FAUNA *of* AUSTRALIA

59. SUIDAE

C.P. GROVES & J. GILES

Pig–*Sus scrofa* [CSIRO Wildlife & Ecology]

DEFINITION AND GENERAL DESCRIPTION

Members of the Suidae are non-ruminant artiodactyls: cloven-hoofed mammals that do not chew cud. They have short legs, compact bodies and short, thin tails. The hoofs, both main and lateral (the small side hoofs that do not touch the ground), are large. The head is large, long-snouted, lacks horns and is characterised particularly by the snout disc; the nostrils face forward on the end of the snout, which is flattened and strengthened by a cartilaginous plate which forms a blunt, rounded tip to the snout. The canine teeth of males are very substantial; they turn outwards on emerging from their sockets, their lingual surfaces wearing against each other. Females have much shorter canines that are simpler and do not (or not markedly) turn outward. The molar teeth are low-crowned with many cusps, especially on the third molars.

HISTORY IN AUSTRALIA

Though probably introduced to Australia by Europeans only, previously unknown feral populations of pigs have been discovered often and earlier Asian introductions are possible.

MORPHOLOGY AND PHYSIOLOGY

Basic anatomical and physiological data for Suidae are given by Frechkop (1955b) and by Hammond, Bowman & Robinson (1983), as far as the domestic and so, inferentially, feral pigs are concerned.

External Characteristics

The typical features of an Australian feral pig are shown in Fig. 59.1. In Australian feral pigs the hair tends to be olive-brown in tone, but many variants occur, such as specimens with white feet. The curly form of the tail in domestic pigs is lost in the wild.

Body Wall

The skin is thick and beneath it is a continuous fat layer, the panniculus adiposus. A rutting boar develops a 20 – 30 mm thick ‘shield’ on the shoulders and anterior flanks that affords protection in fights with other boars.

Skeletal System

The snout disc is supported by bones, the ossa narialia, that are not part of the skull and are connected loosely to the nasals, premaxillae and sometimes the mesethmoid bone. The skull (Fig. 59.2) is characterised by a very long rostrum with a marked preorbital depression that continues forward on the rostrum to near the end. The canine roots in the males extend into bony protruberances, the canine apophyses, that curve out and up from the sides of the snout to encircle the preorbital fossae in that region. The orbits are small, placed well back on the cranium and almost, but not quite, ringed behind by bone. The braincase slants up and back behind the orbits, with a prominent backward projecting occipital crest. The auditory canal is peculiar – it is formed by a fusion of the tympanic bone to the squamosal. The vertebral column in wild pigs comprises: seven cervicals, 14 to 15 thoracics, six to seven lumbars, four sacrals and 20 to 23 caudals. Wild pigs thus have generally 14 ribs, but domestic breeds, especially those bred for bacon, have more ribs. The number in feral pigs is not known.

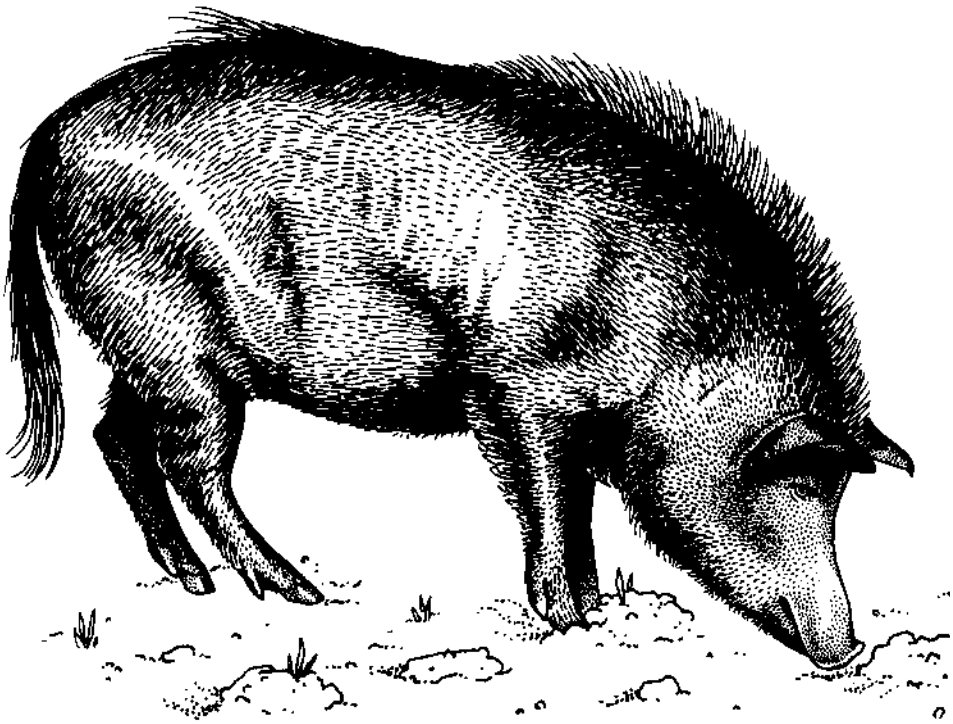

Figure 59.1. The sparsely haired skin, rounded body contours, short legs and snout disc are the most outstanding features. The hooves of the pig, both main and lateral (the small side hooves that do not touch the ground) are large. The head is large, long-snouted, lacks horns and is characterised particularly by the snout disc. The nostrils face forward on the end of the snout, which is flattened and strengthened by a cartilaginous plate which forms a blunt, rounded tip to the snout.The ears of feral pigs are mostly pricked, not pendant like many domestic pigs. Some individuals develop a crest of bristles down the midline of the neck and back. © Environment Australia] [K. McInnes]

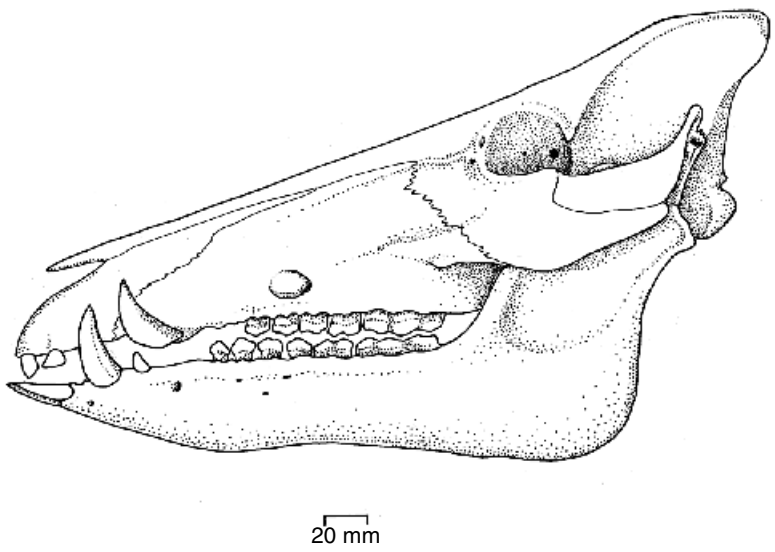

Figure 59.2 Lateral view of the skull of *Sus*. (© ABRS) [S. Weidland]

Locomotion

The metapodials remain separate, whereas in ruminants they fuse together in each limb. Digits III and IV are the weight-bearing digits and are large; digits II and V are reduced, but still may touch the ground. Digit I, as in all artiodactyls, is absent. Again, unlike ruminants, the ulna is complete and not fused to the tibia. In these respects, Suidae are more primitive than ruminants.

Feeding and Digestive System

The dental formula is I 3/3 C 1/1 PM 4/4 M 3/3. As was explained above, the canines of males are turned outward and occlude with each other on their lingual surfaces. The lower incisors are narrow and procumbent. The cheekteeth (especially the molars) are brachyodont (low-crowned), bunodont (with separate, bulbous cusps) and multicuspid (with many extra cusps, above the normal four). Of the premolars, only the fourth premolars are significantly molarised. The others are small, narrow and bladelike.The third molars are grossly elongated, triangular and multicusped, especially in the lower jaw. The temporal muscle, the most prominent masticatory muscle, is very large and its fibres often originate at the top of the braincase, separated from that on the other side by a sagittal crest. The mandibular condyles are flat and triangular.

The tongue has all the usual types of papillae and two fraenula. The stomach is simple, not partitioned as in ruminants, with very small oesophageal and very large cardiac regions, plus fundic and pyloric parts. It takes 24 hours to empty. The small intestine is 15 – 21 m long. The caecum is very small, only 200-300 mm long; the colon, which is long and coiled, is 3 – 4.5 m in length. All these characteristics are those of a relatively unspecialised feeder; pigs have been shown many times to be omnivores (see, among other descriptions, Barrett 1978; Giles 1980).

In the wild, pigs show a strong preference for fresh green grasses, legumes, palatable herbs and succulents, meat (especially carrion), and small fauna such as frogs, worms and beetles. They rarely browse and do not eat the leaves of vegetation that has begun to hay off. Having neither a complex stomach nor enlarged caecum, pigs cannot digest cellulose efficiently. They like seeds, including commercial grains and fruits, and eat large quantities of root bulbs and corms, especially when green grasses and forbs are unavailable.

Protein and energy requirements are high, particularly during late pregnancy, lactation and early growth. In domestic pigs, piglets suckled by sows with a crude protein intake of less than 15% (w/w) have low survival rates (Duncan & Lodge 1960). Crude protein intake has also proved to be the primary limiting factor in survival of wild piglets (Barrett 1978; Giles 1981).

Circulatory System

The heart weighs 450 g, representing approximately 0.35% of body weight, and has no os cordis. The vascular system is uncomplicated.

Respiration

The left lung has two to three lobes, the right lung four and the two lungs together weigh 1 kg. The larynx is unusually loose and flexible in structure and unlike almost all other mammals is free from the hyoid bone and has a special saccule. The exact function of this peculiarity is unknown, but may relate to the necessity to close off all airways, including the nostrils, for long periods while rooting in the soil with the snout disc.

Excretion

The kidneys together weigh 235 g and are smooth, flattened and symmetrically placed.

Sense Organs and Nervous System

The eyes are small and positioned well back on the head. Vision does not seem to be very acute, but moving objects are detected from some distance. The pupil is round. Ears are large and pointed and pigs possess a good sense of hearing. The sense of smell is exceptional. Food items underground are detected with the forward-facing nostrils while rooting. In Perigord, south-western France, domestic pigs are trained to detect and root up buried truffles in the woodlands (Zeuner 1963).

The brain weighs 125 g – it is simple and has few fissures. The cerebellum is overlapped by the cerebrum with the pons indistinct and the medulla short. The olfactory bulbs are large. Domestic pigs have smaller brains, relative to their body size, than do genuinely wild pigs (a common finding when comparing domestic and wild forms of the same species). This change appears to be irreversible. After many generations of feral existence the brain remains small, but the proportions change, the diencephalon and medulla becoming larger and cerebellum smaller (Kruska & Rohrs 1974).

Endocrine and Exocrine Systems

The following specialised cutaneous glands are present: (1) carpal, on the posterior surface of the carpus, with two to nine porelike orifices; (2) proctoideal, in the entrance to the rectum; (3) perineal, between anus and genital region; (4) preorbital, with a small orifice in front of the eye; (5) mental, consisting of numerous tubular glands in a swelling, marked by vibrissae, between the two halves of the jaw; (6) rhinarial, in the midline of the upper part of the snout disc; and (7) smegma glands, very large mixed sebaceous and apocrine glands in the distal region of the prepuce. Little is known about the function of all these glands, except that those associated with the genitalia double in size in rutting boars, as do the mental glands of both sexes.

Reproduction

The penis is S-shaped when flaccid. It contains much connective tissue, being intermediate between the engorging type of most mammals and the fibro-elastic type of ruminants. The scrotum is not pendulous and testes descend only during the rut. Seminal vesicles, urethral and Cowper's glands are voluminous. During copulation, the boar produces around 255 ml of ejaculate each time in waves of different sperm concentrations.

Feral sows have five or six pairs of nipples, but in many domestic breeds this number is increased, even doubled. The oestrous cycle lasts for 21 days and oestrus itself 2 – 3 days. The vulva is swollen for up to 9 days on either side of oestrus. Ovulation occurs near the end of oestrus, at which time 10 to 25 ova are shed. Domestic and feral pigs can breed throughout the year, with no marked peaks, as do wild pigs in tropical Asia. In contrast, those of temperate Eurasia usually have only one litter per year, mating in winter and farrowing in spring unless the food supply is exceptionally good (Mauget 1972). Some feral populations, however, do breed seasonally. In the mountains of Hawaii, 90% of the litters were born from January to April (Nichols 1962) and a mixed wild-feral population in Monterey County, California, mated from October to January and produced only a single litter each year (Pine & Gerdes 1973). In year-round breeding populations, sows come into oestrus again 5 – 10 days after weaning their piglets.

Feral sows commence breeding at 3–18 months of age. In domestic pigs, both age and weight influence age at first breeding (Day 1962). In New South Wales, few sows breed at less than 6 – 8 months of age, and breeding at this early age is always in areas where they had access to mature crops of commercial grains. The critical weight for first breeding in these feral pigs is 20 – 30 kg (Giles 1980). Similarly, in domestic pigs, puberty may be delayed by severe restriction in energy intake (Duncan & Lodge 1960). This is probably also the case in feral pigs.

Litter size in utero in 294 pregnant sows, of 9 months of age and older, examined in New South Wales from 1971 to 1977 was 6.44 (Giles 1980). Mean litter sizes in feral and mixed wild/feral pig populations in the mainland United States of America vary between 4.2 and 5.6 (Barrett 1978; Henry 1968; Pine & Gerdes 1973; Springer 1977; Wood & Brenneman 1977). In Hawaii it is 5.4 (Nichols 1962). By contrast, in 571 domestic sows in New South Wales, mean litter size was reported to be 8.9, considered low by international standards (Penny, Edwards & Mulley 1971).

Litter size of domestic sows increases with age up to the fourth litter (Penny *et al*. 1971). An increase in litter size with age was found by Giles (1980) in all feral populations examined in New South Wales. Sludskii (1956) notes that the first one or two litters in the Siberian Wild Boar were smaller than subsequent litters.

Wastage of ova in feral pigs, in New South Wales and elsewhere, is similar to the range of 21 – 40% given for domestic pigs by Rasbech (1969), Penny *et al*. (1971) and Schoefield, Clegg & Lamming (1974). Most wastage of ova occurs in the first 25 days after conception.

Embryology and Development

Gestation lasts 110 – 116 days. The placenta is diffuse and epitheliochorial; implantation occurs about 11 days after fertilisation. Birth weight is from under 1 to almost 3 kg and the newborn of large litters weigh less than those of small litters. Young of wild pigs of the genus *Sus* are striped longitudinally, generally alternating black and yellow, although in the Javanese species *Sus verrucosus*, these stripes are muted and not visible from a distance. Feral piglets in north-western New South Wales are commonly striped at birth, but striped young do not occur in other districts. The stripes are lost at about 6 months of age.

Sow's milk contains 7.9% fat, 5.9% protein and 4.9% lactose and the young suckle every hour for 5 minutes. A domestic sow produces an average of 300 kg of milk in a lactation of 56 days. The anterior teats give more milk than the posterior.

At birth, the deciduous canines and I3 (third incisors) are already erupted and the rest of the milk teeth erupt in the following 5 weeks or so. Of the permanent set, M1 erupt at 4 – 6 months of age, M2 and I3 at 8 – 12 months, the premolars at 12–15 months and the remainder at 16–20 months.

NATURAL HISTORY

Life History

Mortality in the first 3 months of life is variable and under harsh environmental conditions can approach 100%. Barrett (1978) estimates that 70 – 90% of the pigs in his study area died before 6 months of age. In New South Wales, mortality was found to vary from about 50% in favourable years to nearly 100% during floods and droughts. The prime cause of mortality is considered to be a deficiency of protein in the diet of lactating sows, and hence poor milk

production. Predation by foxes, dingoes, raptors and even adult pigs also contributes, although sows will defend their farrowing nests and losses by predation are probably small overall. However, piglet survival in excess of 50% has been observed in good conditions of food supply.

The feral pig population has a great capacity for rapid increase, even when the mortality rate of young is very high. For example, even when only 10% survive their first year, the population will increase by 21% in 1 year. As the mortality rate varies widely depending on circumstances, a mean figure is fairly meaningless in the environmentally fluctuating Australian context.

Control programs and shooting aside, the major cause of mortality in Australia is probably starvation. This is not only the case with piglets; old pigs may starve when excessive tooth wear begins to interfere with mastication. Gum ulceration was found to occur in Californian feral pigs by Barrett (1978). Apart from humans and dingoes, adult feral pigs in Australia have no effective predators.

Ecology

Feral pigs occur most commonly where there is surface water and dense vegetation; during drought, they are confined to such areas. After a succession of good seasons or where food such as grain crops is abundant, they increase in number and disperse into a wide range of habitats. Water and shade are essential in hot areas as pigs overheat and dehydrate quickly (Mount 1968).

Sows about to farrow tend to select the densest cover available. Here they build a nest of grass and sticks, usually over a shallow depression.

Adult boars range more widely than sows and stray into quite open country, particularly during cool weather. There is some anecdotal evidence (Hone & Waithman 1979) of expansion of populations in New South Wales between 1970 and 1976 when high rainfall and frequent flooding occurred. Feral pigs became problems to landowners in areas where they were unknown previously. Some of these areas were quite atypical of the conventional idea of favourable feral pig habitat.

No studies of feral pigs in Australia have revealed any large array of parasites or pathogens. Leptospirosis and Murray Valley Encephalitis are common in New South Wales, but these diseases also are endemic in some other animals in swampy habitats. Brucellosis is recorded in Queensland (Norton & Thomas 1976), but is uncommon in New South Wales (Giles 1980). Mycobacterial infections have been found in the Northern Territory (Corner & Pearson 1976).

The only ectoparasites found on feral pigs in Australia thus far are pig lice (Haematopinus suis), present on almost all feral pigs, and macroscopically obvious infections of the mange mite (Sarcoptes scabei), that were fairly uncommon (Pavlov 1980; Giles 1980). These workers also found that stomach worms (Physocephalus species) and one intestinal parasite, Macracanthorynchus hirudinaceus, were common in the Northern Territory and in New South Wales after 1971 (but not in 1970–71), sometimes in severe infestations. These worms have dung-feeding beetles as their intermediate hosts. Lungworms (Metastrongylus species), which have earthworms as intermediate hosts, are locally common, but infestations are normally light. R.H. Barrett (personal communication) found severe infestations of kidney worms (Stephanurus dentatus) to be common in adult pigs in the Northern Territory, often causing marked kidney damage. This parasite has not been found in New South Wales.

The pleurocercoid of the dog and the fox tapeworm, Spirometra erinacei, is found commonly in the muscles of pigs in or near swamps. This parasite has a complicated life cycle through dogs or foxes, thence through water fleas and frogs (Gordon, Forsyth & Robinson 1954). Pigs become infected by eating frogs.

Behaviour

Radio-tracking studies indicate that pigs are fairly sedentary under most conditions (Giles 1980; Pavlov 1980; and other sources). Boars tend to have larger home ranges than sows or young (10 – 50 km^2, versus 1 – 20 km^2 and 1 – 5 km^2, respectively). In the United States of America, ranges may be even smaller (Kurz & Marchinton 1972), but those of wild pigs in northern Eurasia may be much larger (Sludskii 1956). The home range may be shifted as a result of drought, flooding or severe disturbance. Ling (1955) reported that new territory is first exploited by males dispersing into a new area and making beds and trails in it. Dispersal rates of 4 – 5 km/year are reported.

Feral pigs are normally most active around dawn and dusk. In very isolated localities, and where they are little disturbed, they may be active diurnally in cool weather. Commonly, they leave their bedding sites about dusk and proceed directly to water to drink and wallow. They then feed for a couple of hours and remain relatively inactive until dawn. They occasionally water again just after dawn, but usually remain in cover and in the early morning return to their bedding sites for the day. The general-use beds are made in similar fashion to the sow's farrowing nest, but are much less elaborate.

Economic Significance

Feral pigs are widespread and abundant in Australia. They cause damage to agricultural and pastoral enterprises and to the natural environment, and are a potential reservoir and vector of several livestock diseases, including foot-and-mouth disease, which are currently exotic in Australia.

Severe environmental damage is caused by pigs rooting drainage channels of swamps, feeding selectively on bulbs and corms, and direct predation on frogs, reptiles, birds and their eggs, and small mammals. Pigs can cause damage to improved pastures, mature crops and stored grain and can take large numbers of young lambs without leaving much evidence of their predation. Pavlov & Hone (1982) described the typical pattern of predation on lambs. A lone animal, of either sex, runs down the lamb, which is knocked off balance and killed with a bite to the chest. Entrails are eaten first, followed by the backbone and flesh of the upper legs. Within 40 minutes, one lower leg or just bloodstained grass will remain. Up to three lambs were seen to be eaten by a single pig in one night and multiple kills were seen when the sheep flock remained in the vicinity.

Over the past 25 years, a variety of control techniques (mainly poisons) has been tried. White phosphorus was initially used, later sodium monofluoracetate (compound 1080). Trapping has been used widely as well as shooting – usually with the help of dogs to locate the pigs and bring them to bay. Shooting from helicopters is most successful during drought.

Damage mitigation by exclusion fencing, usually electrified, has been successful in some areas. This technique also should be useful in separating essential elements of the habitat of pigs in order to reduce the area’s carrying capacity, for example where pigs rest in forest areas, but feed on nearby farmlands.

Control must aim at a sharp reduction in population size so that a return to pre-control levels by recruitment with increased juvenile survival rates (fewer animals and thus more food per head) does not occur within a few months of the control program. Even with an initial reduction in numbers of 60 – 70%, theoretical modelling (Giles 1980) predicted full recovery of numbers within 12 – 18 months, an estimate corroborated by the observations of Hone, O'Gray & Pedersen (1980). Usually only substantial poisoning programs achieve these sharp reductions and annual repetitions of these programs may give rise to undesirable environmental effects that are best avoided in view of the public sensitivity of such issues.

Studies on domestic pigs (Hammond *et al*. 1983) have shown these animals to be exceptionally efficient converters of feed; protein conversion efficiency is 14 – 16% (pork) and 12 – 14% (bacon), compared with 7 – 11% for beef, 6% for lambs. Energy conversion efficiency is 34 – 40%, compared with 14 – 19% for beef, 10% for lamb.

BIOGEOGRAPHY AND PHYLOGENY

Distribution in Australia

Pullar (1950) gave a history of feral pigs in Australia and general information on their distribution and biology. Several populations had already become established by the mid-20th Century and all appeared to him to have resulted from introduction by Europeans. He does, however, note the presence of populations with striped piglets in northern Queensland, indicating that the founding stock more likely were derived from some wild, or less long established, domestic type than from European domestic pigs. Striped piglets, as well as agouti-coloured adults, are now found (Giles 1980) to be common in the area of New South Wales west of the Darling River at Bourke and north of a line from Wilcannia to Broken Hill, although it was not possible to detect any differences in biochemical blood markers between these 'wild' and 'European' phenotypes. As for other areas, pigs were imported to the Port Essington settlement from Timor and Kisar, as well as from New South Wales (Calaby & Keith 1974), so that there is at least a chance of some *Sus celebensis* ancestry (Groves 1981). There has been little study of the cranial characters of Australian feral pigs. Although all successful feral populations can be expected to have 'reverted' to wild type to some degree, if only to a limited extent, the differences between species in *Sus* are quite clear. Cranial capacity studies should throw light on the question of the possibility of non-domestic ancestry.

Affinities with other Groups

The relationships of the Suidae are discussed by Groves (1981), Thenius (1970) and other authors. They generally are placed with the Dicotylidae and Hippopotamidae in a suborder Suiformes of the Artiodactyla. The other suborders are Tylopoda (camels) and Pecora (ruminants). Although, as has been mentioned above, the Suiformes are in many respects (lack of foregut or hindgut fermentation chambers; bunodont molars; lack of radius/ulna or tibia/fibula fusion) primitive with respect to the other two suborders, there is ample evidence that the suborder is indeed monophyletic.

Affinities within the Suidae

Of the five extant genera of Suidae, *Babyrousa* stands well apart phyletically from the rest and is placed in a separate subfamily. The other four genera, belonging in the subfamily Suinae, are *Sus*, *Potamochoerus*, *Hylochoerus* and

Phacochoerus. Of these, the last is divergent from the other three, *Hylochoerus* is next most divergent, and *Sus* and *Potamochoerus* are related closely. The fossil records of most of the genera are well known.

In the genus *Sus*, the latest revision (Groves 1981) recognises five species, although there is a possibility that one or two further species may be separable in the Philippines. Two of these, *S. scrofa* and *S. salvanius*, stand apart from the rest in their having highly derived states in such characters as the canine teeth and the preorbital fossa. It seems likely, however, that even sympatric species pairs are interfertile in captivity. One of the three 'primitive' species of the genus, *S. celebensis*, shares certain derived features with the *S. scrofa salvanius* lineage. There is evidence that it was tamed, probably genuinely domesticated, in eastern Indonesia prior to the importation of domesticated S. scrofa and that hybridisation between the two species took place, resulting in the formation of the New Guinea Pig, so-called *Sus papuensis.* There is, therefore, a possibility that some Australian feral pig populations could be derived from *S. celebensis* (still kept under domestication in parts of Timor and on some neighbouring islands) or from the hybrid type, although it is probable that most are derived from domesticated *S. scrofa.*

CLASSIFICATION

A general classification of the Suidae follows:

Family Suidae

Subfamily Babirousinae

Genus *Babyrousa* (Babirusa)

Subfamily Suinae

Genus *Phacochoerus* (Warthog)

Genus *Hylochoerus* (Giant Forest Hog)

Genus *Potamochoerus* (African Bushpig, Red River Hog)

Genus *Sus*, with the following species:

Sus scrofa (Eurasian/W. Indonesian Wild Boar; source of most domestic pigs)

Sus salvanius (Pygmy Hog)

Sus celebensis (Celebes Wild Boar; source of a very few domestic pigs)

Sus verrucosus (Javan Warty Pig)

Sus barbatus (Bearded Pig)

KEY TO PRESUMED AUSTRALIAN SPECIES OF SUIDAE

1 Mandibular canines of male with inferior surface narrower than posterior, and strongly curved back as well as laterally; preorbital fossa shallow; malars not inflated, widening evenly behind maxillae; long-limbed, large-eared; no warts on face; no hair whorl on jaw angle . . . . . *S. scrofa*

2 Mandibular canines of male with inferior surface broader than posterior, and mainly laterally directed so that its tip is free rather than occluding with maxillary canine; preorbital fossa deep, sharply outlined posteriorly; malars strongly inflated; short-limbed, small-eared; in male, three pairs of warts on face (preorbital, infraorbital, gonial/mandibular); a whorl marks site of gonial wart before the latter is developed . . . . . *S. celebensis*

3 Canines and ears generally as in S. scrofa, facial architecture as in S. celebensis; limbs and warts intermediate in condition; hybrid form . . . . . ('Sus papuensis').

LITERATURE CITED

Barrett, R.H. (1978). The feral hog on the Dye Creek Ranch California. *Hilgardia* 46: 282-355

Calaby, J.H. & Keith, K. (1974). Mammals. Pp. 179-208 *in* Frith, H.J. & Calaby, J.H. (eds) *Fauna Survey of the Port Essington District, Cobourg Peninsula, Northern Territory of Australia*. Division of Wildlife Research Technical Paper No.28. . CSIRO Publications : Canberra

Corner, L.A. & Pearson, C.W. (1976). Mycobacterial infection of feral pigs. Pp. 50-51 *CSIRO Division of Animal Health Annual Report*. Australian Goverment Publishing Service : Canberra

Day, B.N. (1962). The reproduction of swine. Pp. 255-265 *in* Hafez, E.S.E. (ed.) *Reproduction in Farm Animals*. Lea & Febiger : Philadelphia

Duncan, D.L. & Lodge, G.A. (1960). Diet in relation to reproduction and the viability of the young, Part III. Pigs. Technical Communication No. 21. Commonwealth Bureau of Animal Nutrition, Rowett Research Institute. Bucksburn : Aberdeen 106 pp.

Frechkop, S. (1955b). Sous-ordre des Suiformes. Pp. 509-567 *in* Grassé, P.-P. (ed.) *Traité de Zoologie* Tome XVII Fascicle 1. Masson et Cie : Paris

Giles, J.R. (1980). The ecology of feral pigs in western New South Wales. Unpublished PhD Thesis, Sydney, University of Sydeny 368 pp.

Gordon, H.McL., Forsyth, B.A. & Robinson, M. (1954). Sparganosis in feral pigs in New South Wales. *Australian Veterinary Journal* 30: 135-138

Groves, C.P. (1981). *Ancestors for the Pigs: Taxonomy and Phylogeny of the Genus Sus*. *Department of Prehistory, Research School of Pacific Studies, Australian National University, Canberra, Technical Bulletin* No. 3: 1-96

Hammond, J., Bowman, J.C. & Robinson, T.J. (1983). *Hammond's Farm Animals*. Arnold : London 5th edn vii 305 pp.

Henry, V.G. (1968). Fetal Development in European Wild Hogs. *Journal of Wildlife Management* 32: 966-970

Hone, J. & Waithman, J. (1979). Feral Pigs are Spreading. *Agricultural Gazette of New South Wales* 90: 2-13

Hone, J., O'Gray, J. & Pedersen, H. (1980). Decisions in the control of feral pig damage. *Agricultural Bulletin* 5: 1-21

Kruska, D. & Rohrs, M. (1974). Comparative-quantitative investigations on brains of Feral Pigs from the Galapagos Islands and of European Domestic Pigs. *Zeitschrift für Anatomie und Entwickelungsgeschichte* 144: 61-73

Kurz, J.C. & Marchinton, R.L. (1972). Radiotelemetry studies of feral hogs in South Carolina. *Journal of Wildlife Management* 36: 1240-1248

Ling, H. (1955). Metssea (*Sus scrofa*) areaalipiiri muutused Noukoguole Baltimadel viimastel sajanditel (Eastonian). *Loodusuurijate Selti Aastaraamat* 48: 176-200

Mauget, R. (1972). Observations sur la reproduction du sanglier (*Sus scrofa* L.) à l'état sauvage. *Annales de Biologie Animal, Biochemique et Biophysique* 12: 195-202

Mount, L.E. (1968). *The Climatic Physiology of the Pig*. Williams & Wilkins : Baltimore 271 pp.

Nichols, L. (1962). Ecology of the wild pig. Hawaii Division of Fish and Game P-R Project, Wildlife Service Report No. 13 20 pp.

Norton, J.H. & Thomas, A.D. (1976). *Brucella suis* in feral pigs. *Australian Veterinary Journal* 52: 293-294

Pavlov, P.M. (1980). The diet and general ecology of the feral pig (*Sus scrofa*) of Girilambone. MSc Thesis, Monash University : Clayton 117 pp.

Pavlov, P.M. & Hone, J. (1982). The behaviour of feral pigs, *Sus scrofa*, in flocks of lambing ewes. *Australian Wildlife Research* 9: 101-109

Penny, R.H.C., Edwards, M.J. & Mulley, R. (1971). The reproductive efficiency of pigs in Australia with particular reference to litter size. *Australian Veterinary Journal* 47: 194-202

Pine, D.S. & Gerdes, G.L. (1973). Wild Pigs in Monterey County, California. *California Fish and Game* 59: 126-137

Pullar, E.M. (1950). The wild (feral) pigs of Australia and their role in the spread of exotic diseases in Australia. *Australian Veterinary Journal* 52: 547-554

Rasbech, N.O. (1969). A review of the causes of reproductive failure in swine. *British Veterinary Journal* 125: 599-616

Schoefield, A.M., Clegg, F.G. & Lamming, G.E. (1974). Embryonic mortality and uterine infection in the pig. *Journal of Reproduction and Fertility* 36: 353-361

Sludskii, A.A. (1956). *Kaban: Morfologia, Ekologia, Khozyaistvennoe i Epizootologicheskoe Znachenie, Promysel*. Izdatel'svo Akademii Nauk Kazakhskoi SSR : Alma Ata 219 pp.

Springer, M.D. (1977). Ecologic and economic aspects of wild hogs in Texas. Pp. 37-59 *in* Wood, G.W. (ed.) *Research and Management of Wild Hog Populations*. Belle W. Baruch Forest Science Institute : Georgetown

Thenius, E. (1970). Zur Evolution und Verbreitungsgeschichte der Suidae (Artiodactyla, Mammalia). *Zeitschrift für Säugetierkunde* 30: 367-380

Wood, G.W. & Brenneman, R.E. (1977). Research and management of feral hogs on Hobcaw Barony. Pp. 23-36 *in* Wood, G.W. (ed.) *Research and Management of Wild Hog Populations*. Belle W. Baruch Forest Science Institute : Georgetown

Zeuner, F.E. (1963). *A History of Domesticated Animals*. Hutchinson : London 560 pp.