixo; Diâmetro: 60cm; Profundidade da gaiola: 100 cm.

Também já usamos tela tipo nylon para jogar em cima do animal bastante doente ou machucado porque não consegue correr muito, e depois carregamos como indicado na Fig. 3.

Gediendson Araújo DMV, MSc, et al (2020) usa armadilhas de laço para captura onça pintada e funcionou uma vez com queixada; mas são poucas experiências com armadilhas de laço no pé (de Araujo et al 2020).

Tiro livre à distância com dardos anestésicos também pode ser uma possibilidade, mas os autores não tem experiência com esta metodologia.

As vantagens e desvantagens de cada método estão descritos na Tabela 1.

Contenção química:

Não há evidências de dimorfismo sexual em relação ao tamanho e peso entre machos e fêmeas para essas duas espécies. e, portanto, o tratamento entre os sexos para adultos é o mesmo (Keuroghlian and Desbiez 2010; Reyna-Hurtado et al 2018). O principal risco ao manejarmos animais deste grupo são as mordeduras, tendo em vista que os caninos possuem grande potencial de injúria e perfuração da pele.

Na gaiola, chiqueiro ou qualquer forma de captura, recomenda cobrir totalmente com um lençol, ou plástico escuro (o barulho dos pesquisadores assusta o animais), antes de anestésiar para o animal não ficar se batendo na gaiola (Fig. 1). **Atenção** para *P. tajacu*, ou cateto, é muito mais arisco, e ira se bater mais dentro da gaiola. Importante cobrir a gaiola imediatamente. O uso de chiqueiros feitos de tábua de madeira ajuda a minimizar o estresse, tendo em vista que diminuem o alcance de visão do animal.

O anestésico deve ser aplicado o quanto antes, e varia de acordo com o método de captura, no entanto, o uso de dardos tranquilizantes aplicados de forma remota é a maneira mais utilizada, com auxílio de zarabatana, pistola pneumática ou rifle. Os dardos devem ser de 3 ou 5 ml, tendo como propelente o CO₂, butano ou ar comprimido. A musculatura do pescoço e/ou o músculo posterior da coxa são locais mais utilizados (Fig. 4) para o alcance do dardo. As principais vias de acesso venoso incluem a safena medial e a cefálica (Fig. 5).

Os tayassuídeos são animais bastante susceptíveis a hipertermia e há relatos de episódios de





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miopatia de captura em catetos (Batista et al., 2008; Paula, et al., 2001). Neste sentido, recomenda-se evitar as horas mais quentes do dia e condutas estressantes durante as atividades de captura e manejo deste bando. Tais condutas incluem barulhos excessivos e desnecessários, como falar alto e manipular os equipamentos fazendo ruído de forma desnecessária, não promover a barreira visual da armadilha, realizar o manejo com o animal sem plano anestésico adequado ou até mesmo através de contenção física, dentre outros fatores.

O monitoramento dos parâmetros fisiológicos é de extrema importância, tendo em vista que permite identificar e reverter, ainda no início, suas alterações (Fig. 6). Os parâmetros básicos que devemos mensurar são temperatura, frequência cardíaca, frequência respiratória, saturação de oxigênio e pressão. Estes parâmetros podem sofrer alterações de acordo com o protocolo anestésico utilizado, e o veterinário responsável deve estar ciente das alterações que o protocolo utilizado gera.

De maneira geral, a temperatura retal de um queixada adulto varia entre 36 a 38,5°C. Temperaturas acima de 40°C devem receber tratamento de suporte para reversão desta, através de enema retal com água a temperatura ambiente, infusão intravenosa de soro fisiológico ou Ringer Lactato, molhar o animal e bolsas térmicas geladas na face interna da coxa, pescoço, dentre outros locais. Temperaturas abaixo de 35°C devem receber tratamento para hipotermia, utilizamos alguns dos procedimentos descritos acima, porém, com os líquidos aquecidos, utilizar cobertas e/ou mantas térmicas e nunca molhar o animal.

Como citado acima, a frequência cardíaca e frequência respiratória variam de acordo com o protocolo anestésico utilizado e a idade do animal, e o veterinário responsável deve considerar na hora de aferir os parâmetros. De maneira geral, os batimentos cardíacos devem girar em torno **de 60 a 100**, independente do protocolo, em um queixada adulto. A frequência respiratória deve variar entre 12 a 40 movimentos respiratórios por minuto. Animais filhotes tendem a ter ambas frequências maiores que de adultos.

**** Sempre manter o olho coberto** com um pano para não estressar o animal durante a manipulação. Quando o animal estiver na gaiola recomenda-se sempre mante-lo com barreira visual, com um lençol ou plástico escuro, antes de anestesiá-lo e quando o animal está acordando.

O protocolo anestésico que será utilizado varia de acordo com a forma de captura e o objetivo do procedimento. Protocolos de animais contidos em armadilhas podem diferir de animais capturados no tiro livre, tendo em vista que devemos levar em consideração o tempo de latência do fármaco. Alguns protocolos anestésicos utilizados durante atividades do projeto queixadas incluem o cloridrato de tiletamina e zolazepam (Zoletil® ou Telazol®), a associação de quetamina, midazolam e xilazina, a associação da quetamina, midazolam, detomidina e butorfanol, dentre outros.

Contenção química em Queixada (*T. pecari*)

O cloridrato de tiletamina e zolazepam (Zoletil) na dosagem de 4-5 mg/kg possui a vantagem de ter curto período de latência, e relativa segurança quanto a depressão cardiorrespiratória, no entanto, possui prolongada recuperação, recuperação e indução agitados, assim como elevação





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da pressão arterial e frequências cardíacas e respiratórias, podendo favorecer hipertermia em dias quentes. Na nossa experiência, a associação da quetamina (5mg/kg), detomidina (0,02mg/kg), midazolam (0,5mg/kg) e butorfanol (0,1 mg/kg), apresentou bons resultados, com estabilidade dos parâmetros, indução e retorno tranquilos. Em animais de cativeiro, Selmi et al. (2013) avaliaram a associação tiletamina-zolazepam/butorfanol (1,46/ 0,14 mg/kg) e tiletamina-zolazepam/ xilazina (1,23/1,23 mg/kg), com resultados satisfatórios para um procedimento simples de até uma hora.

Contenção química em Cateto (*T. tajacu*)

O cateto apresenta maior período de recuperação que o queixada, utilizando a associação da tiletamina e zolazepam, sendo a dosagem de 2,75 mg/kg adequada para realizar um procedimento de manejo envolvendo pesagem, biometria, instalação de colar e coleta de sangue.

Em experiência pessoal com animais de cativeiro, a utilização de 5 mg/kg de quetamina, 0,5 mg/kg de midazolam e 0,5 mg/kg de xilazina, possibilitou a avaliação clínica do animal e coleta de material biológico, num procedimento em torno de 30 minutos. A associação cloridrato do tiletamina e zolazepam (Zoletil), associada a xilazina já foi descrita na literatura, apresentando efeitos satisfatórios, na dosagem de 2,35 mg/kg e 2,35 mg/kg, respectivamente (Gabor, 1997).

Em catetos de cativeiro, a associação tiletamina-zolazepam/butorfanol (1,68/0,17 mg/kg) e tiletamina-zolazepam/ xilazina (1,51/1,51 mg/kg) não apresentaram resultados satisfatórios para sedação (Selmi et al. 2013).

***Para Queixada e Cateto**, na dosagem citada acima, o tempo de latência é de 10 a 12 minutos e varia com a idade do animal, proporcionando cerca de 30 a 40 minutos de procedimento.

Dados de comprimento e peso de animais em diferentes classes etárias estão apresentados nas Figs. 7 e 8, para ajudar na estimativa de quantidade de anestésico. A Tabela 2 apresenta dados da idade de cada classe etária baseados em gasto dentaria (Keuroghlian e Desbriez 2010).

Dados de peso e comprimento de catetos adultos capturados no Pantanal podem ser encontrados na Tabela 3.

Após o procedimento, o animal deve ser recolocado na armadilha, coberto com lençol ou pano e mantido em silêncio, sendo solto apenas após completa recuperação da anestesia. O animal não deve ser solto quando ainda está instável e sem equilíbrio. Isso pode levar de 4 a 6 horas. Sabemos por experiências anteriores que os animais são capazes de localizar outros membros do bando no prazo de um dia.

Transporte em veículo: deveria ser dentro de caixa de madeira completamente fechada e com buracos para ventilação (Fig. 9).

Figura 1: Exemplos da gaiola, tamanho da malha da grade, chiqueirinhos e exemplo de barreira visual para captura de queixadas e catetos.

Figura 2: Sistema de guilhotina usado.

Figura 3: Mostrando o animal na tela de nylon e como poderia carregar desta forma. Aqui foi uma forma de pesar, mas pode ser utilizada para andar com o animal sedado na tela.

Figura 4: A musculatura do pescoço e/ou o músculo posterior da coxa são locais mais utilizados para injetar com dardo.

Figura 5: As principais vias de acesso venoso incluem a safena medial e a cefálica

Figura 6: Monitoramento dos parâmetros fisiológicos durante o procedimento anestésico em queixada adulta (*Tayassu pecari*).





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Figura 7: Média e desvio padrão do peso de queixadas (*Tayassu pecari*) para machos e fêmeas, e diferentes categorias de idade. Dados coletados entre 2001 e 2005 na Fazenda Rio Negro, Aquidauana, Mato Grosso do Sul, Brasil (N=233). Fonte: Keuroghlian e Desbiez 2010.

Figura 8: Média e desvio padrão do comprimento corporal (ponta do focinho ate base do rabo) de queixadas adultos (*Tayassu pecari*) para machos e fêmeas, de diferentes categorias de idade. Dados coletados entre 2001 e 2005 Pantanal Sul, Aquidauana, Mato Grosso do Sul, Brasil (N=233). Fonte: Keuroghlian e Desbiez 2010.

Figura 9: Exemplo de caixa de madeira completamente fechada e com buracos para ventilação ideal para uso de transporte no veículo.

Tabela 1 Vantagens e desvantagens para diferentes metodos de captura.

Vantagens	Desvantagens
Gaiola	
Segurança para a equipe e para o animal	Captura de um número baixo de animais ao mesmo tempo
Permite realizar um planejamento do manejo, com tranquilidade, mantendo os animais em local tranquilo	Pode ocasionar lesões no focinho do animal, quando o mesmo se choca contra a grade
Mobilidade, permitindo montar e desmontar em diferentes locais	Necessidade de adaptação dos animais a gaiola
Desarme pode ser feito de forma automática ou através de espera, e com <i>trapsite transmitters</i>	Para escolha do local onde a gaiola será instalada, há necessidade de conhecimento prévio da área, instalando a mesma nos regiões mais frequentadas pelos animais
	Apesar de permitir mobilidade e instalação em diferentes locais, o material, geralmente feito de ferro, é bem pesado
Curral ou brete de captura	
Segurança para a equipe e para o animal	A construção demanda muito material, que pode ser inviável em situações onde o deslocamento deve ser feito a pé
Possibilita a captura de vários indivíduos do bando ao mesmo tempo.	Pouca ou nenhuma mobilidade para montar um curral em locais diferentes. O uso sazonal de sua área de vida pode levar a capturas sem sucesso. No entanto, se colocado em uma área de sobreposição sazonal, o sucesso pode ser o ano todo. Ou o pesquisador pode montar currais em locais-chave para cada estação. Envolve pesquisa.
Quando planejado, o desenho do brete permite separar os indivíduos durante o manejo, conferindo maior tranquilidade e segurança para equipe e animais.	Necessidade de tempo de adaptação dos animais ao brete.
Desarme pode ser feito de forma automática ou através de espera.	Exige maior area para cobrir a parte exterior do curral para reduzir stress dos animais (Fig. 1).
Redes	
Possibilita a captura de vários indivíduos do bando ao mesmo tempo.	Alto risco de injúrias para a equipe.
Não há necessidade de tempo de adaptação dos animais à armadilha.	Necessidade de manter alguém na espera do bando.
	Não há tempo para planejamento e deslocamento da equipe.
	Manejo é mais estressante para os animais e equipe
Tiro livre	
Não há necessidade de tempo de adaptação dos animais à armadilha.	Necessidade de experiência e perícia do atirador.
Pouco material para transportar no campo	Possibilidade de causar injúrias no animal.
Alta mobilidade na paisagem.	Possibilidade de perder o animal do alcance após o tiro.
	Necessidade de drogas anestésicas de período de latência curto (limitação do espectro de drogas).
	Captura de um indivíduo por vez.





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Tabela 2: Classificação de idade através de desgaste dentários de *Tayassu pecari* modificada do Bodmer *et al.* (1997) e Maffei (2003). Fonte: Keuroghlian e Desbiez 2010).

Classe de idade	Idade em anos	Descrição da classe
0,5	≤ 5 meses	filhote
1	6-10 meses	juvenil
1,5	1 - 2	sub adulto
2	2 - 3	adulto jovem
2,5	3 - 5,5	adulto jovem
3	5,5 - 8	adulto
3,5 - 4,0	7 - 9+	adulto+

Tabela 3: Biometria de *Pecari tajacu* adultos (N=21) no alto e baixo Rio Negro, sub-região Pantanal Sul, Mato Grosso do Sul. Fonte: Alexine Keuroghlian (dados não publicados).

Medidas corporais	Média	Máximo	Mínimo
Comprimento corpo (cm)	92	99	87
Peso (kg)	18	24	12

Pig in clover: how the world's smallest wild hog was saved from extinction

<https://www.theguardian.com/environment/2021/mar/03/how-the-pygmy-hog-was-saved-from-extinction-aoe>

Kalpana Sunder, The Guardian, 3 Mar 2021

The pygmy hog is still endangered but a reintroduction programme in Assam, India, has given it a greater chance of survival.

The greyish brown pygmy hog (*Porcula salvania*), with its sparse hair and a streamlined body that is about the size of a cat's, is the smallest wild pig in the world, and also one of its rarest, appearing on the International Union for Conservation of Nature (IUCN) red list as endangered.

The pygmy hog's habitat has increasingly come under pressure from human encroachment, overgrazing and the clearing of land for agriculture. "The pygmy hog is the first to disappear when the habitat changes, unlike its cousin the wild boar which adapts well to changes in its environment," says Dr Goutam Narayan, project adviser at the Pygmy Hog Conservation Programme (PHCP).

"Though we tend to focus on



An adult male pygmy hog. Photo: P.J. Deka





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conservation of habitats for large iconic animals like the rhino, small animals like the pygmy hog are great barometers of habitat, and we should manage these eco-sensitive animals better. They draw our attention to even minute changes in the grasslands, much before the larger species,” he adds. In the 1960s, the pygmy hog was thought to be extinct, before it was “rediscovered” by a tea estate manager in 1971. Early attempts to introduce captive breeding failed until 1995, when the PHCP was established by the Durrell Wildlife Conservation Trust, the IUCN Wild Pig Specialist Group, Assam’s forest department and India’s environment ministry. The organisation set up a captive breeding programme with the aim of reintroducing the animals into the wild. “The successful captive breeding started with six hogs caught in Manas reserve in Assam,” says Parag Deka, PHCP’s project director, a veterinary scientist who joined the programme in 1997 as an intern. “Reintroduction of the captive hogs into the wild began in 2008, with 16 pygmy hogs released into the Sonai Rupai wildlife sanctuary,” he adds. At the PHCP’s Assam headquarters in Basistha, the animals are bred and eventually released into Orang, Sonai-Rupai, and Bornadi wildlife sanctuaries. Before they are released into the wild, the hogs are kept in a special facility for five months.

“The Durrell Wildlife Conservation Trust has experience of bringing back several species from the brink of extinction, like the Madagascar teal and the Rodrigues fruit bat, and sophisticated methods of captive breeding are followed, learning from the species and fulfilling their requirements in the wild,” says Deka. “We make sure that the pygmy hogs live with minimal human contact, their supplementary diet is reduced to 15% and they learn to forage and build social relations with other hogs, before they are released into the wild. About 12 hogs a year are released.” An omnivore that feeds on tubers, fruit, grass, insects, eggs and small reptiles, the pygmy hog is one of the few mammals in the world that actually builds a house – a shallow depression in the earth lined with vegetation and even a roof of branches. Once reintroduced into the wild, however, keeping track of the hogs is no easy task. “They are extremely shy and elusive creatures and it’s almost impossible to sight them during field work,” says Narayan. “With the help of camera traps as well as tracking their droppings and footprints, we manage to keep track of the hogs, and evidence of breeding,” adds Deka. “We made several attempts to develop better tracking systems and now use a coin-sized implant.” The grasslands that are their habitat protect forest lands from floods and provide fodder for livestock. “We work with local communities and the forest department in proper management of grasslands, restricting overgrazing and suggesting alternatives to burning the entire grasslands,” says Deka.

“Burning of grassland to encourage fresh growth during the dry season is the greatest threat to pygmy hogs, as they need thick cover and build grass nests throughout the year.”

The PHCP’s aim, says Deka, is that by 2025, on the 100th anniversary of British naturalist Gerald Durrell’s birth, “the ecosystem will be restored, and the pygmy hog can thrive once again in these grasslands”. “The purpose of my life has been bringing back this one species from the brink of extinction,” he adds.

The PHCP is optimistic that the goal will be reached but, says Narayan: “Though we have these milestones to achieve we also need to be aware of the various constraints – social and people-related issues that are interconnected with the conservation of the pygmy hog, from encroachment to supporting local livelihoods.

“Our attempt is to sensitise the community to conserving these last remaining pockets of grasslands, which are important habitats for not only the pygmy hogs, but for many other animals and birds.”





This 45,500-year-old pig painting is the world's oldest animal art

<https://www.nationalgeographic.com/science/article/45500-year-old-pig-painting-worlds-oldest-animal-art>

Maya Wei-Haas, National Geographic, 13 January

The depiction of a warty pig adds to the mounting number of cave art finds throughout Indonesia. Some 45,500 years ago, on the Indonesian island of Sulawesi, ancient humans ventured into a cave and sketched out the rotund form of a native pig, complete with a bristly back and face warts. Archaeologists now believe this portly swine marks the oldest drawing of a creature yet discovered anywhere in the world. In a study published this week in *Science Advances*, an image of the drawing shows the animal apparently looking at two other pigs mid-squabble. The outlines of two human hands are positioned near the rump of the pig, and a bristly patch in the center of the mix might hint at a fourth creature. The painting, made with strokes of red ochre on the interior cave walls, was discovered in December 2017 by local archaeologist Basran Burhan, currently a Ph.D. student at Australia's Griffith University. He led a small team to search caves in South Sulawesi for traces of ancient human activity when he discovered the newfound pig art at a site known as Leang Tedongnge. According to Adam Brumm, first author of the new study and archaeologist at Australia's Griffith University, the ancient porcine painting may depict prime hunting trophies. "They're very, very, small little pigs, but these ancient artists portrayed them with such resplendent fatness, which I imagine was something to do with their interest in killing the largest and fattest pigs they could find, which yielded the largest amount of meat and protein," he



Photo: AFP





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says. While the newfound painting is the world's oldest art depicting a figure yet found, it's not necessarily the oldest art. "It depends on what definition of 'art' you use," says study co-author Maxime Aubert, an archaeologist at Griffith University. Some strikingly ancient glimmers of creativity have been recently identified, including a 73,000-year-old hashtag-like doodle from South Africa that some believe to be the oldest known drawing. But the newfound paintings do add to an increasingly rich tradition of cave art discovered throughout Indonesia. In Sulawesi alone, scientists have identified imagery in some 300 caves over the last 70 years. This includes the next-oldest figurative cave paintings—a vignette at least 44,000 years old that portrays the thrill of an ancient hunt as two- to four-inch-tall humanoids chase down pigs and diminutive relatives of water buffalo. The array of discoveries in Indonesia have started to shift scientists' thinking about when, where, and how the first sparks of human creativity flew, Aubert says, turning away from the "Eurocentric view of the world" that sophisticated painting began only when humans arrived in Europe.

Early glimmers of art

To determine when the large pig painting was created, an international team of researchers relied on radioactive uranium, which naturally forms in limestone. As water percolates through the cave, it dissolves bits of the limestone and its uranium, depositing them both in thin sheets along the cave walls. Since uranium decays into thorium at a known rate, scientists can estimate a minimum age for the art by analyzing the relative amounts of these two elements. The researchers used a small chisel to remove a knobby cluster of minerals deposited on the rear leg of the most complete pig figure for uranium-thorium dating, and the results indicated that the painting was at least 45,500 years old. It's also possible the paintings are even older, since this method only dates the mineral deposits on top of the art and not the painting itself. Without additional dating of the other elements in the scene, the authors can't yet confirm if the entire mural was created all at once. One of the partial pigs is made of two different color pigments, which the authors note might reflect multiple periods of painting.

Study co-author Adhi Agus Oktaviana, a researcher at Pusat Penelitian Arkeologi Nasional in Jakarta, Indonesia, says he gained fresh respect for the ancient artists as he digitally traced photographs of the figures for the study. "I think it's incredible. I think they knew exactly how to use the tools for drawing, how to manage the composition for the panels," says Oktaviana, who is also a Ph.D. student at Griffith University. Such early glimmers of art reflect a vital shift in the way our ancient ancestors engaged with their environment and the surrounding landscape, says April Nowell, a Paleolithic archaeologist at the University of Victoria in British Columbia who was not part of the study team. "They're imbuing their place with meaning, significance, maybe symbolic dimension," she says. The new *Science Advances* study also documents the age of another pig painting in a nearby cave—Leang Balangajia 1—discovered by the team on a 2018 expedition and dated to at least 32,000 years ago. And the age of human activity on Sulawesi Island was previously confirmed by the presence of tools used for ocher processing at the nearby site Leang Bulu Bettue, buried in sediment layers dating to at least 40,000 years old. "It's possible that they were using that pigment to create the rock art, but we haven't been able to make the direct connection between the [tools] and the rock art itself," says Brumm. Still, with the number of cave art finds of similar age in the region, Brumm thinks the connection is probable.

Changing conversations

Until recently, much of the scholarly conversation around sophisticated cave paintings has centered on Europe. The menageries that race across the walls of southern France's Chauvet-





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Pont-d'Arc cave date to roughly 36,000 years old. The herd of bison dancing on the ceiling of Altamira in northern Spain are from the same time period. And the crowd of outstretched hands and red disks of Spain's Castillo cave date back more than 40,800 years. But in 2014, a team including Aubert and Brumm flipped the script when they announced the discovery of cave paintings on Sulawesi that were at least 39,900 years old. Up to then, the artworks were presumed to be no more than 12,000 years old. "It really erodes that idea of Europe being the finishing school of human evolution," Nowell says. While the newfound creature is just a smidgen older than the previous record-holder, its discovery adds even more depth to the art in the region. "Some people could say it's just another pig," Nowell says. "But that's not the point, it really speaks to a larger sustained change in behavior." The increasing number of discoveries in Indonesia suggests the possibility that complex artistry could have developed independently in Europe and Asia, Aubert says. Or perhaps humans already had the capacity for such works of art when they trekked out of Africa, "and now we're starting to find traces of it wherever they went." The age of the newfound art also starts to fill a 20,000-year-long blank spot in the archaeological record as ancient humans island-hopped through what is now Indonesia to Australia. Recent excavations in northern Australia have revealed the presence of modern humans at least 65,000 years ago, while evidence for human activity in Indonesia appears to begin 20 millennia later. Even with the new find, however, a chronological void still remains. There's no reason to think Sulawesi's inhabitants suddenly started painting some 45,000 years ago, Aubert says, adding it's likely older artworks are still out there. One thing is for sure, Brumm says: More surprises await. "It just shows how much artwork is there waiting to be found on this island," he says. "It's hiding in plain sight."

Research links industrial pig farming and virus outbreaks

<https://news.mongabay.com/2020/10/research-links-industrial-pig-farming-and-virus-outbreaks/>

Research links industrial pig farming and virus outbreaks

Sibélia Zanon, translated by Roberto Cataldo, Mongabay, 8 October 2020

In recent months, meatpacking companies in different parts of the world have been associated with large clusters of COVID-19 infections. The Tönnies meat-processing plant in North Rhine-Westphalia, Germany, was temporarily closed, and U.S.-based pork processor Smithfield became a major focus of the disease in South Dakota, one of the country's least-populated states. In Brazil, complaints abound about COVID-19 at slaughterhouses: 20% of the industry's workers have been infected, according to the National Confederation of Workers in Food and Related-Industries (CNTA). These outbreaks, along with China's global leadership as a pork producer, caught the attention of three researchers who started looking into the matter: Larissa Mies Bombardi, a geography professor at the University of São Paulo (USP), German pharmacist Immo Fiebrig, and Pablo Nepomuceno, a technician at USP's Laboratory of Remote Sensing and Geoprocessing. In two papers, they show the spatial correlation between increasing numbers of COVID-19 infections and intensive pig farming in Brazil, the U.S. and Germany. They also put forward a hypothesis, still unproven, that the current agriculture model, specifically industrial pig farming, may favor the spread of the virus, with the animals as contamination vectors. "This is a hypothesis, but the spatial correlation is very high," Bombardi says. They presented the state of Santa Catarina, which accounts for 25% of Brazil's pork production and a high COVID-19





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infection rate, as evidence in their first paper. The low population density in the state's western region, compared to the more crowded coastal area where infection rates are high, should have slowed the spread of the coronavirus inland. But that wasn't the case. "The novel coronavirus is moving to smaller towns in Brazil, and that is highly connected to meatpackers," Bombardi says. "This has to do with two things: unhealthy human labor and poor conditions in pig farming." The paper warns about untreated pig excrement entering into water bodies, posing the risk of infecting drinking water and spreading disease. "Testing pigs' waste would be crucial," Bombardi says. The spatial correlation between COVID-19, pig farming and low population density found in Santa Catarina is repeated in the other states in southern Brazil, a region that accounts for 66% of the country's pork production. The same pattern is seen in the United States. Northwest Germany, which has the highest pig production in the country, repeats that spatial correlation but with a higher population density, unlike the other two countries analyzed in the second paper on the topic.

Why pigs?

The widespread theory that the SARS-CoV-2, the virus that causes COVID-19, spread from a wet market in Wuhan, China, was challenged in research published in May. According to that study, the virus had been circulating in China before that, and the first animal-to-human transmission occurred before the outbreak linked to the Huanan market. Experts from the Wuhan Institute of Virology (WIV) also said the initial transmission of SARS-CoV-2 did not occur at the Huanan market, which served instead as the site where it was further disseminated. Scientists have also discounted the theory that the virus was genetically engineered in a lab and then somehow got out. What many experts do believe, though, is that there was likely an intermediary host between bats, where the virus is suspected to originate from, and humans. China is the world's largest pork producer, and Hubei province, where Wuhan is located, is one of China's five largest pork producers. "There are many similarities between pigs and us, from the respiratory system to the gastrointestinal system," Bombardi says. Pigs can catch the avian flu virus and human influenza virus at the same time, and then engender novel combinations that can be transmitted again and infect human beings.

This happened in March 2009, when a flu including respiratory infection appeared in an area close to an industrial pig farm in Mexico. The following month, the World Health Organization (WHO) declared the H1N1 swine flu pandemic. A recent study published in the journal *Proceedings of the National Academy of Sciences (PNAS)* describes the analysis of influenza viruses found in China's pigs between 2011 and 2018. They include a version of H1N1 with potentially pandemic characteristics. According to the study, the virus poses no imminent threat, but scientists have called for urgent, rigorous monitoring of the virus and human populations, especially pork industry workers.

Intensive production

Pig farming is usually intensive in Brazil: more than 70% of the animals are raised in confinement. "These animals have no access to soil or sunlight and consume mostly transgenic animal feed, because more than 90% of the soy produced in Brazil is transgenic," Bombardi says. "Their daily diets also include antibiotics or other medications because they eat and defecate in virtually the same places. So they are potentially immunosuppressed animals." For biologist Rob Wallace, the intensive animal farming practiced over the past 40 years is the cause of the new viruses that threaten the planet with epidemics and pandemics. Wallace, the author of *Pandemia e Agroindústria* (*Pandemia and Agroindustry*), now on preorder in Brazil, says that balancing





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diversity is crucial in nature. But this doesn't happen in intensive farming, where a large number of animals are packed into uniform conditions: same breed, age and biological systems. Overcrowding inhibits the immune response, he says, which makes this farming model akin to a giant pest. While Brazil is the world's fourth-largest pork producer, "competition with other countries is a challenge due to the lack of factors that support production, such as biosafety, hygiene, investment in labor and especially in animal welfare," says a March 2019 study on animal welfare in pig farming. Certain practices that are widely used in Brazil are avoided or restricted in other countries, such as the use of individual cages for pregnant animals. Conditions unfavorable to animal welfare often result in abnormal behavior, including self-mutilation, cannibalism, excessive aggression or apathy. The Brazilian swine industry says it has been waiting for two years for the Normative Instruction on Animal Welfare for swine, and that current projects in the industry should adjust to the new standards.

Higher demand for pork and soybeans

China is by far the world leader in pig farming. Next, come the European Union, the U.S. and then Brazil, which is also the fourth-largest pork exporter. According to data from the Swine Bulletin from the Center for Advanced Studies in Applied Economics (Cepea) of the Department of Economics, Administration and Sociology at the Luiz de Queiroz School of Agriculture (Esalq), in the first seven months of 2020, Brazil's pork exports hit a record high. If shipments continue at this pace, the industry estimates that, by September, it will have exceeded the 639,500 tonnes exported for all of 2019. Such high demand has caused prices to increase. Pigs are given animal feed produced from corn and soybeans; around 79% of the world's soybean production goes toward making this feed. The high demand for pork therefore translates into increased demand for grain. Fifty percent of the soybeans exported worldwide come from Brazil, and the commodity accounts for 40% of the country's total agricultural exports. Soybean plantations in Brazil cover an area the size of Germany. Industry projections indicate increasing demand for soybeans worldwide, and especially in Asia. According to estimates by the Brazilian Association of Soy Producers (Aprosoja), Brazil exported 60 million tonnes to China in 2019 and may export up to 66 million this year. With new records, Aprosoja says in its newsletter, "China continues to buy soy from Brazil because it is the 'cheapest.'"

The environmental impacts from industrial pig farming and slaughter include the threat of deforestation in the Cerrado grasslands and Amazon rainforest associated with the expansion of farmland for soybeans and corn. There's also the burning and contamination from the intensive use of pesticides to produce transgenic grains. To this, researchers add the social impact on the country's food security as crops meant for direct human consumption are crowded out. "The expansion of soy and corn plantations is clearly correlated to animal feed, both in domestic consumption and in the amount of grains that are meant for exports," Bombardi says. In February 2020, Bombardi, who is also one of the authors of the atlas *Geografia do Uso de Agrotóxicos no Brasil e Conexões com a União Europeia* (Geography of the Use of Pesticides in Brazil and Its Connections with the European Union), gave the lecture "Living under poison" on the Fru.to food platform. She quoted Uruguayan writer Eduardo Galeano by saying that "sovereignty begins at the mouth," which underscores the point that decisions about food production and consumption have their weight and consequences. Deforestation for farming and logging, along with global climate change, is taking the Amazon to a point of no return that could result in the forest's rapid extinction. A large part of this is driven by agribusiness. As the researchers warn, industrial pig farming needs to be monitored. Other effects and consequences may yet emerge. "The





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possibilities that these animals become repositories and laboratories for other viruses are enormous,” Bombardi says. “We will have to deal with that, I think, in the short term. This can be a channel for another pandemic.”

500 years of species loss: Humans drive defaunation across Neotropics

<https://news.mongabay.com/2020/09/500-years-of-species-loss-humans-drive-defaunation-across-neotropics/>

Elizabeth Claire Alberts, Mongabay, 15 September 2020

A new study provides an in-depth look at the detrimental impacts of human activities on wildlife in the Neotropical region of the Americas over the past 500 years.

The study, published Sept. 15 in *Nature Scientific Reports*, found that more than 56% of species in mammal assemblages, or groups of coexisting species, living in the Neotropics, have died out since 1500, about the time that European colonization began. The biggest losses were seen in ungulate species, such as the lowland tapir (*Tapirus terrestris*) and the white-lipped peccary (*Tayassu pecari*). Humans are largely responsible for this extensive loss of wildlife, or defaunation, the study found, with overhunting, habitat loss, intentional or accidental fires, and the introduction of invasive species and disease all playing a part. While wildlife and habitat have steadily declined since the 16th century, losses have become even more pronounced in the past 50 years, according to co-author Carlos Peres, professor of tropical conservation ecology at the University of East Anglia (UEA) in the U.K. “We’ve had a big hike in habitat loss, which more or less coincides with the first big road that reaches the Amazon from the rest of Brazil,” Peres told Mongabay. “As you know, the Amazon was isolated from the rest of Brazil until 1971, and so that’s a big landmark in terms of tropical deforestation.” The study, led by researchers from UEA and the University of São Paulo (USP), Brazil, used animal inventories at 1,029 Neotropical study sites across 23 countries, from Mexico to Chile and Argentina. These inventories were mostly published in the past 30 to 40 years, but the data go back to the time of European colonization. What the researchers ultimately found was that anthropogenic pressures, such as habitat loss and overhunting, were the primary cause of local species extinction and “assemblage downsizing,” which refers to the reduction of body size within each mammal assemblage. “Any given species removed from an assemblage will open up an ecological space and consequently a failure in ecosystem functioning,” lead author Juliano Bogoni, a postdoctoral researcher at UEA, told Mongabay in an email. “For example, the loss of a large-bodied frugivorous species will compromise the seed dispersal process, forest regeneration, and changes in phytodemographic dynamics (i.e., the forestry composition dynamics and trees dominance). The loss of an apex-predator will alter the top-down control of their prey or promote failures in the control of disease reservoirs. With a local species extinction, the ecosystem also loses their genetic variability and their ecological roles (that is, the functional diversity).” Peres, who has been researching subsistence and commercial hunting in the American tropics for the past 40 years, said the findings ultimately surprised him. “I’ve been to more sites in the Brazilian Amazon, doing wildlife studies, than any other biologist who has ever lived, both people who are alive today and dead,” Peres said. “But I’m used to seeing places where only the very large-bodied species are lost. What our paper is showing is that there are a lot of local extinctions of even medium-bodied species.” The researchers say they hope this study can help inform conservation efforts in the





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Neotropics, particularly in the Amazon region and the Pantanal wetlands, which are still considered “faunally intact.” Conversely, regions such as the Brazilian Atlantic Forest and the Caatinga have become so degraded that they are now considered to be “empty ecosystems,” according to the study. Bogoni says future conservation efforts should include “effective implementation and law enforcement in existing protected areas, and curbing political pressures to either downgrade or downsize these areas.” Additionally, he says action needs to be taken to stop illegal hunting, deforestation and human-caused fires. While conservation work can help protect the intact biomes of the Amazon and Pantanal regions, the fires currently burning throughout these areas would be having a devastating effect on wildlife and their habitats, Peres said. The Pantanal region is getting hit particularly hard since it’s “not really meant to burn,” he said. “The Pantanal hasn’t burned properly for many, many years,” Peres said. “So there’s a lot of biomass, a lot of fuel to burn. What people are reporting are ... huge numbers of carcasses and huge levels of mortality. The Pantanal fires are really really severe ... and they’re not done yet. People are talking about rain next week, but we don’t know if the rains are going to come.” While the findings of the study clearly indicate that humans have contributed to the widespread defaunation of the Neotropics, the paper ends with a call to action — and offers a nugget of hope. “Hominins and other mammals have coexisted since the earliest Paleolithic hunters wielding stone tools some 3-4 million years ago,” the authors write. “Over this long timescale biodiversity losses have only recently accelerated to breakneck speeds since the industrial revolution. Let us make sure that most of this impoverishment is behind rather than ahead of us, or else the prospects for Neotropical mammals will look increasingly bleak.”

Citation:

Bogoni, J. A., Peres, C. A., & Ferraz, K. M. (2020). Extent, intensity and drivers of mammal defaunation: A continental-scale analysis across the Neotropics. *Scientific Reports*, 10(1). doi:10.1038/s41598-020-72010-w

Human-hippo conflicts are exploding in this pristine patch of Kenya

<https://www.nationalgeographic.com/animals/article/hippos-flooding-fishing-covid-collide-kenya>
Jacob Kushner, National Geographic, January 29, 2021

Floods and the economic fallout from COVID-19 are pitting hungry fishermen against hungry hippos - with deadly results.

NAIVASHA, Kenya In May, George Mwaura went fishing with his close friend Babu along the swampy shores of Lake Naivasha, in central Kenya. “Babu was a quiet guy, a nice guy,” Mwaura recalled. “He’s the one who taught me patience. And he was quite good at fishing.” They couldn’t afford a boat, so they’d waded into the water up to their chests to see what fish—tilapia, carp, catfish—had swum into their nets overnight. “We had a lucky catch that day,” Mwaura said. “But before we got the full catch, the hippo came again.” They’d seen it that morning, its ears and eyes poking above the surface. “We beat the water with a stick to make noise, so the hippo went away,” he said. The friends were too focused on their fish to notice when it returned. “Babu always told me hippos are dangerous animals,” Mwaura said. Hippos had attacked Babu four times, but he had always managed to escape. “But the fifth one—he did not make it.” The hippo lunged first at Mwaura, who was able to dart away because he knew how to swim. Then it lunged for Babu, who couldn’t swim. The hippo’s enormous jaw clamped down on him. Its lower two teeth pierced





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his back—once, twice, a third time. Dozens of fishermen raced to the water's edge, but when a hippo takes a human, there's nothing anyone can do. When the attack was over, the other fishermen waded in to retrieve Babu, but he was already dead. "It is so sad seeing your best friend's dying day," Mwaura said. A few days later, Mwaura returned to the lake to fish. By some estimates, about 40 people—mostly fishermen—were attacked by hippos on Lake Naivasha in 2020, and as many as 14 of them died. Every year across Africa, hippos kill an estimated 500 people, making them the world's deadliest mammal, after humans, and nearly twice as deadly as lions. Hippopotamuses are herbivores and rarely bother other animals. But males can become aggressive if they sense danger. Mothers may attack to protect their young. And nearly all hippos become nervous when something—or someone—stands between them and the water where they live. The second-largest land mammals on Earth, hippos usually appear docile, but they have the ability to become deadly. Although they can weigh up to four tons, they can run up to 20 miles per hour. Their jaws can open to 180 degrees, clamp down with a force 10 times that of human jaws, and their lower canines can grow to more than one and a half feet long. And they can be hard to spot since they can hold their breath under water for up to five minutes.

Despite the dangers posed by hippos, the extent of the tragedy unfolding at Lake Naivasha is unusual, stemming from two extraordinary events that changed how humans and hippos interact. Heavy rains that began in October 2019 caused Lake Naivasha to swell to its largest size in nearly a century, flooding the land upon which hundreds of hippos had grazed. With the water pushing up against the fences of farms and homes that surround the lake, they're now forced to mill about at the same shallow edge where fishermen like Mwaura and Babu cast their nets. And the number of fishermen—once in the dozens, perhaps a few hundred at most—swelled into the thousands after the global economic crisis caused by the COVID-19 pandemic hit the region. Kenya is the fourth-largest flower exporter in the world, but when the pandemic hit, Europeans stopped buying them. Thousands of flower workers around Lake Naivasha were let go. With few other sources of income, many turned to fishing. Naivasha has long been a place where humans and wildlife converge. On the lake's eastern edge lies a peninsula whose name, Crescent Island, was a misnomer until the recent flooding submerged the narrow strip of land that connects it to the mainland.

Tourists access the site by boat, then wander on foot to photograph giraffes and buffalo, gazelles and impalas, vervet monkeys and sometimes hyenas—all of which are now stranded because of the lake's rise. Meanwhile, hundreds, maybe thousands, of hippos bathe near the shore, pressed up against the submerged fences of the now-flooded flower farms, homes, and tourist cabins. The result is a deadly mix: humans and hippos competing over a thin strip of territory. Nature is reclaiming Naivasha, and the result has led to dangerous melees—ones that humans do not win. With most work in the area tied to the lake, there's no clear solution in sight. Ruth Mumbi lost her husband when a hippo overturned his fishing boat four years ago. The family's sole income earner, he left behind four children, one of whom now spends his days mending fishing nets. "If it was up to me, I wouldn't allow my children to work on the lake," Mumbi said. "But because I don't have much money and there's nothing else to do, if that's what they want to do, then I'll just have to accept it."

A rift in the valley

Lake Naivasha is what scientists call an "amplifier lake" because it shrinks and swells quickly, along with the rains. "When there's a change in the climate, they will show that—changes in lake level, salinity," said Lydia Olaka, a professor of environmental geology and climate science at the





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University of Nairobi. Covering some 70 square miles during normal times, Lake Naivasha's surface is more than three times the size of Manhattan, but a mere 60 feet deep at most. It's fed by three rivers as well as runoff from the surrounding land. The lake has no outlet. Each year, about six feet of water evaporates from its surface into the sunny sky. A decade ago, after a series of droughts, residents feared the lake might disappear, taking an entire ecosystem and the tourism industry down with it. But in late 2019, Lake Naivasha's basin received three times its usual rainfall—the result of a phenomenon thousands of miles east, called the Indian Ocean Dipole. It occurs when the surface waters of the ocean beyond Africa's east coast turn unusually warm, as waters near Asia turn cool. The 2020 rainy seasons were also wetter than usual. More rainfall brought increased cloud cover, reducing evaporation from the lake. Part of the lake's rise also is manmade—the result of decades of deforestation in the lake's basin, which has increased the amount of runoff that reaches the lake. Naivasha is not alone. A four-hour drive north of Naivasha in Kenya's Great Rift Valley, Lake Bogoria and Lake Baringo have flooded, displacing thousands of people and countless wildlife. The disappearance of dry land for the hippos to graze upon is due not only to Lake Naivasha's rising waters, which have climbed 12 vertical feet, but also to illegal human encroachment on the protected riparian boundary. People built houses, tourist cabins, and even greenhouses on this land, but now many of these structures are underwater. The lakeside town of Kihoto, for example, drowned last year. Today, walls of concrete blocks jut up above the dark waters. Several miles west, the curved tops of flooded greenhouses mark where flower farms have been swallowed. If the lake keeps growing, more buildings will submerge. Yet recently, Kenya's Water Resources Authority considered allowing people to settle even closer. "We are living through very unprecedented times," Olaka said, noting that climate models project more rain to come and that Lake Naivasha's larger size "could be a new normal."

Gone fishing

Naivasha's commercial fishing industry began by accident, decades ago, when a torrent of rain flooded a fish farm upstream on the Malewa River. A trove of common carp escaped into the lake, where they ate up most the crayfish and ravished the eggs of the tilapia, black bass, and other species prized by sport fishers. The carp multiplied, and fishing became a livelihood. When Lake Naivasha suddenly expanded in 2019, it seemed at first like a boon to the fishing industry. Fish bred in the rich, untouched soil of newly inundated riparian land. They grew into thousands of pounds of fresh food—more fish than anyone can remember. "All of the activities—tourism, pastoralists, floriculture—they all depend on Lake Naivasha," said David Kilo, chairman of the Naivasha Boat Owners Association. Before COVID-19 arrived, there were 180 licensed fishing boats on the lake—already as many as the lake's ecosystem could sustainably handle. Now, on the southwestern shore, Karagita boat landing is overrun each morning with fishermen unloading their catches. In town, women weave long strands of string into fishing nets, which they sell for 1,000 shillings (\$9). Teenage boys are paid pennies to repair old nets that have been tangled or cut by a propeller. And each day, tourists arrive at the landing and hire boat captains to take them on hippo tours. Early one morning, a captain named Douglas Mokano puttered toward a pod of hippos. "They're sleeping now," he said. Pointing to a hippo whose head and back broke the water's surface, he said, "This one's the baby." It was the size of a full-grown cow.

The hippos nestle their giant heads against each other's backs. Despite their girth, they manage to squeeze together so tightly that a pod of five hippos looks like a single blob of grey and pink flesh. It's impossible to tell where one hippo ends and the next begins. Mokano revs the motor, trying to agitate them so they'll lift their magnificent heads above the surface. The hippos can't be





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bothered. “You can’t allow everybody to fish. It will affect the ecosystem of the lake,” Kilo said. And yet, that’s what has happened since COVID-19 arrived. Kenya Wildlife Service has been unable or unwilling to put a stop to the illegal fishing. The agency did not respond to repeated requests for comment. Volunteers from the Naivasha Fishermen’s Association have helped the rangers conduct night patrols, with spotlights scanning for illegal fishers. One night when they tried to arrest a group of fishermen, the fishermen fought back. They tied up the rangers, overturned their boat, and set it on fire, stranding the rangers until they could be rescued. These days, “they rarely patrol,” Kilo said.

Hungry hippos

Scientists estimate that between 29 and 87 percent of hippo attacks are fatal. You’d have a better chance of surviving a shark attack, a crocodile encounter—and magnitudes better odds at surviving a grizzly bear attack. Though hippos are herbivores, when grass is hard to come by, on rare occasions they have been known to eat other animals—even deceased hippos. Kilo has witnessed or investigated eight attacks in which fishermen died. Attacks have become so common that he has transformed his car into a makeshift rescue vehicle, removing the back seats so victims can be loaded easily and laying down plastic to catch the blood. “My vehicle, it looks like an ambulance,” Kilo said. “If people see my vehicle reversing, they say—there’s a hippo attack!” But Kilo is no EMT. He doesn’t know how to apply tourniquets or pack wounds, interventions that are crucial for saving a victim’s life, according to George Wabomba, a doctor at Naivasha County Referral Hospital. Wabomba treats an average of one or two hippo victims each week. “When you mention there’s a hippo victim, everyone is anxious in the hospital,” he said. “You never know what you’re going to get.” Hippos can trample victims or drag them. “Sometimes it’s just a bite, and the hippo lets go. But you also get lots of abdominal injuries,” Wabomba said, adding that lacerations may be filled with soil and grass. “We don’t know what’s in a hippo’s mouth, what’s in the water.” Such injuries require immediate attention, Wabomba said, but often victims don’t arrive for hours. Fishermen have to wait until it’s safe to retrieve the victim—when the hippo moves away—then transport the injured man to the hospital. The closest hospital is only five miles from Karagita, but it’s 24 miles along rough roads from the far side of the lake. Wabomba estimates that 40 percent of the hippo victims he sees ultimately die. He recalled a 35-year-old fisherman he treated last year who was attacked before sunrise as he was placing his nets but didn’t get to the hospital until noon. “Some of his bowels were sticking out,” Wabomba said. “We repaired what could be repaired. This is what we call damage-control surgery.” “We couldn’t save him,” he said. Less than a half-hour after the surgery, he died.

Cull the hippos?

The only solution to Naivasha’s standoff is “to work things around hippo behavior,” said Richard Hartley, who manages two conservation areas around the lake. Driving his Land Cruiser across one of them on a recent afternoon, he stopped to watch a lone hippo resting in a shallow pool of mud. “He’s a maturing male who’s looking for females, and the old bulls don’t want him around,” Hartley said. Signs reading “Danger” warn tourists not to go out walking at night. But jump in a Land Cruiser, turn on your brights, and you’re sure to spot the silhouettes of hippos grazing in the grasslands. Sometimes they stare at you, caught in the headlights. But usually they trot away, showing you only their pink behinds as their tiny tails wag frantically.

Since the lake’s rise, partially submerged trees topple daily with a splash as their roots are dislodged. Fishermen have taken to casting lines from these trunks, their legs dangling just feet above the heads of hippos. Periodically the hippos grunt, reminding the fishermen that danger is





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only a slip away. “You have fishermen who quite honestly don’t seem to feel any fear whatsoever. They will park themselves literally feet away—and they get it wrong,” Hartley said. “There’s a mama with a calf, or there is an aggressive male hippo that’s going to go for you or your boat. And you don’t see them coming because they’re submerged—and they come fast.” When a particular hippo is believed to have attacked multiple times, fishermen sometimes ask rangers to kill it. “There’s so much community pressure for that animal to be destroyed. And yet it’s almost never the hippo’s fault,” Hartley said. He said one ranger tasked with the job sometimes shoots to miss on purpose, saving the hippo’s life. As more and more fishermen take to the lake, some have called for the hippos to be culled, to decrease their numbers. Naivasha’s last thorough hippo census was conducted in the 1990s. It estimated that there were 1,250 hippos. Last year, according to Kilo, the Kenya Wildlife Service estimated the number was closer to 700. Hippos are notoriously difficult to count, spending their days underwater in pods, often with only their eyes and ears above the water. Kilo and Hartley say that, while there is some poaching, there’s no reason to believe the hippo population has decreased that drastically. Culling is sometimes considered when a habitat can no longer support the number of animals living on it—when the population exceeds the supply of grass needed to feed them, said Hartley. If the lake continues to swallow more grassland, he says wildlife rangers might consider culling the hippos rather than let dozens starve to death. That would be an international embarrassment for Kenya, a nation known for its wildlife, Hartley says. “Culling would be admitting defeat. Culling would be saying we no longer care about the wildlife.”

“At times I don’t feel like myself”

Standing by the lake, Meshack Ogjah limped toward the swampy shore. He pointed to a small area of open water, surrounded by water hyacinth and fallen trees. He said that one evening at dusk he was working in the dark water when a hippo brushed his left side. He knew the dangers of fishing in a hippo-infested lake. “There was a friend of ours who was attacked — and he didn’t know how to swim,” Ogjah said. The hippo bit him at least twice. He did not survive. Still, Ogjah kept fishing. “It’s only when you feel it yourself that you understand,” he said. Ogjah was diving into murky water to place a fish trap made of plastic netting when the hippo grazed him. “It started touching me, its belly to my thigh,” he recalled. “I moved to the surface so I could see its movement. Then I started to swim—but it chased me.” He screamed for help, but there was nothing other fishermen could do. He dived down, hoping the hippo wouldn’t see him. When he reached the shallows, “it saw me well,” said Ogjah—and took a bite. The hippo’s teeth were “six inches long—and thick,” he said. They pierced his right thigh, and his blood colored the water. “I was feeling like my heart wasn’t there.” Ogjah managed to escape. Another fisherman hoisted him onto a motorcycle and drove him to the hospital. Doctors cleaned the wound and sewed it shut. Ogjah was lucky to survive. Even so, he says a part of him is missing. “At times I don’t feel like myself. It’s torture,” said Ogjah, who now struggles to walk. “I still have a long way to go.” Asked whether he blames the hippo—whether he thinks the government should cull the hippos—Ogjah’s friend Wycliffe Injindi, who saw the attack from shore, interjects. Could you burn all the vehicles just because one had an accident?” Injindi said. “Hippos in Kenya, we are very lucky—other countries have no hippos.” The solution, he says, is for humans to learn to live with them—to fish more safely from a boat, rather than wading into a murky lake. “Killing the hippos—no, that is not fair.” Ogjah and Injindi both shake their heads no when asked if they will return to fishing. “I cannot go back into the water,” Injindi said. “That was a terrible day.”

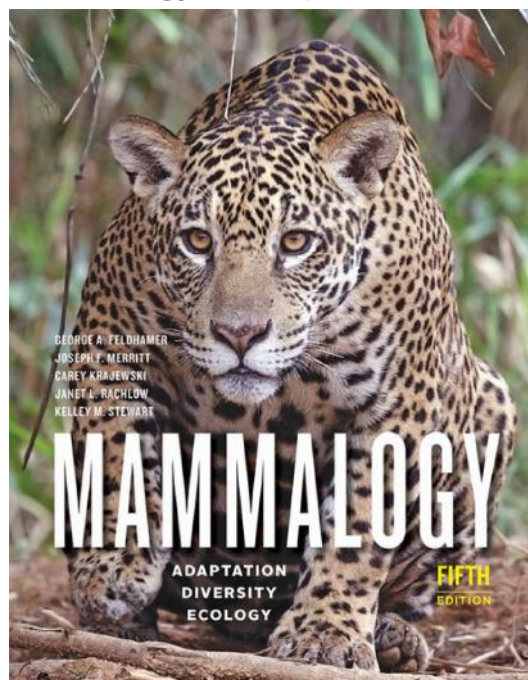




New books about Suiformes



Mammalogy — Adaptation, Diversity, Ecology



The study of mammals (mammalogy) often deals with very specific questions concerning one or several species, such as their physiology, ecology, or life history patterns. In mammalogy, it is sometimes necessary to broadly assess these topics, examining different feeding specializations, movement patterns, or community ecology. However, very few books deal with all the different aspects of mammalogy. This book (5th edition) was written by five leading mammalogists to rectify this and provide a comprehensive overview of mammalogy.

The book is separated into five parts:

Part one—the introduction—deals with the science of mammalogy, methods for studying mammals, phylogeny and diversification, evolution and characteristics, and biogeography. Part two focuses on mammal structure and function and offers chapters on mammal integument, structure and function, movement, feeding mechanisms, environmental adaptations, and reproduction. Part three

is the largest section of the book and discusses adaptive radiation and the diversity of all different mammalian Orders. Part four covers mammal behavior and ecology, while part five discusses parasites, zoonotic diseases, and conservation, which have become very pertinent given the current, global COVID-19 pandemic. At the end of each chapter the authors provide a summary, suggested reading material, and discussion questions that offer the chance to delve deeper into each subject.

Regarding Suiformes, the authors discuss the six genera of Suids and the number of accepted species based on recent scientific publications. The authors briefly discuss the anatomy and morphology of Suids, invasive feral hogs, and the most endangered species within this suborder. Authors also provide similar information on peccaries, brief facts on the giant peccary (*Peccari maximus*), and important behavioral characteristics. The authors discuss Whippomorpha, a suborder that includes Hippopotamidae and Cetacea, and provide a succinct introduction on hippos.

This book not only provides a cornucopia of facts and information about the > 6,400 mammal species that have been described, but helps readers to understand what makes mammals special and their different patterns, diversity, and evolution. To help bring the written text to life and make concepts more understandable, the book includes 300 photos, 149 color and 189 black and white illustrations, and 22 color maps. This combination of content makes the book enjoyable to flick through. The large glossary is also very helpful. The book's target audience is students and people interested in a compact scientific overview of mammals. It is the reference book for mammalogy.

Mammalogy — Adaptation, Diversity, Ecology

by George A. Feldhamer, Joseph F. Merritt, Carey Krajewski, Janet L. Rachlow, Kelley M. Stewart
727 pages, 5th Edition

May 2020, John Hopkins University Press,

reviewed by Thiemo Braasch

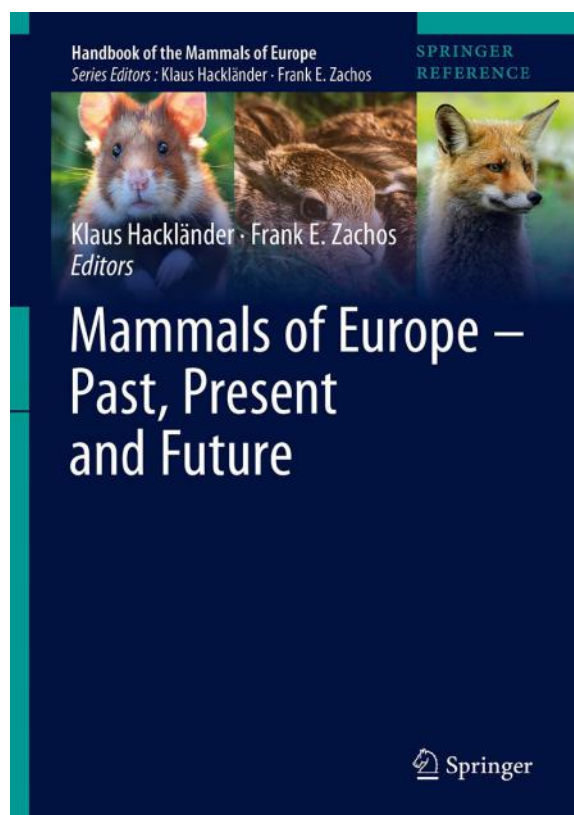




New books about Suiformes



Mammals of Europe — Past, Present and Future



This book is the introductory volume of a series on European mammals. While there are already detailed books on European mammals, many are not written in English (e.g. *Handbuch der Säugetiere Europas*) or are relatively old and do not include the new insights in mammalian phylogenetics that have occurred since the 1990s due to significant advances in molecular science.

The editors of this new book series — Klaus Hackländer and Frank E. Zachos — first explain their rationale for creating this series and the areas that they included. Subsequent chapters, written by several authors, deal with a huge array of topics: the history of mammal research in Europe; the different former book series and handbooks; recent advances in mammalian phylogenetics; mammal habitats in Europe and their geology, vegetation, and climate; the history of mammals in Europe in the late Pleistocene and Holocene; and management of European mammals.

The chapter on the history of mammals in Europe in the late Pleistocene and Holocene (written by Robert Sommer) is particularly interesting and explains the zoogeographical patterns and environmental changes during these epochs. The extinction of woolly mammoths, woolly rhino, and other prominent species of the Ice Age fauna in Europe are also briefly described, in addition to extant species, such as roe deer, stoat, and Norwegian lemming. During one period—the Weichselian Glacial—temperate species, such as roe deer, red deer, and wild boar, were restricted to glacial refugia in southern European regions and later recolonised other parts of Central and Northern Europe. This chapter also offers interesting insights into the other species of this epoch.

The last chapter briefly discusses the remarkable return of some mammals, such as the Eurasian wolf and Eurasian beaver, and the species most impacted by humans, such as the common hamster or European hare. Authors then discuss the Bern Convention as a framework for mammal management, the EU Habitats Directive, and the EU LIFE Programme and its flagship approach to mammal conservation.

Overall, each chapter is written in the format of a scientific publication, with an abstract at the beginning and references at the end. This first book raises anticipation for subsequent volumes in the series, and it will be interesting to read what the authors write about ungulates, especially wild boars.

Mammals of Europe — Past, Present and Future

Editors: Klaus Hackländer and Frank E. Zachos

117 pages

2020 Springer Nature

reviewed by Thiemo Braasch

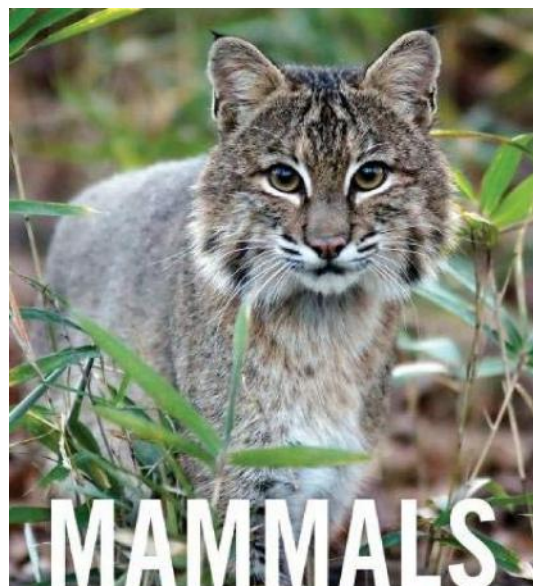




New books about Suiformes



Mammals of the Southeastern United States



Troy L. Best and John L. Hunt

This book discusses the mammals present in southeastern US, specifically Florida, South Carolina, Georgia, Alabama, Mississippi, east Louisiana, southeast Arkansas, south Tennessee, and south North Carolina. Many mammal species are endemic to these areas, including the Florida bonneted bat (*Eumops floridanus*), Florida deermouse (*Peromyscus floridanus*), and round-tailed muskrat (*Neofiber alleni*). After a short introduction on the conservation status of mammals in southeastern US, the authors present an overview of the rationale behind the conservation status of species and the terms used by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the International Union for the Conservation of Nature and Natural Resources (IUCN), the United States Fish and Wildlife Service (USFWS), and by the different associated states. Furthermore, authors provide an overview of the different terms concerning species conservation statuses. The main

part of the book covers species' profiles, with small introductions on taxonomic orders and families. Each species profile consists of many elements: species description, dental composition, physical measurements, sexual dimorphism, general distribution in North America, detailed distribution in southeastern US, habitat, diet, predators, parasites and diseases, behavior, reproduction, conservation status, taxonomy, remarks, and references. Additionally, each species has a photo its whole body, three different views of its skull, and two distribution maps: one for the whole of North America and one for southeastern US. Authors provide details of native and introduced species, such as the cyopu, capybara, California sea lion, chital, and pronghorn. For example, the book discusses the population of pronghorns that were introduced to Osceola County in Florida until the late 1970s, and the only species of Suina living in southeastern USA—wild boar—which was supposedly introduced to the area by Hernando de Soto and his team in 1539. All species' profiles are concise and well-written overviews of their ecologies and natural histories. However, the taxonomy sections in these profiles seem to be slightly short, offering only the translation of scientific names rather than discussing debates on some species' taxonomy, such as the red wolf. Nevertheless, taxonomy is not the focus of this book and interested readers can look elsewhere for this information, e.g. Handbook of the Mammals of the World. The first appendix gives an overview of all the whale, dolphin, and porpoise species in the coastal waters of southern US, while appendix 2 includes measurement conversions. The glossary is also very helpful.

While the book is too large to be taken to the field, it offers a valuable source of information that is perfect for a home or office. Overall, the two authors have written an extraordinary book about the US's mammals and present well-investigated information about each species.

Mammals of the Southeastern United States

by Troy L. Best and John L. Hunt

496 pages

August 2020, University of Alabama Press

reviewed by Thiemo Braasch

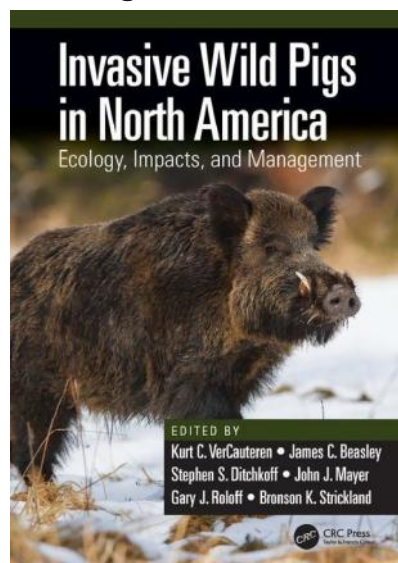




New books about Suiformes



Wild Pigs in North America – Ecology, Impacts, and Management



Wild boars are an established, invasive species in North America. This book discusses the ecology, impacts, and management of these pigs in the US.

After a short introductory chapter, many different aspects of invasive wild pigs in and around North America are discussed: taxonomy; morphology; genetics and physiology; spatial ecology and behaviour; population dynamics; diseases and parasites; their naturalized niche in North America; the damage they cause to resources; management practices; research methods; human dimensions and education; policies and legislation; populations in North America, the Pacific Islands, Mexico, and the Caribbean; populations along urban gradients; and their future in North America. This substantial chapter list demonstrates how comprehensively this book covers the scientific knowledge of wild pigs in North America.

Regarding wild pig taxonomy, the authors agree with the recognition of 15 subspecies, which is backed by several other authors: Wilson and Reader (2005), Grooves (2008), and Mayer and Brisbin (2008). Wild pigs in North America mostly belong to the subspecies *Sus scrofa scrofa*, but introductions of up to seven different subspecies may have been possible. Furthermore, most extant wild boars on this continent are hybrids between domestic or feral pigs, rendering subspecies designations invalid. The escape of 20 warthogs in southern Texas in 2013 is also discussed; currently, this feral warthog population appears to be declining. It would be far beyond the scope of this review to discuss the details of each of the chapters. Each chapter includes a detailed list of references at the end. The editors of this book have done an extraordinary job: the cornucopia of information, facts, and scientific investigations about wild pigs is impressive and overwhelming. Everyone interested in wild boars, not only in North America but more generally, will grasp deep and helpful insights into this species. The book will hopefully appeal to and receive a wide audience, and the facts the authors present will help to deal with invasive wild boars in other parts of the world where they can have devastating impacts.

Wild Pigs in North America – Ecology, Impacts, and Management

by Kurt C. VerCauteren, James C. Beasley, Stephen S. Ditchkoff, John J. Mayer, Gary J. Roloff and Bronson K. Strickland (eds.)

479 pages, CRC Press, January 2020

reviewed by Thiemo Braasch

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Veterinary, Genetic and Physiological Studies

Evolution of the ASF Infection Stage in Wild Boar Within the EU (2014-2018)

Martinez-Aviles, M., Iglesias, I. and A. De La Torre 2020

Frontiers in Veterinary Science, <https://doi.org/10.3389/fvets.2020.00155>

African swine fever (ASF) is one of the most important emerging transboundary diseases of pigs, causing trade restrictions, and a health impact on susceptible pigs. Nine countries in the continental European Union (Estonia, Lithuania, Latvia, Poland, Czech Republic, Bulgaria, Belgium, Romania, and Hungary) have been affected by ASF from 2014 to 2018 and it keeps spreading despite the efforts to control it. For a number of years, we have witnessed high case-fatality rates in wild boar found dead particularly in new infected areas, which is typical of the peracute and acute forms of the infection at the beginning of an ASF epidemic. Experimental evidence with currently circulating strains indicates that some infected animals can remain asymptomatic and might even survive the infection. An increased presence of virus of moderate virulence can complicate ASF diagnosis as well as the mitigation and control of the disease. We analyze the ASF surveillance data in wild boar in the four EU countries where ASF has been present for longer, comparing the spatial density of antibody positive notifications with the time ASF has been present per region. Results indicate an increasing annual distribution of notifications based on antibodies over nucleic acid detection in hunted wild boar in Estonia, Latvia and Poland. Potentially, Lithuania, and Poland seem to have experienced more acute forms in 2017 and 2018 than Latvia and Estonia. Overall there was a positive statistical correlation between time with infection (TWI) and antibody positive density, with some variations in certain regions, particularly of Lithuania and Estonia. The increasing trend in potential survivors (hunted wild boar with confirmed PCR negative and antibody positive results) enhances the importance of surveillance design to sample and test shot wild boar. In conclusion, surveillance data based on ASFV detection by PCR and serology can be used to assess the status of the epidemic in wild boar.

African swine fever: Etiology, epidemiology, control strategies and progress toward vaccine development: A comprehensive review

Das, S., Deka, P., Deka, P., Kalita, K., Ansari, T., Hazarika R. and N.N. Barman 2021

Journal of Entomology and Zoology Studies 9(1): 919-929

African swine fever (ASF) is a fatal viral disease caused by African swine fever virus (ASFV), the only known DNA arbovirus, of family Asfarviridae, genus Asfivirus, which can cause substantial morbidity and mortality events in domestic and wild pigs of all ages and sexes. ASF continues to be a threat to the global pig industry in Africa, Europe and recently in Asia. ASFV can be transmitted by three different modes: direct, indirect, and vector borne. Direct transmission can occur through contact with infected pigs and their products; indirect transmission occurs from contaminated fomites; and vector borne transmission is typically via the *Ornithodoros* ticks. Depending on the existence of wild reservoirs, competent tick vectors, and geographical characteristics, different epidemiological scenarios exist. The clinical presentations vary from peracute to chronic disease; including asymptomatic courses according to virulence of viral strains and immune status of the susceptible host. The disease is characterized by sudden death, high fever and haemorrhages in the skin and internal organs with mortality rates approaching up to 100%. Currently, there is no approved vaccine for ASF. The control and eradication measures are





based on early detection combined with strict quarantine and biosecurity. In this review, we summarise ASFV with respect to the current global situation, the disease it causes and different epidemiological scenarios including the potential vectors. We discuss the control methods in domestic and wild pigs and the current state in development of vaccines and antivirals against ASFV. Furthermore, existing ASFV research gaps and future perspectives in developing efficacious vaccine for controlling ASF are highlighted briefly.

African Swine Fever Virus Circulation between Tanzania and Neighboring Countries: A Systematic Review and Meta-Analysis

Hakizimana, J.N., Yona, C., Kamana, O., Nauwynck, H. and G. Misinzo 2021

Viruses 13(2): 306

For over 100 years after the description of the first case of African swine fever (ASF) in Kenya, ASF virus (ASFV) cross-border spread in eastern and southern Africa has not been fully investigated. In this manuscript, we reviewed systematically the available literature on molecular epidemiology of ASF in Tanzania and its eight neighboring countries in order to establish the transmission dynamics of ASFV between these countries. Data were retrieved from World Animal Health Information System (WAHIS), Google Scholar, PubMed, Scopus, and CrossRef databases, using the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and reviewed to document ASF outbreaks and ASFV genotypes distribution. Using phylogeographic approach applied to ASFV p72 sequence dataset, the evolutionary history and the dispersal pattern of the ASFV strains were assessed. From 2005 to 2019, a total of 1588 ASF outbreaks affecting 341,742 cases that led to 302,739 domestic pig deaths were reported. The case fatality rates (CFR) varied from 15.41% to 98.95% with an overall CFR of 88.58%. Fifteen different p72 ASFV genotypes were reported and the time to the most recent common ancestor (TMRCA) for ASFV strains dated back to 1652.233 (1626.473, 1667.735) with an evolutionary rate of 4.805×10^{-5} (2.5857×10^{-5} , 9.7789×10^{-5}). Phylogeographic dispersal analysis revealed several transboundary spread events of ASFV strains between these countries. These results suggest persistent circulation of ASFV in these countries and advocate for more research to improve our understanding of the transmission dynamics of the virus and for a regional approach to mitigate the spread of ASFV.

Antibody prevalence to African Swine Fever virus, *Mycobacterium bovis*, Foot-and-Mouth disease virus, Rift Valley Fever virus, Influenza A virus and *Brucella* and *Leptospira* spp. In free-ranging warthog (*Phacochoerus africanus*) populations in South Africa

Neiffer, D., Hewlett, J., Buss, P., Rossouw, L., Hausler, G., deKlerk-Lorist, L.-M., Roos, E., Olea-Popelka, F., Lubisi, B., Heath, L. and M. Miller 2021

J. Wild. Dis. 57(1): 60-70

The warthog (*Phacochoerus africanus*) can be used as a model for investigating disease transmission at the human, wildlife, and livestock interface. An omnivore and scavenger, a warthog moves freely between natural ecotypes, farmland, and human communities and is susceptible to diseases of zoonotic, agricultural, and conservation concern. A retrospective study using 100 individual serum samples collected from May 1999 to August 2016 was performed to determine antibody prevalence to seven pathogens in warthogs from five locations in northeastern South Africa. Higher prevalence of antibodies to African swine fever virus and *Mycobacterium bovis* were detected in warthogs from the Greater Kruger National Park





ecosystem in comparison to lower prevalence of antibodies to *M. bovis* and no antibodies to African swine fever virus in warthogs from uMhkuze Game Reserve. Low prevalence of antibodies to foot-and-mouth disease virus, Rift Valley fever virus, and influenza A virus was detected in all locations, and no antibodies against *Brucella* and *Leptospira* spp. were detected. No statistically significant difference in antibody prevalence was found between sexes for any disease. At the univariate analysis, *M. bovis* seropositivity was significantly different among age categories, with 49% (35/71) of adults found positive versus 29% (4/14) of juveniles and 9% (1/11) of sub-adults (Fisher's exact test, $P=0.020$), and between the sampling locations (Fisher's exact test, $P=0.001$). The multivariate model results indicated that juvenile warthogs had lower odds of testing positive to *M. bovis* antibodies than adults (juveniles' odds ratio [OR]=0.17, 95% confidence interval [CI]: 0.02–1.0), although this result was not statistically significant at the 5% level ($P=0.052$). For warthogs sampled at Satara Buffalo Camp, the odds (OR=0.22, 95% CI: 0.035–0.96) of being *M. bovis* antibody positive were significantly lower ($P=0.043$) than for warthogs sampled at Skukuza. Of particular interest in this study was the detection of warthogs seropositive for influenza A virus.

A scoping review of African swine fever virus spread between domestic and free-living pigs

Brookes, V.J., Barrett, T.E., Ward, M.P., Roby, J.A., Hernandez-Jover, M., Cross, E.M., Donnelly, C.M., Barnes, T.S., Wilson, C.S. and S. Khalfan 2021

Transbound. Emerg. Dis., <https://doi.org/10.1111/tbed.13993>

Since 2007, African swine fever virus (ASFV) has spread to countries in Europe, Asia and Oceania and has caused devastating impacts on pigs and the pork industry. Transmission can be direct or indirect, and epidemiologic scenarios have been described in which spread occurs between free-living and domestic pigs. The purpose of this scoping review was to identify primary research in which authors made statements to support ASFV transmission between free-living and domestic pigs and assess the circumstances in which transmission events occurred. A search was conducted in five bibliographic databases and the grey literature. Two reviewers (from a team of ten) independently screened each record and charted data (demographics of the pig populations, their husbandry [domestic pigs] and habitat [free-living pigs], the spatial and temporal distribution of ASF, the occurrence or burden of ASF in the populations, and whether ticks were present in the geographic range of the pig populations). Data synthesis included statistics and a narrative summary. From 1,349 records screened, data were charted from 46 individual studies published from 1985 to 2020. Outbreak investigations revealed that whilst poor biosecurity of domestic pig operations was often reported, direct contact resulting in transmission between free-living and domestic pigs was rarely reported. Studies in which quantitative associations were made generally found that spread within populations was more important than spread between populations, although this was not always the case, particularly when domestic pigs were free-ranging. We conclude that there is limited evidence that transmission of ASFV between free-living and domestic pigs is an important feature of ASF epidemiology, especially in the current ASF epidemic in Europe and the Russian Federation. If ASFV elimination cannot be achieved in free-living pigs, compartmentalization of domestic pig populations from free-living populations via biosecurity strategies could be used to support trade of domestic pigs.





Application of the World Café method to discuss the efficiency of African swine fever control strategies in European wild boar (*Sus scrofa*) populations

Jori, F., Chenais, E., Boinas, F., Busauskas, P., Dholllanderf, S., Fleischmann, L., Olsevskis, E., Rijksi, J.M., Schulz, K., Thulke, H.H., Viltrop, A. K. Stahl 2020

Preventive Veterinary Medicine 185: 105178

In the current epidemic of African swine fever (ASF) in Europe, the maintenance and spread of the disease among wild boar populations remains the most important epidemiological challenge. Affected and at-risk countries have addressed this situation using a diversity of wild boar management methods with varying levels of success. The methods applied range from conventional animal disease intervention measures (zoning, stakeholder awareness campaigns, increased surveillance and biosecurity measures) to measures aimed at reducing wild boar population movements (fencing and baiting/feeding) or population numbers (intensive hunting). To assess the perceived efficiency and acceptance of such measures in the context of a focal introduction of ASF, the authors organised a participatory workshop inviting experts from the fields of wildlife management, wild boar ecology, sociology, epidemiology and animal disease management to discuss the advantages and disadvantages of various control approaches. The discussions between professionals from different countries took place using the World Café method. This paper documents the World Café method as a tool for increasing the level of participation in multi-stakeholder group discussions, and describes the outputs of the workshop pertaining to the control measures. In summary, the World Café method was perceived as an efficient tool for quickly grasping comprehensive perspectives from the professionals involved in managing ASF and wild boar populations, while promoting engagement in multi-disciplinary discussions. The exercise achieved a good overview of the perceived efficiency and applicability of the different control methods and generated useful recommendations for ASF control in wild boar populations in Europe.

Hepatitis E virus (HEV) genotype 3 diversity: Identification of a novel HEV subtype in wild boar in Central Italy

Pierini, I., Di Bartolo, I., Manuali, E., Pirani, S., Bazzucchi, M., Moscati, L., De Mia, G.M. and M. Giammarioli 2020

Transboundary and Emerging Diseases, <https://doi.org/10.1111/tbed.13860>

In the last decade in Europe, the number of autochthonous cases of hepatitis E has significantly increased. Most of the cases arise from foodborne infections caused by the zoonotic hepatitis E virus (HEV) genotypes HEV-3 and HEV-4. Several human cases have been linked to consumption of raw or undercooked animal products of both pork (liver sausages) and wild boar meat. In this study, the occurrence of HEV infection was investigated in 611 livers and 88 paired lungs from wild boars collected during the hunting seasons of 2016–2020 in the Umbria-Marche Apennines (Central Italy). Using real-time reverse transcription polymerase chain reaction, 15 liver samples (2.45%) and one lung sample were found to be positive for HEV RNA. The phylogenetic tree built on the partial ORF2 gene revealed that the detected HEV strains belonged to HEV-3f (n = 5), HEV-3e (n = 1) and HEV-3c (n = 1) subtypes. Interestingly, 8 strains were genetically placed in a different cluster, further away from all other subtypes. To corroborate this finding, four complete genomes were obtained by next generation sequencing. The full genome of the HEV strains clustered together with another wild boar strain previously detected in Southern Italy in 2015 but the strains were divergent from all the HEV-3 strains classified in any





subtype defined so far. Thus, these strains represent a novel subtype that might have originated in Italy, which we have tentatively named HEV-3n.

Clinical Course and Gross Pathological Findings in Wild Boar Infected with a Highly Virulent Strain of African Swine Fever Virus Genotype II

Rodriguez-Bertos, A., Cadenas-Fernandez, E., Rebollada-Merino, A., Porras-Gonzalez, N., Mayoral-Alegre, F.J., Barreno, L., Kosowska, A., Tome-Sanchez, I., Barasona, J.A. and J. M. Sanchez-Vizcaino

Pathogens 9(9): 688

African swine fever (ASF) is a notifiable disease that in recent years has spread remarkably in Europe and Asia. Eurasian wild boar (*Sus scrofa*) plays a key role in the maintenance and spread of the pathogen. Here we examined gross pathology of infection in wild boar with a highly virulent, hemadsorbing genotype II ASF virus (ASFV) strain. To this end, six wild boars were intramuscularly inoculated with the 10 HAD50 Arm07 ASFV strain, and 11 wild boars were allowed to come into direct contact with the inoculated animals. No animals survived the infection. Clinical course, gross pathological findings and viral genome quantification by PCR in tissues did not differ between intramuscularly inoculated or contact-infected animals. Postmortem analysis showed enlargement of liver and spleen; serosanguinous effusion in body cavities; and multiple hemorrhages in lungs, endocardium, brain, kidneys, urinary bladder, pancreas, and alimentary system. These results provide detailed insights into the gross pathology of wild boar infected with a highly virulent genotype II ASFV strain. From a didactic point of view, this detailed clinical course and macroscopic description may be essential for early postmortem detection of outbreaks in wild boar in the field and contribute to disease surveillance and prevention efforts.

Bilateral total deafness after preparation of wild boar meat

Salaneuve, K., Meunier, A. and K. Aubry 2020

European Annals of Otorhinolaryngology-Head and Neck Diseases 137(5): 419-421

Introduction: *Streptococcus suis* is responsible for a zoonosis for which Suidae (pigs and wild boars) constitute the reservoir, mainly in Asia, with a much lower prevalence in Europe. The predominant clinical manifestation is meningitis, possibly resulting in deafness. Case report: We report the case of a woman hospitalised for meningitis complicated by labyrinthitis, occurring several hours after preparing a meal composed of wild boar meat. Despite the presence of intracochlear fibrosis, the patient was managed by sequential bilateral cochlear implants. Discussion: The discussion presents a review of the international literature and describes the mechanisms responsible for hearing loss related to this rare zoonosis.

Joining the club: First detection of African swine fever in wild boar in Germany

Sauter-Louis, C., Forth, J.H., Probst, C., Staubach, C., Hlinak, A., Rudovsky, A., Holland, D., Schlieben, P., Goldner, M., Schatz, J., Bock, S., Fischer, M., Schulz, K., Homeier-Bachmann, T., Plagemann, R., Klaass, U., Marquart, R., Mettenleiter, T.C., Beer, M., Conraths, F.J. and S. Blome 2020

Transboundary and Emerging Diseases, <https://doi.org/10.1111/tbed.13890>

African swine fever (ASF) has spread across many countries in Europe since the introduction into Georgia in 2007. We report here on the first cases of ASF in wild boar detected in Germany close to the border with Poland. In addition to the constant risk of ASF virus (ASFV) spread through





New literature on Suiformes



human activities, movements of infected wild boar also represent a route of introduction. Since ASF emerged in Western Poland in November 2019, surveillance efforts, in particular examination of wild boar found dead, were intensified in the regions of Germany bordering with Poland. The first case of ASF in wild boar in Germany was therefore detected by passive surveillance and confirmed on 10 September 2020. By 24 September 2020, 32 cases were recorded. Testing of samples from tissues of carcasses in different stages of decomposition yielded cycle threshold values from 18 to 36 in the OIE recommended PCR, which were comparable between the regional and national reference laboratory. Blood swabs yielded reliable results, indicating that the method is suitable also under outbreak conditions. Phylogenetic analysis of the ASFV whole genome sequence generated from material of the first carcass detected in Germany, revealed that it groups with ASFV genotype II including all sequences from Eastern Europe, Asia and Belgium. However, some genetic markers including a 14 bp tandem repeat duplication in the O174L gene were confirmed that have so far been detected only in sequences from Poland (including Western Poland). Epidemiological investigations that include estimated postmortem intervals of wild boar carcasses of infected animals suggest that ASFV had been introduced into Germany in the first half of July 2020 or even earlier.

First report of HEV-3 subtypes e and f in the wild boar population in Abruzzo region, Italy

Scattolini, S., D'Angelantonio, D., Di Lollo, V., Olivieri S., Marcacci, M., Mangone, I., Lorusso, A., Pomilio, F., Migliorati, G. and G. Aprea 2020

European Journal of Public Health 30: V612-V612

Background

Hepatitis E virus (HEV) is a zoonotic pathogen and wild boars are recognised as reservoirs. HEV is the most common cause of acute viral hepatitis worldwide and it is usually transmitted by faecal-oral route. EU reported more than 21.000 human cases over the last 10 years (1). At the present, HEV comprises 8 genotypes and several subtypes. HEV genotypes 3 and 4 (HEV-3 and HEV-4) are zoonotic. This is the first report of HEV-3 subtype e and f in the wild boar population in Abruzzo region.

Methods

During the hunting season 2018-2019, liver samples from wild boars were analysed using Real Time RT-PCR for the detection of HEV RNA. Among these, positive sample were subjected to Whole Genome Sequencing for genotyping. After the quality check, reads were mapped using the nearest identified ref. sequence (KU176129) and the resulting HEV RNA sequences have been analysed using HEV net (open source software).

Results

Overall, 40 samples were tested positive for the detection of HEV RNA. Among these, 19 samples, with a Ct value ≤ 38 , were selected for phylogenetic analysis. All RNA viral samples belonged to HEV-3. In particular, 2 RNA viral samples belonged to subtype e and 1 to subtype f. The others, instead, belonged to HEV-3 subtype c.

Conclusions

Up to now, only HEV-3 subtype c has been reported among wild boars in Abruzzo, an Italian region officially recognized as an HEV hot spot because of the high number of human cases and for the strong sero-prevalence among blood donors. In this study, we report for the first time the presence of HEV-3 subtypes e and f in the wild boar population of this area. Since HEV-3 subtypes e and f are commonly associated to human disease from consumption of





raw/undercooked pork meats, these findings suggest the potential risk also associated with the consumption of wild boar meat. Nevertheless, this speculation needs further investigations.

Whole Genome Sequencing Characterization of HEV3-e and HEV3-f Subtypes among the Wild Boar Population in the Abruzzo Region, Italy: First Report

Aprea, G., Scattolini, S., D'Angelantonio, D., Chiaverini, A., Di Lollo, V., Olivieri, S., Marcacci, M., Mangone, I., Salucci, S., Antoci, S., Camma, C., Di Pasquale, A., Migliorati, G. and F. Pomilio
2020

Microorganisms 8(9), <https://doi.org/10.3390/microorganisms8091393>

Hepatitis E virus (HEV) is an emergent zoonotic pathogen, causing worldwide acute and chronic hepatitis in humans. HEV comprises eight genotypes and several subtypes. HEV genotypes 3 and 4 (HEV3 and HEV4) are zoonotic. In Italy, the most part of HEV infections (80%) is due to autochthonous HEV3 circulation of the virus, and the key role played by wild animals is generally accepted. Abruzzo is an Italian region officially considered an HEV hot spot", with subtype HEV3-c being up to now the only one reported among wild boars. During the year 2018-2019, a group of wild boars in Abruzzo were screened for HEV; positive RNA liver samples were subjected to HEV characterization by using the whole genome sequencing (WGS) approach methodology. This represents the first report about the detection of HEV-3 subtypes e and f in the wild boar population in this area. Since in Italy human infections from HEV 3-e and f have been associated with pork meat consumption, our findings deserve more in-depth analysis with the aim of evaluating any potential correlation between wild animals, the pork chain production and HEV human infections.

***Trichinella* spp. in wild boar (*Sus scrofa*) populations in Croatia during an eight-year study (2010-2017)**

Balic, D., Marucci, G., Agicic, M., Benic, M., Krovina, Z., Miskic, T., Aladic, K. and M. Skrivanko
2020

One Health 11, <https://doi.org/10.1016/j.onehlt.2020.100172>

Wild animals represent a constant source of *Trichinella* spp. infections for domestic animals and humans. To date, four species of *Trichinella* have been isolated in wild boar populations in Europe: *T. pseudospiralis*, *T. spiralis*, *T. britovi* and *T. nativa*, in addition to several mixed infection types and one hybrid formation between *T. britovi* and *T. spiralis*. Meanwhile, insufficiently thermally processed wild boar meat has been reported to be a source of trichinellosis in humans in several European countries. In Croatia, there have been no reported or proven cases of trichinellosis caused by wild boar meat consumption. The aim of this study was to obtain data on the prevalence of *Trichinella* species present in Croatia and to anticipated the potential risk of infection for humans in specific Croatian regions based on information obtained over an eight-year surveillance period. A veterinary inspection of wild boar carcasses for *Trichinella* larvae in Croatia has been mandatory since 1989, and the artificial digestion method was introduced as a compulsory test for wild boar samples in 2008. Based on the official data submitted to the Ministry of Agriculture, Directorate of Veterinary Services, in the period 2010-2017, 303 of 183,184 (0.17%) wild boar meat samples tested positive for *Trichinella* spp. Infected wild boar were found in 18 of 21 counties. Of these positive samples, 85 were submitted by the authorised veterinary inspectors to the National Reference Laboratory for further examination. The intensity of infection in muscle samples was 0.04-152.66 (mean: 23,37) larvae per gram, and *Trichinella* species were





identified as *T. spiralis*, *T. britovi*, *T. pseudospiralis* and *T. spiralis* + *T. britovi*. Genetic analysis of *T. pseudospiralis* isolates demonstrated their belonging to the Palaearctic population.

Non-Invasive Method to Detect Infection with *Mycobacterium tuberculosis* Complex in Wild Boar by Measurement of Volatile Organic Compounds Obtained from Feces with an Electronic Nose System

Beleno-Saenz, K.D., Caceres-Tarazona, J.M., Nol, P., Jaimes-Mogollon, A.L., Gualdron-Guerrero, O.E., Duran-Acevedo, C.M., Barasona, J.A., Vicente, J., Torres, M.J., Welearegay, T.G., Osterlund, L., Rhyan, J. and R. Ionescu 2021

Sensors 21(2), <https://doi.org/10.3390/s21020584>

More effective methods to detect bovine tuberculosis, caused by *Mycobacterium bovis*, in wildlife, is of paramount importance for preventing disease spread to other wild animals, livestock, and human beings. In this study, we analyzed the volatile organic compounds emitted by fecal samples collected from free-ranging wild boar captured in Donana National Park, Spain, with an electronic nose system based on organically-functionalized gold nanoparticles. The animals were separated by the age group for performing the analysis. Adult (>24 months) and sub-adult (12-24 months) animals were anesthetized before sample collection, whereas the juvenile (<12 months) animals were manually restrained while collecting the sample. Good accuracy was obtained for the adult and sub-adult classification models: 100% during the training phase and 88.9% during the testing phase for the adult animals, and 100% during both the training and testing phase for the sub-adult animals, respectively. The results obtained could be important for the further development of a non-invasive and less expensive detection method of bovine tuberculosis in wildlife populations.

Occurrence of *Alaria alata* in wild boars (*Sus scrofa*) in Poland and detection of genetic variability between isolates

Bilska-Zajac, E., Marucci, G., Pirog-Komorowska, A., Cichocka, M., Rozycki, M., Karamon, J., Sroka, J., Belcik, A., Mizak, I. and T. Cencek 2021

Parasitology Research 120(1): 83-91

Alaria alata is a trematode included among several emerging zoonotic parasites. The mesocercarial larval stage of *A. alata* named *Distomum musculorum suis* (DMS) may potentially be infective for humans. In the past, DMS was often observed in wild boar meat during the official *Trichinella* inspection by artificial digestion before a more specific and effective detection method, the *A. alata mesocercariae* migration technique (AMT), was introduced. In the present study, the AMT method was used to screen 3589 tissue samples collected from wild boars hunted in Poland during the 2015-2019 period. The survey mainly focused on the southern part of Poland with the majority of samples coming from Malopolskie, swietokrzyskie, and Dolnoslaskie provinces; samples from ten additional provinces were also included. The total prevalence was 4.2% with mean abundance of 4.7 DMS. Occurrence was dependent upon environmental conditions (i.e., wetland habitats and water reservoirs) rather than on sex of the host or season in which they were hunted. The recovered trematodes were identified as *Alaria* spp. according to their morphological features. Molecular analysis of 18S rDNA and COI genes confirmed the species identification to be *A. alata* and documented genetic variability among the isolates.





Seroprevalance of *Trichinella* spp. in wild boars (*Sus scrofa*) from Bihor county, western Romania

Boros, Z., Vallee, I., Panait, L.C., Gherman, C.M., Chevillot, A., Boireau, P. and V. Cozma 2020
Helminthologia 57(3): 235-240

The wild boar (*Sus scrofa*) has a wide geographical distribution and can be an important source of *Trichinella* spp. infection in humans in Romania. The objective of this study was to identify the presence of *Trichinella* spp. in the wild boar population in Bihor County, Romania. Eighty four plasma and diaphragm samples, collected from wild boars, were included in this study. Artificial digestion, ELISA and Western blot were performed on these specimens. All diaphragm samples were negative for *Trichinella* larvae in artificial digestion, while in ELISA, 54 (64.2 %) plasma samples were positive and 6 (7.1 %) plasma samples were doubtful. Western blot was performed on 26 plasma samples from which only 6 (23.0 %) gave a positive result. Serological evidences indicate the presence of *Trichinella* spp. in wild boars from western Romania. Therefore, human consumers might be at risk to ingest *Trichinella* larvae, even in low numbers.

Phylogenetic relationships investigation of *Mycobacterium caprae* strains from sympatric wild boar and goats based on whole genome sequencing

Ciaravino, G., Vidal, E., Cortey, M., Martin, M., Sanz, A., Mercader, I., Perea, C., Robbe-Austerman, S., Allepuz, A. and B.P. de Val 2020

Transboundary and Emerging Diseases, <https://doi.org/10.1111/tbed.13816>

Tuberculosis (TB) in wildlife challenges epidemiological surveillance and disease control. An outbreak of TB was detected in a free-ranging wild boar population of a Natural Park in Catalonia (Spain) and the outbreak investigation was conducted in the area. During the study period (2015-2020), 278 wild boars were analysed by gross pathology, histopathology, mycobacterial culture and DVR-spoligotyping. In addition, all cattle (49) and goat (47) herds of the area were tested with tuberculin skin test. TB compatible lesions were detected in 21 wild boars, and *Mycobacterium caprae* was isolated in 17 of them with two different spoligotypes: SB0415 (13) and SB1908 (4). Only two goat herds showed TB positive animals that were subsequently slaughtered. *M. caprae* with the spoligotypes SB0416 and SB0415 were isolated from these animals. To investigate the phylogenetic relationships and the transmission chain of the outbreak, nine strains isolated from six wild boars and three goats of the study area were analysed by whole genome sequencing (WGS) followed by single nucleotide polymorphism (SNP) analysis by maximum likelihood and median-joining network inference methods. Results indicated that infected wild boars maintained *M. caprae* strains circulation in their own population and have likely transmitted the infection to goats, thus acting as TB reservoirs, compromising the success of livestock TB eradication campaigns and posing a risk for public health. The results also highlighted the usefulness of WGS followed by SNP analysis in providing relevant epidemiological information when detailed contact data are missing.

Presence of pathogenic *Leptospira* spp. in the reproductive system and fetuses of wild boars (*Sus scrofa*) in Italy

Cilia, G., Bertelloni, F., Piredda, I., Ponti, M.N., Turchi, B., Cantile, C., Parisi, F., Pinzauti, P., Armani, A., Palmas, B., Noworol, M., Cerri, D. and F. Fratini 2020

Plos Neglected Tropical Diseases 14(12), <https://doi.org/10.1371/journal.pntd.0008982>

Leptospirosis is a re-emerging and globally spread zoonosis caused by pathogenic





New literature on Suiformes



genomospecies of *Leptospira*. Wild boar (*Sus scrofa*) are an important *Leptospira* host and are increasing in population all over Europe. The aim of this investigation was to evaluate *Leptospira* spp. infection in the reproductive systems of wild boar hunted in two Italian regions: Tuscany and Sardinia. From 231 animals, reproductive system tissue samples (testicles, epididymides, uteri) as well as placentas and fetuses were collected. Bacteriological examination and Real-Time PCR were performed to detect pathogenic *Leptospira* (lipL32 gene). *Leptospira* spp. were isolated from the testicles and epididymides of one adult and two subadult wild boar. Four isolates from the two subadult males were identified as *Leptospira interrogans* serogroup Australis by MLST, whereas *Leptospira kirschneri* serogroup Grippotyphosa was identified from the adult testicles and epididymis. Using Real-Time PCR, 70 samples were positive: 22 testicles (23.16%) and 22 epididymides (23.16%), 10 uteri (7.35%), 3 placentas (6.66%), and 13 fetuses (28.88%). Amplification of the *rrs2* gene identified *L. interrogans* and *L. kirschneri* species. The results from this investigation confirmed that wild boar represent a potential source of pathogenic *Leptospira* spp. Isolation of *Leptospira* serogroups Australis and Grippotyphosa from the male reproductive system and the positive Real-Time PCR results from both male and female samples could suggest venereal transmission, as already demonstrated in pigs. Furthermore, placentas and fetuses were positive for the lipL32 target, and this finding may be related to a possible vertical transmission of pathogenic *Leptospira*.

Detection of African swine fever virus in free-ranging wild boar in Southeast Asia

Denstedt, E., Porco, A., Hwang, J., Nga, N.T.T., Ngoc, P.B.T., Chea, S., Khammavong, K., Milavong, P., Sours, S., Osbjør, K., Tum, S., Douangngeun, B., Theppanya, W., Long, N.V., Phuong, N.T., Quang, L.T.V., Hung, V.V., Hoa, N.T., Anh, D.L., Fine, A. and M. Pruvot 2020 *Transboundary and Emerging Diseases*, <https://doi.org/10.1111/tbed.13964>

African Swine Fever (ASF) is a highly contagious and fatal viral disease affecting both domestic and wild suids. The virus was introduced to Southeast Asia in early 2019 and has since spread rapidly throughout the region. Although significant efforts have been made to track and diagnose the disease in domestic pigs, very little is known about ASF in free-ranging wild boar and their potential role in maintaining the disease within Southeast Asia. Through a collaboration between government and non-government actors in Laos, Viet Nam, and Cambodia, investigations were conducted to (a) characterize the interface between domestic pigs and wild boar, (b) document risk factors for likely ASF spillover into wild boar populations by way of this interface, and (c) determine whether ASF in wild boar could be detected in each country. An extensive overlap between wild boar habitat and domestic pig ranging areas was found around villages bordering forests in all three countries, creating a high-risk interface for viral spillover between domestic pig and wild boar populations. Fifteen and three wild boar carcasses were detected through passive reporting in Laos and Viet Nam, respectively, in 2019 and early 2020. Four of five carcasses screened in Laos and two of three in Viet Nam were confirmed positive for African swine fever virus using real-time PCR. There were no confirmed reports of wild boar carcasses in Cambodia. This is the first confirmation of ASF in wild boar in Southeast Asia, the result of a probable viral spillover from domestic pigs, which highlights the importance of early reporting and monitoring of ASF in wild boar to enable the implementation of appropriate biosecurity measures.

Testing Different Deterrents as Candidates for Short-Term Reduction in Wild Boar Contacts - A Pilot Study





Denzin, N., Helmstadt, F., Probst, C. and F.J. Conraths 2020

Animals 10(11), <https://doi.org/10.3390/ani10112156>

Simple Summary African swine fever is an important pig disease currently present in the wild boar population, in particular in parts of Europe, with occasional introductions into domestic pig farms. Lately, the first cases were detected in wild boar in Eastern Germany. The presence of the disease dramatically affects the chances of a country to participate in international trade with pigs and products thereof. Limiting disease spread with the goal of eventual eradication is therefore of paramount importance. Carcasses of wild boar that succumbed to African swine fever represent an important source of infection and support the perpetuation of the infection cycle. Hence, timely removal of carcasses from the environment in infected areas is an important disease control measure but is sometimes difficult due to logistic limitations-e.g., in forests or thickets. Deterring wild boar from carcasses may therefore constitute an interim solution. We aimed at identifying suitable deterrence strategies and found that certain chemical and physical deterrents seem to deter wild boar, to some extent, are easy to apply and may thus contribute to disease control. In depth investigation of the deterrence effect of the promising deterrent candidates identified in this pilot study should be considered. African swine fever (ASF) is a viral infection of pigs and represents a major threat to animal health and trade. Due to the high tenacity of the causative virus in carcasses of wild boar, contacts of wild boar with infectious carcasses are regarded an important driver of the so-called habitat cycle. The latter is believed to play a major role in maintaining the present ASF situation in wild boar in Europe. Therefore, search campaigns and timely removal and disposal of carcasses are considered important disease control approaches. If timely disposal is not feasible due to logistic reasons, deterrence of wild boar may be a provisional option. The performance of seven deterrents (physical and chemical) was tested in a forest near Greifswald, Germany. Carcasses as entities of attraction for wild boar were substituted by luring sites. It could be demonstrated in this pilot study that certain physical (LED blinkers, aluminum strips) and chemical (HAGOPUR Wildschwein-Stopp (TM), Hukinol (TM)) deterrents are capable of reducing the odds of wild boar contacts to one third, but in depth testing of the aforementioned promising deterrent candidates is recommended. A choice of those deterrents identified as suitable, reasonable, and easy to apply should be carried out, when carcass search campaigns are launched in the case of an outbreak of ASF in wild boar.

All about *Toxoplasma gondii* infections in pigs: 2009-2020

Dubey, J.P., Cerqueira-Cezar, C.K., Murata, F.H.A., Kwok, O.C.H., Hill, D., Yang, Y.R. and C. Su 2020

Veterinary Parasitology, DOI: 10.1016/j.vetpar.2020.109185

Toxoplasma gondii infections are common in humans and animals worldwide. *Toxoplasma gondii* infection in pigs continues to be of public health concern. Pigs are important for the economy of many countries, particularly, USA, China, and European countries. Among the many food animals, pigs are considered the most important for *T. gondii* transmission in USA and China because viable parasites have rarely been isolated from beef or indoor raised chickens. Besides public health issues, *T. gondii* causes outbreaks of clinical toxoplasmosis in pigs in China, associated with a unique genotype of *T. gondii* (ToxoDB genotype #9 or Chinese 1), rarely found in other countries. The safety of ready to eat pork products with respect to *T. gondii* infection is a matter of recent debate. Here, we review in detail seroprevalence, prevalence of viable and nonviable *T. gondii*, epidemiology, risk assessment, diagnosis, and curing of pork products





containing *T. gondii* for the past decade. This review will be of interest to biologists, parasitologists, veterinarians, and public health workers.

Gamma radiation effect on *Trichinella pseudospiralis* and *Trichinella spiralis* infected wild boar meat

Ercole, M.E., Bessi, C., Pasqualetti, M.I., Ribicich, M.M., Aronowicz, T., Bonboni, A., Acerbo, M. and F. A. Farina 2020

Veterinary Parasitology 287, <https://doi.org/10.1016/j.vetpar.2020.109257>

Trichinellosis is a foodborne parasitic disease caused by *Trichinella* spp. Different methods, such as cooking, freezing and irradiation, have been suggested to inactivate the parasite in meat infected with *Trichinella* spp. The International Commission on Trichinellosis (ICT) recommends an irradiation dose of 0.3 kGy to inactivate *Trichinella* spp. larvae, but its effectiveness in all *Trichinella* species has not yet been demonstrated. Therefore, the objective of the present study was to determine the effectiveness of gamma radiation in treating wild boar meat to inactivate *Trichinella pseudospiralis* and *Trichinella spiralis*. Two wild boars (*Sus scrofa*) were each inoculated per os (PO) with 20,000 muscle larvae (ML) of *Trichinella*. One wild boar was inoculated with *T. pseudospiralis* and the other one with *T. spiralis*. Both wild boars were euthanized 20 weeks post infection (pi). A 250 g sample from each selected muscle type (side ribs, shoulder and upper forelegs) was obtained in duplicate from each animal. One group of samples was not irradiated (Gc; n = 6) while the other group of samples was irradiated (Gt; n = 6) at the Atomic Centre of the Argentinean National Commission of Atomic Energy (CNEA) with a minimum and maximum dose of 0.32 - 0.41 kGy. Twenty gram of each muscle from Gt and Gc were taken at 24 h, 7 days, 14 days and 21 days post-irradiation, and all samples were individually processed by means of artificial digestion. The ML were then inoculated into mice to evaluate the intestinal phase and the muscular phase. All recovered larvae from Gt and Gc samples showed integrity of the cuticle and active motility. Adult worms and ML were recovered from all mice inoculated with ML from Gc. However, no adult worms or ML were obtained in mice inoculated with ML from Gt. These results show the efficacy of irradiation to inhibit the development of *T. pseudospiralis* and *T. spiralis* in the host, which could possibly be extended to other non-encapsulated species, but further studies are needed to demonstrate this hypothesis.

Could wild boar be the Trans-Siberian transmitter of African swine fever?

Fekede, R.J., Wang, H.N., Hein, V. and X.L. Wang

Transboundary and Emerging Diseases, <https://doi.org/10.1111/tbed.13814>

China has experienced a sudden multi-focal and multi-round of African swine fever (ASF) outbreaks during 2018. The subsequent epidemiological survey resulted in a debate including the possibility of a transboundary spread from European Russia to China through wild boar. We contribute to the debate by assessing a hypothetical overland Euro-Siberian transmission path and its associated ASF arrival dates. We selected the maximum entropy algorithm for spatial modelling of ASF-infected wild boar and the Spatial Distribution Modeller in ArcGIS to plot Least Cost Paths (LCPs) between Eastern Europe and NE China. The arrival dates of ASF-infected wild boar have been predicted by cumulative maximum transmission distances per season and cover with their associated minimum time intervals along the LCPs. Our results show high costs for wild boar to cross Kazakhstan, Xinjiang (NW China) and/or Mongolia to reach NE China. Instead, the Paths lead almost straight eastward along the 59.5 degrees northern latitude through Siberia and





would have taken a minimum of 219 or 260 days. Therefore, infected wild boar moving all the way along the LCP could not have been the source of the ASF infection in NE China on 2 August 2018.

Computer Vision Applied to Detect Lethargy through Animal Motion Monitoring: A Trial on African Swine Fever in Wild Boar

Fernandez-Carrion, E., Barasona, J.A., Sanchez, A., Jurado, C., Cadenas-Fernandez, E. and J.M. Sanchez-Vizcaino 2020

Animals 10(12), <https://doi.org/10.3390/ani10122241>

Early detection of infectious diseases is the most cost-effective strategy in disease surveillance for reducing the risk of outbreaks. Latest deep learning and computer vision improvements are powerful tools that potentially open up a new field of research in epidemiology and disease control. These techniques were used here to develop an algorithm aimed to track and compute animal motion in real time. This algorithm was used in experimental trials in order to assess African swine fever (ASF) infection course in Eurasian wild boar. Overall, the outcomes showed negative correlation between motion reduction and fever caused by ASF infection. In addition, infected animals computed significant lower movements compared to uninfected animals. The obtained results suggest that a motion monitoring system based on artificial vision may be used in indoors to trigger suspicions of fever. It would help farmers and animal health services to detect early clinical signs compatible with infectious diseases. This technology shows a promising non-intrusive, economic and real time solution in the livestock industry with especial interest in ASF, considering the current concern in the world pig industry.

Stability of African Swine Fever Virus in Carcasses of Domestic Pigs and Wild Boar Experimentally Infected with the ASFV "Estonia 2014" Isolate

Fischer, M., Huhr, J., Blome, S., Conraths, F.J. and C. Probst 2020

Viruses 12(10), <https://doi.org/10.3390/v12101118>

Europe is currently experiencing a long-lasting African swine fever (ASF) epidemic, both in domestic pigs and wild boar. There is great concern that carcasses of infected wild boar may act as long-term virus reservoirs in the environment. We evaluated the tenacity of ASF virus (ASFV) in tissues and body fluids from experimentally infected domestic pigs and wild boar, which were stored on different matrices and at different temperatures. Samples were analysed at regular intervals for viral genome and infectious virus. ASFV was most stable in spleen or muscles stored at -20 degrees C and in blood stored at 4 degrees C. In bones stored at -20 degrees C, infectious virus was detected for up to three months, and at 4 degrees C for up to one month, while at room temperature (RT), no infectious virus could be recovered after one week. Skin stored at -20 degrees C, 4 degrees C and RT remained infectious for up to three, six and three months, respectively. In urine and faeces, no infectious virus was recovered after one week, irrespective of the matrix. In conclusion, tissues and organs from decomposing carcasses that persist in the environment for a long time can be a source of infection for several months, especially at low temperatures.

Foodborne Zoonoses Common in Hunted Wild Boars

Fredriksson-Ahomaa, M., London, L., Skrzypczak, T., Kantala, T., Laamanen, I., Bistrom, M., Maunula, L. and T. Gadd 2020

EcoHealth, <https://doi.org/10.1007/s10393-020-01509-5>





The northern European wild boar population has increased during the last decade. Highest wild boar numbers in Finland have been reported in the southeastern part near the Russian border. Wild boars may be infected with several human and animal pathogens. In this study, we investigated the presence of important foodborne pathogens in wild boars hunted in 2016 in Finland using serology, PCR and culturing. Seroprevalence of *Salmonella* (38%) and *Yersinia* (56%) infections was high in wild boars. Antibodies to hepatitis E virus, *Toxoplasma gondii* and *Brucella* were found in 18%, 9% and 9% of the wild boars, respectively. *Trichinella* antibodies were detected in 1% of the animals. We recorded no differences in the seroprevalence between males and females. However, *Yersinia* and *T. gondii* antibodies were detected significantly more often in adults than in young individuals. *Listeria monocytogenes* (48%) and stx-positive *Escherichia coli* (33%) determinants were frequently detected in the visceral organs (spleen and kidneys) by PCR. *Yersinia pseudotuberculosis* O:1 and *L. monocytogenes* 2a and 4b were identified by culturing from the PCR-positive samples. *Brucella suis* biovar 2 was isolated from visceral organs. No African swine fever, classical swine fever or Aujeszky's disease were detected in the wild boars. Our study shows that wild boars are important reservoirs of foodborne pathogens.

Population Genetic Structure of the Wild Boar (*Sus scrofa*) in the Carpathian Basin

Mihalik, B., Frank, K., Astuti, P.K., Szemethy, D., Szendrei, L., Szemethy, L., Kusza, S. and V. Steger 2020

Genes 11(10), <https://doi.org/10.3390/genes11101194>

In the Carpathian Basin the wild boar (*Sus scrofa*) belongs among the most important game species both ecologically and economically, therefore knowing more about the basics of the genetics of the species is a key factor for accurate and sustainable management of its population. The aim of this study was to estimate the genetic diversity and to elucidate the genetic structure and location of wild boar populations in the Carpathian Basin. A total of 486 samples were collected and genotyped using 13 STR markers. The number of alleles varied between 4 and 14, at 9 of the 13 loci the observed heterozygosity was significantly different ($p < 0.05$) from the expected value, showing remarkable introgression in the population. The population was separated into two groups, with an F_{st} value of 0.03, suggesting the presence of two subpopulations. The first group included 147 individuals from the north-eastern part of Hungary, whereas the second group included 339 samples collected west and south of the first group. The two subpopulations' genetic indices are roughly similar. The lack of physical barriers between the two groups indicates that the genetic difference is most likely caused by the high reproduction rate and large home range of the wild boars, or by some genetic traces' having been preserved from both the last ice age and the period before the Hungarian water regulation.

Wild boar as a potential reservoir of zoonotic tick-borne pathogens

Hrazdilova, K., Lesiczka, P.M., Bardon, J., Vyroubalova, S., Simek, B., Zurek, L. and D. Modry 2021

Ticks and Tick-Borne Diseases 12(1), <https://doi.org/10.1016/j.ttbdis.2020.101558>

The wild boar (*Sus scrofa*) population has increased dramatically over the last decades throughout Europe and it has become a serious pest. In addition, the common habitat of wild boar and of the tick, *Ixodes ricinus*, indicates the potential of wild boar to play a role in epidemiology of epizootic and zoonotic tick-borne pathogens, including *Anaplasma phagocytophilum*. In Europe,





epidemiological cycles and reservoirs of *A. phagocytophilum*, including its zoonotic haplotypes, are poorly understood. In this study, we focused on detection and further genetic characterization of *A. phagocytophilum* and piroplasmids in 550 wild boars from eleven districts of Moravia and Silesia in the Czech Republic. Using highly sensitive nested PCR targeting the *groEL* gene, the DNA of *A. phagocytophilum* was detected in 28 wild boars (5.1 %) representing six unique haplotypes. The dominant haplotype was found in 21 samples from 7 different districts. All detected haplotypes clustered in the largest clade representing the European ecotype I and the dominant haplotype fell to the subclade with the European human cases and strains from dogs and horses. Nested PCR targeting the variable region of the 18S rRNA gene of piroplasmids resulted in one positive sample with 99.8 % sequence identity to *Babesia divergens*. The presence of these two pathogens that are primarily circulated by *I. ricinus* confirms the local participation of wild boar in the host spectrum of this tick and warrants experimental studies to address wild boar as a reservoir of zoonotic haplotypes of *A. phagocytophilum*.

***Salmonella* seroprevalence in wild boar from Southeast Spain depends on host population density**

Ortega, N., Fanelli, A., Serrano, A., Martinez-Carrasco, C., Escribano, F., Tizzani, P. and M.G. Candela 2020

Research in Veterinary Science 132: 400-403

Salmonellosis is the second most prevalent zoonosis in Europe and it has considerable economic and health implications for its monitoring and control as well as being among the most prevalent pathogens on livestock farms. The wild boar (*Sus scrofa*) has been identified as a competent host and spreader of *Salmonella* spp. There has been a significant increase in wild boar population in Europe in recent decades, and it is even present in urban areas. This study evaluates the spatial distribution of the seroprevalence of *Salmonella* spp. in wild boar from Murcia (Southeast Spain) and its relationship with host-related risk factors (sex, age, location and density). The presence of antibodies against *S. Typhimurium* and *Choleraesuis* in 269 serum of wild boars hunted in Murcia between 2015 and 2019 were analyzed using a commercial ELISA test (PrioCHECK porcine *Salmonella* kit). The seroprevalence were spatially distributed using Kernel function, and wild boar density using Gaussian kernel estimates (spatialEco version 1.1.1). The risk function was estimated as the ratio between the intensity of positive samples and the wild boar density. The overall seroprevalence was 19.3% (IC95% 16.9-21.8), showing a significant spatial aggregation. The highest seroprevalence detected was 51.8% (IC95% 42.2-61.5) in a specific area with high risk of infection (76-100%) and was related to the wild boar density. Only marginal differences were detected for sex and age. The use of ELISA combined with QGIS (version 3.6.0) has allowed the identification of areas of *Salmonella* occurrence associated with high density as risk factor.

African swine fever in the Lithuanian wild boar population in 2018: a snapshot

Pautienius, A., Schulz, K., Staubach, C., Grigas, J., Zagrabskaite, R., Buitkuviene, J., Stankevicius, R., Streimikyte, Z., Oberauskas, V., Zienius, D., Salomskas, A., Sauter-Louis, C. and A. Stankevicius 2020

Virology Journal 17, <https://doi.org/10.1186/s12985-020-01422-x>

The first cases of African swine fever (ASF) were detected in the Lithuanian wild boar population in 2014. Since then, the disease spread slowly through the whole country, affecting both, wild





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boar and domestic pigs. In the other Baltic states, which both are also affected by ASF since 2014, the recent course of ASF prevalence suggests that the countries might be well under way of disease elimination. In contrast, in Lithuania the epidemic seems to be still in full progress. In the present study, we aimed to extend a previous prevalence study in Lithuania. Looking at ASF virus (ASFV) and seroprevalence estimates of wild boar in all months of 2018 and in all affected municipalities in Lithuania, the course of ASF was evaluated on a temporal and spatial scale. A non-spatial beta-binomial model was used to correct for under- or overestimation of the average prevalence estimates. Within 2018 no big differences between the prevalence estimates were seen over time. Despite of the lower sample size, highest ASFV prevalence estimates were found in dead wild boar, suggesting higher detection rates through passive surveillance than through active surveillance. Accordingly, with the maximum prevalence of 87.5% in May 2018, the ASFV prevalence estimates were very high in wild boar found dead. The number of samples originating from hunted animals (active surveillance) predominated clearly. However, the ASFV prevalence in those animals was lower with a maximum value of 2.1%, emphasizing the high value of passive surveillance. A slight increase of the seroprevalence in hunted wild boar could be seen over time. In the center of Lithuania, a cluster of municipalities with high ASFV and seroprevalence estimates was found. The results of the study indicate that ASFV is still circulating within the Lithuanian wild boar population, constituting a permanent risk of disease transmission into domestic pig holdings. However, additional, more recent data analyses are necessary to re-evaluate the course of ASF in Lithuania and thus, to be able to make a statement about the stage of the ASF epidemic in the country. This is of huge importance for Lithuania for evaluating control measures and their efficacy, but also for neighbouring countries to assess the risk of disease spread from Lithuania.

Social structure defines spatial transmission of African swine fever in wild boar

Pepin, K.M., Golnar, A. and T. Podgorski 2021

Journal of the Royal Society Interface 18(174), <https://doi.org/10.1098/rsif.2020.0761>

The spatial spread of infectious disease is determined by spatial and social processes such as animal space use and family group structure. Yet, the impacts of social processes on spatial spread remain poorly understood and estimates of spatial transmission kernels (STKs) often exclude social structure. Understanding the impacts of social structure on STKs is important for obtaining robust inferences for policy decisions and optimizing response plans. We fit spatially explicit transmission models with different assumptions about contact structure to African swine fever virus surveillance data from eastern Poland from 2014 to 2015 and evaluated how social structure affected inference of STKs and spatial spread. The model with social structure provided better inference of spatial spread, predicted that approximately 80% of transmission events occurred within family groups, and that transmission was weakly female-biased (other models predicted weakly male-biased transmission). In all models, most transmission events were within 1.5 km, with some rare events at longer distances. Effective reproductive numbers were between 1.1 and 2.5 (maximum values between 4 and 8). Social structure can modify spatial transmission dynamics. Accounting for this additional contact heterogeneity in spatial transmission models could provide more robust inferences of STKs for policy decisions, identify best control targets and improve transparency in model uncertainty.

Wild boar recognition using convolutional neural networks

Silva, L.C., Padua, M.B.S., Ogusuku, L.M., Albertini, M.K., Pimentel, R. and A.R. Backes 2020





New literature on Suiformes



Concurrency and Computation-Practice and Experience, <https://doi.org/10.1002/cpe.6010>

Wild boar (*Sus scrofa*) is a destructive species of swine. They spread diseases, represent a threat to native species, and destroy natural habitats by destabilizing river banks, thus reducing water flow. The monitoring of populations of wild boars is central to the execution and evaluation of methods to control them. To address this issue, in this article, we retrain and apply four convolutional neural networks (CNNs; AlexNet, VGG-16, Inception-v3, and ResNet-50) to classify different species of bush pigs" in real-world footage: two native species of the Brazilian fauna, collared peccary (*Pecari tajacu*) and white-lipped peccary (*Tayassu pecari*), and one invasive species, wild boar (*S. scrofa*). Results show that CNN can be used to classify animals with very similar behavior and appearance and that ResNet-50 outperforms all compared CNN in terms of accuracy (98.33%) and the lowest probability of false positives (i.e., native species classified as wild boar).

Development of Wild Boar Species-Specific DNA Markers for a Potential Quality Control and Traceability Method in Meat Products

Szemethy, D., Mihalik, B., Frank, K., Nagy, T., Ujvary, D., Kusza, S., Szemethy, L., Barta, E. and V. Steger 2021

Food Analytical Methods 14(1): 18-27

In the food supply chain, quality control has a very important role in maintaining customer confidence. In the EU, food safety aspects are strictly regulated; however, composition requirements and standard control methods are generally undefined. The rapidly increasing wild boar population has a growing market share in venison or game meat production. Several methods have been described for species identification and control of composition in food products, but only some of these are suitable for routine measurements. The aim of our research was to design a rapid, reliable and simple PCR insertion/deletion (InDel)-based genetic tool suitable for species identification in food quality control laboratories. In total, 59 different swine (*Sus scrofa*) whole genomes were tested with bioinformatic tools to identify wild boar-specific insertions or deletions. Three independent InDels were suitable for marker development, multiplex PCR amplification and separation in agarose gel. Altogether, 209 samples of wild boar and ten other domestic pig breeds were taken for DNA extraction and validation of the three multiplexed InDel markers. Statistical analysis showed a very high combined predictive value (0.996), indicating the capability of the newly developed markers to detect wild boars with a probability over 99%. Breed assignment tests confirm that the InDel markers developed are suitable for rapid, sensitive and reliable identification of the wild boar meat content of food products. The use of the reported method in food quality control can mean a simple and cost-effective way to maintain consumer confidence and to support the competitiveness of fair producers.

A case study of the molecular diagnosis of *Echinococcus multilocularis* in wild boar with comments on its public health significance in Turkey

Kesik, H.K., Kilinc, S.G., Celik, F., Simsek, S. and H. Ahmed 2020

Journal of Parasitology 106(6): 730-734

Echinococcus multilocularis is a parasite species of zoonotic importance which can be fatal to humans and causes Alveolar Echinococcosis (AE). This report describes the development of a cyst from the liver of a wild boar and molecular confirmation of its identification. The cyst material





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was obtained from the liver of a wild boar killed by hunters. Genomic DNA was extracted from the germinal layer of the cyst material, and 875 bp mitochondrial cytochrome c oxidase subunit I (COI) gene fragment was amplified by PCR and sequenced. A BLAST search matched 100% with published *Echinococcus multilocularis* sequences. This study confirms the occurrence of *E. multilocularis* in a wild boar for the first time in Turkey.

The presence of antibodies against pseudorabies virus in wild boars (*Sus scrofa*) in Korea

Kim, H.H., Ji, M., Wang, J.Y., An, D.J. and D.K. Yang 2020

Journal of Zoo and Wildlife Medicine 51(4): 981-984

The control and elimination of pseudorabies (PR) is one of the most important goals in the pig industry. After the first PR outbreak in Korea in 1986, all pigs infected with PR virus (PRV) were removed, and a vaccination program for pigs was implemented. No PR has occurred in Korea since 2010, and vaccination was discontinued after 2013. Information on the seroprevalence of PRV in pigs, including wild boars (*Sus scrofa*), is important for evaluating the PR status in a country. In this study, 2.65% (28/1057) of the wild boars tested had antibodies against PRV in 2018, indicating that PRV has been circulating continuously in the wild boar population in Korea. Effective means should be implemented to prevent the transmission of PRV between wild and domestic pigs, because the wild boar is a potential reservoir host for PRV.

Distinct African Swine Fever Virus Shedding in Wild Boar Infected with Virulent and Attenuated Isolates

Kosowska, A., Cadenas-Fernandez, E., Barroso, S., Sanchez-Vizcaino, J.M. and J.A. Barasona 2020

Vaccines 8(4), <https://doi.org/10.3390/vaccines8040767>

Since the reappearance of African swine fever virus (ASFV), the disease has spread in an unprecedented animal pandemic in Eurasia. ASF currently constitutes the greatest global problem for the swine industry. The wild boar (*Sus scrofa*) in which the pathogen has established wild self-sustaining cycles, is a key reservoir for ASFV, signifying that there is an urgent need to develop an effective vaccine against this virus. Current scientific debate addresses whether live attenuated vaccines (LAVs), which have shown promising results in cross-protection of susceptible hosts, may be feasible for vaccinations carried out owing to safety concerns. The objective of this study was, therefore, to compare the ASFV shedding in wild boar infected with virulent and attenuated (LAV) isolates. Different shedding routes (oral fluid and feces) and viremia rates were characterized in wild boar inoculated with Lv17/WB/Rie1 isolate (n = 12) when compared to those inoculated with the virulent Armenia07 isolate (n = 17). In general, fewer animals infected with the Lv17/WB/Rie1 isolate tested positive for ASFV in blood, oral fluid, and feces in comparison to animals infected with the virulent Armenia07 isolate. The shedding patterns were characterized in order to understand the transmission dynamics. This knowledge will help evaluate the shedding of new LAV candidates in wild boar populations, including the comparison with gene deletion mutant LAVs, whose current results are promising.

Wild Boar as a Sylvatic Reservoir of Hepatitis E Virus in Poland: A Cross-Sectional Population Study

Kozyra, I., Jablonski, A., Bigoraj, E., and A. Rzezutka 2020

Viruses 12(10), <https://doi.org/10.3390/v12101113>





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The most important wildlife species in the epidemiology of hepatitis E virus (HEV) infections are wild boars, which are also the main reservoir of the virus in a sylvatic environment. The aim of the study was a serological and molecular assessment of the prevalence of HEV infections in wild boars in Poland. In total, 470 pairs of samples (wild boar blood and livers) and 433 samples of faeces were tested. An ELISA (ID.vet, France) was used for serological analysis. For the detection of HEV RNA, real-time (RT)-qPCR was employed. The presence of specific anti-HEV IgG antibodies was found in 232 (49.4%; 95%CI: 44.7-54%) sera, with regional differences observed in the seroprevalence of infections. HEV RNA was detected in 57 (12.1%, 95%CI: 9.3-15.4%) livers and in 27 (6.2%, 95%CI: 4.1-8.9%) faecal samples, with the viral load ranging from 1.4 to 1.7×10^{11} G.C./g and 38 to 9.3×10^7 G.C./mL, respectively. A correlation between serological and molecular results of testing of wild boars infected with HEV was shown. HEV infections in wild boars appeared to be common in Poland.

Spotted fever group rickettsiae in *Dermacentor marginatus* from wild boars in Italy

Sgroi, G., Iatta, R., Lia, R.P., D'Alessio, N., Manoj, R.R.S., Veneziano, V. and D. Otranto
Transboundary and Emerging Diseases, <https://doi.org/10.1111/tbed.13859>

Following the increase in wild boar population recorded in urban and peri urban areas throughout Europe, the present survey aimed to assess the occurrence of zoonotic tick borne pathogens (TBPs) in wild boars living in southern Italy and in their ticks for evaluating the potential risk of infection for animals and humans. From October to December 2019, a total of 176 ticks collected from 93 wild boars and their spleen samples were molecularly screened for selected TBPs. Overall, all the wild boars were infested by ticks (mean intensity, 1.9) with *Dermacentor marginatus* and *Ixodes ricinus* being identified in 99.4% and 0.6%, respectively. Out of 93 wild boars, 17 (18.3%) were infested by ticks which scored positive to spotted fever group (SFG) *Rickettsia* species. *Rickettsia slovaca* and *Rickettsia raoultii* were identified in 16 (9%) and 1 (0.6%) *D. marginatus*, respectively, whereas a single *I. ricinus* (0.6%) was infected by *R. slovaca*. A single wild boar (1.1%) tested positive to *R. slovaca*. All ticks and wild boars scored negative to *Babesia/Theileria* spp., *Ehrlichia* spp., *Anaplasma* spp., *Candidatus Neoehrlichia* spp., *Coxiella burnetii* and *Borrelia burgdorferi* sensu lato complex. Data herein obtained suggest that wild boars are involved in the maintenance of *D. marginatus* in the environment as in peri urban areas herein investigated. An integrated management approach is advocated for wild boar population control and in preventing the potential risk of TBPs infection in animals and humans.

***Taenia hydatigena* cysticercosis in wild boar (*Sus scrofa*) from southern Italy: an epidemiological and molecular survey**

Sgroi, G., Varcasia, A., D'Alessio, N., Varuzza, P., Buono, F., Amoroso, M.G., Boufana, B., Otranto, D., Fioretti, A. and V. Veneziano 2020
Parasitology 147(14): 1636-1642

Taenia hydatigena cysticercosis is a widespread parasitic disease of wild and domestic animals. In Europe, the increase in wild boar population may potentially contribute to the spread of this parasitic infection. To determine the occurrence of cysticerci (metacestodes) in wild boar population from southern Italy, carcasses were inspected during three hunting seasons (2016-2018). Out of 3363 wild boar examined, 229 (6.8%) harboured cysticerci with 188 (82.1%) infected by a single cyst, vs 41 (17.9%) boars having more than one. Most of the positive animals





(187; 81.7%) showed cysts on the liver, whereas a multiple localization of cysticerci was reported in 10 (4.4%) wild boar. The total number of cysts retrieved from positive animals was 301 (average 1.3). Molecular analysis revealed the occurrence of a common haplotype (Hap 8) shared between wild boar and domestic animals. Our findings suggest the presence of a *T. hydatigena* semi-domestic life cycle in which wild boar may play an important role, due to a large number of offal available to hunting dogs, wolves and foxes during hunting seasons. Hunters may be players in the management of wildlife species to control and prevent the circulation of parasitic diseases.

Genotyping of *Toxoplasma gondii* in wild boar (*Sus scrofa*) in southern Italy: Epidemiological survey and associated risk for consumers

Sgroi, G. Viscardi, M., Santoro, M., Borriello, G., D'Alessio, N., Boccia, F., Pacifico, L., Fioretti, A., Veneziano, V. and G. Fusco 2020

Zoonoses and Public Health 67(7): 803-811

Toxoplasma gondii is a widespread protozoan parasite (phylum Apicomplexa), which causes a zoonotic parasitic disease, known as toxoplasmosis. The aim of this study was to evaluate the occurrence and genotypes of *T. gondii* in wild boars of southern Italy and thus to assess the risk of infection for consumers. The boars were inspected during the hunting season within the regional project 'Wild Boar Emergency Plan in Campania', and molecular analyses were performed on 338 boars analysing a total number of 884 matrices (263 brains, 310 hearts and 311 masseter muscles). *Toxoplasma gondii* was detected in 134 out of 338 boars (39.6%). No significant statistical difference between genders was found ($\chi^2 = 0.15$; $p = .70$). The prevalence was 47.1%, 39.3% and 39.2% in piglets, yearlings and adults, respectively ($\chi^2 = 0.41$; $p = .81$). The highest prevalence of *T. gondii* was found in masseter muscles (74/311, 23.8%), followed by the heart (70/310, 22.6%) and brain (58/263, 22.0%), respectively. Microsatellite (MS) analysis of 11 samples revealed eleven *T. gondii* genotypes (nine atypical, one belonging to type II one to type III). Most of the genotypes found were thus atypical and may be virulent in humans. Hierarchical clustering analysis showed the presence of three distinct clusters, with the majority of atypical genotypes in the GII-GIII cluster. The high prevalence of infection in masseters highlights the potential risk for public health, considering that this muscle is commonly used to prepare raw meat products ('guanciale' and sausages), which may be a source of *T. gondii* infection in humans. Wild boars may act as an interface role between wildlife, livestock and humans. Our data highlight the urgent need to minimize the risk of infection for animals and humans by setting up a surveillance programme and preventive strategies in a One Health approach to wildlife species.

Colonization of Germ-Free Piglets with Mucinolytic and Non-Mucinolytic Bifidobacterium boum Strains Isolated from the Intestine of Wild Boar and Their Interference with *Salmonella Typhimurium*

Splichalova, A., Pechar, R., Killer, J., Splichalova, Z., Bunesova, V.N., Vlkova, E., Salmonova, H.S. and I. Splichal 2020

Microorganisms 8(12), <https://doi.org/10.3390/microorganisms8122002>

Non-typhoidal *Salmonella* serovars are worldwide spread foodborne pathogens that cause diarrhea in humans and animals. Colonization of gnotobiotic piglet intestine with porcine indigenous mucinolytic *Bifidobacterium boum* RP36 strain and non-mucinolytic strain RP37 and





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their interference with *Salmonella typhimurium* infection were compared. Bacterial interferences and impact on the host were evaluated by clinical signs of salmonellosis, bacterial translocation, goblet cell count, mRNA expression of mucin 2, villin, claudin-1, claudin-2, and occludin in the ileum and colon, and plasmatic levels of inflammatory cytokines IL-8, TNF-alpha, and IL-10. Both bifidobacterial strains colonized the intestine comparably. Neither RP36 nor RP37 *B. boum* strains effectively suppressed signs of salmonellosis. Both *B. boum* strains suppressed the growth of *S. typhimurium* in the ileum and colon. The mucinolytic RP36 strain increased the translocation of *S. typhimurium* into the blood, liver, and spleen.

Increasing Hepatitis E Virus Seroprevalence in Domestic Pigs and Wild Boar in Bulgaria

Takova, K., Koynarski, T., Minkov, I., Ivanova, Z., Toneva, V. and G. Zahmanova 2020

Animals 10(9), <https://doi.org/10.3390/ani10091521>

Simple Summary Hepatitis E virus (HEV) is a lesser-known hepatitis virus, but its worldwide spread is undisputed and has increased in recent years. The zoonotic spread of HEV, mainly due to genotype (gt) 3, emerged in developed countries in the past decade. In addition, transmission via contaminated meat from pigs and boars was also established. Detailed analysis of viral dynamics and distribution is needed in order to identify associated risk factors. The aim of the current study is to present new and additional data on the HEV distribution among pigs, and for the first-time, also among the wild boar population in Bulgaria. (1) Background: Hepatitis E virus (HEV) is a causative agent of acute viral hepatitis, predominantly transmitted by the fecal-oral route. In developed countries, HEV is considered to be an emerging pathogen since the number of autochthonous cases is rising. Hepatitis E is a viral disease with a proven zoonotic potential for some of its genotypes. The main viral reservoirs are domestic pigs and wild boar. Consumption of undercooked meat, as well as occupational exposure, are key factors for the spread of HEV. In order to evaluate the risks of future viral evolution, a detailed examination of the ecology and distribution of the virus is needed. The aim of the present study is to investigate the prevalence of anti-HEV IgG Ab in domestic pigs and wild boar in Bulgaria; (2) Methods: In this study, during the period of three years between 2017 and 2019, 433 serum samples from 19 different pig farms and 1 slaughterhouse were collected and analyzed. In addition, 32 samples from wild boar were also collected and analyzed during the 2018-2019 hunting season. All samples were analyzed by commercial indirect ELISA; (3) Results: Overall, HEV seroprevalence was 60% (95% CI 42.7-77.1) in domestic pigs and 12.5% (4/32) in wild boar. The observed seroprevalence of the slaughter-aged pigs was 73.65% (95% CI 58.7-87.3). Prevalence in domestic pigs was significantly higher in the samples collected during 2019 (98% (95% CI 96.1-99.9)) compared to those collected during 2017 (45.33% (95% CI 2.7-87.3)) and 2018 (38.46% (95% CI 29.1-49.7.)); (4) Conclusions: Our findings suggest that domesticated pigs and wild boar might be the reason for the increased HEV transmission across Bulgaria. The genotypic characterization of HEV found in pigs, wild boar and humans will give a more accurate view of the zoonotic transmission of this virus.

Levels of Metals and Organochlorine Pesticides in Kidney, Liver, and Muscle Tissues of Wild Boars (*Sus scrofa*) from Hatay Province, Eastern Mediterranean Region, Turkey

Tekeli, I.O., Yipel, M., Sengul, S.A. and F. Sakin 2021

Bulletin of Environmental Contamination and Toxicology 106: 257-263

Increases in the levels of environmental contaminants are reflected in wild animals, which are





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early indicators of pollution. Hatay is an ecologically important region with a high intensity of industrial and agricultural activities. This study aimed to investigate the contamination levels of metals and organochlorine pesticides associated with environmental pollution in tissues of wild boars from Turkey. The highest mean levels (mg kg⁻¹) of metals were 0.05 for As, 0.51 for Cd, 6.30 for Cu, 0.07 for Hg, 0.54 for Ni, and 0.57 for Pb in kidney tissues and 0.22 for Cr, 353.38 for Fe, 2.86 for Mn, and 46.76 for Zn in liver tissues. The Cd and Pb levels exceeded the maximum residue limits (MRLs) in some tissues. Among the studied pesticides, only p,p'-DDE contamination was quantified, and the mean levels were 3.6, 0.1, and 0.5 µg kg⁻¹ in liver, kidney, and muscle tissues respectively. In conclusion, Hatay Province requires monitoring in terms of environmentally important contaminants, mainly Cd, Pb, and DDT isomers.

Hunters' Acceptance of Measures against African Swine Fever in Wild Boar in Estonia

Urner, N., Motus, K., Nurmoja, I., Schulz, J., Sauter-Louis, C., Staubach, C., Conraths, F.J. and K. Schulz 2020

Preventive Veterinary Medicine 182, <https://doi.org/10.1016/j.prevetmed.2020.105121>

African swine fever (ASF) was first identified in Estonia in 2014, initially detected in wild boar and spreading to affect almost the whole country from late 2016 onwards. Passive surveillance and the control measures applied in Estonia are the main actions in the attempt to control the wild boar population and therefore limit the spread of ASF. Implementation and success of both activities depend mainly on the involvement and commitment of the executing force: the Estonian hunters. Thus, their acceptance of the measures is of utmost importance and with the help of participatory methods, their acceptability can be assessed. Participatory epidemiology allows the involvement of key stakeholders in planning control measures and surveillance strategies and gathering information otherwise inaccessible. By conducting focus group discussions and utilizing participatory tools, this study aimed to assess the acceptance of ASF control measures by hunters in Estonia. Furthermore, the study aimed to detect means to improve the motivation of hunters to support passive surveillance. Among hunters, the results ranked the trust in lower authorities (e.g. local official veterinarians) towards implementing control measures as high (in contrast to higher officials e.g. 'Ministry of Rural Affairs'), while perceiving themselves as the most trustworthy group among those implementing ASF control measures. Hunting and every measure supporting increased hunting, for example selective hunting, bait feeding and incentives for hunting wild boar, were deemed favourable for hunters. These measures also received the highest trust for controlling ASF. All measures hindering hunting and the movement of wildlife, for example fencing or involvement of the army in ASF control, were described as unpleasant or even unethical and trust in these measures to control the disease successfully was lacking. When assessing the perceived consequences for hunters of finding a dead wild boar, arising financial costs, additional workload and time consumption were highlighted. In line with these results, the two tools with the strongest motivational effect for taking part in passive surveillance were: (1) higher monetary incentives as compensation for the hunters' work, and (2) the reduction of the negative consequences by limiting the hunters' duties to solely reporting found dead wild boar. In conclusion, participatory methods can be used as a highly suitable tool for the evaluation of acceptance of measures and surveillance systems. Potentially, the results can help to improve control and passive surveillance in Estonia, as well as functioning as an example for other countries battling or awaiting ASF.





Undetected Circulation of African Swine Fever in Wild Boar, Asia

Vergne, T, Guinat, C. and D.U. Pfeiffer 2020

Emerging Infectious Diseases 26(10): 2480-2482

African swine fever is a growing threat to the livestock industry. We examined data indicating that in most countries in Asia, most notified events were related to farm outbreaks; meanwhile, only a few wild boar cases were reported. We hypothesize the virus circulates unnoticed in wild boar populations in Asia.

Comparison of the fecal microbiomes of healthy and diarrheic captive wild boar

Wang, B., Deng, B., Yong, F., Zhou, H.X., Qu, C.P. and Z. Y. Zhou 2020

Microbial Pathogenesis 147, <https://doi.org/10.1016/j.micpath.2020.104377>

Diarrhea caused by Enterotoxigenic *Escherichia coli* (ETEC) is one of the most common clinical diseases observed in captive wild boars, is usually caused by an imbalance in the gut microbiome, and is responsible for piglets significant mortality. However, little research has been undertaken into the structure and function of the intestinal microbial communities in wild boar with diarrhea influenced by enterotoxigenic *E. coli*. In this study, fecal samples were collected and 16S-rRNA gene sequencing was used to compare the intestinal microbiome of healthy captive wild boar and wild boar with diarrhea on the same farm. We found that the intestinal microbial diversity of healthy wild boar (HWB) was relatively high, while that of diarrheic wild boar (DWB) was significantly lower. Line Discriminant Analysis Effect Size showed that at the genus level, the abundance of *Escherichia-Shigella* and *Fusobacterium* was significantly higher in DWB. Phylogenetic Investigation of Communities by Reconstruction of Unobserved States analysis showed that the expression of genes in pathways including infectious diseases: bacterial, metabolism of amino acids, membrane transport, and signal transduction was significantly higher in DWB. In summary, this study provides a theoretical basis for the design of appropriate means of diarrhea treatment in captive wild boar.

Sex Differences in Intestinal Microbial Composition and Function of Hainan Special Wild Boar

Wang, X.Z., Zhang, Y., Wen, Q., Wang, Y., Wang, Z.X., Tan, Z., and K. B. Wu 2020

Animals 10 (9), <https://doi.org/10.3390/ani10091553>

The gut microbiome plays an important role in the health and disease status of the host. Research on the effect of sex on animal intestinal microorganisms is still limited; and the effect of castration on the gut microbiome of male pigs has not been fully investigated. In this study, 30 Hainan special wild boars at the same growth stage were divided into three groups (10 entire males, 10 females, and 10 castrated males). High-throughput 16S rRNA sequencing was used to investigate the fecal microbiota of the Hainan special wild boar. Firmicutes, Bacteroidetes, Actinobacteria, Spirochaetes, and Proteobacteria were the five dominant phyla found in the specimens. The relative abundance of Bacteroidetes was higher in the microbiota of female pigs than in male pigs, while Firmicutes was on the contrary. The percentage of Streptococcus and Lactobacillus was higher in males than females. The microbial diversity of females was significantly higher compared to males; castration increased the intestinal microbial diversity of males. Functional prediction showed that male fecal microorganisms were rich in membrane transport and carbohydrate metabolism; energy metabolism, glycan biosynthesis, and metabolism of cofactors and vitamins were rich in the female group; the fecal microorganisms of castrated males had higher membrane transport abundance.





Assessing methods to live-capture wild boars (*Sus scrofa*) in urban and peri-urban environments

Torres-Blas, I., Mentaberre, G., Castillo-Contreras, R., Fernandez-Aguilar, X., Conejero, C., Valdeperes, M., Gonzalez-Crespo, C., Colom-Cadena, A., Lavin, S. and J.R. Lopez-Olvera 2020 Veterinary Record, <https://doi.org/10.1136/vr.105766>

Background Wild boar (*Sus scrofa*) populations are increasing worldwide and invading urban areas. Live-capture can improve the management of this challenge, maximising efficiency, allowing scientific studies and potentially improving animal welfare. This study assesses teleanaesthesia, drop-net, corral trap and cage trap to live-capture wild boar in urban and peri-urban areas, evaluating efficiency and animal stress through haematology and serum biochemistry. **Methods** From 2012 to 2018, 655 wild boars were captured in 279 operations (drop-net=17, teleanaesthesia=186, cage trap=66 and corral trap=10) in the urban and peri-urban areas of Barcelona (Spain). Haematological and serum biochemical variables were determined in 145 wild boars (42 drop-netted, 41 teleanaesthetised, 38 cage-trapped and 24 corral-trapped). **Results** Performance (wild boars captured per operation) was highest for drop-net, followed by corral and cage traps, and finally teleanaesthesia. The three physical capture methods were more stressful than teleanaesthesia, causing a more intense physiological reaction, muscular damage, renal function impairment and homeostasis adaption. Stress response was predominantly adrenergic for drop-net and cortisol-induced for cage and corral traps. **Conclusion** Teleanaesthesia is the choice in reactive urban situations thanks to its adaptability; drop-net effectively targets wild boars in peri-urban environments; cage and corral traps are useful as long-term methods in specific areas.

Hunters' view on the control of African swine fever in wild boar. A participatory study in Latvia

Urner, N., Serzants, M., Uzule, M., Sauter-Louis, C., Staubach, C., Lamberg, K., Olsevskis, E., Conraths, F.J. and K. Schulz 2021

Preventive Veterinary Medicine 186, <https://doi.org/10.1016/j.prevetmed.2020.105229>

African swine fever (ASF) has massively spread in recent years and threatens the global pig industry. ASF has been present in Latvia since 2014. Hunters play a major role in the implementation of measures to control ASF and in passive disease surveillance. The probability to detect an ASF-positive wild boar is much higher in animals found dead than in hunted animals. Thus, the willingness and the motivation of hunters to support passive surveillance is of utmost importance. Using participatory methods, this study aimed to assess the acceptability of control measures for ASF in wild boar among hunters. In addition, new approaches to increase hunters' motivation to report wild boar found dead were investigated. A total of ten focus group discussions with hunters from different regions in Latvia were conducted. To assess the quantity and quality of contacts between hunters and stakeholders involved in the control of ASF, relation diagrams were used. Using ranking tools, the trust of the participants in stakeholders to implement control measures successfully was evaluated. Defined control measures were presented to the hunters and their acceptability investigated. An impact diagram and a list of defined motivation options for passive surveillance were offered to identify new ways to increase the willingness of hunters to support passive surveillance actively. A satisfactory and regular relationship was identified between the hunters, the Food and Veterinary Service (FVS) and the State Forest Service (SFS). The hunters' trust in these authorities was high. Although there is no vaccine against ASF, hunters





were convinced of the potential of vaccination in controlling ASF. However, building fences was considered as useless and ineffective. To increase the willingness of hunters to support passive surveillance, reducing the infection pressure in the forests was regarded as most motivating. Furthermore, hunters would appreciate a decrease in their costs and workload. The study provides new insight into the concerns and experiences of hunters. Including their views and expectations in the further design and implementation of control and surveillance activities may help to improve current efforts to control ASF in wild boar populations. Although representing the perceptions of Latvian hunters, the main conclusions may be adaptable to adjust ASF control and surveillance in other countries.

Accumulation of diastereomers of anticoagulant rodenticides in wild boar from suburban areas: Implications for human consumers

Alabau, E., Mentaberre, G., Camarero, P.R., Castillo-Contreras, R., Sanchez-Barbudo, I.S., Conejero, C., Fernandez-Bocharan, M.S., Lopez-Olvera, J.R. and R. Mateo 2020

Science of the Total Environment 738, <https://doi.org/10.1016/j.scitotenv.2020.139828>

We studied the prevalence of anticoagulant rodenticides (ARs) in liver and muscle tissues of wild boar captured in the urban area of Barcelona, the suburban area of Collserola Natural Park and the rural area of Santa Quiteria, next to Cabaneros National Park, in Spain. The objective was to assess the influence of both urbanisation and wild boar (*Sus scrofa*) trophic opportunism on the accumulation of these compounds. We have also evaluated the risk for human consumers of this game meat. Wild boars from Barcelona city showed the highest prevalence of ARs detection (60.8%), followed by the adjoining suburban area of Collserola N.P. (40%) and the rural distant area of Santa Quiteria (7.7%). Liver bioaccumulated ARs (45.2%) more frequently than muscle (11.9%). A significant proportion (13.7%) of wild boar captured in Barcelona city exceeded 200 ng/g of total ARs in liver, a threshold for adverse effects on blood clotting. For difenacoum, there was a predominance of cis isomer, while for brodifacoum and bromadiolone cis and trans isomers appeared in a similar proportion. According to the scarce available information on ARs toxicity in humans, the risk of acute poisoning from game meat consumption seems to be low. However, repeated exposure through liver consumption should be considered in further risk assessments because of the high concentration detected in some samples (up to 0.68 mg/kg).

Genetic origins and diversity of bushpigs from Madagascar (*Potamochoerus larvatus*, family Suidae)

Lee, C., Day, J., Goodman, S.M., Pedrono, M., Besnard, G., Frantz, L., Taylor, P.J., Herrera, M.J. and J. Gongora 2020

Scientific Reports 10, <https://doi.org/10.1038/s41598-020-77279-5>

The island of Madagascar, situated off the southeast coast of Africa, shows the first evidence of human presence ~ 10,000 years ago; however, other archaeological data indicates a settlement of the modern peoples of the island distinctly more recent, perhaps > 1500 years ago. Bushpigs of the genus *Potamochoerus* (family Suidae), are today widely distributed in Madagascar and presumed to have been introduced from Africa at some stage by human immigrants to the island. However, disparities about their origins in Madagascar have been presented in the literature, including the possibility of endemic subspecies, and few empirical data are available. Furthermore, the separation of bushpigs in Madagascar from their mainland relatives may have favoured the evolution of a different repertoire of immune genes first due to a founder effect and





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then as a response to distinct pathogens compared to their ancestors. Molecular analysis confirmed the species status of the bushpig in Madagascar as *P. larvatus*, likely introduced from the central region of southern Africa, with no genetic evidence for the recognition of eastern and western subspecies as suggested from previous cranial morphology examination. Investigation of the immunologically important SLA-DQB1 peptide-binding region showed a different immune repertoire of bushpigs in Madagascar compared to those on the African mainland, with seventeen exon-2 haplotypes unique to bushpigs in Madagascar (2/28 haplotypes shared). This suggests that the MHC diversity of the Madagascar populations may have enabled Malagasy bushpigs to adapt to new environments.

***Macracanthorhynchus hirudinaceus* in expanding wild boar (*Sus scrofa*) populations in Eastern Spain**

Lizana, V., Gortazar, C., Prats, R., Sanchez-Isarria, M.A., Carrion, M.J. and J. Cardells 2021
Parasitology Research 120: 919-927

Prevalence and temporal evolution of the infection by the acanthocephalan *Macracanthorhynchus hirudinaceus* is studied in the Valencian Community (Eastern Spain), a region only recently fully colonized by the expanding native Eurasian wild boar (*Sus scrofa*). For 8 years, a total of 1486 wild boars were sampled in order to look for the parasite. The mean prevalence was 20.7% (95% CI, 18.6-22.8; 307/1486). We observed an increasing trend through time, both in the number of wild boars and affected districts. The prevalence of *M. hirudinaceus* rose in parallel to the annual capture of wild boars, and its presence has been expanding towards the East. A hotspot of *M. hirudinaceus* is located to the west of the study area, in Muela de Cortes Game Reserve, where 89.6% of the wild boars were positive for the infection, constituting one of the world's highest known prevalence areas.

Mathematical Approach to Estimating the Main Epidemiological Parameters of African Swine Fever in Wild Boar

Loi, F., Cappai, S., Laddomada, A., Feliziani, F., Oggiano, A., Franzoni, G., Rolesu, S. and V. Guberti 2020

Vaccines 8(3), <https://doi.org/10.3390/vaccines8030521>

African swine fever (ASF) severely threatens the swine industry worldwide, given its spread and the absence of an available licensed vaccine, and has caused severe economic losses. Its persistence in wild boar (WB), longer than in domestic pig farms, and the knowledge gaps in ASF epidemiology hinder ASF virus (ASFV) eradication. Even in areas where disease is effectively controlled and ASFV is no longer detected, declaring eradication is difficult as seropositive WBs may still be detected. The aim of this work was to estimate the main ASF epidemiological parameters specific for the north of Sardinia, Italy. The estimated basic (R_0) and effective (R_e) reproduction numbers demonstrate that the ASF epidemic is declining and under control with an R_0 of 1.139 (95% confidence interval (CI) = 1.123-1.153) and R_e of 0.802 (95% CI = 0.612-0.992). In the last phases of an epidemic, these estimates are crucial tools for identifying the intensity of interventions required to definitively eradicate the disease. This approach is useful to understand if and when the detection of residual seropositive WB is no longer associated with any further ASFV circulation.

Anomalous erosion patterns on the cheek teeth of babirusa (genus *Babyrusa*)

Macdonald, A.A. 2020





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Can. J. Zool. 99: 1–8

Two types of anomalous erosive wear, designated “Wear” and “Groove”, were found in the molar teeth of adult babirusa (genus *Babirusa* Perry, 1811) species from Buru or the Sula Islands and Sulawesi, Indonesia. A survey of 590 specimens of babirusa crania and mandibles from international museums and private collections revealed their presence in 20 of 187 specimens from Buru or the Sula Islands, in 99 of 391 specimens from Sulawesi, and in 4 of 31 subfossil specimens from South Sulawesi. “N_Wear” comprised a discrete indentation or almost circular erosion of the enamel and underlying dentine in a molar tooth; “W_Wear” comprised tooth indentations of irregular shape larger than 7 mm 7 mm in size; “E_Wear” comprised extensive tooth indentation. “Wear” anomalies were found on 10% of specimens from Buru or the Sula Islands and on 17% of all Sulawesi crania and mandibles. It was hypothesised that tooth grinding of the abrasive seeds of the wild banana (*Musa balbisiana* Colla) initiated this anomaly. Groove was a deep, oval-shaped cleft cut into the enamel and dentine between two molar teeth. Groove anomalies were evident in 3% of Buru or the Sula Islands specimens and in 12% of all Sulawesi specimens. No conclusion was reached regarding the initiator of the Groove anomaly.

Comparative chromosome painting in Chacoan peccary, *Catagonus wagneri*

Musilova, P., Kubickova, S., Cernohorska, H. and J. Rubes 2021

Journal of Applied Genetics, <https://doi.org/10.1007/s13353-021-00619-2>

Chacoan peccary (*Catagonus wagneri*, $2n=20$) is the most endangered of three extant species of Tayassuidae. Its karyotype has been studied only by differential chromosome staining methods so far. To establish a comparative cytogenetic map of the peccary, we used cross-species hybridization with porcine (*Sus scrofa*, $2n=38$) painting probes. Painting revealed 30 evolutionary conserved autosomal segments between pig and peccary. The q-arm of the submetacentric chromosome X is homologous to the porcine X chromosome, while the p-arm is composed of heterochromatin. Nucleolar organizer regions were detected on chromosomes 8 and 9 which are homologous to pig chromosomes 8 and 4/18, respectively. Fusions of chromosomes homologous to pig chromosomes 4/7 and 4/18 and fission of chromosome 7 are synapomorphic characters shared by *Catagonus wagneri* and *Tayassu pecari* but not by *Pecari tajacu*. Our results confirmed a high rate of karyotype evolution in Tayassuidae and a closer relationship of *Catagonus wagneri* with *Tayassu pecari* than with *Pecari tajacu*.

Effect of growth differentiation factor 9 (GDF-9) on in vitro development of collared peccary preantral follicles in ovarian tissues

Campos, B.L., Silva, A.M., Praxedes, E.C.G., Bezerra, L.G.P., Freitas, J.L.S., Melo, L.M., Pereira, A.F., Figueiredo, J.R. and A.R.Silva 2021

Animal Reproduction Science 226: 106717

The aims were to identify the effects of growth differentiation factor 9 (GDF-9) on the in vitro development of ovarian preantral follicles (PAFs) of collared peccaries. Ovarian fragments were in vitro cultured for 1 or 7 days without or with inclusion of GDF-9 in the medium (0, 50, 100, or 200 ng/mL). The non-cultured (control) and cultured fragments were evaluated for PAF viability, activation, and cell proliferation. Although there were no differences in the percentage of morphologically normal follicles, the percentage of growing follicles was greater compared to the control in all treatment groups, especially those cultured with 200 ng/mL GDF-9 for 7 days ($P < 0.05$). The inclusion of GDF-9 in the medium did not interfere with PAF viability ($P > 0.05$);





however, treatment with 200 ng/mL GDF-9 resulted in greater ($P < 0.05$) cell proliferation in PAFs cultured for 1 or 7 days (-2.5 nucleolar organizing regions – NORs) compared to the follicles of the control group (2.0 NORs). In addition, peccary ovarian cortices were subjected to PCR analysis and there was detection of the mRNA GDF-9 receptor transcripts of the BMPR2 (type I receptor) and ALK-5 (type II receptor) types. In conclusion, GDF-9, especially at a 200 ng/mL inclusion in the culture medium, was actively involved in the in vitro development of collared peccary PAFs.

Diagnosis of *Mycobacterium bovis* infection in free! ranging common hippopotamus (*Hippopotamus amphibius*)

Kerr, T.J., Goosen, W.J., Gumbo, R., de Klerk Lorist, L.-M., Pretorius, O., Buss, P.E., Kleynhans, L., Lyashchenko, K.L., Warren, R.M., van Helden, P.D. and M.A. Miller 2021

Transboundary and Emerging Diseases, <https://doi.org/10.1111/tbed.13989>

Bovine tuberculosis (bTB), caused by *Mycobacterium bovis* (*M. bovis*) infection, is a multi host disease which negatively affects the wildlife industry, with adverse consequences for conservation, ecotourism, and game/wildlife sales. Although interspecies transmission has been reported between some wildlife hosts, the risk of spread in complex ecosystems is largely unknown. As a controlled disease, tools for accurate detection of *M. bovis* infection are crucial for effective surveillance and management, especially in wildlife populations. There are, however, limited species specific diagnostic tests available for wildlife. Hippopotamuses are rarely tested for *M. bovis* infection, and infection has not previously been confirmed in these species. In this study, blood and tissue samples collected from common hippopotamus (*Hippopotamus amphibius*) residing in a bTB endemic area, the Greater Kruger Protected area (GKPA), were retrospectively screened to determine whether there was evidence for interspecies transmission of *M. bovis*, and identify tools for *M. bovis* detection in this species. Using the multi species DPP® VetTB serological assay, a bTB seroprevalence of 8% was found in hippopotamus from GKPA. In addition, the first confirmed case of *M. bovis* infection in a free ranging common hippopotamus is reported, based on the isolation in mycobacterial culture, genetic speciation and detection of DNA in tissue samples. Importantly, the *M. bovis* spoligotype (SB0121) isolated from this common hippopotamus is shared with other *M. bovis* infected hosts in GKPA, suggesting interspecies transmission. These results support the hypothesis that *M. bovis* infection may be under recognized in hippopotamus. Further investigation is needed to determine the risk of interspecies transmission of *M. bovis* to common hippopotamus in bTB endemic ecosystems and evaluate serological and other diagnostic tools in this species.

Volvulus in a 20 years old captive hippopotamus (*Hippopotamus amphibius*, Linnaeus, 1758)

Pires, I., Garcês, A., Alvura, N., Gama, A., Alves, A., Silva, F. and P. Rodrigues 2020

Journal of Advanced Veterinary Research 10(4): 261-262

A volvulus is a twisting of the intestine on its mesenteric axis that could result in bowel obstruction and ischemic injury. Here the authors report a case of intestinal volvulus in a 20 years old captive hippopotamus (*Hippopotamus amphibius*, Linnaeus, 1758), the first well described case in this specie. The animal died suddenly after a previous history of diarrhea. At post mortem examination the animal presented a good body condition and abdominal distention. Upon opening of the peritoneal cavity, a large twisted segment of small intestine was observed. The





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segment rotated on its mesenteric axis and was dilated with gas and fluid and with dark red coloration, due to hemorrhage. The cause of death was intestinal volvulus. Its diagnosis is a challenging to veterinary surgeons due to the progressive onset of the symptoms that can delay the both diagnosis and the treatment thus resulting in progressing to the acute fulminating type with bowel infarction and death.

Taxonomic, Biogeographic and Evolutionary Studies

How Changes in Functional Demands Associated with Captivity Affect the Skull Shape of a Wild Boar (*Sus scrofa*)

Neaux, D., Blanc, B., Ortiz, K., Locatelli, Y., Laurens, F., Baly, I., Callou, C., Lecompte, F., Cornette, R., Sansalone, G., Haruda, A., Schafberg, R., Vigne, J.D., Debat, V., Herrel, A. and T. Cucchi 2021

Evolutionary Biology 48: 27-40

The process of animal domestication is a key evolutionary transition in human history, within which the control of wild populations is considered a crucial first step. Yet, phenotypic changes associated with animal captivity remain challenging to document. Here, we investigated the craniofacial changes in wild boar (*Sus scrofa*) associated with a lifetime of growth in captivity under conditions of controlled mobility and diet. Using three-dimensional landmark-based geometric morphometrics, we assessed cranial and mandibular size and shape differences between captive and wild-caught wild boar, their link with masticatory forces, and how these plastic changes relate to traits selected in domestic pigs. We observed shape divergence associated with greater masticatory forces in captive wild boar (e.g., wider zygomatic arches, more upright mandibular rami, and reduced gonial angle) corroborating the fundamental role of biomechanical loading and constructional constraints in the skull shape changes associated with captivity. Despite their resemblance with domestic traits, these localised plastic changes follow a different phenotypic trajectory, suggesting that they did not contribute to the setup of the craniofacial morphology of current domestic breeds. A parallel increase of masticatory force in captive wild boars and domestic pigs may explain this phenotypic convergence but needs to be further explored.

Systematic study of the new remains of *Propotamochoerus hysudricus* (Suidae, Mammalia) from the Late Miocene–Early Pliocene of Middle Siwaliks (Pakistan)

Aslam, S., Khan, A.M., Ahmad, R.M., Iqbal, A. and M.T. Waseem 2021

Arabian Journal of Geosciences 14:73

New remains of *Propotamochoerus hysudricus* are described from localities of the Dhok Pathan and Nagri formations of the Middle Siwaliks of Pakistan. *Propotamochoerus hysudricus* is a moderate-sized extinct suid with comparatively larger cheek teeth, elongated first molar, and basal pillars. The *Propotamochoerus hysudricus* material described in this article is a good addition in the field of paleontology as these new remains comprise of the maxilla, mandibles, isolated incisors, and canine along with premolars and molars. The genus *Propotamochoerus* in the Siwaliks is represented only by a single species, i.e., *Propotamochoerus hysudricus*. Its closest relative *Korynochoerus* is found in Eurasia. The age range of the species is from about 10 million to about 6 million years. The probable ancestor of *Propotamochoerus* is *Hyotherium* of Chinji times about 11 million years ago. The primitive genus *Propotamochoerus* was pretty near





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to the *Palaeochoerus* and was treated as a precursor of other suinae. Ancient Propotamochoeroid stock gave rise to three major groups, one leading to genera *Potamochoerus* and *Sus*, the other to the genera *Hippohyus* and *Sivahyus*, another leading to the genera *Microstonyx*, *Hippopotamodon*, and *Jhelumia*. The major difference between *Propotamochoerus hysudricus* and other species of the genus *Propotamochoerus* is mainly the dental morphology of premolars.

A new record of Tayassuidae (Mammalia: Cetartiodactyla) from the Pleistocene of northern Brazil

Copetti, C.L., Parisi-Dutra, R., Da-Rosa, A.S. and L. Kerber 2021

Anais da Academia Brasileira de Ciências 93(2), <https://doi.org/10.1590/0001-3765202120191080>

In this contribution, we described a new fossil of a Pleistocene Tayassuidae from northern Brazil. The specimen is a left dentary with molars assigned to cf. *Pecari tajacu* recovered from an outcrop of the Rio Madeira Formation, State of Rondônia, Brazil. It represents the first Pleistocene fossil of this clade with stratigraphic provenance in the Amazon region of Brazil. This record contributes to the knowledge on the paleofauna of Rio Madeira Formation as well as extend the past geographic distribution of peccaries in South America.

Paleoecological Inferences from Long Bone Microanatomical Specializations in Hippopotamoidea (Mammalia, Artiodactyla)

Houssaye, A., Martin, F., Boisserie, J.-R. And F. Lihoreau 2021

J Mammal Evol, <https://doi.org/10.1007/s10914-021-09536-x>

Hippopotamoids are herbivorous mammals that originated in the late middle Eocene. This taxon includes animals with a great variety of sizes and body proportions, from small and gracile forms with slender limbs to heavy massive ones. Many hippopotamoids have previously been considered semi-aquatic but recent studies have highlighted a diversity of ecologies. This study focuses on bone microanatomy, one of the various proxies that enable inferring the ecology of extinct taxa. The comparative analysis of the inner structure of the stylopod bones in various hippopotamoids, based on both transverse and longitudinal virtual sections, highlights a diversity of patterns and clarifies previously proposed hypotheses about the ecology of the sampled hippopotamoids. The filling of the medullary area by spongy deposits in the pygmy hippopotamus, *Choeropsis liberiensis*, appears associated with frequent incursions into the water by an animal that essentially forages in forests. The common hippopotamus, *Hippopotamus amphibius*, which spends most of the day submerged in water, shows a greater filling of the medullary area by spongy bone and a thicker cortex. These observations coupled with comparisons with diverse terrestrial and semi-aquatic mammals of various sizes confirm that semi-aquatic lifestyle and heavy weight-bearing are associated with similar microanatomical specializations causing an increase in bone mass. However, for a given mass, comparisons enable determining if an additional increase in bone compactness occurs, as in *Hippopotamus amphibius*, in which case a semi-aquatic lifestyle could be inferred. Accordingly, this study suggests an essentially terrestrial lifestyle for *Microbunodon minimum*, *Bothriodon velaunus*, *Elomeryx borbonicus*, *Merycopotamus medioximus*, *Paenanthracotherium bergeri*, and probably also *Saotherium* cf. *S. mingo*, a slight degree of water dependence in *Brachyodus onoideus*, and a stronger one in *Libycosaurus bahri* and *Hexaprotodon garyam*, though less intense than in *Hippopotamus amphibius*. Comparisons with other large terrestrial and semi-aquatic taxa, and





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based on a large part of the diaphysis, are required to better decipher the microanatomical changes associated with a semi-aquatic lifestyle from those linked to loading in heavy quadrupedal mammals.

Ecological, Behavioural and Conservation Studies

Multi-level movement response of invasive wild pigs (*Sus scrofa*) to removal

Bastille-Rousseau, G., Schlichting, P.E., Keiter, D.A., Smith, J.B., Kilgo, J.C., Wittemyer, G., Vercauteren, K.C., Beasley, J.C. and K. M. Pepin 2021

Pest Management Science 77(1): 85-95

BACKGROUND Lethal removal of invasive species, such as wild pigs (*Sus scrofa*), is often the most efficient approach for reducing their negative impacts. Wild pigs are one of the most widespread and destructive invasive mammals in the USA. Lethal management techniques are a key approach for wild pigs and can alter wild pig spatial behavior, but it is unclear how wild pigs respond to the most common removal technique, trapping. We investigated the spatial behavior of wild pigs following intensive removal of conspecifics via trapping at three sites within the Savannah River Site, SC, USA. We evaluated changes in wild pig densities, estimated temporal shifts in home-range properties, and evaluated fine-scale movement responses of wild pigs to removal. **RESULTS** We observed a significant reduction in the density of wild pigs in one site following removal via trapping while a qualitative reduction was observed in another site. We found little evidence of shifts in pig home-ranging behavior following removal. However, we did observe a nuanced response in movement behavior of wild pigs to the removal at the scale of the GPS locations (4 h), including increased movement speed and reduced selection for vegetation rich areas. **CONCLUSION** Our work provides a better understanding of the impact of removal via trapping on wild pig movement and its implications for management. The lack of shift in home-range characteristics observed illustrates how targeted trapping could be used to provide temporary relief for species sensitive to wild pig consumption such as ground nesting birds or agricultural crops.

Oldest cave art found in Sulawesi

Brumm, A., Oktaviana, A.A., Burhan, B., Hakim, B., Lebe, R., Zhao, J.X., Sulistyarto, P.H., Ririmasse, M., Adhityatama, S., Sumantri, I. and M. Aubert 2021

Science Advances 7(3), DOI: 10.1126/sciadv.abd4648

Indonesia harbors some of the oldest known surviving cave art. Previously, the earliest dated rock art from this region was a figurative painting of a Sulawesi warty pig (*Sus celebensis*). This image from Leang Bulu' Sipong 4 in the limestone karsts of Maros-Pangkep, South Sulawesi, was created at least 43,900 years ago (43.9 ka) based on Uranium-series dating. Here, we report the Uranium-series dating of two figurative cave paintings of Sulawesi warty pigs recently discovered in the same karst area. The oldest, with a minimum age of 45.5 ka, is from Leang Tedongnge. The second image, from Leang Balangajia 1, dates to at least 32 ka. To our knowledge, the animal painting from Leang Tedongnge is the earliest known representational work of art in the world. There is no reason to suppose, however, that this early rock art is a unique example in Island Southeast Asia or the wider region.





Too many wild boar? Modelling fertility control and culling to reduce wild boar numbers in isolated populations

Croft, S., Franzetti, B., Gill, R. and G. Massei 2020

PLoS ONE 15(9), <https://doi.org/10.1371/journal.pone.0238429>

Wild boar and feral swine number and range are increasing worldwide in parallel with their impact on biodiversity and human activities. The ecological and economic impact of this species include spread of diseases, vehicle collisions, damage to crops, amenities and infrastructures and reduction in plant and animal abundance and richness. As traditional methods such as culling have not contained the growth and spread of wild boar and feral pigs, alternative methods such as fertility control are now advocated. We used empirical data on two isolated wild boar populations to model and compare the effects of different regimes of culling and fertility control on population trends. We built a Bayesian population model and applied it to explore the implications for population control of various management options combining culling and/or contraception. The results showed that, whilst fertility control on its own was not sufficient to achieve the target reduction in wild boar number, adding fertility control to culling was more effective than culling alone. In particular, using contraceptives on 40% of the population to complement the culling of 60% of the animals, halved the time to achieve our target reduction compared with culling only. We conclude that, assuming the effort of adding fertility control to culling was found to be cost-effective in terms of population reduction, these two methods should be used simultaneously if a rapid decrease in wild boar number is required for a closed population.

Effects of Cs-137 contamination after the TEPCO Fukushima Dai-ichi Nuclear Power Station accident on food and habitat of wild boar in Fukushima Prefecture

Nemoto, Y., Oomachi, H., Saito, R., Kumada, R., Sasaki, M. and S. Takatsuki 2020

Journal of Environmental Radioactivity 225, <https://doi.org/10.1016/j.jenvrad.2020.106342>

After the Tokyo Electric Power Company Fukushima Dai-ichi Nuclear Power Station accident, wild boar was found to have greater radiocesium (Cs-137) activity concentrations in their bodies than other wild animals in Japan; however, the reason for this remains unknown. To understand the mechanism of Cs-137 transfer from the environment to wild boar, and the factors that affect variation in Cs-137 contamination in wild boar, we sampled muscle and stomach contents from wild boar captured in Fukushima Prefecture and analyzed the relationships among Cs-137 concentrations in muscle tissue and in the stomach contents, Cs-137 ground deposition at capture sites, and wild boar food habits. Significant positive relationships were observed among Cs-137 activity concentrations in muscle and stomach contents, as well as Cs-137 deposition density at capture sites. These results suggest that Cs-137 is transferred from the environment to plant and animal materials consumed by wild boar, and then from these foods to the bodies of wild boar through digestion. However, no correlation was observed between Cs-137 concentrations in stomach contents and the presence of any particular food item in stomachs of wild boar, including mushrooms. These findings suggest mushrooms and underground food items, which were found to affect Cs-137 concentrations in wild animals in Europe, were not important contributors to high levels of Cs-137 contamination in Japanese wild animals.

Helminths of the Wild Boar (*Sus scrofa*) from Units of Conservation Management and Sustainable Use of Wildlife Installed in the Eastern Economic Region of Mexico

De-la-Rosa-Arana, J.L., Ponce-Noguez, J.B., Reyes-Rodriguez, N.E., Vega-Sanchez, V., Zepeda-Velazquez, A.P. Martinez-Juarez, V.M. and F. R. Gomez-De-Anda 2021





Animals 11(1), <https://doi.org/10.3390/ani11010098>

Simple Summary Wild boars (*Sus scrofa*) were introduced in Mexico for sport hunting and meat trading for human consumption, but their role in the transmission of diseases to human or domestic animals is limited. Thus, we did research looking for parasitic worms in wild boars that live in three units of conservation management and sustainable use of wildlife installed in the eastern economic region of Mexico. Samples of feces and serum were collected from 90 animals that came from three different ranches. Stool examination and antibody determination were performed. Eggs of *Strongyloides* sp. (72.2%), *Metastrongylus* sp. (57.7%), *Oesophagostomum* sp. (53.3%), and *Trichuris* sp. (37.7%) were found in addition to oocysts of *Eimeria* sp. (75.6%). Antibodies to *Fasciola* (8.9%), *Taenia* (4.4%), *Ascaris* (32.2%), *Toxocara* (20%), and *Trichinella* (5.5%) were found. This is the first report of parasitic worms of wild boar produced in Mexico. The importance of the results is based on the limited data available about the impact of wild boar and feral pigs on the transmission of diseases to domestic animals. This study identifies the potential risk of wild boar as a transmission channel of diseases than can have an impact on public health. Wild boars (*Sus scrofa*) were introduced in Mexico for sport hunting and meat trading for human consumption, but the available data regarding their role in pathogen transmission are limited. This research and field work aimed to identify the helminths of the wild boar produced in three units of conservation management and sustainable use of wildlife placed in the eastern economic region of Mexico. Samples of feces and serum were collected from 90 animals that came from three different ranches. Stool examination and antibody determination to *Fasciola hepatica*, *Taenia crassiceps*, *Ascaris suum*, *Toxocara canis* (ELISA), and *Trichinella spiralis* (Western blot) were performed. In addition, 30 diaphragm samples from one ranch were obtained for artificial digestion. Eggs of *Strongyloides* sp. (72.2%), *Metastrongylus* sp. (57.7%), *Oesophagostomum* sp. (53.3%), and *Trichuris* sp. (37.7%) were found in addition to oocysts of *Eimeria* sp. (75.6%). Antibodies to *Fasciola* (8.9%), *Taenia* (4.4%), *Ascaris* (32.2%), *Toxocara* (20%), and *Trichinella* (5.5%) were found. The eggs of *Strongyloides* and *Oesophagostomum* were associated to female hosts. One nematode larva was found by artificial digestion. This is the first report to identify helminths from wild boars in Mexico. In addition, this study identifies the potential risk of the wild boar as a transmission channel of parasites that can have an impact on public health.

Behavioural patterns of free roaming wild boar in a spatiotemporal context

Erdtmann D. and O. Keuling 2020

PeerJ, <https://doi.org/10.7717/peerj.10409>

Although the almost worldwide distributed wild boar *Sus scrofa* is a well-studied species, little is known about the behaviour of autochthonous, free living wild boar in a spatiotemporal context which can help to better understand wild boar in conflict terms with humans and to find solutions. The use of camera traps is a favourable and non-invasive method to study them. To observe natural behaviour, 60 camera traps were placed for three months in a state forest of 17.8 km² in the region of the Luneburg Heath in northern Germany. In this area wild boar, roe deer, red deer, wolves and humans are common. The cameras recorded 20 s length video clips when animals passed the detection zone and could be triggered again immediately afterwards. In total 38 distinct behavioural elements were observed, which were assigned to one of seven behavioural categories. The occurrence of the behavioural categories per day was evaluated to compare their frequencies and see which are more essential than others. Generalised Additive Models were used to analyse the occurrence of each behaviour in relation to habitat and activity time. The





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results show that essential behavioural categories like foraging behaviour, locomotion and vigilance behaviour occurred more frequently than behaviour that just "served for the well-being of wild boar. These three behavioural categories could be observed together mostly in the night in broad-leaved forests with a herb layer of 50-100%, comfort behaviour occurred mostly at the ponds in coniferous forest. It is also observable that the behavioural categories foraging and comfort behaviour alternated several times during the night which offers the hypothesis that foraging is mostly followed by comfort behaviour. These findings pave the way towards implementing effective control strategies in the wild and animal welfare in captivity.

Wild boar behaviour during live-trap capture in a corral-style trap: implications for animal welfare

Fahlman, A., Lindsjö, J., Norling, T.A., Kjellander, P., Agren, E.O. and U.A. Bergvall 2020
Acta Veterinaria Scandinavica 62(1), <https://doi.org/10.1186/s13028-020-00557-9>

Background Wildlife traps are used in many countries without evaluation of their effect on animal welfare. Trap-capture of wild animals should minimise negative effects on animal welfare, irrespective of whether the animals are trapped for hunting, research, or management purposes. Live-trap capture of wild boar (*Sus scrofa*) followed by killing inside the trap by gunshot is a recently introduced but disputed hunting method in Sweden. Approval of trap constructions is based on gross necropsy findings of 20 trapped and shot wild boars. For improved animal welfare evaluation, our aim was to study wild boar behaviour during live-trapping in a 16 m² square corral-style trap. Behavioural assessments were conducted after filming 12 capture events of in total 38 wild boars (five adults, 20 subadults, 13 piglets). Selected behavioural traits were compared with pathological changes (trap-related lesions) found at necropsy of the 20 subadults, to determine if these variables were useful proxies of capture-induced stress in wild boar. Results The wild boars spent less time resting in the evening than in the night and morning. Using Friedman's ANOVA, there was an overall difference in the time spent foraging. However, we only found a difference between the evening and morning in the Wilcoxon matched pairs test after the Sequential Bonferroni correction, where the wild boars spent more time foraging in the evening than in the morning. Single captured individuals showed more escape behaviours and reacted more strongly to external stimuli than individuals captured in a group. It was more common for animals to charge against the mesh walls of the trap upon human approach compared to upon initial capture when the trap door closed. Trap-related pathological findings due to trauma were documented in 13 of the 20 subadults that were necropsied. Behavioural alterations indicative of capture-induced stress (e.g. charging into the trap walls) were documented in trapped wild boars with no or minor physical injuries (e.g. skin abrasions, subcutaneous haemorrhage). Conclusions Behavioural assessment provided valuable information for determination of capture-induced stress in wild boar when evaluating live-trapping in a corral-style trap, whereas pathological evaluation through necropsy did not fully reflect the animal welfare aspects of live-trapping. We emphasize the inclusion of species-specific behavioural data assessment for evaluation of capture-related stress during live-trapping and for testing of new trap constructions before approval.

Consistently high multiple paternity rates in five wild boar populations despite varying hunting pressures

Gayet, T., Say, L., Baubet, E. and S. Devillard





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Mammalian Biology, <https://doi.org/10.1007/s42991-020-00090-2>

Intraspecific variations in mating systems have been reported in numerous species, especially when they live in varying ecological contexts. This leads to variability between populations with regard to the proportion of females engaging in multiple male mating, which depends on the number of males available. For hunted ungulate species, hunting is known to influence population structure, especially when males are preferentially targeted for trophy hunting. Here, we investigated how variations in hunting pressure and the yearly proportion of heavy males removed have impacted multiple paternity rates in five wild boar (*Sus scrofa scrofa*) populations located in similar ecological contexts. We found high rates of multiple paternity in all studied populations, confirming the recently reported promiscuous mating system of wild boar. However, variations in hunting pressure and removal of heavy males did not significantly influence multiple paternity rates, contrary to our expectation. Nonetheless, a slight tendency for a decreasing multiple paternity rate with increasing hunting pressure and for increasing multiple paternity rate with increasing removal of heavy males from the population was detected. Based on these results, we discuss an alternative hypothesis on the ecological processes sustaining the influence of hunting regimes on the mating system. Overall, hunting pressure and management rules might be sufficient to disrupt the mating system in any of the populations, so it is important to continue the sampling of wild boar populations at the European scale, especially in populations with little hunting pressure.

Guest or pest? Spatio-temporal occurrence and effects on soil and vegetation of the wild boar on Elba island

Greco, I., Fedele, E., Salvatori, M., Rustichelli, M.G., Mercuri, F., Santini, G., Rovero, F., Lazzaro, L., Foggi, B., Massolo, A., De Pietro, F. and M. Zaccaroni 2021

Mammalian Biology 101: 193-206

Where allochthonous large mammals, such as the wild boars, occur in high density, human-wildlife conflicts may arise. Thus, assessing their spatio-temporal patterns is paramount to their management. We studied the wild boars on Elba island, Italy, where they have been introduced and are perceived as pests to address their occurrence and impact of foraging on natural habitat. We surveyed the western island with three camera trapping surveys within one year. We found that the species' estimated occupancy probability was higher in summer-autumn (0.75 ± 0.14) and winter-early spring (0.70 ± 0.10) than in spring-summer (0.53 ± 0.15), whereas detection probability did not vary. Occupancy was significantly associated with lower elevation and woodland cover. Lower site use of wild boars during spring-summer might reflect lower food availability in this season and/or boars' movements towards landfarms outside the sampled area. Detectability increased with proximity to roads during spring-summer and decreased with humans' relative abundance in other periods. Boars were mainly nocturnal, with decreasing overlap with human activity when human presence was higher in the park. Soil degradation caused by wild boars was higher in pine plantations, which is the cover with a lower conservation interest. The spatio-temporal activity of wild boars on the island appears driven by seasonal preferences for food-rich cover and avoidance of human disturbance. The lowered site use in months with lower resources could partially reflect increased proximity to settled and farmed areas, which may trigger crop-raiding and the negative perception by residents.





Epigeic invertebrates of pig-damaged, exposed wetland sediments are rooted: An ecological response to feral pigs (*Sus scrofa*)

Marshall, J.C., Blessing, J.J., Clifford, S.E., Negus, P.M. and A.L. Steward 2020

Aquatic Conservation-Marine and Freshwater Ecosystems 30(12): 2207-2220

1. Feral pigs (*Sus scrofa*) are widespread and cause significant damage to the ecological and cultural values of wetlands through their rooting, pugging, and wallowing behaviour. 2. The impacts of feral pigs on the epigeic (ground surface) invertebrates of exposed wetland sediments were investigated using 48 composite pitfall samples collected from 21 sites over three occasions in the Archer River catchment, north Queensland, Australia. Feral pig damage was quantified in transects along the margins of the wetlands. We tested the prediction that invertebrate assemblages would demonstrate reduced taxon richness and abundance, and altered assemblage composition, with an increasing intensity of pig damage. 3. Pig damage to exposed wetland sediments was a stressor to epigeic invertebrates in this environment, where there was a diverse invertebrate fauna. As expected, both taxon richness and abundance were significantly limited by pig damage, as was variability in multivariate assemblage composition. Thirty-one epigeic invertebrate taxa (66%) showed a decrease in their frequency of occurrence, mean abundance, or both, at sites with high levels of pig damage, relative to sites with low levels of pig damage. Certain families of spiders, beetles, snails, and freshwater crabs were among the taxa more prevalent when pig damage was low, whereas none of those taxa was more prevalent when pig damage was high. 4. There are biodiversity conservation ramifications from these results as pigs threaten elements of this fauna and thus wetland biodiversity, but the taxonomy, ecology, and distributions of epigeic invertebrates of exposed wetland sediments are poorly known. 5. The intensity of pig damage and the richness and abundance of epigeic invertebrates, as measured here, provide useful monitoring indicators to evaluate the effectiveness of pig control measures wherever pigs damage wetlands.

Wild boar rooting and rural abandonment may alter food-chain length in arthropod assemblages in a European forest region

Matas, A., Mac Nally, R., Albacete, S., Carles-Tolra, M., Domenech, M., Vives, E., Espadaler, X., Pujade-Villar, J. and A. Maceda-Veiga 2021

Forest Ecology and Management 479, <https://doi.org/10.1016/j.foreco.2020.118583>

Food-chain length, or the trophic level of an apex predator, is among the most important properties of food-webs with implications for community structure, ecosystem processes and pollutant accumulation in forests. Three main hypotheses (ecosystem-size, productivity, and disturbance) have been erected to explain variation in foodchain length in freshwater ecosystems, yet the support for these hypotheses in less spatially restricted terrestrial ecosystems has not been extensively studied. Here, we used nitrogen ($\delta N-15$) and carbon ($\delta C-13$) stable isotopes to explore variation in the realized trophic positions ($\delta N-15$) of a beetle *Carabus lineatus lateralis* and a wasp *Vespula vulgaris* in 32 chestnut woodland patches in northwestern Spain, while accounting for the insects' relative mobility by using inferences based on $\delta C-13$. We used five potential predictors of ecosystem-size productivity, seven of disturbance and six covariates in anticipation that biological assemblages in woodlands might be influenced by ecosystem-size productivity, and from a change from the human management to a much-increased activity of ecosystem engineers, especially wild boar. Our results provided support for the disturbance hypothesis and suggested that the beetle FCL seems to be more





affected by wild boar disturbance than by human-forest management, possibly due to increased forest cover and to rural abandonment in recent decades. Moreover, we found a negative association between the wasp FCL and the ecosystem-size productivity hypothesis, as indicated by the plant Ellengberg's indicator value for nitrogen, which contrasts to the hypothesis that ecosystem-size productivity should increase FCL. Our findings are discussed in relation to: (1) differences in intensity and frequency between human and wild boar-induced disturbances; (2) the diets and mobilities of the two predators; and (3) the near lack of hard ecological boundaries in terrestrial ecosystems, such as chestnut woodlands.

The Relationship between Hunting Methods and the Sex, Age and Body Mass of Wild Boar *Sus scrofa*

Kamieniarz, R., Jankowiak, L., Fratzczak, M., Panek, M., Wojtczak, J. and P. Tryjanowski 2020
Animals 10(12), <https://doi.org/10.3390/ani10122345>

Increases in the wild boar *Sus scrofa* population create many conflicts that must be managed, especially because hunting represents a major cause of mortality in this game species. However, hunting effort is not distributed randomly and is influenced by many factors, including hunting methods. This can be especially important in understanding the nature of hunting pressure for both theoretical (ecological and evolutionary) and applied reasons (for management purposes, especially during infectious diseases, for example, African swine fever, outbreaks). We analyzed hunting data from the survey area in Western Poland from the years 1965–2016. In this period a total of 2335 wild boar were culled using two hunting methods: by individual hunters (43.8%) and by teams of hunters (52.0%). During the study period, the number of wild boars increased significantly but in a non-linear manner. More adult males and yearlings of both sexes were shot during individual hunts; more adult females were culled during team hunting. Moreover, the body mass of culled wild boars was positively influenced by the distance to a forest and during the team hunts heavier females and males were shot. To effectively control populations of wild boars, programs to reduce the number of individuals should be better planned and ensure the maintenance of proper age- and sex structure in the wild boar population.

Genetic consequences of long-term small effective population size in the critically endangered pygmy hog

Liu, L.Q., Bosse, M., Megens, H.J., de Visser, M., Groenen, M.A.M. and O. Madsen 2021
Evolutionary Applications 14(3): 710-720

Increasing human disturbance and climate change have a major impact on habitat integrity and size, with far-reaching consequences for wild fauna and flora. Specifically, population decline and habitat fragmentation result in small, isolated populations. To what extent different endangered species can cope with small population size is still largely unknown. Studies on the genomic landscape of these species can shed light on past demographic dynamics and current genetic load, thereby also providing guidance for conservation programs. The pygmy hog (*Porcula salvania*) is the smallest and rarest wild pig in the world, with current estimation of only a few hundred living in the wild. Here, we analyzed whole-genome sequencing data of six pygmy hogs, three from the wild and three from a captive population, along with 30 pigs representing six other Suidae. First, we show that the pygmy hog had a very small population size with low genetic diversity over the course of the past similar to 1 million years. One indication of historical small effective population size is the absence of mitochondrial variation in the six sequenced





individuals. Second, we evaluated the impact of historical demography. Runs of homozygosity (ROH) analysis suggests that the pygmy hog population has gone through past but not recent inbreeding. Also, the long-term, extremely small population size may have led to the accumulation of harmful mutations suggesting that the accumulation of deleterious mutations is exceeding purifying selection in this species. Thus, care has to be taken in the conservation program to avoid or minimize the potential for further inbreeding depression, and guard against environmental changes in the future.

The Feral Pig in a Low Impacted Ecosystem: Analysis of Diet Composition and Its Utility

Montes-Sanchez, J.J., Huato-Soberanis, L., Buntinx-Dios, S.E. and J. L. Leon-de La Luz 2020
Rangeland Ecology and Management 73(5): 703-711

The feral pig is an exotic species in the Sierra La Laguna Biosphere Reserve, Baja California Sur, Mexico, and is considered harmful to the woodlands and tropical deciduous forest because of its foraging habits. To determine the taxonomic, nutrient, and energy content of the feral pig diet in this area, stomach contents of forty feral pigs were analyzed during the dry and rainy seasons in the woodlands and the tropical deciduous forest. Results indicate that feral pigs are frugivore-herbivore and stenophagous, feeding on a high percentage of fruits and seeds (77-87%) that provide high metabolizable energy (8293-11,585 kJ kg⁻¹ dry matter) and moderate crude protein (94.1-151.6 g kg⁻¹ dry matter) year round in the woodland and during the dry season in the tropical deciduous forest, or high percentage of leaves, stems, and tubers (44%) that provide low metabolizable energy (4740 kJ kg⁻¹ dry matter) and moderate crude protein (107.5 g kg⁻¹ dry matter) in the rainy season in the tropical deciduous forest. Therefore, diets based on fruits and seeds favor a lower quantity of food to meet the energy for maintenance of feral pigs than those based on other plant tissues: pine nuts < acorns approximate to wild figs < leaves, stems, and tubers. The observed diet based on acorns, along with estimates of acorn production results in a carrying capacity estimate of 0.031 adult feral pig ha⁻¹ yr⁻¹ during years of low acorn production. Thus, feral pigs in the area use fruits and seeds in both woodlands and tropical deciduous forest because of their quality as food resources. The availability of the food resources preferred by pigs (pine nuts, acorns, fan-palm fruits, and wild figs) during the year can be used to inform potentially sustainable feral pig carrying capacities and establish hunting programs.

First records of non-native Eurasian wild boar *Sus scrofa* (Linnaeus, 1758) (Mammalia: Artiodactyla) in a coastal ecosystem of Temperate Forest of south-central Chile

Moreira-Arce, D., Hernandez, F. and K. Abufarhue 2020
Bioinvasions Records 9(4): 865-872

We report the first casual record of Eurasian wild boar *Sus scrofa* in Nahuelbuta Mountain Area, located in the coastal Temperate Forest of south-central Chile. Camera-trapping was conducted between January 2018 and February 2019 at two sites comprised by native native forest and commercial tree plantations. Wild boars were detected within plantations of Monterey pine mainly during Austral summer (December to February), daytime (between 11:00 and 20:00) and close (3 km) to Nahuelbuta National Park. The combination of its highly adaptable generalist behaviour and the extensive presence of commercial tree plantations in Nahuelbuta Mountain Area may favour the expansion of the invasive wild boar throughout this imperilled ecosystem, including its potential occurrence within the small and isolated protected areas present in it.





Does wild boar rooting affect spatial distribution of active burrows of meadow-dwelling voles?

Mori, E. and L. Lazzeri 2020

Biologia, <https://doi.org/10.2478/s11756-020-00622-8>

Soil overturn by wild boar *Sus scrofa* is known to affect biodiversity, from plant communities to invertebrates, reptiles and small mammals. Rooting activity has been shown to be particularly intensive in open areas and particularly on fallows and meadows located on hill or mountain tops. In these habitat types, the impact of wild boar on small mammal assemblies has never been assessed. In this work, we evaluated whether rooting activity affected the spatial distribution of the Savi's pine vole *Microtus savii* in a hilly area of Central Italy, throughout four seasons. The spatial distribution of this vole has been determined through the open-hole index, i.e. by assessing the vole propensity to reopen tunnel entrances which we previously closed with soil. Rooting intensity was the highest in cold months, i.e. when drive hunting may increase wild boar occurrence within protected areas and outside wooded areas. According to our GLMM, reopening of vole burrow entrances increased with increasing distances from rooted areas and with increasing geophytic diversity. Meadow-dwelling voles living on shallow underground burrow systems seem to avoid soil overturn by wild boar and that they prefer creating their tunnels where plant diversity building up the staple of their diet is the highest. Our results furtherly emphasized the importance of wild boar monitoring also in open areas and hill grasslands, particularly when rooting intensity is the highest, i.e. in cold months.

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

Luskin, M.S., Johnson, D.J., Ickes, K., Yao, T.L. and S.J. Davies 2021

Proc. R. Soc. B. 288, <http://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 m² 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.





African Swine Fever threatens Southeast Asia's 11 endemic wild pig species

Luskin, M.S., Meijaard, E., Surya, S., Sheherazade, Walzer, C. and M. Linkie 2020
Conservation Letters, DOI: 10.1111/conl.12784

The spread of the most recent African Swine Fever (ASF) outbreak in Asia since late 2018 poses a significant threat to endemic pig species and socioeconomic security. Within domestic pigs and free-living Eurasian wild boars (both *Sus scrofa*) in Asia, ASF causes almost 100% case fatality. The ongoing ASF epidemic has so far caused the death of over one hundred million domestic pigs, causing unprecedented economic impacts on the global pork industry. Transmission among free-living wild boars has been reported, and transmission to threatened Asian pig species is probable but lacks research. Our assessment reveals a nearterm risk for Southeast Asia's 11 endemic pig species, which have small population sizes and small ranges that may be insufficient to withstand the initial, lethal onslaught of the disease. The decline of pigs also triggers cascading impacts for endangered carnivores, plant communities, and livelihoods of millions of people. Our management recommendations include time-critical research themes, improved emerging infectious disease detection through site-based monitoring and surveillance paired with online reporting and proper carcass disposal.

Reliable estimates of wild boar populations by nocturnal distance sampling

Focardi, S., La Morgia, V., Montanaro, P., Riga, F., Calabrese, A., Ronchi, F., Aragno, P., Scacco, M., Calmanti, R. and B. Franzetti 2020
Wildlife Biology, <https://doi.org/10.2981/wlb.00694>

The wild boar is one of the most invasive species among large mammals in both its native and introduced ranges. This species represents a main threat for crops and biodiversity and a pest for the pig industry due to the rapid expansion of the African swine fever. Because of its peculiar life history traits, population control programmes and recreational hunting are usually unable to effectively reduce the number of wild boars. Therefore, a reliable approach based on appropriate, cost-effective, monitoring methodologies is urgently required. Effective monitoring should adopt effective sampling strategies, otherwise the detection of population trends can be erroneous and resulting in a mismatch of appropriate management actions. First, we review the status-of-the-art of wildlife monitoring with a special focus on wild boar and feral pigs. Then, we show that nocturnal distance sampling, carried out using thermal cameras, can be an effective monitoring technique for wild boar population assessment regardless of the characteristics of the sampled area. Using data from multiple surveys performed in four study areas in Italy, characterised by contrasting topography, habitats and level of environmental visibility, we found that the estimate of precision is generally good and almost independent of landscape conditions. A simple method to estimate visibility, which may empirically help wildlife managers to design effective nocturnal distance sampling surveys, is proposed. The bias of our population estimates is evaluated using simulations showing that in some areas the estimate is unbiased, while in others there is the tendency towards a negative bias. Based on reported results, we provide guidelines to perform nocturnal distance sampling of wild boar populations.

Pattern of crop raiding by wild large mammals and the resultant impacts vary with distances from forests in Southwest Ethiopia

Mamo, A., Lemessa, D., Diriba, O.H. and D. Hunde 2021
Ecology and Evolution, <https://doi.org/10.1002/ece3.7268>





New literature on Suiformes



Crop raiding is a major form of human wildlife interaction mainly in the ecotone areas of human modified natural landscapes. The aim of this study was to examine the spatial pattern of crop raiding and the resultant impacts on how farmers perceive forests at different distances from Yayu Coffee Forest Biosphere Reserve which is located in southwest Ethiopia. For this, thirty transects (each 1 km long) were laid out at 200 m interval parallel to forest edges: ten transects close to forest (<0.5 km), ten at intermediate (0.5–1 km), and ten transects were taken far from forest (>1 km). Along each transect, 2–6 households were randomly selected and interviewed using semistructured questionnaire. The perception of the respondents on forests at different distances from forest edges was analyzed using Pearson's Chi square test. The variation in the amount of damage among these three locations was tested using one way ANOVA. Four wild large mammals including olive baboon, vervet monkey, bush pigs, and crested porcupine were identified as top crop raiders in the area. The frequencies of occurrence of crop raiders decreased with increasing distance from forest edges. Similarly, the amount of damage in maize fields was higher close to forests when compared with that of either at intermediate or far from forest edges ($p < .001$). Eighty one percent of the households living close to the forests perceive that forest is a threat to their survival. Overall, our results imply that strategies need to be sought in order to minimize the socio ecological impacts of crop raiders mainly in locations close to forest edges.

Large herbivores regulate the spatial recruitment of a hyperdominant Neotropical palm

Valverde, J., da Silva Carvalho, C., Jordano, P., and M. Galetti 2020

Biotropica 53(1): 286-295

Large mammalian herbivores play an important role in shaping the diversity of tropical forests by affecting the survival of seedlings and saplings beneath parent plants. The white-lipped peccary (*Tayassu pecari*) accounts for the largest herbivore biomass that controls seed and seedling survival in Neotropical ecosystems. However, hunting and habitat loss has driven peccaries to local extinction for most of their original distribution, so it is likely that their absence will affect plant recruitment dynamics. We tested the effects of peccary local extinction on the density and spatial distribution of the hyperdominant palm *Euterpe edulis* by performing a fine scale characterization of its spatial recruitment in six forest sites in the Brazilian Atlantic forest. We compared the age structure and the spatial patterns of seedlings, saplings, and adults as well as the relationship between them. We found that while under the presence of peccaries there was a decrease in recruitment rates under adults, the local extinction of these large mammals led to a more clumped process of spatial recruitment. Despite such contrasting spatial patterns of recruitment dynamics, neither age structure nor the random spatial distribution of adults was affected by the presence or absence of peccaries, indicating that their early effects on these palm populations are mitigated as recruitment advances. Our findings highlight the role of large-bodied forest-dwelling herbivores in regulating the fine-scale spatial recruitment of plants and advance our understanding on the effects of defaunation in tropical forests.

Seed removal of *Araucaria angustifolia* by native and invasive mammals in protected areas of Atlantic Forest

Rosa, C., Zanin Hegel, C.G. and M. Passamani 2020

Biota Neotropica 21(1), <https://doi.org/10.1590/1676-0611-bn-2020-1111>

Araucaria Forest is one of the most threatened tropical forests in the world. Wild pig (*Sus scrofa*) are invasive pig that is expanding through these forests and seed removing that would be





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available to native fauna. Our aim was to evaluate the rates of seed *Araucaria* (*Araucaria angustifolia*) removal by both small, medium, and large mammals in areas with and without wild pig. We conducted a seed-removal experiment with three treatments differing in mammals' access to seeds, in areas with and without the occurrence of wild pig. Similar numbers of seeds *Araucaria* were removed by small, medium and large mammals, even in areas with wild pig. However, we verified that seed removal by small mammals is graduate over time, while large mammals, especially wild pig, remove in one event. So, we recommend long-term studies to investigate competition between wild pig and native biota and the effects of wild pig on seed dispersal and seed survival.

Potential ecological and socio-economic effects of a novel megaherbivore introduction: the hippopotamus in Colombia

Subalusky, A.L., Anderson, E.P., Jiménez, G., Post, D.M., Lopez, D.E., García-R., S., Nova León, L.J., Reátiga Parrish, J.F., Rojas, A., Solari, S. and L.F. Jiménez-Segura 2021
Oryx 55(1): 105-113.

Introduced species can have strong ecological, social and economic effects on their non-native environment. Introductions of megafaunal species are rare and may contribute to rewilding efforts, but they may also have pronounced socio-ecological effects because of their scale of influence. A recent introduction of the hippopotamus *Hippopotamus amphibius* into Colombia is a novel introduction of a megaherbivore onto a new continent, and raises questions about the future dynamics of the socio-ecological system into which it has been introduced. Here we synthesize current knowledge about the Colombian hippopotamus population, review the literature on the species to predict potential ecological and socio-economic effects of this introduction, and make recommendations for future study. Hippopotamuses can have high population growth rates (7–11%) and, on the current trajectory, we predict there could be 400–800 individuals in Colombia by 2050. The hippopotamus is an ecosystem engineer that can have profound effects on terrestrial and aquatic environments and could therefore affect the native biodiversity of the Magdalena River basin. Hippopotamuses are also aggressive and may pose a threat to the many inhabitants of the region who rely upon the Magdalena River for their livelihoods, although the species could provide economic benefits through tourism. Further research is needed to quantify the current and future size and distribution of this hippopotamus population and to predict the likely ecological, social and economic effects. This knowledge must be balanced with consideration of social and cultural concerns to develop appropriate management strategies for this novel introduction.

Multiscale drivers of hippopotamus distribution in the St Lucia Estuary, South Africa

Prinsloo, A.S., Pillay, D. and M.J. O'Riain 2020
African Zoology 55(2): 127-140

This study provides preliminary data on predictors of *Hippopotamus amphibius* (Linnaeus, 1758; hippo) distribution in St Lucia Estuary, the largest estuarine system in Africa and a key habitat for one of South Africa's largest hippo populations. We use binary logistic regression models to evaluate selected habitat features as predictors of hippo occurrence at two spatial scales and a negative binomial model with log-link function to evaluate predictors of frequency of use at a fine spatial scale. At the scale of the whole estuary, models indicate that hippos preferentially select diurnal refuge sites that are closer to river inlets and farther from human settlements. At a fine





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scale (within the Narrows in which more than 50% of the population resides), occurrence and frequency of use models suggested that hippos preferentially settle in sites with water depths between 0.5 and 1.49 m, that are farther from human settlements, closest to natural wetland vegetation and near neighbouring groups. Preliminary data on habitat variables influencing hippo distribution highlights the necessity to manage water levels, restore wetland floodplains, protect wetland vegetation and halt human settlement encroachment in order to ensure the viability of this UNESCO site and its hippo population.

Activity and Pool Use in Relation to Temperature and Water Changes in Zoo

Hippopotamuses (*Hippopotamus amphibius*)

Fernandez, E.J., Ramirez, M. and N.C. Hawkes

In the wild, hippopotamuses spend much of their daily activity in the water. In zoos, it is less clear the extent to which hippos spend time in the water. We examined how much time Woodland Park Zoo's three hippos spent in their outdoor pool, based on: (a) temperature of the pool water, and (b) when the pool water was changed (approximately three times a week). Several digital temperature data loggers collected water and air temperature readings once every hour for six months. We correlated the water temperature readings with several behaviors the hippos could engage in, where the hippos were on exhibit (pool vs. land), and how many days it had been since a dump (0, 1, or 2 days). The results indicated that water changes had little effect on pool usage, while increasing water temperatures resulted in both increased activity and pool use. The results are discussed in terms of how these findings relate to wild hippo activity, current knowledge of zoo-housed hippo welfare, and future directions for zoo-housed hippo welfare and research.

A hippo in the room: Predicting the persistence and dispersion of an invasive mega-vertebrate in Colombia, South America

Castelblanco-Martínez, D.N., Moreno-Arias, R.A., Velasco, J.A., Moreno-Bernal, J.W., Restrepo, S., Noguera-Urbano, E.A., Baptiste, M.P., García-Loaiza, L.M. And G. Jiménez 2021

Biological Conservation 253: 108923

Biological invasions are a big concern due to their potential to impact ecosystems, as well as local people. The hippo *Hippopotamus amphibius*, native to Africa, has invaded extensive areas of the Magdalena River basin (Colombia) over the past decades, and has been considered the largest invasive animal in the world. Here, we propose the use of two approaches of predictive modeling, in order to guide recommendations for the management of this biological invasion. First, we developed a population viability analysis (PVA) to simulate a hypothetical population growth under different management scenarios. Next, we explored the potential invasion area under future climate change scenarios throughout ecological niche modeling analyses. PVA models predicted that in the absence of an intense culling/hunting pressure, the population size will continue to steadily increase, which is consistent with the population growth observed during the last 20 years. Furthermore, our static and dynamic habitat suitability projections suggested that without dispersal limiting factors, potential colonization habitat for hippos may become very extensive across the landscape and can be favored by climate change in the future. Therefore, our findings show the urgent need of taking critical management decisions by the Colombian authorities, which should be focused on limiting the hippos' population growth and expansion. Ignoring cost-benefit considerations for the control of this invasive species may have unexpected and long-term





social and ecological implications. However, the proposal of a course of action can become controversial when the species has a charismatic value for the society, regardless of its ecological or social impact.

Reconciling Landscape Fragmentation and Hippopotamuses Population Decrease in Virunga National Park Wetland

Journal of Geoscience and Environment Protection 8: 63-76

Wetlands have been noted to be beneficial worldwide. Despite wetlands being a natural asset that is of great significance to the human community, they are threatened by human and natural events. In Virunga National Park (VNP) wetlands are the habitat of Hippopotamus (*Hippopotamus amphibius*) which are among the animal species threatened by extinction in VNP since the past few decades. As shown by the last studies the number of Hippos population declined for 96% for the period of less than 40 years. This study evaluated landscape fragmentation status and its implication on the decline of the hippos population in VNP wetland for the period from 1990 to 2018. This study's land cover data was obtained using remote sensing techniques with the help of software package ERDAS IMAGINE v16.6 and ArcGIS v10.3. It was mapped and classified using the maximum likelihood supervised classification technique. The landscape was classified into seven classes, which included Cropland, Forest, grassland, wetland, scrubland, bare area, and water. Satellite data (Landsat) was used to evaluate NDVI and NDWI and finally the landscape patterns in the study were analyzed using Fragstats 4.2, which was also used to calculate landscape indices for the respective periods. The results obtained from the LULC, NDVI, NDWI and the landscape metrics showed that during the period of our study the VNP wetland was fragmented. A strong negative correlation between the number of hippos and the wetland's LFI (Landscape Fragmentation Index) values showed that wetland fragmentation was one of the reasons of the decline of Hippos in the park.

Human–wildlife conflict in Mhokwe Ward, Mbire District, North-East Zimbabwe

Musiwa, A.R. and W. Mhlanga 2020

Afr. J. Ecol. 58:786–795

This research investigates the economic and social aspects of human–wildlife conflict (HWC) in Mhokwe, Mbire district, Zimbabwe. Data were collected through key informant interviews and a questionnaire survey. Most households in Mhokwe rely on crop and livestock production, and hence, HWC is an important factor affecting livelihoods. More than 60% of respondents experienced problems with lions (*Panthera leo* Linnaeus), spotted hyaenas (*Crocuta crocuta* Erxleben), armoured bush crickets (*Acanthopplus speiseri* Brancsik) and quelea birds (*Quelea quelea* Reichenbach). Other problem animals included elephant (*Loxodonta africana* Blumenbach), vervet monkey (*Chlorocebus pygerythrus* Cuvier), kudu (*Tragelaphus strepsiceros* Pallas), chacma baboon (*Papio ursinus* Kerr), bushpig (*Potamochoerus porcus* Linnaeus) and common duiker (*Sylvicapra grimmia* Linnaeus). Few incidences of conflicts were reported for hippopotamus (*Hippopotamus amphibius* Linnaeus), side-striped jackal (*Canis adustus* Sundevall), porcupine (*Hystrix africaeaustralis* Peters), Nile crocodile (*Crocodylus niloticus* Laurenti), African wild cat (*Felis lybica* Forster), African python (*Python sebae* Gmelin) and guinea fowl (*Numida meleagris* Linnaeus). Livestock and crop losses were US\$45,285 and US\$57,541 in 2013 and 2014, respectively. Despite the losses, most respondents had positive attitudes towards wildlife. Construction of strong kraals and implementation of integrated pest management (IPM) can contribute to conflict reduction.





Spatial and temporal dynamics of human–wildlife conflicts in the Kenya Greater Tsavo Ecosystem

Mukeka, J.M., Ogutu, J.O., Kanga, E. and E. Røskraft 2020

Human–Wildlife Interactions 14(2):255–272

Biodiversity conservation in developing countries is faced with many and mounting challenges, including increasing human–wildlife conflicts (HWCs). In Africa and other developing countries, increasing HWCs, particularly those adjacent to protected areas, can adversely affect local stakeholder perceptions and support for conservation. We analyzed HWC reports for multiple wildlife species compiled >23 years (1995–2017) from the Greater Tsavo Ecosystem (GTE) in Kenya to determine HWC trends. The GTE is the largest protected area in Kenya, covering 22,681 km². Overall, 39,022 HWC incidents were reported in 6 GTE regions (i.e., Taveta, Mutomo, Kibwezi, Rombo, Galana, Bachuma). The 5 wildlife species most often implicated in HWC incidents were the African elephant (*Loxodonta africana*, 61.6%, n = 24,032), nonhuman primates (11.5%, n = 4,480), buffalo (*Syncerus caffer*, 6.2%, n = 2,432), African lion (*Panthera leo*, 4.2%, n = 1,645), and the hippopotamus (*Hippopotamus amphibius*, 3.8%, n = 1,497). The HWC reports also revealed spatial distinctions across the 6 GTE regions. More human–elephant conflicts (HECs; 43.3%, n = 10,427) were reported in the Taveta region than other regions. The Mutomo region was the epicenter of primate, snake, and python (*Python* spp.) conflicts. More large carnivore depredations on livestock were reported in the Taveta, Rombo, and Mutomo regions. Lions, spotted hyenas (*Crocuta crocuta*), and leopards (*P. pardus*) were implicated in more livestock depredations than other carnivores. The number of HWCs reported varied by year and season and were related to similar variations in the availability, quality, and distribution of food and water governed by rainfall fluctuations. Reported HECs were positively and linearly related to human, elephant, and livestock population densities. The Kenya Wildlife Service responded to >90% of the reported HWCs. In general, the number of HWCs and trends reported were higher in the regions that also exhibited the highest human population growth rates and densities. Sustainable biodiversity conservation in human-dominated landscapes is contingent upon communities deriving meaningful benefits from wildlife conservation. Far-sighted measures and different conservation approaches are required to mitigate HWCs in communities neighboring protected areas.

Evaluation of low-cost consumer-grade UAVs for conducting comprehensive high-frequency population censuses of hippopotamus populations

Fritsch, C.J. and C.T. Downs 2020

Conservation Science and Practice, DOI: 10.1111/csp2.281

The hippopotamus *Hippopotamus amphibius* (hereafter referred to as hippo) is classified as vulnerable according to the IUCN Red data list. They play a significant role in aquatic systems as allochthonous nutrient providers, and as facilitators and competitors in grasslands. Traditional census methodologies for hippo are difficult and costly to repeat. Previous research has been conducted on the use of unmanned aerial systems (UASs) to conduct hippo population estimates; however, findings either needed justification through additional field testing or used high-cost UASs that may be unaffordable for management authorities in developing countries in Africa. Therefore, using a low-cost, consumer-grade, DJI Phantom 3 Advanced multi-rotor unmanned aerial vehicle (UAV), 47 surveys were conducted of the hippo population at Ndumo Game





New literature on Suiformes



Reserve (NGR), South Africa, between August 2016 and July 2017. In addition, comparisons were drawn between the results of and the logistical requirements and costs of the respective helicopter and UAV surveys conducted on the same day of the same hippo population. The use of a consumer-grade UAV permitted frequent, accurate, and comparatively lowcost surveys to identify temporal changes in the number of hippos present in NGR and at different locations within NGR. Hippos are a data deficient species, particularly in remote developing countries. UAVs surveys of hippo will allow accurate, highly repeatable, and comparatively low-cost data collection for management of hippos and the ecosystems within which they occur.

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The IUCN/SSC Wild Pigs, Peccaries and Hippos Specialist Groups (WPSG, PSG and HSG) are three of several Specialist Groups of the Species Survival Commission (SSC) developed by the IUCN to foster conservation, research and dissemination of information for species of conservation concern.

These groups consist of technical experts focusing on the conservation and management of wild pigs, peccaries and hippos.

The broad aim of these groups is to promote the longterm conservation of wild pigs, peccaries and hippos and, where possible, the recovery of their populations to viable levels.

Pigs, peccaries and hippopotamuses are nonruminant ungulates belonging to the Suborder Suiformes of the Order Artiodactyla (the even-toed ungulates). Within the Suborder Suiformes, pigs belong to the Family Suidae, peccaries to the Family Dicotylidae and hippopotamuses to the Family Hippopotamidae.

