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The Conservation of the Babirusa (*Babyrousa babyrussa*)

Alastair A Macdonald

Veterinary Biomedical Sciences
The Royal (Dick) School of Veterinary Studies
The University of Edinburgh
Summerhall
Edinburgh EH9 1QH
Scotland, U.K.

Introduction

The babirusa (*Babyrousa babyrussa*) is believed to be the most distinct pig genus in the world. For example, among a number of unique anatomical characteristics, it is the only mammal with vertically growing canine teeth. Endemic to Sulawesi, and found on a few neighbouring islands such as Buru, Mangole, Taliabu and the Togian islands, the babirusa has a very limited geographical distribution. The available evidence seems to indicate that this is because Sulawesi has long been isolated by water from mainland Asia; the strait between Sulawesi and Borneo was apparently never narrower than about 50 kilometres during Pleistocene times. The current hypothesis is that the *Babyrousa* developed along a separate evolutionary line since Oligocene times (Thenius, 1970). This concept is supported by analyses of chromosome banding patterns that indicate that the chromosomes of the babirusa differed from those of other wild pigs (see Bosma *et al*, 1991). However, more recent work using DNA probes have shown that there are closer similarities between the chromosomes of *Sus* and *Babyrousa* than previously thought (Thomsen *et al*, 1996). DNA studies are beginning to reveal detailed molecular information with regard to the nature of the relationships babirusa has with other extant pig species (Randi *et al*, 1995; Lowden *et al*, 2002). New genetic analyses can be expected to give a much better understanding of the origin of the babirusa.

Following Groves (1980) three living subspecies are recognised: *B. b. babyrussa* (Linnaeus, 1758), from Buru and the Sula islands, *B. b. togeanensis* (Sody, 1949), from the Togian Islands, and *B. b. celebensis* (Deninger, 1910) from the northern peninsula and the north-east part of mainland Sulawesi. It is possible that some central or southern Sulawesi populations may represent a fourth subspecies, *B. b. bolabatuensis* (Hooijer, 1950), which is presently known only as a Holocene subfossil within the Tolian deposits collected from caves and rock shelters in south-western Sulawesi. Tissue samples and skeletal material need to be collected from each of the

Sulawesi populations in order to establish the nature of the species or subspecies identity, and relationships between the animals in each region.

Pleistocene fossil remains (*B. b. beruensis* (Hooijer, 1948)) found in caves and rock shelters on the east side of the south-west peninsula (see Hooijer, 1950) indicated that babirusa were the principal large prey species of prehistoric man in some localities on the island (Franssen, 1949). Man continues to hunt the babirusa. By the middle of last century the species was reported to survive in the east and north-east parts of Sulawesi but to have largely vanished from the whole of the south-western peninsula (see Macdonald, 1993). By the 1930's it was said to be 'being squeezed slowly into the hinterland of Sulawesi' (Heynsius-Viruly and van Heurn, 1935). The results of the population and habitat viability assessment (PHVA) of the babirusa undertaken in 1996 indicated that this process of attrition of the babirusa was being accelerated rather than reversed (Manansang *et al*, 1996). In the last few years the building of roads connecting the larger towns and cities of Sulawesi has made the situation worse (Keeling *et al*, 1999; Milner-Gulland and Clayton, 2002). Habitat and forest destruction continues, with babirusa hunted to extinction in many parts of north Sulawesi and becoming increasingly rare in other parts of the island due in large part to babirusa being eaten in the towns of North Sulawesi.

How is the species to be protected and conserved into the future?

Various national and international steps have been taken to lay the groundwork for the protection of the babirusa. A number of laws have been enacted in Indonesia since 1931, under which the animal has been provided with protection against illegal hunting and illegal trade to foreign destinations. The latter has been extended since 1982 by CITES agreement (Appendix I) to international trade between countries. It has been categorised as 'vulnerable (VU – A1cd)' in the IUCN Red Data Book (IUCN, 2004), and listed as 'endangered' by the United States Department of the Interior (1980) and a number of other bodies have drawn attention to its declining numbers in the wild.

Additional groundwork has been the effort made over the last few decades by way of research studies of various sorts designed to increase our understanding of the biology of the species. Summaries of these have been made in published reviews (Macdonald, 1991, 1999; Macdonald and Leus, 1995) and some examples are indicated below. Much of the available data has been collated by the Pigs, Peccaries and Hippos Specialist Group of the International Union for the Conservation of Nature (IUCN) in an effort to identify where there were gaps in current knowledge which would be of benefit to the conservation of the species (Macdonald, 1993). Following that, a population and habitat viability assessment (PHVA) of the babirusa was organised and undertaken in order to gather further information and to facilitate a more general and better understanding of the current situation, and the short to medium term prognosis for the species (Manansang *et al*, 1996).

The recently published World Zoo and Aquarium Strategy (<http://www.waza.org/conservation/wzacs.php>) now provides a new set of guidelines of how the zoological community can further contribute to the conservation of species such as the babirusa. It is clear from this document that the teamwork approach is being promoted whereby various types of cooperation between field staff, researchers,

zoo staff, both at a national and international level are seen as ways in which the environment and the wildlife it contains can be protected.

The application and enforcement of existing legislation is certainly one important aspect of community social and legal pressure to conserve a threatened species. Education of the general public, from the age of the youngest pre-school child, together with updated explanations of the reasons and need for babirusa conservation are inherent to a local understanding of the topic.

Integrated management of the animal in the wild and in zoological collections is now becoming a vital component in the long-term survivability of the species. Discussion in support of the opinion that there is plenty of space in the wild for the long-term conservation of the babirusa generally fails to take into account the findings of a number of recent studies. It used to be thought that the provision of a substantial number of large national parks was sufficient to provide the habitat required. However, it has become increasingly clear that by their very nature, these large parks were located at a distance from one another, and with the exploitation of the surrounding areas for agricultural and forestry use, they have become progressively more isolated from one another. This means that the animals within their boundaries are less and less likely to be able to breed with animals of the same species in other reserves because of these expanding man-made barriers of commercial farming and timber extraction. Thus, effectively, 'isolated islands' of animals have been created.

Recent studies of 102 vertebrates have shown that a minimum of about 7000 breeding age adults are required in order to maintain a minimum viable population of a species in the wild (Reed et al, 2003). If the numbers fall to 550 within a single habitat area then the chance of that population persisting for over 40 generations drops to 50%. Where populations of a species are segregated from one another, then the chance of their continued existence shrinks accordingly. The populations of babirusa in each of the 'forest fragments' that now remain are estimated to be separately smaller than the number calculated to give long-term sustainability of the species. If they remain isolated from one another then there is a greatly enhanced risk that the species will not survive in the wild.

The situation is made still more serious by the continued cropping of both vegetation and the babirusa themselves from these isolated patches of National and Provincial forest. The cropping of vegetation in terms of mature trees and other forest products removes the fruiting environment upon which the animal depends for daily life. If in addition, the babirusa are trapped and killed, then the breeding stock of this species, which can only reproduce slowly, is diminished and the genetic variability, upon which its long-term survival depends, is compromised.

So what is to be done?

It is important that there is a much wider and deeper understanding that the current system of parks, although of great benefit to many smaller species, does not represent a safe long-term haven for a species such as the babirusa. Only by linking these large areas, either physically with effective corridors of forest, or metaphorically by the transfer of the appropriate numbers and sex of animals from one forest to another, can the metapopulation size of the babirusa hope to achieve and maintain the target of

7000 adult individuals. An analysis of the genetic variability of the babirusa and its distribution in the wild is an essential requirement to understand the basis upon which to manage these currently segregated populations.

Genetic studies of this sort are currently under way, investigating the animals in zoological collections in order to provide the scientific foundations for this work. There are currently about 250 babirusa in 43 world zoos, but most of these stem from perhaps 5-8 founders. The majority of these animals are held in zoos outside Indonesia, where they provide opportunities for a wider international audience to learn about this animal and its homeland, and how they can contribute to its conservation. In addition, because of its unique characteristics, priority has been given to the conservation of the genus *Babyrousa* over a number of other genera of wild pigs in the regional conservation breeding plans of the American and European associations of zoos and aquaria (AZA and EAZA) which were published recently (Holland, 2000; Macdonald, 2001).

At the babirusa Population Habitat and Viability Assessment (PHVA) in 1996 it was agreed to bring 40 babirusa from the wild for conservation breeding and for subsequent multiplication in international zoos (Manansang et al, 1996). Since then, eight babirusa have arrived from Sulawesi in Surabaya zoo and a number of those have bred and produced young. This success means that there is already an opportunity to achieve a significant improvement in the genetic composition of the world zoo population of babirusa. However, to attain this, and promote the proper functioning of the international breeding programme, it is essential that the F1 generation of Surabaya animals are sent to breed with animals in zoos outside Indonesia.

The silently monitored destruction of apparently thousands of babirusa for human food consumption in the north of Sulawesi during the 1980s and 1990s has allowed the extirpation of babirusa from much of that peninsula and thereby removed a considerable amount of the genetic variation from the island's babirusa population (Clayton, 1997). Ironically, it is conceivable that the few fragments of that variability that may continue to exist on the planet live as individuals and pairs of babirusa in zoological collections around the world which are studbook listed and under conservation breeding management (Plasa, 2002).

It is a necessary adjunct to the long-term conservation of the animal in the wild that a metapopulation of babirusa is maintained in world-wide zoological collections. A population size of somewhere between 250 and 300 individuals, from a founder base of 40 unrelated individuals, if properly managed would enable 95% of the variability of the founders to survive for 100 years (Manansang et al, 1996). It is noteworthy that although only this relatively small number of babirusa need to be housed in zoological gardens, it is just as essential that these widely distributed zoos are able to exchange genetic material in order to maintain the genetic variability of the species over the long term. To this end, appropriate transport techniques and personnel training methods have been evaluated and implemented, and these continue to be developed. The international studbook, by means of which the breeding of the animals has been registered and monitored, has been in existence for over 20 years. In the very near future newer animal management software (ZIMS) will enable a more day-to-day

appreciation of the conservation breeding programme and indicate the status of the babirusa population in zoos worldwide (ZIMS, 2006).

Integration of the populations of species in the wild and in zoological collections has been achieved for a number of other species threatened with extinction. These demonstrate that the process is long term and involves the continuous investment of time and resources. It is not a 'quick fix'. One reason why it has to be a long-term commitment lies intimately linked to the large size, rapid growth and increasing expectations of the human population. It also takes time to build expertise in small population management, to teach conservation in the forests and to successfully engage local communities and their governments with the protection of resources in the wild. Increased team-work between zoos and other conservation organisations, lies at the heart of the new strategy document ((WAZA, 2005). Research links to national and international Universities and other research partners form another strand within the document.

Examples of topics of research

Habitat and food supplies

The babirusa inhabit tropical rain forest, and are active during daylight hours (Selmier, 1983; Patry *et al*, 1995; Clayton and MacDonald, 1999). Whereas previously the animal had been reported to occur in low lying areas near coasts, recent anecdotal and survey reports indicate that the species is now confined mostly to the interior, on higher and less accessible ground (Macdonald, unpublished; Burton, personal communication). Although often associated with pond and riverine areas, there is still insufficient data to be conclusive on this point. The association of the babirusa with species of food bearing plants has also not yet been studied in the forest. However, those reports and anecdotes that have been published have been gathered together and analysed by Leus (1996). The foundations for a series of studies lie within the appendix to her paper.

Babirusa social behaviour

The information available from field and zoo studies indicates that babirusa are social animals (Selmier, 1983; Macdonald *et al*, 1989; Patry *et al*, 1995; Clayton and MacDonald, 1999). Groups or troops of up to thirteen have been observed in the rainforest, especially around water, communal wallowing areas and salt licks. Rarely aggregations as large as 46 individuals comprising several distinct groups have congregated at a salt lick. Most sightings of solitary animals (84% of all solitary animals) were of adult males. Single adult males were seen with single adult females, but never with two or more females unless young animals were present. Adult females were rarely seen without company; they were sometimes found together with other adult animals, but most often they were with young babirusa. Groups containing adult females and young numbered 84 (of the 226 groups studied), of which two thirds (56 groups) had no adult males present (Patry *et al*, 1995). It can therefore be anticipated that in zoological collections, the continuous association of one adult male with one adult female may not be associated with the same breeding success as those situations where the female has access to a number of males, or has access to males on an intermittent basis.

Very little is known about the territorial ranges used by babirusa in the wild. Nothing has been reported either recently or in the older literature to indicate how far babirusa travel. The results of the recent investigations by Patry *et al.*, (1995) were such that it was not possible to differentiate between the females entering the study sites. It was therefore not possible to say with confidence the extent to which they remained in the same locality, or had a wide range that overlapped with those of other females. However, because the males could be identified from one another by the shape and size of their canine teeth, the observations suggest that the adult male babirusa do have home ranges that overlap at the salt lick with those of a number of other adult males. There is also evidence that babirusa swim well and can swim relatively large distances: a single adult male babirusa was recently reported approximately 500m from the shore of lake Poso in Sulawesi, across which it appeared to be swimming (Melisch, 1994). This observation substantiates a claim that has frequently been repeated in the older literature.

The daily activity profile of babirusa has not been studied in the wild. However some preliminary indication may be suggested by the distribution of daily behaviour exhibited by the 36 babirusa (Leus *et al.*, 1992) that were housed together as one large group in Surabaya zoo. Animals slept at night, which is consistent with the general lack of activity at night recorded in North Sulawesi (Patry *et al.*, 1995). About an hour before sunrise at 6.00 individuals began to wake up and move about. Voiding of faecal material and urine occurs at this time, and animals appeared to prefer to defecate under branches and tree trunks. Foraging extended throughout the day, but occupied a larger proportion of the time in the morning. This behaviour did not involve rooting if the ground was dry or compact. Anatomical reasons prevent this; the nose of the babirusa lacks the rostral bone that in other pigs provides support for the tough connective tissue plate of the rhinarium (Macdonald, 1993). Food items were looked for on the ground, under logs and stones, in wet areas and on bushes and trees (Leus and Vercammen, 1996). Animals will stand with their forelimbs against tree trunks to reach hanging leaves and fruit, and will even stand on their hindlimbs to pluck leaves from the trees (Leus *et al.*, 1992; Macdonald and Leus, 1995; Macdonald and Leus, unpublished observations). From about mid morning onwards an increasing proportion of the time was taken up with non-foraging activity. The animals were either wallowing or lying down. Both in the wild and in captivity, males have been observed to wallow more often than females. However, there is considerable individual variation in the pattern of daily activity (Leus *et al.*, 1992), and further studies are required, both of animals in the wild and those housed in as natural an environment as possible to explore this in more detail.

Food selection and diet

What the babirusa select to eat in the wild remains largely a mystery. There is relatively little detailed information available and few observations of the eating behaviour and food chosen by the babirusa in the wild (Whitten *et al.*, 1987, 2002; Leus, 1994, 1996; Reksowardojo, 1995; Leus and Vercammen, 1996). Leus (1996) has compiled an annotated list of species of trees and palms that grow in Sulawesi and produce fruits which may contribute to the diet of babirusa. However, despite the weekly cataloguing of very substantial babirusa mortality from hunting in North Sulawesi two decades ago, sadly there is almost nothing published on the stomach contents of even a proportion of the several thousands of animals that were reported to have been killed.

However, the anatomical structure of the stomach and digestive tract of the babirusa has been studied using specimens collected from the few animals which died in zoos over the same period (Leus, 1994; Leus, *et al*, 1999; Agungpriyono *et al*, 2000; Leus *et al*, 2002). In common with most of the other suids, babirusa would seem to be omnivorous. In zoos, adult babirusa have been observed to chase, catch and eat small mammals and birds implying that they may show similar behaviour in the wild (Leus *et al*, 1992). From observations of both wild and captive individuals they are known to consume a wide variety of leaf, root, and fruit material. Recent studies suggest that fruits in particular may be an important component of the diet (Leus, 1994, 1996; Leus *et al*, 2000). Their jaws and teeth are strong enough to crack very hard nuts with ease (Peters, 1985; Leus and Macdonald, unpublished observations). Seeds of the canari (*Canarium* (Burs.)), oaks (*Lithocarpus* (Burs.)) and chestnuts (*Castanopsis* (Burs.)) are available on Sulawesi (Leus, 1996). Fruits are also an important component of the diet of Sulawesi *Macaca* spp. The extent to which babirusa feed on the fruit remains discarded by these primates also awaits study. The babirusa's apparent requirement for fruit-bearing trees as a component part of their environment has been implied by Whitten *et al* (1987, 2002) when they reported that as soon as mature trees were cleared by forestry operations or conversion to food crop production, the babirusa were no longer to be found in the area. Further detailed studies, of the diet in the wild and the fruiting patterns of the forest, are required to fill these gaps in our current knowledge, and help explain how diet availability in wet and dry seasons may influence babirusa group size, structure and home range.

Agonistic behaviour

Mackinnon (1981) extrapolated from the tooth wear pattern, shown as scratches on the sides of the canine teeth of adult male babirusa, that this damage was caused by fighting behaviour. Unfortunately, despite evidence to the contrary, this mistaken view has been carried forward into the latest revision of the Ecology of Sulawesi by Whitten *et al* (2002). Recent observations make it more likely that these scratch marks were caused by marking behaviour, when the side of the head was rubbed against a solid substrate such as the ground or some upright structure like a branch or sapling (Leus *et al*, 1995; Macdonald *et al*, 1996).

Studies of agonistic behaviour in zoological collections and in the wild have shown that the teeth were not involved in "interlocked tooth" wrestling matches (Macdonald *et al*, 1989, 1993; Patry *et al*, 1995). The relatively shallow tooth sockets supporting the upper canines are not strong enough to withstand such activity (Macdonald *et al*, 1993). Instead, the adult males progress through a repertoire of behaviours that fall within the broad classifications of threatening, display and fighting behaviour. These could be categorised as "threat at a distance", "surprise rush", "nose in the air", "head under jaws submission", "front half supported", and "boxing" as the level of threat increased. The boxing behaviour was the final stage observed, and this involved the two adult males raising themselves off the ground until both were standing on their hind legs facing one another. Once in this position the babirusa leaned and paddled against the chest and shoulders of their opponent. Their snouts were held as high as possible. The animals seemed able to remain on their hind legs for about one minute at a time. If one of the animals fell onto all four legs it reared up again and the boxing continued. The boxing match usually lasted for 2 to 5 minutes, but could extend for up to 20 minutes. If the inferior animal submitted at the earlier stage of "head under

jaws submission" it would utter a very short squawk or a continuous rattling stream of sound, the pitch and intensity of which increased as the animal below seemed to perceive increased threat. Ironically, the upper canine teeth of the inferior male appear to function as protection to the throat of the superior male, preventing potential (accidental) damage from the lower canines of the inferior animal (Leus *et al*, 1992; Macdonald *et al*, 1993).

Female babirusa do exhibit the "threat at a distance" and "surprise rush" agonistic behaviours, although "nose in the air" and "head under jaws submission" were rarely seen between adult females, and "front half supported", and "boxing" were never seen. When two females confronted one another their behaviour was often quite violent, fast moving and noisy (Macdonald *et al*, 1993; Patry *et al*, 1995). The object seemed to be to bite the leg or foot of the opponent.

Reproduction

In zoological collections, babirusa may become sexually mature as early as five to ten months of age (Macdonald, 1993). However, it is likely that the age of sexual maturity in the wild is influenced by a number of factors including the level of nutrition. Precise data does not yet exist, but animals are unlikely to breed until they are more than one year old. Oestrus cycle lengths of between 28 and 42 days have been recorded but recent endocrine studies suggest it may lie between 35 and 37 days (Macdonald, 1993; Chaudhuri *et al*, 1990; Schwarzenberger *et al*, 2005). Captive females generally re-cycle within 3 months after the birth of their young. Oestrus lasts 2-3 days, and the female is not receptive to males at other times. Further studies are being undertaken to better define the nature of reproduction in the female.

Gestation length is usually 155-158 days, though up to 171 days has been reported (Vercammen, 1991; Macdonald, 1993). The body weight of the sow increases during gestation (Macdonald 2000). The normal litter size is one or two uniformly brown coloured piglets, but a low incidence of triplet births has been recorded both in zoos and in the wild, and a litter of four fetuses has been reported *in utero* in a wild female (Patry, 1990). Neonatal babirusa are small in size and weigh less than 800g at birth. There are usually four mammary glands in the babirusa, but an additional pair has sometimes been reported (Leus *et al*, 1992). Although the female can have a life span of as long as 24 years in zoological collections (Mohr, 1960), it is unlikely that the babirusa in the wild live as long, perhaps no more than 7-12 years.

In zoos, babirusa sows produce young at all times of the year (Plasa, 2002), and may produce two litters within a 12 month period. However, since it seems likely that diet or seasonal factors would normally influence inter-birth intervals, litters may be produced less frequently in the wild. Observation of babirusa in the North Sulawesi revealed adult females accompanied by subadult animals as well as juveniles (Patry *et al*, 1995). However, there was no observable criterion with which to establish whether or not these youngsters of two different ages represented the progeny of consecutive litters from the same adult female.

Threats to survival

Adult babirusa appear to have few, if any, natural predators. The small numbers of young born to the babirusa suggest that the species is not adapted to a high rate of natural predation. No studies seem to have quantified the predatory impact on

babirusa of the larger snakes of Sulawesi. However, hunting by humans with snares, nets, spears and dogs has undoubtedly been an important factor since prehistoric times (Guillemard, 1886; Franssen, 1949). Studies over the last fifteen years consistently show that widespread snare trapping constitutes the main threat to the remaining populations of babirusa in North Sulawesi and, more recently, elsewhere in Sulawesi (Blouch, 1990; Budiarto *et al*, 1991; M. Patry, pers. comm.; Manansang *et al*, 1996; Clayton, *et al*, 1997; Keeling *et al*, 1999; Lee *et al*, 2005). The babirusa is not hunted specifically for its own meat, but represents a by-catch to the hunting of the Sulawesi warty pig, *S. celebensis*. This other species of endemic pig is present in the forest in larger numbers because it produces more piglets in each litter. The same prices are paid for the meat of both species, which gives the hunters no incentive to selectively catch one pig in preference to the other (Blouch, 1990; Budiarto *et al*, 1991; Milner-Gulland and Clayton, 2002). Therefore, the population of babirusa in the wild is being placed under severe and increasing pressure by the market demand for wild pig meat in North-east Sulawesi. The widespread lack of public awareness and understanding of the problem has allowed large areas of North-east Sulawesi to be stripped of babirusa, with a permanent loss of the genetic variability that these animals represented to the whole population.

Large commercial and local-scale logging operations also pose a major and increasingly serious threat to this species (Smiet, 1982). The loss and degradation of habitat has already resulted in the dramatic diminution in the known range of this species in North and South Sulawesi, and on the island of Sulawesi. Between 1985 and 1997 Sulawesi lost 20% of its natural forest cover (World Bank, 2001; FWI/GFW, 2002). The Babirusa is one of the first animals to become locally extinct after logging or land opening. The species does not seem to be as adaptable as the Sulawesi warty pig. Little is known about the susceptibility of the babirusa to natural or introduced pig-borne diseases (Munro *et al*, 1990).

Conservation measures

Populations of babirusa occur in a number of the national parks, nature reserves, hunting reserves and protected forests in Sulawesi. Some of these areas have been designated specifically for their protection. However, the animals are patchily distributed and are still subject to local hunting pressure in many of these areas. Efforts are being made by the Parks Service to educate people and to control animal poaching and timber cutting within the existing protected areas, but chronic lack of financial resources, pressure from an expanding human population and insufficient up-to-date information seem to combine with other factors to make much of the protective legislation ineffective at a local level. The decline in forest cover over the last 100 years is illustrated. The World Bank has recently published recommendations and guidelines concerning improvements in forest and natural resource management (World Bank, 2001). However, the power of those individuals and industrial concerns engaged in illegal logging is having a seriously detrimental effect (Kinnaird and O'Brien, 2002). About 20% of the forestry cover of Sulawesi has been lost between 1985 and 1997 (FWI/GFW, 2002). The amount of suitable habitat remaining within the 'protected' areas is also considerably less than the designated size of the reserves. There is a serious possibility that small populations of babirusa are being isolated in relatively small pockets of forest, and as such are not viable in the medium to long term. Efforts have started, therefore, to identify where these pockets lie and to explore ideas and investigate methods of forming appropriate

corridors to connect them, and ways to protect them. Education efforts supported by schools, newspapers, zoological societies, local and international NGOs have begun to distribute wildlife conservation information to the children and raise awareness among the general public on Sulawesi. Conservation breeding programmes devised following the PHVA held in Bogor in 1996 have been enacted since 2001 (Manansang *et al*, 1996; Macdonald, 1999; Plasa 2002). Efforts are being made to identify the range of genetic variability that exist within the babirusa population and to bring that into conservation breeding before the animals it represents are killed and eaten.

Surabaya Zoo has a long and well-established record of conservation breeding of babirusa. It's successfulness in breeding the species has led to it's designation by the Indonesian Zoo Association as the Indonesian zoo responsible for leading the national conservation breeding of this species. Surabaya Zoo has also created and supported strong babirusa-research links with staff in IPB, Bogor, the Royal Zoological Society of Antwerp and the University of Edinburgh, resulting in the publication of scientific articles which add to our knowledge of the biology of this species (e.g. papers by Agungpriyono, Leus and Macdonald). Other Indonesian zoos have contributed to this conservation effort; for example Taman Safari Indonesia were the hosts to the joint Babirusa and Anoa PHVSs in 1996 (Manansang *et al*, 1996). Similarly, conservation research links between Indonesian zoos and the Wildlife Conservation Society, the Zoological Society of London, Poznan Zoo and other international zoos have been established.

In conclusion, a new climate of cooperation has been signalled between the various agencies responsible for the conservation of wildlife, in the wild and under conservation breeding management. A number of very real threats to the long-term survival of the babirusa have been flagged up and placed into context by the recent recognition that a metapopulation size of 7000 adults is required for survival in the wild. Conservation breeding of a small subset of these (40 founders) will provide a measure of safety within the active management husbandry of zoological collections.

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