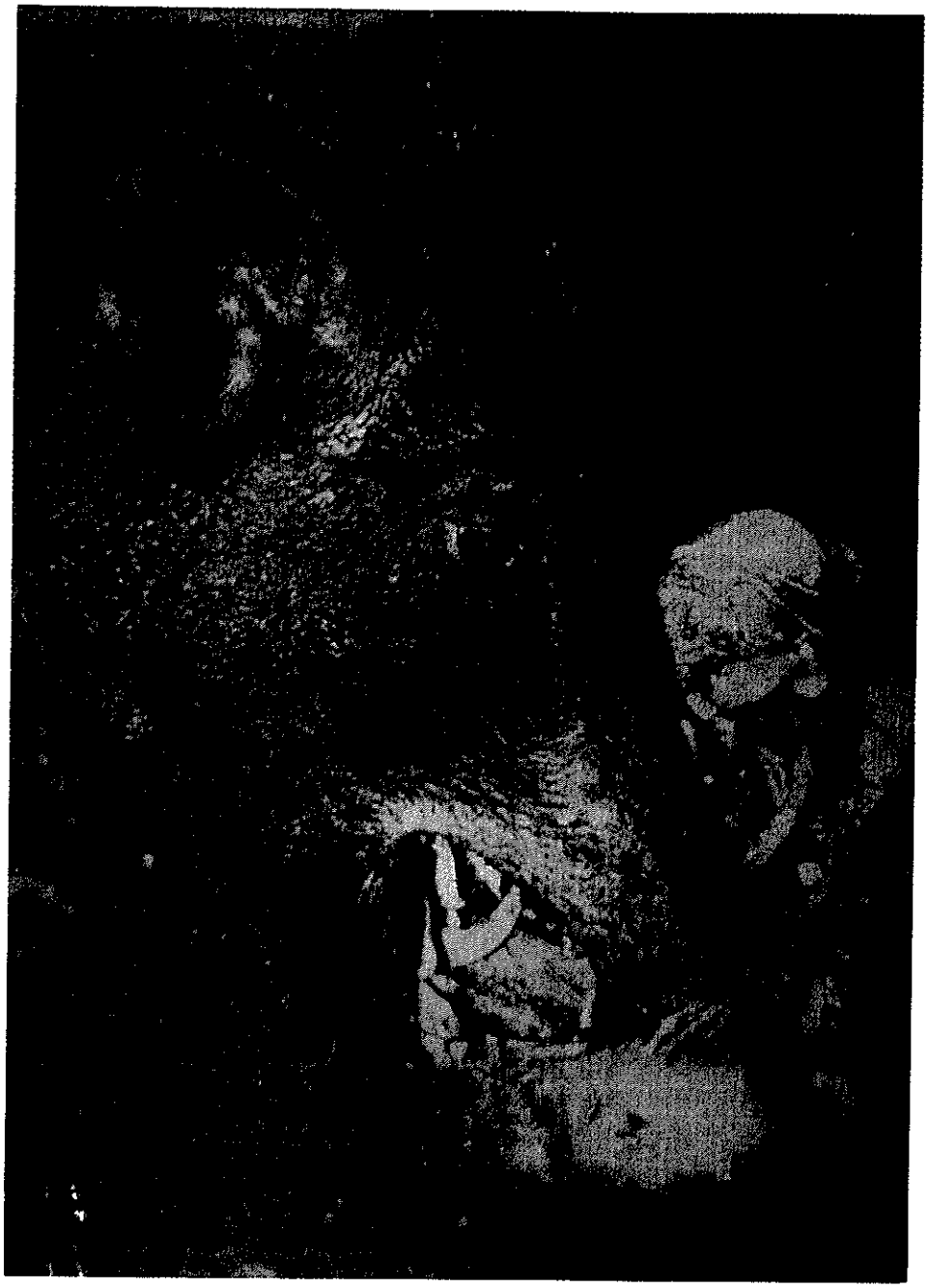
ECOLOGY OF THE WILD (FERAL) PIG (*SUS SCROFA*) ON GUAM

TECHNICAL REPORT NO. 7

JUNE 1989



BY

PAUL J. CONRY

Division of Aquatic and Wildlife Resources
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ACKNOWLEDGMENTS

Staff biologist from the Division of Aquatic & Wildlife Resources, Department of Agriculture have been studying the wild pig on Guam for over 20 years. Results of their studies provided the data for major portions of this report. In particular, the contributions of T. A. McGowan, M. H. Taylor, G. S. A. Perez, A. M. Courtright, J. J. Jeffrey, R. D. Strong, N. Drahos, M. E. Wheeler, and G. J. Wiles deserve special recognition. The many conservation officers of the Division have also contributed over the years by collecting data, helping necropsy pigs, and generally helping out whenever needed.

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INTRODUCTION

The wild (feral) pig (*Sus scrofa*) has long been an important natural resource on Guam, providing recreational hunting for island sportsmen and a popular item on the menu at local fiestas and celebrations. Despite its heavy use, the public generally has a poor opinion of the value of this resource. Local hunters perceive the animal as a second class game species in relation to the immensely popular sambar deer (*Cervus unicolor*), farmers consider the animal a pest that ruins crops, forest-conservationists consider the animal an undesirable alien impeding forest regeneration, and the urban dweller, untrained in the ways of the wild, typically considers the animal a fearsome, dangerous beast of the jungle. Some of these perceptions have merit while others do not.

From a recreational hunting perspective, the wild pig is the most important game species on the island, its exploitable resource value in terms of total days of recreation provided, hunter success, and quantity of meat harvested greatly exceeds that of any other game animal (Wheeler 1979, DAWR 1986). Offsetting this positive recreational value are the detrimental impacts that wild pigs can have. Although not extensively documented on Guam, crop damage reports and field observations indicate that pigs can cause a considerable amount of damage to agricultural and native forest resources. In contrast to its high resource value and potential for ecological damage, the wild pig has received little attention and emphasis in the game management program over the years. This report is intended to summarize what is known about the wild pig on Guam and provide a data base from which to develop an effective game management program.

The Division of Aquatic and Wildlife Resources has conducted investigations into the ecology and management of wild pigs as part of the national Federal Aid to Fish and Wildlife Restoration Program since 1967. Most data collected during that time period were obtained incidentally while working on other species. The results were briefly reported in annual reports of the Division. There have been notable exceptions to that generalization. Staff biologists conducted one study during the late 1960s to determine the feasibility of night spotlight counts to survey pigs and deer. During 1972-1975, staff biologist N. Drahos conducted an intensive study of the reproductive biology of a captive wild pig herd that was summarized in a draft technical report which due to unforeseen circumstances was not completed. More recently, the author has conducted more intensive investigations into the food habits, disease, and reproductive biology of wild free-ranging populations in northern Guam. This report combines much of the early work of Division biologists with the more recent field work and observations of the author.

STUDY AREA

The United States Territory of Guam, located at 13° 13' N and 145° 00' E in the west-central Pacific, is the largest and southernmost island in the Mariana chain (Fig. 1). The island is 550 km^2 in size, being 45 km long and 6-13 km wide. Elevations range from sea level to 406 m along the southern mountain ridgeline. Cocos Island, a 20-ha fringe atoll islet, is located 2 km off the southern tip.

The southern half of Guam is composed of rolling hills of volcanic material with a mountainous ridgeline down the southwestern side. Rivers run off this ridgeline to the east, south and west forming verdant stream valleys. A few of these rivers have been dammed to make freshwater reservoirs, the largest of which is the 78-ha Fena Reservoir in south-central Guam. The largest natural body of water is the 71-ha Agana Swamp in central Guam. Upland soils in southern Guam are of two main types; a deep, red, acidic clay and a shallow, dark, slightly acidic clay (Young 1988). Limestone caps occur on many of the southern peaks. Most urban development is concentrated in a band along the

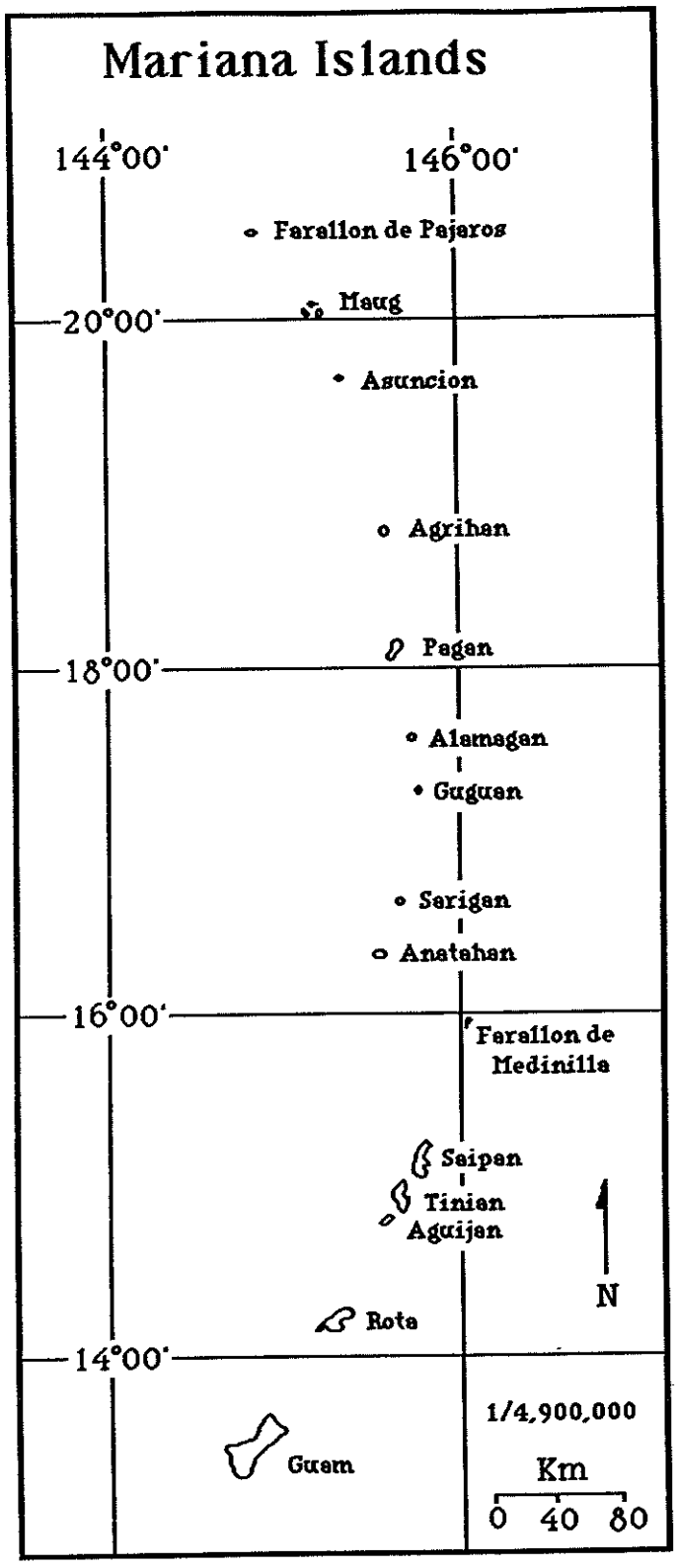


Figure 1. Map of the Mariana Islands.

villages. The vast interior of the southern portion of the island is rural and sparsely populated. Small farms and ranches are sometimes inhabited in agricultural areas and agricultural development occurs on arable lands. Wildland fire is an annual and serious problem, causing soil erosion and destruction of large tracts of grassland and forest vegetation.

The northern half of the island is an extensive limestone plateau with three small, protruding volcanic hills. Soil on the limestone plateau is typically a very shallow cobbly-clay-loam that is neutral to mildly alkaline (Young 1988). Large tracts of forest have been converted to urban habitat such as air fields, roads, buildings, residential areas, and maintained lawns (particularly on military bases) and small farms and ranches are scattered throughout the central plateau. Agricultural development occurs in suitable areas.

Habitat types and vegetation are described in detail by Fosberg (1960) and Stone (1970). Photographs of representative habitats used by wild pigs are presented in Figure 2. The major vegetation types in southern Guam are ravine forest, savanna, limestone forest and wetlands. Ravine forest occurs on volcanic soils in valleys and ravines and has a low irregular canopy 5-10 m high. These forests have a varying character but are generally dense, brushy and tangled. Common species include *Hibiscus, Pandanus, Ficus, Glochidion, Areca, Freycinetia, Premna, Calophyllum, Triphasia, Cycas, Cocos,* and *Scleria.* Savanna habitat is a mosaic of grass, small shrubs, ferns, weeds, and scattered trees and grows on volcanic soils with low soil moisture. Swordgrass (*M. floridulus*) often dominates this plant community. Other common species include *Pennisetum, Casuarina, Dimeria, Phragmites, Gleichenia, Scaevola, Chrysopogon, Blechnum, Hyptis,* and *Stachytarpheta.*

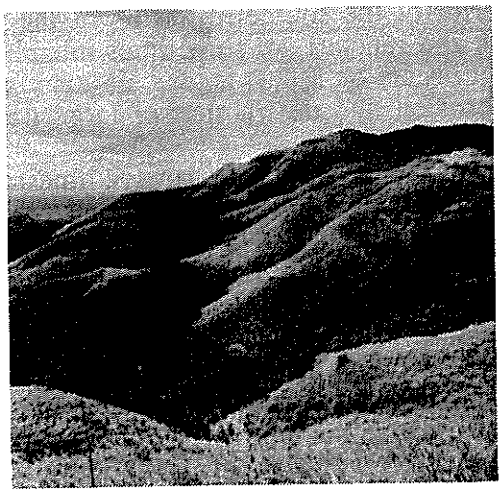
Stone (1970) described vegetation in northern Guam as "typhoon forest" with an intermix of mature limestone forest, secondary limestone forest, groves of *Leucaena leucocephala,* and other weed-shrub communities. Primary limestone forest has a dense canopy 10-15 m high and an understory of varying density. Common species include *Ficus, Aglaia, Guamia, Cycas, Neisosperma, Macaranga, Premna, Elaeocarpus, Pisonia, Pandanus* and *Triphasia.* Secondary limestone forest has a shorter, broken canopy with a dense understory and contains many of the same species as primary forest plus *Hibiscus, Wikstroemia, Leucaena, Casuarina, Cocos, Carica,* and *Morinda.* Scrub forest has a species composition similar to secondary forest but is shorter and more open with small grassy patches of *Pennisetum* interspersed with scattered trees and shrubs.

A recent habitat mapping study reported in Null (1983) identified the following habitat coverage for the island: range land (grass, shrub and savanna habitats), 22,000 ha (40%); forest, 20,670 ha (37.6%); urban, 11,280 ha (20.5%); crop, 577 ha (1.1%); pasture, 300 ha (0.5%); and water, 79 ha (0.1%).

Located south of the Tropic of Cancer, Guam's climate is tropical in nature with a strong oceanic influence. Two distinct seasons interchange, a dry season from January to April in which 15% of the annual precipitation falls and a wet season from July to November which receives 55% of the annual rainfall (NOAA 1983). The months of May, June and December are considered transitional periods. September is the wettest month of the year and receives an average of 362 mm of rain. April is the driest month and has an average of 105 mm of rain. Temperature and humidity remain uniformly warm and humid throughout the year. Daily temperatures range from the mid seventies to low nineties with historic extreme temperatures of 54° F (12.2° C) and 96° F (35.5° C) (NOAA 1983). Humidity commonly exceeds 85% at night throughout the year (NOAA 1983).

Guam lies in the northern typhoon belt and can experience high winds (>118 km/hr) and heavy rains associated with these tropical disturbances (Weir 1983). The typhoon season generally coincides with the wet season, July to November, but typhoons have passed close to Guam in every month. Severe typhoons occur every 15 to 20 years and extraordinarily severe storms with winds up to 370 km/hr occur about once every hundred years. Stone (1970) considers these storms a major formative cause of Guam's vegetational aspect.

A



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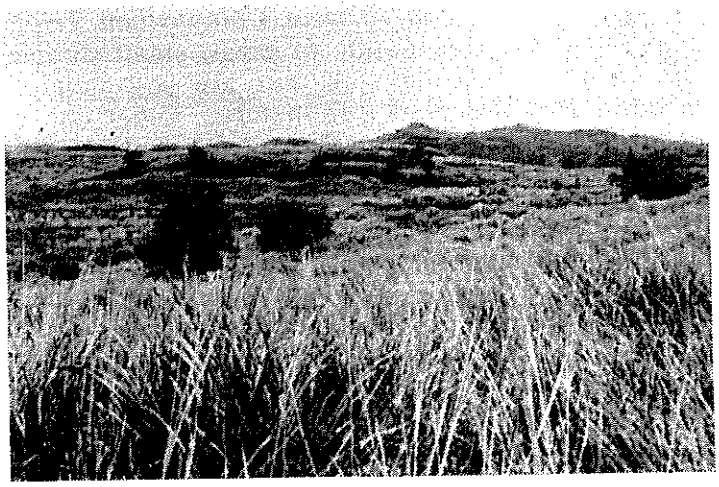

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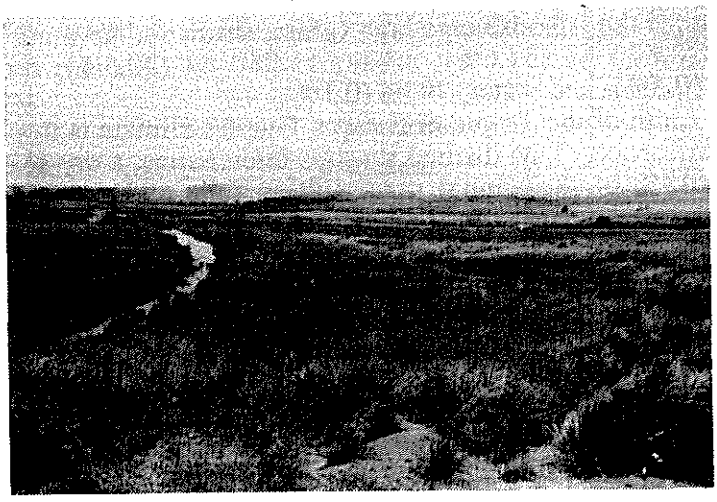

Figure 2. Representative photographs of various habitat types used by feral pigs on Guam: (A) ravine forest near Merizo, (B) savanna at Pulantat, (C) mixed agricultural-savanna at Dandan, (D) primary limestone forest near Ritidian Point, and secondary limestone forest at (E) Northwest Field and (F) Conventional Weapons Area, Andersen Air Force Base.

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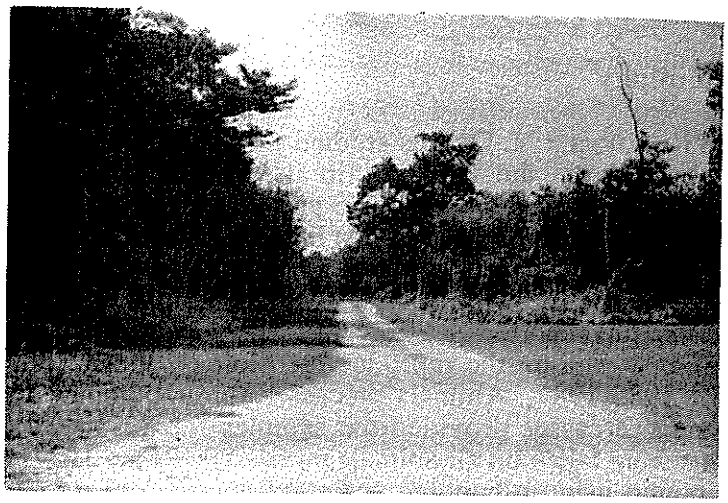


Figure 2. (Continued).

METHODS

Roadside Counts

Roadside counts to survey the relative abundance of game birds, deer and pigs were conducted in the Conventional Weapons Area (CWA) on Andersen Air Force Base (AAFB) during 1983-1987. Surveys were made twice per month. Observers recorded the number of pigs seen while driving at 25 km/hr along an established 32-km long route through the area. All pigs were classified by group size and age (juvenile or adult).

During 1968-1971, a nightly spotlight count was established at the Federal Aviation Agency (FAA) housing area at Finegayan. FAA security personnel drove the compound perimeter and conducted hourly security checks between the hours 1800 to 0600. Under the training and supervision of DAWR staff, security people counted pigs and deer with a spotlight along the forest edge during their hourly rounds. Data are reported here as the average number of pigs seen per night during the months surveyed. A map of Guam showing study locations mentioned in the text is provided as Figure 3.

Relative Abundance of Pig Sign in Selected Habitats

Three areas with different habitats were surveyed in 1988 for relative abundance of pig sign using a line transect method developed by Barrett and Stone (1983) for the tropics. The areas and habitats studied included secondary forest at Northwest Field, savanna at the Cotal Conservation Reserve on Cross Island Road, and a mixed agricultural-savanna zone at Dandan. Transects ran across the width of a study area and were followed using a set compass bearing and a 30-m tape. Transects varied in number and length depending on the size of each study area and were arranged systematically at 500-m intervals with a random starting point. Northwest Field had nine transects that ranged from 450-2,030 m long and totalled 11,670 m. Six transects were placed at the Cotal Conservation Reserve and varied from 500-1,320 m in length for a total of 4,750 m. Dandan had three transects that totalled 1,470 m and varied from 210-810 m. The presence and age (fresh or old) of rooting, trails, scats, and wallows, and sightings of pigs were noted on consecutive 10 x 2-m plots along the centerline of the transect. Transects were run by the same two observers and required up to six hours per 1,000 m of distance covered in forest and 3-4 hours per 1,000 m of distance covered in savanna or agricultural land. Results are reported as frequency of occurrence of each type of sign per area and calculated as the percent of plots containing various types of sign. The category "any" refers to a plot that contains one or more of any type of sign.

Breeding Biology

DAWR biologist N. Drahos studied the reproductive biology of feral pigs using progeny obtained from the wild. Animals were kept in pens at the Department of Agriculture and maintained on a 12-17% protein diet of commercial pig feed. Data were recorded on age at first estrus, age at first breeding, breeding attempts prior to conception, length of conception, litter size, and lactation. Results of that study were summarized in an unpublished report on file with DAWR. Major findings of that Drahos' study have been incorporated into this report.

Additional data on the reproductive biology of wild pigs were obtained by the author during 1983-1987. Animals processed through hunter check stations, road-kills, and confiscated carcasses provided the samples for this study. Standard weights and measurements were taken on all animals processed (Riney 1982). Weights were taken to the nearest pound using a hanging scale and measurements were taken to the nearest millimeter. Female reproductive tracts were removed in the field and preserved in 10% formalin for further study. In analyzing reproductive condition, pregnancy was determined

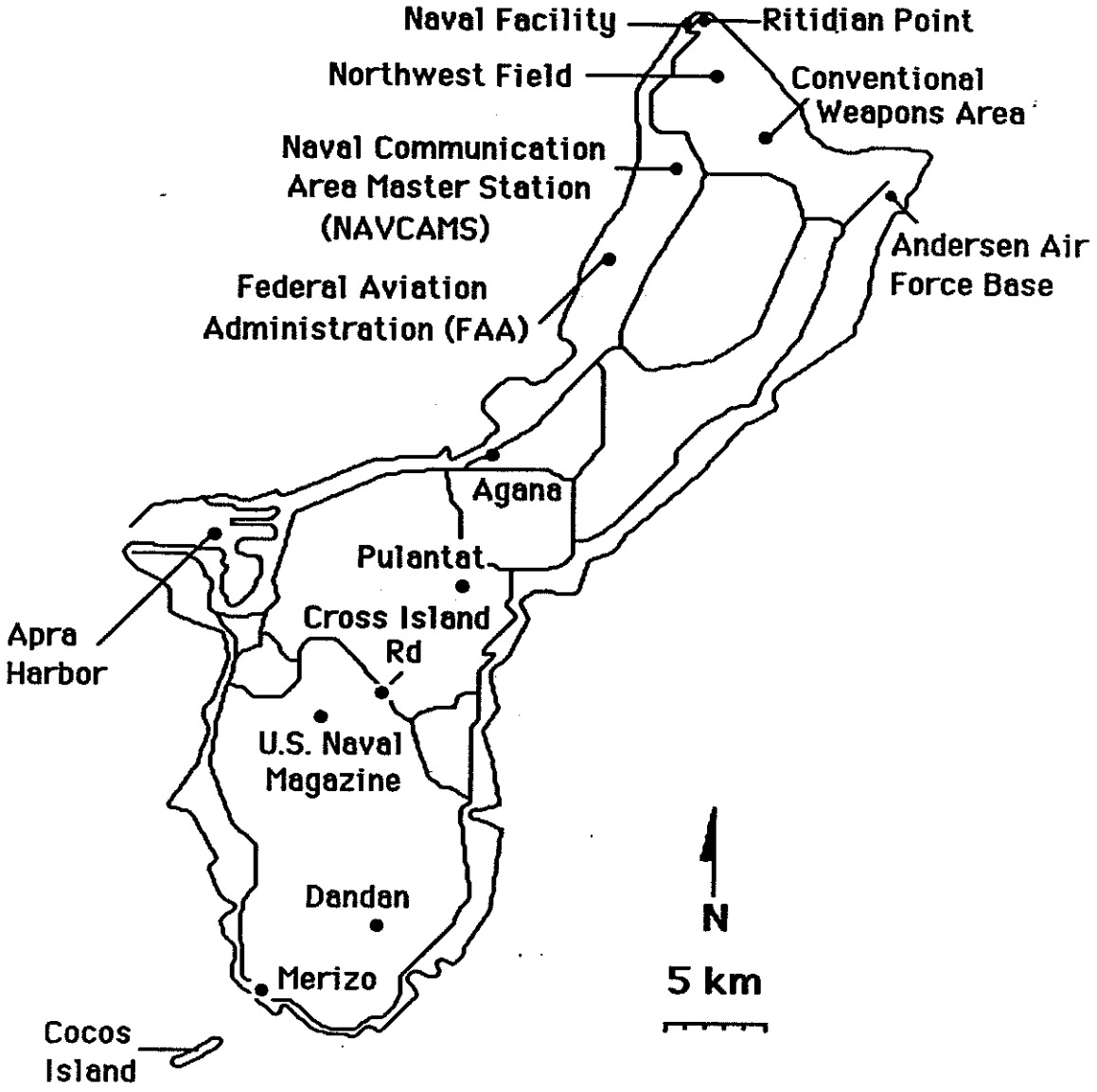


Figure 3. Map of Guam showing study locations.

by the presence of corpra lutea or fetuses. Both left and right ovaries were examined and their respective corpra lutea counted and measured (Corner 1915, 1921). Fetuses were counted, measured, weighed, sexed, and categorized as to their position in the uterus (Warwick 1928, Henry 1968a). These data were compiled and summarized as ovarian and fetal pregnancy rates. Puberty was determined by ovarian analysis. Ovaries were examined macroscopically with a dissecting microscope and Graafian follicles, corpora lutea, and corpora albicantia were counted and measured. The presence of enlarged Graafian follicles (greater than 4.0 mm) in both ovaries was interpreted as evidence of puberty. The presence of corpora albicantia or corpora lutea was interpreted as evidence of a prior successful conception (Corner 1915).

Breeding and farrowing seasonality were determined from conception and birth dates of wild and captive litters using a gestation period of 115 days (Henry 1968b, Swenson 1970). Breeding and farrowing dates of mid-term pregnancies were calculated from the average age of all fetuses in a litter and based on a 115 day gestation period (Warwick 1928). Fetal age was estimated from the relationship of crown-rump length and age determined by Warwick (1928) for domestic pigs.

Age Classification

Drahos studied tooth eruption and replacement in 106 captive-born piglets during his captive-rearing project. Teeth were checked weekly for one month in new litters and on a monthly basis for older animals. Study animals were sacrificed at certain ages to compile a reference collection of known-aged skulls. Unfortunately, additional details on methods such as the number of animals examined for each age class were not reported in his results.

Food Habits

Stomach contents obtained from 22 animals killed by hunters at Northwest Field provided data on wild pig food habits. Whole stomachs were collected and stored in 10% formalin prior to laboratory analysis. Two different processes were used to analyze stomach contents. The preferred process was a wet segregation method (Henry and Conley 1972). This method involved washing, mixing the total sample, and selecting and analyzing a 200-ml subsample. Material from each sample was segregated into animal categories of vertebrate or invertebrate; or plant categories of fruit, leaf, grass, bark or root and weighed to the nearest centigram. The plant categories of leaf, grass, bark and root were lumped into a browse category.

Ten samples were processed using a dry method (Wood and Roark 1980). This method involved oven-drying the total sample and selecting and analyzing a 10-gm subsample. Material from each sample was placed in a large pan, segregated by the categories listed above, and weighed to the nearest centigram. Stomach material was further identified to species when possible in both the wet and dry analyses. Data were summarized by frequency of occurrence and weight (dry or wet weight).

Harvest

Harvest statistics were derived from harvest questionnaires distributed annually to island hunters. Prior to 1984, hunter report cards were distributed with each license and turned in at the end of the season. Starting in 1984, a direct-mail questionnaire was used to sample hunter habits and harvest. Hunters were asked to report the number of pigs taken and the amount of effort expended in each locality hunted. Further information on hunting activity was obtained from hunter check stations run by DAWR staff or from mandatory hunter logs maintained at military bases and monitored by military personnel. Estimates of harvest density and biomass were derived from reported harvests on military bases. The sizes of hunting areas were measured with a polar planimeter.

HISTORICAL BACKGROUND

The exact date and circumstance under which pigs were introduced to Guam are unknown. Based on the chronicals of the early explorers, it is fairly certain that pigs were not on Guam prior to the European period of exploration. The first European contact with the Marianas occurred in 1521 with Magellan's voyage. Pigafetta chronicled the events of that visit and made no mention of the presence of ungulates at first contact (Intoh 1986). [Note: Burney's 1803 translation of Pigafetta's journal reports that Magellan procured hogs from Guam but this account is doubtful]. The Loaysa expedition visited Guam from September 4-10, 1526 to take on water and likewise reported no quadrupeds (Safford 1901, Intoh 1986). In 1668, the first Spanish missionaries arrived on Guam and brought with them the first sheep and cattle. They reported that dogs, cats and chickens had already been introduced via a shipwreck in 1638 but made no mention of swine.

Pigs were most likely introduced to Guam and the Marianas between 1672 and 1685 by early Spanish colonizers (Intoh 1986). The first stock probably came from domestic stock in the Philippines and were intended for husbandry purposes. The warfare that broke out between the Chamorros and Spaniards between 1672-1695 saw an increase in the Spanish military on Guam and the supplies that were brought in from the Philippines likely included the pig. The first record of pigs occurring on the island comes from 1685, at which time the Spanish Governor of Guam presented 30 pigs to a visiting English ship for assistance in fighting the Chamorros (Burney 1803, cited in Safford 1905 and Intoh 1986). A considerable number of animals must have already been present on the island by that time to allow such a generous gift.

In the following years both friendly and unfriendly ships were reprovisioned with large numbers of pigs (Safford 1905, Intoh 1986). Safford (1905) reported that the Spanish Governor supplied 60 hogs and other supplies to the English pirate Woodes Rogers in 1710 under the threat of bloodshed. Woodes Rogers described the pigs as "the best pork in the world, because they are fed altogether on coconuts and breadfruit, which are plentiful here." By the time of Crozet's visit in 1772, domestic pigs and other stock had apparently escaped or been released and established large feral populations (Roth 1891). Crozet reported that "the forests are also full of goats, pigs, and poultry, of which the first stock was brought over by the Spaniard. All these animals have run wild, and can only be obtained by shooting or running them down, or by lassoing. Their flesh is excellent" (Roth 1891).

This early feral population was apparently hearty and well established. Haswell (1917) hunted pigs during his visit to the island in 1801 and described the population as "very numerous, but very thin...the largest that I saw did not weigh 100 pounds." He thought that the population was so prolific that it was not susceptible to continuous hunting pressure by the Chamorros, who had been able to decimate the feral goat population. Some form of hunting regulations existed at that time because Haswell reported that deer had been protected from hunting for the three years preceding his arrival. Pigs were evidently abundant enough to hunt at all times. This free-handed approach to pig hunting ended soon after Haswell's visit. In 1828, D'Urville (Safford 1901) reported that deer were plentiful but that cattle, pigs and goats could be hunted only with the permission of the Governor. It is unclear if this prohibition was motivated by a biological need to protect declining populations of free-ranging animals or if it was initiated to prevent rustling of animals the Governor considered his domestic stock.

Pigs remained abundant and were apparently well distributed throughout the island during the 1800s. Soon after the start of the American period in 1898, Safford (1905) referred to the existence of both a healthy feral and captive population. He reported that "wild hogs roam the forests in the northern part of the island. They live on fallen wild breadfruit and various roots. Hogs kept on ranches and fed on coconuts, breadfruit, and

other vegetable substances are prized for food."

TAXONOMY AND PHYSICAL DESCRIPTION

Nomenclature

Most authorities (Barrett 1978, Groves 1981, Cassels 1983, Oliver 1984, Intoh 1986) believe that the domestic or semi-domestic swine spread throughout the world by early European traders and settlers is of the *Sus scrofa* species. The wild pig introduced to Guam is no exception and is considered to be a feral population of domestic swine.

Groves (1981) studied skull characteristics of the genus *Sus* and found that the shape of the mandibular canine (tusk) in the adult male was an excellent discriminator for a number of species. He reported that the inferior surface of the tusk in *S. scrofa* is narrow in relation to the posterior surface. Inferior widths fall within a 61.5-109.1% range of the posterior width. Another species that he looked at was the Philippine bearded pig (*S. barbatus philippensis*), which could have been a source of the domestic pigs brought to Guam. In the bearded pig, the inferior width of the tusks is broader than the posterior width. Inferior widths fall within the range of 105.6-177.8% (Groves 1981). The shape of tusks in *Sus* specimens from Guam meet the criterion for *S. scrofa* as described by Groves. Tusks from three skulls in the DAWR collection have inferior widths from 68.4% to 91.3% of posterior widths. To my knowledge, no study specimens from Guam have been identified to the subspecies level.

Most local inhabitants use the term "wild pig" when referring to the free-ranging pigs that inhabit the island. The Chamorro name for wild pigs is "Babui'n Halomtano", which is literally translated as "pig of the jungle". Because wild pigs on Guam are descendants of domestic stock that escaped captivity or were deliberately released, they are technically feral animals. The term "feral" generally refers to animals that were once domesticated, or descended from domesticated stock, that now live as free-ranging and free-breeding populations without care or protection from humans (Barrett 1978, Munton et al. 1984). Such pig populations have been variously termed as feral pigs (Giffin 1978) or feral hogs (Barrett 1978). In this report, "feral "or "wild" are used interchangeably to describe the wild, free-ranging populations of pigs on the island. "Domestic" refers to domestic stock under the control of man, and "wild boar" is used to refer to native races of *S. scrofa* that have no history of domestication.

Description

Feral pigs on Guam display characteristics of the Eurasian wild boar and the common domestic swine. Black is the dominant color but other colors and color combinations also occur. Of 204 wild pigs classified by color at hunter check stations, 76% were entirely black, 8% were black with white spots, 4% were brown, 3% were brown with black spots, 2% were white, 2% were red, 2% were black with brown spots, and 1% were white with black spots. In Hawaii, Giffin (1978) found all-black and mixed-colored pigs in that feral population. Mixed-colored pigs were more common in lowland forests where mixing with escaped domestic stock occurred.

The wild pig on Guam has a long sloping snout, a high head crest and upright ears. The hide is covered by course hair with elongated but sparse guard hairs. Hair along the midline of the back and neck can be raised at will. The hide is thick, particularly on the neck and shoulders of adult males. The body shape is long and narrow, the shoulders are higher than the hips, and the chest is deep. Pigs have short legs and four hoofed toes on each foot. The central pair of toes are larger and carry the weight of the animal. The lateral toes, which are known as dew claws, are small and may only leave indentations when the animal is walking in soft mud. The tail is straight with a small tassel of hair at the end. In

a captive-breeding study on Guam, most (67%) of the 85 piglets born were all black, but a few (11.8%) retained the light and dark longitudinal stripes typical of the wild ancestral *S. scrofa*.

Weights and measurements of 62 wild pigs from Northwest Field are categorized by sex and age in Table 1. Weights of adult (≥12 months) males varied from 23-55 kg and total body lengths varied from 117-165 cm. Weights of adult sows varied from 23-42 kg and lengths varied from 112-146 cm.

Pigs of much larger sizes have been reported from Guam. The largest animal processed through the hunter check station at Northwest Field between 1983 and 1987 was a male that weighed 73 kg. Division annual reports spanning the period of 1968-1987 contain a substantiated report of a 139-kg male (DAWR 1971) and an unsubstantiated hunter report of a 159-kg male (DAWR 1970).

Feral pigs in other locations appear to attain larger sizes than those on Guam. Weights reported in various studies range from 41-170 kg (Barrett 1978, Giffin 1978, Sweeney and Sweeney 1982), with average weights being as high as 108 kg (Sweeney and Sweeney 1982). Native populations of wild boar also tend to reach much larger sizes than feral pigs on Guam. Weights of adult wild boar vary from 54 to 230 kg (Lekagul and McNeely 1977, Groves 1981). It is evident from the above statistics that the size and weight of feral hogs are highly variable depending upon the genetic history of the population and the local environment in which the population exists. Nowak and Paradiso (1983) report that under domestic care, pigs can reach weights of 450 kg.

Enlarged tusks or canine teeth are found in upper and lower jaws in both sexes. Tusk development is a sexually dimorphic characteristic attaining a large size in males. The apical foramen remains open at the end in males and the tusk grows continuously throughout the life of the animal (Diong 1973). In females, the apical foramen closes at about 2.5 years of age and tusk growth ceases (Diong 1973). Lower tusks in males grow upward and flair outward and backward and are aligned in front of the upper tusks. Friction between the upper and lower tusks produces a sharp edge on the lower tusks which is useful in feeding and fighting. As elsewhere, the elongated tusk of the boar is a highly prized trophy among island sportsmen.

Barrett (1978) measured tusk growth in feral pigs in California and found that lower tusks grew 5.6 mm per month in adult boars but that approximately 4.0 mm was lost by abrasion with the upper tusk. He concluded that tusk length increased 1.5 mm per month in adult boars and that it took three years to produce a trophy class boar with 5 cm tusks.

The largest tusk in the sample of 33 males examined at Northwest Field during 1983-1987 measured 9.0 cm from gum line to tip along the outer curve of the tooth (Table 2). Length of the lower tusks in adult females averaged 1.5 cm and did not exceed 2.4 cm (Table 2). Tusks length was not directly related to age. Many old animals had broken tusks and others had atypical wear patterns that resulted in shortened tusks. Tusks from a particularly large specimen in the DAWR skull collection measured 9.2 cm along the outer curve from gum line to tip (A photograph of the skull is presented in Appendix I). The whole extracted tusk from the animal measured 20.8 cm and weighed 40.4 gm.

Age Determination

Drahos studied the tooth eruption schedule of 106 pen-raised wild pigs from Guam and his results are presented in Table 3. The basic dental formula for wild pigs is: deciduous (milk) teeth, i-3/3, c-1/1, p-3/3 (nos. 2-4) = 28; and permanent teeth, I-3/3, C-1/1, P-4/4 (upper P1 may be missing), M-3/3 = 44. Drahos reported that the last deciduous teeth to erupt are the second premolars at about 3 months and the upper second incisor at 4 months. [Note: Giffin (1978) reported all deciduous teeth have erupted by 3 months of age]. The permanent canine, fourth premolar and the molars in the lower jaw are useful teeth with which to age animals. With the exception of the third molar, these

Table 1. Average and extreme weights (kg) and measurements (cm) of wild pigs on Guam by sex and age.

Age Group (months)	N	Weight	Total length	Tail	Hind foot	Hoof	Ear	Shoulder height	Girth	Neck
Females										
Juvenile (4-6)	2	11.4 (6.8-15.9)	90.0 (83-97)	15.9 (14.5-17.3)	16.5 (14.7-18.2)	6.1 (5.6-6.6)	7.5 (7.0-8.0)	43.0 (39-47)	52.0 (49-55)	37.8 (33-42.5)
Sub-adult (7-12)	8	16.6 (11.4-23.2)	100.4 (94-112)	16.9 (9.0-20.1)	17.2 (8.0-19.9)	6.9 (6.0-7.7)	8.6 (7.7-10.0)	48.7 (40-55)	56.8 (49-67.5)	41.5 (36-48)
Adult (13-24)	8	27.7 (22.7-37.3)	123.3 (112-134)	21.5 (18.0-24.0)	21.6 (20.0-24.0)	8.3 (7.2-9.3)	9.5 (8.7-10.1)	57.9 (52.5-63)	71.9 (64-77)	52.0 (45-58.5)
Adult (25-36)	5	34.7 (29.5-41.8)	139.3 (133-146)	24.3 (22.0-26.0)	23.7 (23.0-24.5)	9.0 (8.3-9.5)	11.0 (10.2-11.6)	64.3 (60.5-68)	73.9 (70-81)	54.8 (50-59)
Unaged sub-adult	2	15.9 (13.6-18.2)	102.5 (101-104)	16.3 (16.0-16.5)	19.6 (18.8-20.3)	4.5 (4.4-4.5)	8.7 (8.5-8.8)	46.2 (45-47.3)	53.6 (51.2-56)	46.1 (43.5-48.6)
Unaged adult	4	31.3 (25.0-36.4)	127.8 (118-138)	23.8 (20.0-28.0)	22.6 (22.0-23.3)	8.7 (8.4-9.2)	10.4 (9.5-11.0)	57.8 (51-62)	71.3 (66-76)	53.9 (49-63.5)
Aged adults	13	30.4 (22.7-41.8)	129.4 (112-146)	22.5 (18.0-26.0)	22.4 (20.0-24.5)	8.6 (7.2-9.5)	10.1 (8.7-11.6)	60.4 (52.5-68)	72.7 (64-81)	53.1 (45-59)
Males										
Juvenile (4-6)	1	7.7	77.0	11.5	14.6	5.4	6.0	37.0	40.5	29.0
Sub-adult (7-12)	6	17.1 (13.6-25.0)	103.0 (95.6-113)	18.1 (16.6-19.6)	18.8 (17.3-22)	7.2 (5.7-10)	8.7 (7.5-10)	47.5 (44-55)	56.1 (53-64)	42.3 (37-55)
Adult (13-24)	11	36.4 (22.7-50.0)	134.0 (117-148)	22.4 (19-27.2)	22.6 (21-24.6)	8.6 (7.6-9.6)	10.5 (9-12)	64.1 (56-75)	76.4 (63-86)	58.0 (48-68.5)
Adult (25-36)	10	40.9 (29.5-54.5)	139.7 (120-165)	21.8 (10-27)	23.1 (20-25.5)	9.2 (8.0-11.0)	10.8 (8.5-12.5)	64.6 (57-75.5)	78.1 (66-89)	66.3 (52-85.4)
Adult (37-48)	1	50.0	154.5	23.0	24.0	9.5	11.0	72.0	88.0	65.0
Unaged adult	4	34.3 (25.5-38.6)	128.3 (116-135)	20.7 (19.1-23)	22.7 (21.3-24)	7.9 (5.4-10)	11.5 (9.9-14)	62.5 (56-67)	76.1 (69-81.5)	60.5 (52-69)
Aged adult	22	39.1 (22.7-54.5)	137.5 (117-165)	22.1 (10-27.2)	22.9 (20-25.5)	8.9 (7.6-11)	10.7 (8.5-12.5)	64.7 (56-75.5)	77.7 (63-89)	62.1 (48-85.4)

Table 2. Average and extreme measurements (cm) of tusks by sex and age from wild pigs on Guam. Measurements are from animals inspected in the field and were taken from the gum line to the tip along the outer curve of the tooth.

Age Group (months)	N	Upper Left	Upper Right	Lower Left	Lower Right
Females					
Juvenile (4-6)	2	0.4 (0.4-0.4)	0.4 (0.4-0.4)	0.5 (0.4-0.6)	0.5 (0.4-0.5)
Sub-adult (7-12)	8	0.5 (0.3-1.2)	0.6 (0.3-1.4)	0.7 (0.4-1.8)	0.7 (0.4-1.7)
Adult (13-24)	8	1.1 (0.1-1.5)	1.1 (0.1-1.8)	1.5 (0.3-2.4)	1.3 (0.3-2.0)
Adult (25-36)	5	1.4 (0.8-2.0)	1.4 (1.3-1.6)	1.8 (1.5-2.3)	1.7 (1.5-2.0)
Unaged adult	4	1.0 (0.3-1.6)	1.1 (0.4-1.5)	1.1 (0.3-1.8)	1.0 (0.5-1.5)
Aged adult	13	1.2 (0.1-2.0)	1.2 (0.1-1.8)	1.6 (0.3-2.4)	1.5 (0.3-2.0)
Males					
Juvenile (4-6)	1	0.3	0.3	0.4	0.6
Sub-adult (7-12)	6	0.4 (0.3-1.0)	0.4 (0.2-1.0)	0.2 (0.0-0.3)	0.4 (0.3-0.4)
Adult (13-24)	11	2.5 (0.4-5.3)	2.3 (0.5-4.6)	3.3 (1.1-5.7)	3.1 (0.9-6.0)
Adult (25-36)	10	2.5 (0.3-5.1)	2.5 (0.5-5.9)	3.1 (0.5-6.4)	3.6 (1.0-9.0)
Adult (37-48)	1	1.2	1.1	3.5	3.3
Unaged adult	4	1.3 (0.8-2.2)	1.3 (0.8-2.1)	2.0 (1.4-2.5)	2.0 (1.2-2.7)
Aged adults	22	2.4 (0.3-5.3)	2.3 (0.5-5.9)	3.2 (0.5-6.4)	3.3 (0.9-9.0)

Table 3. Average tooth eruption sequence for Guam wild pigs based on 106 pen-raised pigs.

	Temporary teeth age at eruption	Permanent teeth age at eruption
Upper Jaw		
Incisor one	14+ days	15 months
Incisor two	120 days	19-21 months
Incisor three	before birth	9-10 months
Canine	before birth	10 months
Premolar one	not present	6-8 months (missing on some)
Premolar two	3 months	16-16.5 months
Premolar three	14-21 days	14.5 months
Premolar four	27-49 days	14.5 months
Molar one	not present	5-6 months
Molar two	not present	12-14 months
Molar three	not present	24-25 months, fully erupted at 27
Lower Jaw		
Incisor one	10-14 days	14.5 months
Incisor two	82 days	19-21 months
Incisor three	before birth	9-10 months
Canine	before birth	10 months
Premolar one	not present	8-10 months
Premolar two	105 days	16-16.5 months
Premolar three	27-40 days	15 months
Premolar four	27 days	15 months
Molar one	not present	5-6 months
Molar two	not present	11-12 months
Molar three	not present	26-28 months, fully erupted at 28-30

Table 4. Criteria for estimating age of feral hogs over 26 months of age based on eruption pattern and wear of the third molars (Source Barrett 1978:289).

Third Molar	Age (months)
Present, but less than 75% erupted	26-30
75-90% erupted	30-36
100% erupted	36+
Cusps 25-50% worn	48+
Cusps 60-90% worn	60+
Cusps completely worn (first molars often lost)	72+

erupt at about 3-month intervals and are readily visible without cutting through the cheek to expose the jaw. Photographs of an adult skull and lower jaws showing dentition at various age classes are compiled in Appendix I.

The first permanent tooth to erupt is the first molar at 5-6 months. The permanent canines or tusks erupt at 10 months and the second molars erupt at about 12 months. The presence of permanent tusks is a useful trait with which to identify adult age classes because most animals are sexually mature by the time this tooth erupts. The fourth premolar is also a useful tooth for aging animals in the field because it has different shapes in its deciduous and permanent stages. As a milk tooth it is bunodont and molar-like with 6 cusps in two lateral rows. The permanent tooth which erupts at about 15 months is blade-shaped with a single lateral row of cusps and much thinner than the first molar beside it. The final key tooth for aging purposes is the third molar which begins to erupt at about two year of age and is fully erupted at 30 months. It is usually necessary to cut the cheek to examine this tooth.

Beyond 30 months, age must be estimated based on wear or tusk length. Barrett (1978) provides guidelines for aging feral hogs over 26 months of age based on eruption and wear of the third molar (Table 4). The tooth eruption sequence outlined above agrees fairly closely with that of Giffin (1987) for feral pigs and Matschke (1967) for wild boar.

REPRODUCTIVE BIOLOGY

Puberty and Estrus

Captive males. Young males in Drahos' captive herd showed signs of reaching sexual maturity at about 6-7 months of age. The youngest age at which a maturing male attempted to mate was 6 months and 20 days. The age at which maturing males were successful in impregnating females ranged from 7.8 to 11.1 months and averaged 8.3 months. Weights of captive males at 6 months (just prior to sexual maturity) averaged 17.5 kg and varied from 13.6 to 21.8 kg.

Free-ranging males. No data were collected on spermatozoa production in wild males.

The age at which young males attain sexual maturity on Guam is similar to the 6-7 month range reported elsewhere (Dukes 1947, Swenson 1970, Barrett 1978, Giffin 1978). Some animals may reach sexual maturity at an earlier age. Giffin (1978) reported one young male successfully bred at 4.5 months of age. However, it is doubtful that 6-7 month old males would actually breed in the wild because of their subordination to older males and their small size relative to adult sows (Barrett 1978, Giffin 1978).

Captive females. Young females in Drahos' captive herd showed signs of reaching sexual maturity at about 6-7 months of age. Occurrence of first estrus as determined by copulation in 18 sows ranged from 5.6 to 7.8 months and averaged 6.6 months. Estrous cycles varied from 18 to 25 days and averaged 20 days. The period of estrus lasted about 3 days. Age at first successful breeding was more variable. First successful breeding in 13 sows averaged 10.3 months and varied from 6.8 to 21.0 months. Most sows successfully bred at 7-10 months of age. Weight of captive sows at 6 months of age (prior to sexual maturity) averaged 14.1 kg and varied from 9.5 to 18.1 kg.

Free-ranging females. Reproductive tracts were collected from 20 wild sows that varied in age from 6 months to older than 3 years. Of these, 9 (45%) were pregnant and 2 (10%) were lactating. Nine of the 20 sows were nonpregnant and nonlactating with two (10%) of these being adults and the other 7 (35%) being in the 6-9 month age class and of questionable breeding status. Successful breeding was noted for two wild sows in the 6-9 month age class (Fig. 4). Two other sows successfully bred at 11 and 12 months of age suggesting that average age for first breeding is about 10 months. Weight of the four young pregnant sows averaged 24.7 kg. Seven of 9 wild sows examined in the 6-9 month

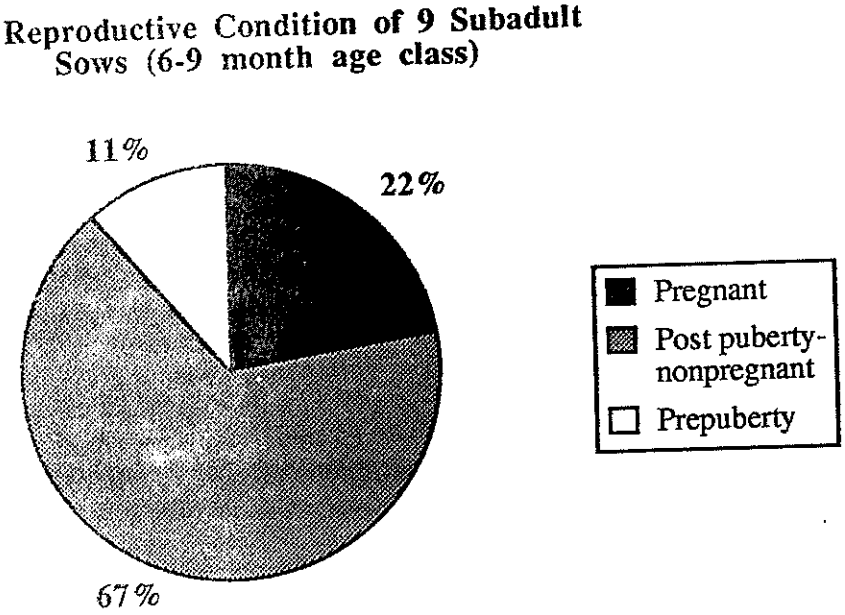


Figure 4. Reproductive status of 9 wild sows in the 6-9 month age class.

age class were not pregnant. Six of these had enlarged Graafian follicles > 4.0 mm in both ovaries suggesting they had reached puberty. The size of the largest Graafian follicle averaged 6.7 mm in these animals. Follicular development > 4.0 mm in both ovaries was considered evidence of sexual maturity. Only one gilt in this 6-9 month age class appeared to be sexually immature. One of its ovaries contained three Graafian follicles ≥ 4.0 mm and ≤ 4.1 mm and the other contained Graafian follicles ≤ 2.4 mm.

Age at first successful breeding for sows on Guam falls within the 5.5-12 month range reported for feral populations elsewhere (Barrett 1978, Giffin 1978). Some domestic sows can breed as early as 3 months (Dukes 1947) but first breeding usually occurs at about 6-7 months in most populations. Nutrition is known to play a role in the onset of puberty and breeding, and age at first breeding tends to be delayed until 8-12 months or more in wild forms (Asdell 1964, Diong 1973) and feral populations with poor diets (Barrett 1978, Giffin 1978). The trend for breeding at an earlier age in captive sows on Guam supports the contention that nutritional levels affect puberty.

The disparity between first estrus and first successful breeding in captive sows on Guam suggests a high incidence of unsuccessful breeding in young sows. Workers noted that a large number of copulations did not produce viable pregnancies. Sows went through 1 to 15 (mean = 3.1) estrous cycles prior to successfully breeding. This delay considerably increased the age at first farrowing. The specific reasons for the lack of immediate breeding success is not known. Many of the matings were between young sows and boars, one or both of which may have exhibited mating behavior without fertile egg or sperm production (Swenson 1970). The artificial nature of the captive breeding experiments may also explain the large number of unsuccessful matings. Timing is critical in conception (Swenson 1970) and boars may not have been placed with the sows at the appropriate time of the estrous cycle to achieve fertilization. Domestic sows are polyestrous with a recurrent estrous cycle of 20-22 days and have an active estrus period of 24-36 hours (Asdell 1964, Swenson 1970). Conception rates are highest in domestic sows inseminated on the second day of estrus (Swenson 1970).

A few free-ranging sows in the 6-9 month age class were pregnant but most were not (Fig. 4). Of the nonpregnant females, most had active ovaries, and may have gone through a number of estrous cycles and unsuccessful matings as occurred in first time breeders in the captive population. Weight of nonpregnant sows in the 6-9 month age class averaged 14.9 kg (range = 13.6-19.1 kg) and was comparable to the 14.1 kg average for pre-estrous captive sows at six months of age but considerably less than the 24.7 kg average for pregnant sows in this age class. These data suggest that nutrition and body condition may be a factor in the onset of successful breeding in free-ranging sows. Other factors may also be involved because captive feral sows fed on a 12-17% protein diet also showed considerable variation in age at first pregnancy.

Gestation and Lactation

The gestation period of 15 litters in Drahos' captive breeding project averaged 113.5 days (range = 112 to 115 days). Gestation periods of 113 and 114 days were most common and accounted for 67% of the sample. No data is available for gestation period in the wild population.

The gestation period on Guam is comparable to the 113 to 115-day average (range of 110-116 days) reported for domestic swine (Dukes 1947, Asdell 1964, Swenson 1970) but slightly less than the 118-day average (range of 109-123 days) reported for feral pigs in Hawaii (Giffin 1978). Gestation tends to be more variable in the ancestral wild form, varying from 101 to 130 days (Henry 1968, Diong 1973, Lekagul and McNeely 1977, Prater 1980).

No data is available on lactation period for wild sows on Guam. In Drahos' captive herd, litters were taken from sows at 74-122 days without losses. A lactation period of 3-4 months is normal (Diong 1973, Barrett 1978) but can vary from 2.5 to 5.5 months (Barrett

1978, Giffin 1978). In Hawaii, captive piglets weaned at 1.3 months were scrawny (Giffin 1978).

Postpartum Breeding

Barrett (1978) reported that estrus normally occurred in lactating sows two to three months postpartum whether they were drying up or not and reported several cases of sows breeding while lactating. Other sows in poor condition did not breed until five months postpartum. Limited observations on Drahos' captive herd indicated that many sows experienced "false heats" after weaning. Estrus occurred an average of 34.1 days post weaning (range = 6-59 days) in 8 sows. With this lag between weaning and postpartum successful breeding, the minimum birth interval would be 240 days if litters were weaned at 3 months or 270 days if litters were weaned at 4 months. Assuming that wild sows first successfully breed at 9 months, first time breeders would produce their first litter at 13 months of age and wean them when she was 16-17 months old. A second litter could be conceived when the sow was 17-18 months old, the young would be born when she was 21-22 months old, and the second litter would be weaned when the sow was 24-26 months old. Once reproductively active, sows appear to be able to produce 3 litters every 2 years.

Seasonality in Farrowing and Breeding

The young of many mammals are born and raised to independence during the most favorable time of year for their survival (Vaughan 1978). Birth dates of 30 litters, 16 from live births in captive sows and 14 from estimated birth dates of fetal litters (four captive sows and ten wild sows), were plotted by month to examine seasonality in farrowing activity (Fig. 5). Litters were born throughout the year with two peaks in activity, one in April-May just prior to the start of the wet season and the other about seven months later in December at the end of the wet season.

Year-round farrowing is reported for feral and wild pigs in California (Barrett 1978, Baber and Coblentz 1986), domestic pigs (Ensminger 1970), and for wild boar in Asia (Thailand-Lekagul and McNeely 1977, India-Prater 1980). Identical to the situation on Guam, most observers (Lekagul and McNeely 1977, Barrett 1978, Prater 1980) reported two peaks in farrowing activity during the year, shortly before and shortly after the rains. Giffin (1978) observed two peaks in the breeding season of feral pigs in a bi-seasonal climate in Hawaii but only one peak in an a seasonal rain forest habitat. The most natural breeding season for domestic sows appears to be early summer and late autumn (Ensminger 1970).

The farrowing peak on Guam in April-May seems to adhere to the trend of producing young at a favorable time. Farrowing in April-May places the critical weaning period during July and August, which is the beginning of the wet season (Fig. 6). The wet season appears to be a period of fruit and forage abundance on Guam. Wheeler (1980) reported that fruit production is seasonally high during April-September, coinciding with the end of the dry season and running through the middle of the wet season. The wet season is an additionally favorable time in which to wean young because of the green-up and abundance of forage following the rains. Wheeler also found that in addition to the seasonal period of fruit abundance, many important food items such as Indian mulberry (*Morinda citrifolia*), papaya (*Carica papaya*), and cycad (*Cycas circinalis*) were fruiting year round. Similar to the situation on Guam, the end of the dry season and beginning of the wet season is also reported as a period of fruit abundance in other tropical climates (Skutch 1976, Dinerstein 1986).

Litters produced in December are weaned during March-April, which is the driest time of the year (Fig. 6). Although Wheeler (1980) reported that April is the beginning of a period of fruit production, green succulent forage would be very limited at this time of year and the benefit of weaning young at this time of year is not readily apparent. No data are

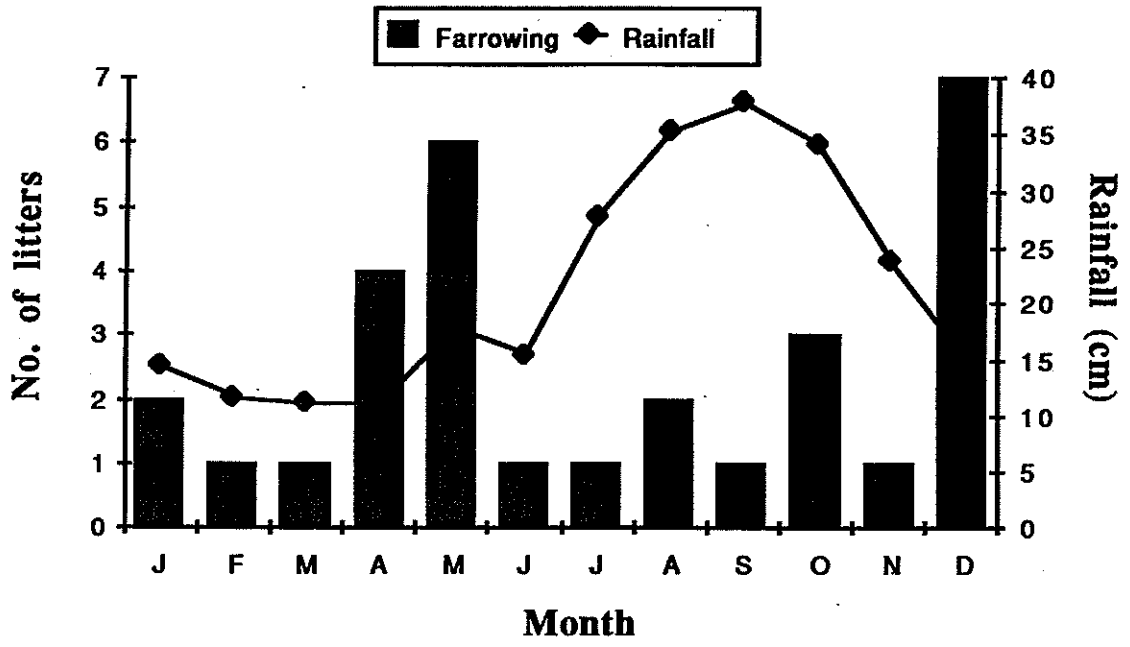


Figure 5. Seasonality of farrowing in feral sows on Guam in relation to rainfall.

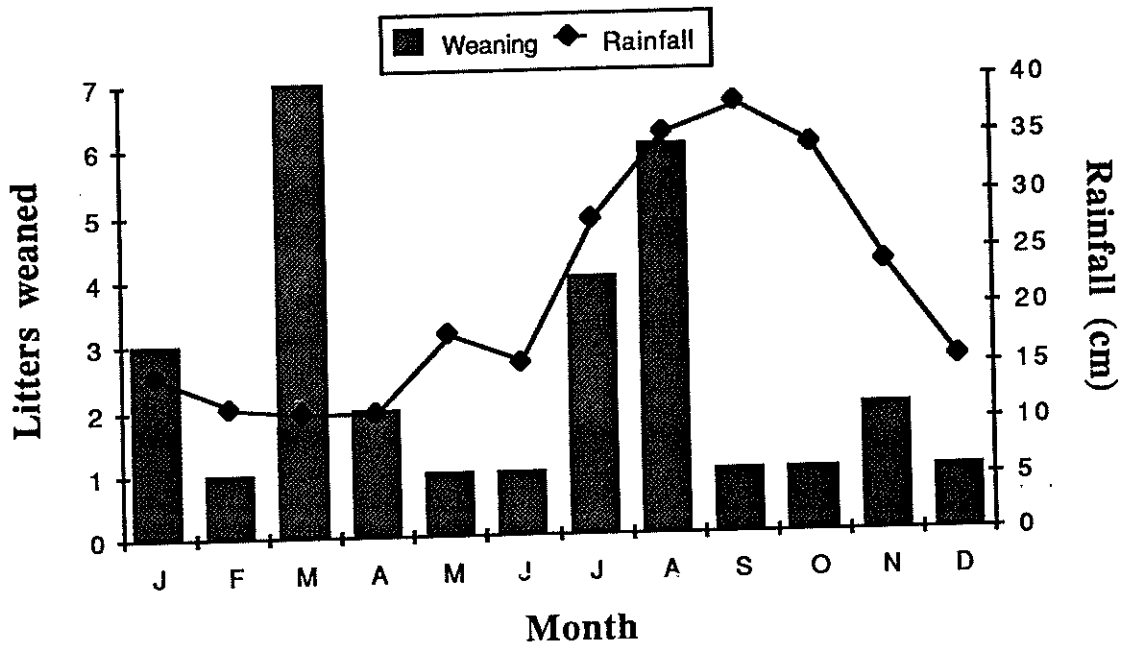


Figure 6. Hypothetical seasonality of weaning on Guam derived from farrowing data (Fig. 5) and based on a 3-month nursing period.

available on litter survival and it is unknown if litters produced during different seasons have different survival rates. Differential mortality is reported for litters born in different seasons in California (Barrett 1978, Baber and Coblentz 1986). Litters born at the beginning of the rainy season and nursed during the period of optimum nutrition had higher survival rates than litters born during the summer dry period. Barrett (1978) found that many if not most sows lost all their young soon after farrowing in the dry summer period.

Litter Size

Data on litter size were obtained from live births in 16 captive sows and from examination of prenatal reproductive tracts from 7 wild sows. Litter size in captive animals averaged 5.0 (range of 1-10) young. Of 80 young born, 43 were male and 37 were female, yielding a sex ratio of 54 males to 46 females, which is not significantly different from an equal sex ratio ($X^2 = 0.3$, d.f. = 1, $P > 0.25$).

Prenatal litter size in seven wild sows averaged 4.9 (range of 1-9) fetuses per sow. This was not significantly different from the litter size of the captive sows (Mann-Whitney U-Test, $U = 62$, $n_1 = 16$, $n_2 = 7$, $P > 0.20$) and is similar to the 5.0-5.6 young per litter of feral pigs in California (Barrett 1978, Baber and Coblentz 1986). Fetal sex ratio in wild sows on Guam was skewed toward females although sample size was small. Of 21 fetuses old enough to be sexed, 7 were male and 14 were female, producing a sex ratio of 33 males to 67 females. This ratio was not statistically different from equality ($X^2 = 1.71$, d.f. = 1, $P > 0.10$). Both horns of the uterus were active in multiple-fetus litters. Nineteen (56%) fetuses were implanted in the right horn of the uterus and 15 (44%) were implanted in the left horn.

Ovarian analysis of seven gravid sows revealed an average of 7.4 (range of 6-10) corpora lutea of pregnancy. The right ovary was slightly more active than the left and accounted for 52% of the 52 corpora lutea found. Corpra lutea ranged in diameter from 4.1 to 11.7 mm. Post-ovulatory Graafian follicles as large as 6.0 mm were also present in the ovaries of pregnant sows. Reabsorbed fetuses were found in two of nine litters and accounted for 8% of the corpora lutea produced. Based on the difference between the average number of corpora lutea and fetuses, the fetal pregnancy rate was 64.8% and intrauterine mortality was 35.2%. Baber and Coblentz (1986) summarized the results of seven reproductive studies on feral pigs in the USA and reported prenatal mortality at 23-35%, which, overall, is similar and slightly lower than the rate found on Guam.

Sizes of piglet groups accompanying a sow were recorded during road side counts in the CWA. These counts only recorded size of litters up through the weaning period. Twenty postnatal litters averaged 3.7 piglets (range of 1-6), a figure which is 74% of the average number of young in litters at birth. These data suggest that at least 26% of all piglets die prior to weaning. Mortality is probably higher as some of the juveniles recorded in these counts may not survive through the entire weaning period or survive the interval between weaning and adulthood. Other studies (Barrett 1979, Baber and Coblentz 1986) report much higher postnatal losses in the range of 60%-90%.

BEHAVIOR AND SOCIAL INTERACTIONS

No specific studies of pig behavior have been conducted on Guam but incidental observations have been compiled on a few topics that are worthy of note. The interested reader is advised to consult other authors who describe various aspects of wild pig behavior (Diong 1973, Barrett 1978, Giffin 1978, Sweeney and Sweeney 1982).

Farrowing Nests

Females commonly construct farrowing nests in the wild prior to parturition (Diong 1973, Barrett 1978, Giffin 1978, Sweeney and Sweeney 1982). Nests in which piglets are born and nursed in the early part of their lives have also been found on Guam. These nests resemble those reported in the studies above and are typically a small mound of vegetation with an inner chamber and small entry hole through which the sow crawls. The covering vegetation protects the sow and piglets from the elements. Four nests have been found on Guam, one in limestone forest, two in scrub forest, and one in savanna. Each of these nests was located in tall stands of foxtail grass (*Pennisetum polystachyon*). The nests in forests occurred in small clearings and the nest in the savanna was situated on the top of a steep ridgeline adjacent to a human and animal trail.

The dimensions of two nests in scrub forest were 3-4 m long, 2-3 m wide, and 0.2-0.3 m tall. Foxtail grass was the main material used in the construction of three nests. Stems from herbaceous growth (*Cromalina odoratum, Nephrolepis hirsutula*) and *Pandanus* leaves were also used as nest material. The nest in limestone forest consisted of cut pieces of cycad (*Cycas revoluta*) fronds. Drahos also encountered two nests during his time. Both were on Northwest Field and were primarily constructed out of *Pennisetum* grass. Sows reportedly stay close to nests for about three weeks after parturition or until the piglets are old enough to leave the nest and begin following the sow as she moves out of the farrowing range (Barrett 1978, Sweeney and Sweeney 1982).

Social Interactions

Pigs seen during roadside counts in the CWA were classified by group size and age. Overall, 469 animals in 196 groups were observed. Groups ranged in size from 1-19 animals and averaged 2.4 animals. Solitary animals were the most frequently encountered size-group, accounting for 53% of all observations (Fig. 7). Sows with piglets were recorded in all months but occurred most frequently during the rainy season in August and September. Not all animals were classified by sex in this work, but elsewhere, adult males are reported to be solitary and associate with female groups only during courting (Diong 1973).

POPULATION CHARACTERISTICS

Harvest Density

Data from mandatory hunter check stations at Northwest Field and Naval Communications Area Master Station (NAVCAMS) provided information on the size of legal harvest from 1980-1987. Combined harvest for these two areas which are approximately 15 km^2 in size varied from 45-329 pigs, yielding a harvest density of 3.0-21.9 pigs killed per km^2 (Table 5). Harvest densities at NAVCAMS (3.8-29.2 pigs/km^2) were generally higher than those at Northwest Field (1.7-18.5 pigs/km^2). The amount of illegal harvest and wounding loss that occurs in these areas is unknown. The presence of military security may deter poaching, particularly of pigs. Regulations for hunting pigs are so liberal that there is little reason to hunt them illegally. The majority of illegal hunting cases in these areas are for deer poaching. As such, figures for total human take cannot be determined but would be somewhat higher than that provided above.

The harvest density of pigs is far greater than that of deer, the other popular game species hunted in these areas. In 1984, 21 deer were harvested on Northwest Field and NAVCAMS yielding a harvest density of 1.4 deer/km^2. The harvest density of pigs (21.9 pigs/km^2) was more than 15 times greater than that of deer.

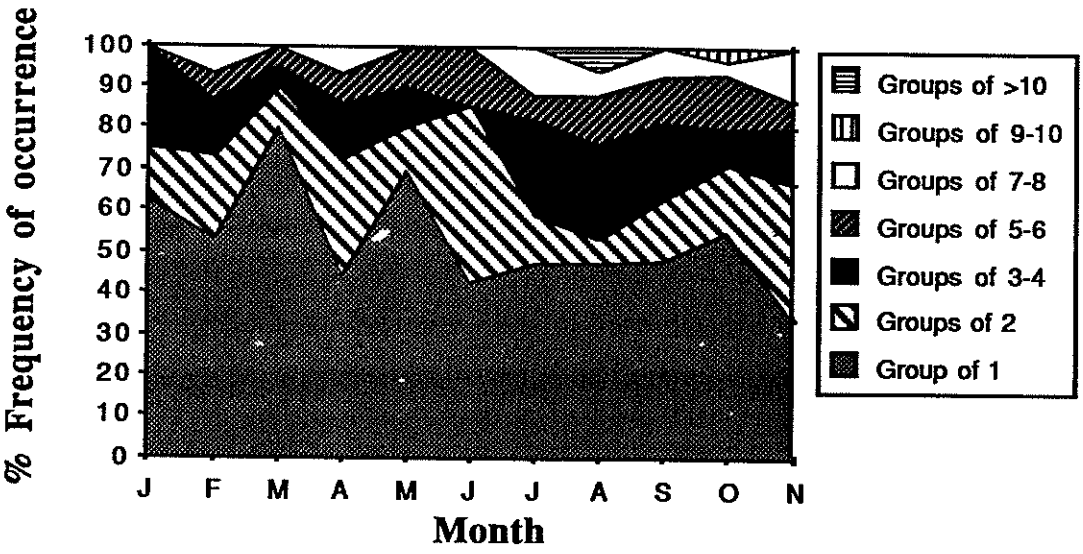


Figure 7. Herd size of pig groups observed on roadside counts in the Conventional Weapons Area on Andersen Air Force Base, Guam, 1983-1987.

Table 5. Annual harvest, weight (kg) of harvest, harvest density (pigs/km^2), harvest biomass (kg/km^2), and a high and low estimate of population density and biomass for feral pigs at the Northwest Field and Naval Communications Area Master Station (NAVCAMS), Guam, 1980-1987. Population density estimates are derived from annual harvest figures, assuming for the high estimate that 20% of the population is harvested and for the low estimate that 50% of the population is harvested on an annual basis. Biomass figures were calculated from density figures using an average weight of 30 kg per pig as obtained from field data at Northwest Field in 1984 (n=181).

	Harvest				Pop. density (No./km^2)		Pop. biomass (kg/km^2)	
Year	No.	kg	density (No./km^2)	biomass (kg/km^2)	low	high	low	high
Northwest Field (9.8 km^2)								
1980	17	510	1.7	52	3.5	8.7	104	260
1981	35	1050	3.6	107	7.1	17.9	214	536
1982	59	1770	6.0	181	12.0	30.1	361	903
1983	57	1710	5.8	174	11.6	29.1	349	872
1984	181	5430	18.5	554	36.9	92.3	1108	2770
1985	158	4740	16.1	484	32.2	80.6	967	2418
1986								
1987	169	5070	17.2	517	34.5	86.2	1035	2587
NAVCAMS (5.2 km^2)								
1980	28	840	5.3	158	10.6	26.4	317	792
1981	23	690	4.3	130	8.7	21.7	260	651
1982	31	930	5.8	175	11.7	29.2	351	877
1983	20	600	3.8	113	7.5	18.9	226	566
1984	148	4440	27.9	838	55.8	139.6	1675	4189
1985	133	3990	25.1	753	50.2	125.5	1506	3764
1986	98	2940	18.5	555	37.0	92.5	1109	2774
1987	155	4650	29.2	877	58.5	146.2	1755	4387
Combined Northwest Field and NAVCAMS (15 km^2)								
1980	45	1350	3.0	90	6.0	15.0	180	450
1981	58	1740	3.9	116	7.7	19.3	232	580
1982	90	2700	6.0	180	12.0	30.0	360	900
1983	77	2310	5.1	154	10.3	25.7	308	770
1984	329	9870	21.9	658	43.9	109.7	1316	3290
1985	291	8730	19.4	582	38.8	97.0	1164	2910
1986								
1987	324	9720	21.6	648	43.2	108.0	1296	3240

Most of the work on pigs has occurred in northern Guam at the Northwest Field and NAVCAMS study areas. Harvest and population levels in southern and central Guam are unknown but pigs are common in most forested areas. Incidental observations of pig rooting and wallowing sign on the Naval Magazine in central Guam indicate that pigs are abundant there. Additionally, reports of crop depredation from all over the island confirm that pigs are common in agricultural fringe areas as well.

Population Estimates Based on Harvest

No specific surveys have been conducted on Guam to determine pig densities. However, harvest data can be used as a basis for estimating densities. Barrett (1978) reported that total human kill which included animals killed by hunters and other human-caused mortality averaged about 20% of the population in his study. Assuming that hunter harvest on Guam varies from a similar rate of 20% of the population to perhaps a much higher rate of 50%, high and low estimates of density can be derived for Northwest Field and NAVCAMS. Table 5 contains estimates of population densities for 1980-1987, based on the assumption that for the low estimate, 50% of the population was harvested, and for the high estimate, 20% of the population was harvested.

The low estimate of pig density for the combined area varied from 6 to 44 pigs/km^2 and the high estimate varied from 15 to 110 pigs/km^2 (Table 5). Density estimates for NAVCAMS were generally higher than those for Northwest Field. Based on the high estimate, density on NAVCAMS may have reached 146 pigs/km^2 in 1987.

Density estimates for pigs in scrubby and limestone forest on Guam exceed those reported in most other areas. Densities of wild boar in Southeast Asian wildlife sanctuaries vary from 0.3 to 6.7 pigs/km^2 (Schaller 1967, Eisenberg and Seidensticker 1976, Seidensticker 1976, Dinerstein 1980). Densities of wild boar and feral pig populations in the mainland U.S. vary from 0.5 to 34.0 pigs/km^2 (Barrett 1978, Baber and Coblentz 1986) but reach much higher levels (3-63 pigs/km^2) in tropical communities in Hawaii (Giffin 1978). As indicated by these comparative data, the harvest density on Guam can exceed total population density of pigs in many other areas.

Biomass Production

The weights of 181 pigs killed at Northwest Field in 1984 averaged 29.7 kg per animal. Based on this 30 kg average size, harvest biomass for NAVCAMS and Northwest Field varied from 90 to 658 kg/km^2 per year during the period 1980-1987 (Table 5). Harvest biomass was generally higher at NAVCAMS (113-877 kg/ km^2 per year) than at Northwest Field (52-554 kg/km^2 per year).

Using the same approach as with density estimates, high and low biomass estimates can be extrapolated for the population from harvest biomass figures. The low estimate of biomass production for the combined Northwest Field and NAVCAMS area varied from 180 to 1,316 kg/km^2 and the high estimate varied from 450 to 3,290 kg/km^2 (Table 5). Biomass estimates for NAVCAMS were generally higher than those for Northwest Field and the high estimate of biomass may have reached 4,387 kg/km^2 in 1987.

As with density, biomass production for wild pigs in scrub and secondary limestone forest on Guam exceed that reported in most other areas. Biomass estimates for wild boar in Southeast Asian wildlife sanctuaries vary from 8 to 360 kg/km^2 (Schaller 1967, Eisenberg and Seidensticker 1976, Seidensticker 1976, Dinerstein 1980). Biomass production in some areas on Guam such as at NAVCAMS may exceed combined biomass production of all wild ungulates in many Asian wildlife reserves (Eisenberg and Seidensticker 1976, Dinerstein 1980). Biomass production for all wild ungulates in

representative Asian parks vary from 383 to 3,120 kg/km^2 which is 22-178% of the biomass production (low estimate) for pigs alone on NAVCAMS in 1987.

Population Trend

The average amount of hunting effort required to harvest an animal can be used as an index to population trend (Downing 1980). Island-wide harvest statistics have been compiled from hunter questionnaires since 1976 and indicate a fairly wide range in effort over that period, varying from a low of 3.6 days/pig killed in 1983 to 11.6 days/pig killed in 1980 (Fig. 8). Based on this data, pig numbers apparently declined during 1976-1980, but have increased and recovered since then (Fig. 8). Significantly less effort (U-test, U = 27, $n_1 = 7$, $n_2 = 4$, P = 0.02) was required to harvest a pig during 1981-1987 (range of 3.6-6.0 days/pig) than during 1976-1980 (range of 5.8-11.6 days/pig).

Pig populations in northern forests appear to have increased dramatically in the past five years. Annual harvests on Northwest Field and NAVCAMS increased from an average of 67.5 (range of 45-90) pigs during 1980-1983 to 314.7 (range of 291-329) pigs during 1984-1987 (Table 5). A direct comparison between these two periods is somewhat misleading because season length and bag limits were increased in 1984. However, a comparison of harvest size during the first three months of the season is appropriate and shows a similar trend. The October-December harvest during 1984-1987 averaged 189.4 (range of 162-237), and was a 280% increase in harvest size over the 1980-1983 period.

The effort per harvest index showed a similar trend (Fig. 9). Effort per harvest decreased from 14.1 (range of 9.2-20.5) days/pig during 1980-1983 to 7.4 (range of 6.9-7.9) days/pig during 1984-1987. These data indicate a general increase in pig numbers on Northwest Field and NAVCAMS since 1980.

Incidental observations by G. J. Wiles indicate a similar increase in pig abundance on Pati Point. Pigs and rooting were rarely observed there in 1981 and 1982, but have been seen much more commonly since 1985.

The reason for the population increase is unclear. No significant habitat modifications that would be beneficial to pigs have occurred at Northwest Field and NAVCAMS during the past decade. In Hawaii, the population size and distribution of pigs has increased in recent years with researchers there speculating that improved forage conditions are the cause (Stone 1985a). Apparently, pig rooting has created favorable conditions for the invasion of exotic plants and invertebrates, which then results in improved foraging for pigs. A similar mutualistic relationship may also occur on Guam but has not been investigated. This hypothesis suggests that the carrying capacity of the range has been permanently increased.

Another explanation for the increase in numbers observed on Guam may be the existence of naturally occurring oscillations in the population. The data presented above illustrate a substantial increase in numbers over the past seven years. A severe decline in pig numbers has also been detected in this general area in the past. Spotlight counts at FAA housing on NAVCAMS documented a decline in pig numbers there during 1968-1971. The monthly average number of pigs sighted per day declined significantly (U-test, U = 214.5, $n_1 = 17$, $n_2 = 13$, P = 0.001) from 1.13 pigs/day during 1968-1969 to 0.16 pigs/day during 1970-1971 (Fig. 10), an 86% decline. These data are not complete enough to illustrate the full magnitude of the decline or the pattern of oscillation over a longer period. The fact that this population was closed to hunting during this period indicates that legal human take was not responsible and suggests a natural phenomenon.

Likewise, the deer population at Pati Point, Andersen Air Force Base has fluctuated up and down over the past 25 years (Wheeler 1979, DAWR 1986). The annual average count was low during 1963-1968 (range of 15-45), high during 1969-1976 (range of 60-116), low again during 1977-1983 (range of 38-68), and has been on the increase since 1984 (range of 80-111) (Wheeler 1979, DAWR 1986). A similar phenomenon may occur

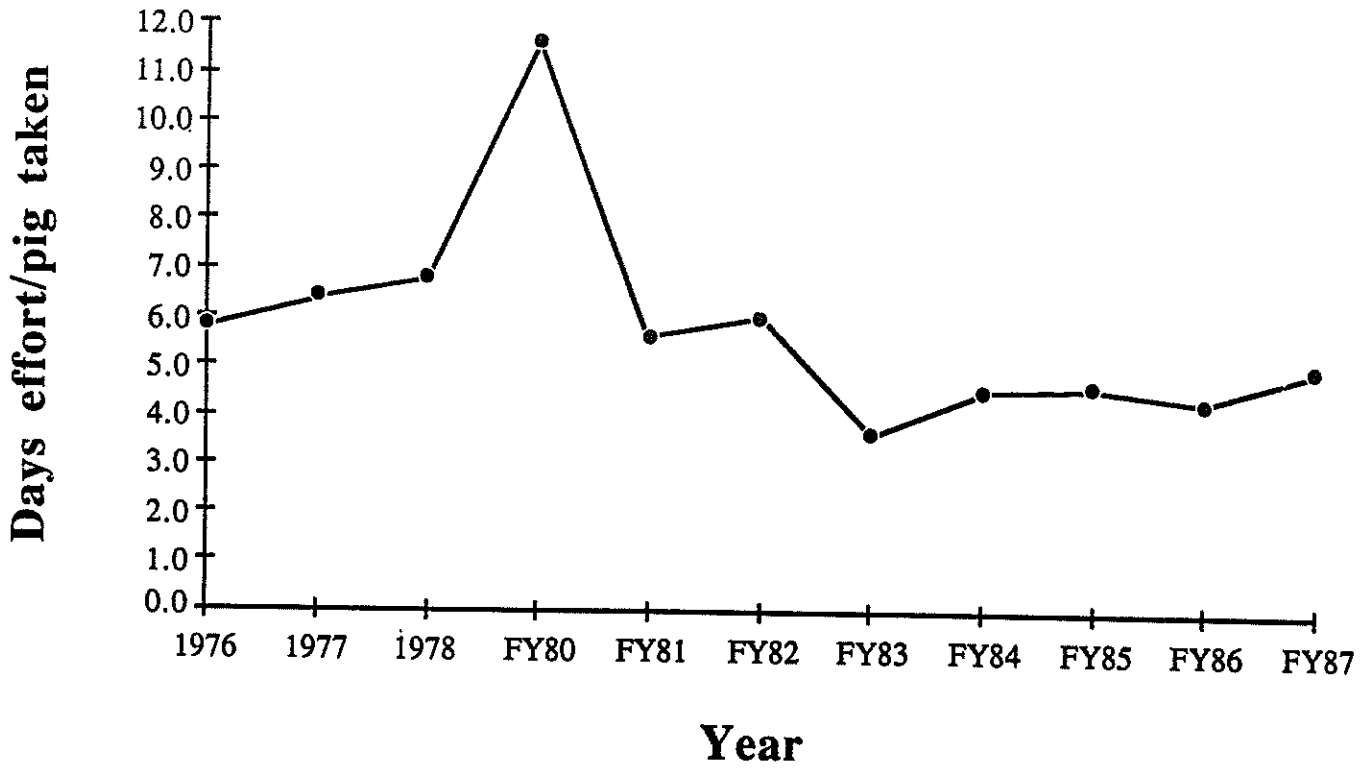


Figure 8. Islandwide trend in hunter effort per pig harvested during 1976-1987 based on hunter questionnaire data.

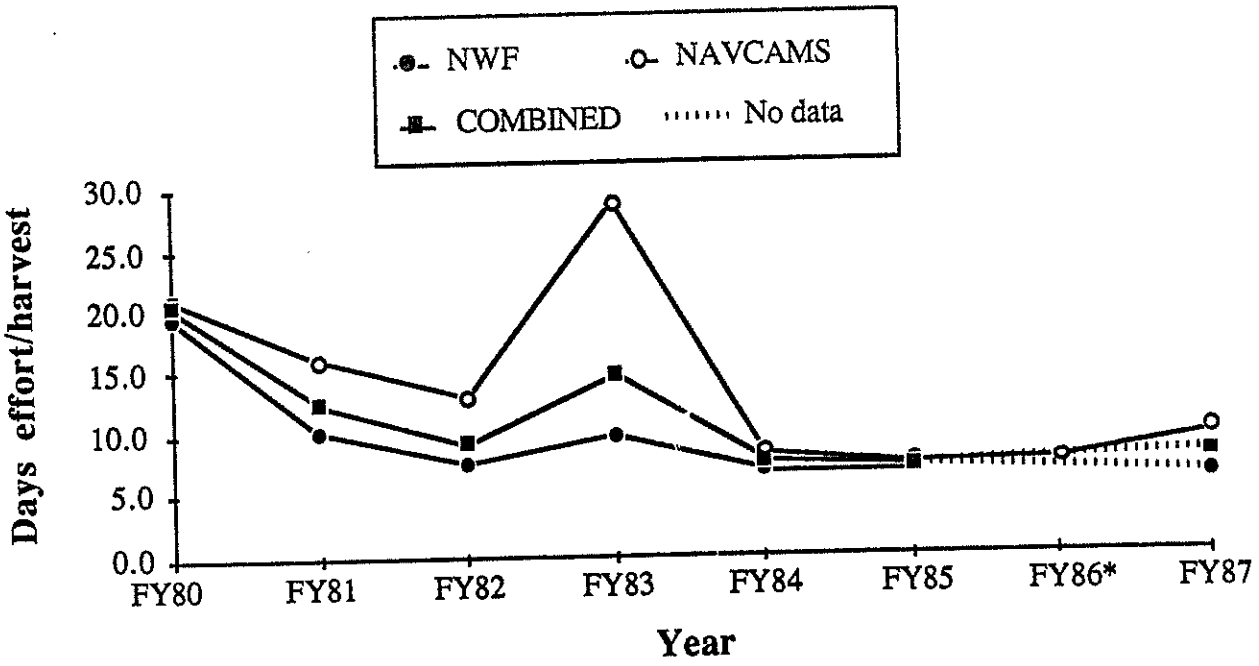


Figure 9. Trend in hunter effort per pig harvested on Northwest Field and NAVCAMS during 1980-1987.

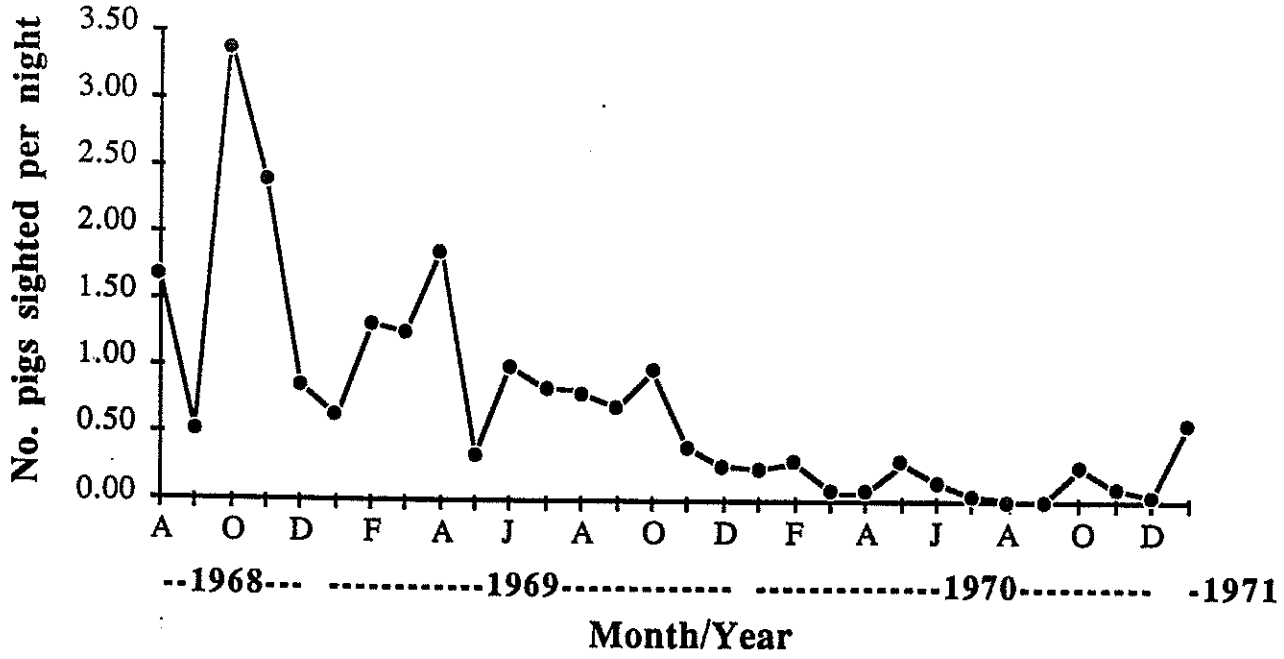


Figure 10. Trend in the pig population index, based on the average number of pigs sighted per night, at FAA Housing, NAVCAMS during October 1968 - January 1971.

in pig populations but additional data is needed to document its existence.

Characteristics of Harvested Pigs

Sex and weight data were recorded on 318 pigs harvested at Northwest Field during 1983-1985. Of these, 202 were male and 116 female producing a harvest sex ratio of 64 males to 36 females. This skewed sex ratio differed significantly ($X^2 = 22.7$, d.f. = 1, $P < 0.001$) from an equal sex ratio. Barrett (1978) also reported that males comprised the larger portion of the hunter bag in California and attributed it to hunter selection.

Most animals in this sample were processed through the hunter check station by untrained AAFB personnel and no data was recorded on the age of the specimens. However, in the animals aged by the author, weight was generally related to age in young pigs (Table 1) and the distribution of weights is being used here to characterize age structure of the harvest. Pigs smaller than 18 kg were considered juveniles (<9 months of age) and animals larger than 18 kg were consider adults (>9 months of age). This criterion corresponds to the weights of known-aged animals in Drahos' captive herd and animals aged in the field.

Structure of the harvest did not vary between the sexes ($X^2 = 9.5$, d.f. = 5, $P = 0.09$) and all data was pooled for analysis a a whole. Weight class structure was pyramidal in shape with the exception of the smallest class (Fig. 11). This truncated structure is likely a product of hunter reluctance to take small-sized animals rather than the existence of a small juvenile age class. The actual structure of the population is probably pyramidal in shape. The juvenile age class comprised 25% of the harvest (Fig. 11).

Barrett (1978) reported a pyramidal age structure in a California population of feral pigs and a modified pyramidal structure in harvested animals. The juvenile age class was truncated in the harvest and Barrett concluded that juveniles were under-harvested in relation to their occurrence in the population. Diong (1973) reported that the juvenile age class comprised 23% of the harvest in Malaysia.

FOOD HABITS

Plant matter comprised 96% (by weight) of the food present in the 12 wet analysis samples and 93% of the food present in the dry analysis samples (Fig. 12). Of plant matter, fruit was the most important component of the diet occurring in all 22 stomachs examined. Leaves also occurred in 100% of the 22 stomachs examined, grass in 50%, bark in 45%, and roots in 23%. In the wet analysis, fruit accounted for 64% of the foods consumed and browse, which included grass, leaves, stems, roots, and bark, accounted for 32% (Fig. 12). Fruit comprised a smaller percentage of the diet (21%) in the dry analysis (Fig. 12), being surpassed in weight by browse (72%). However, this appears to be an artifact of the methods used rather than a difference in diet. In the dry analysis, much of the fruit weight is lost as water in the drying process. Because of these differences, the relative importance of the various items in the diet is best assessed from the wet analysis results.

Fruit of the Indian mulberry (*Morinda citrifolia*) was the most common single item found in the diet. This food item occurred in 91% of the 22 stomachs examined and accounted for 45% of the food consumed in the wet analysis (Table 6). Indian mulberry is abundant throughout Guam's secondary forests and fruits year-round (DAWR 1980). Its large, odorous fruit can be easily located and consumed when it ripens and falls to the ground. *Pandanus* fruit, primarily that of *P. tectonius*, comprised 16% of the diet and was the second most important component in the wet samples. Like Indian mulberry, *Pandanus* is a common secondary forest species with a large somewhat fragrant fruit. When ripe, the fleshy seeds of the fruit fall to the ground and may be abundant locally. Pigs also feed on

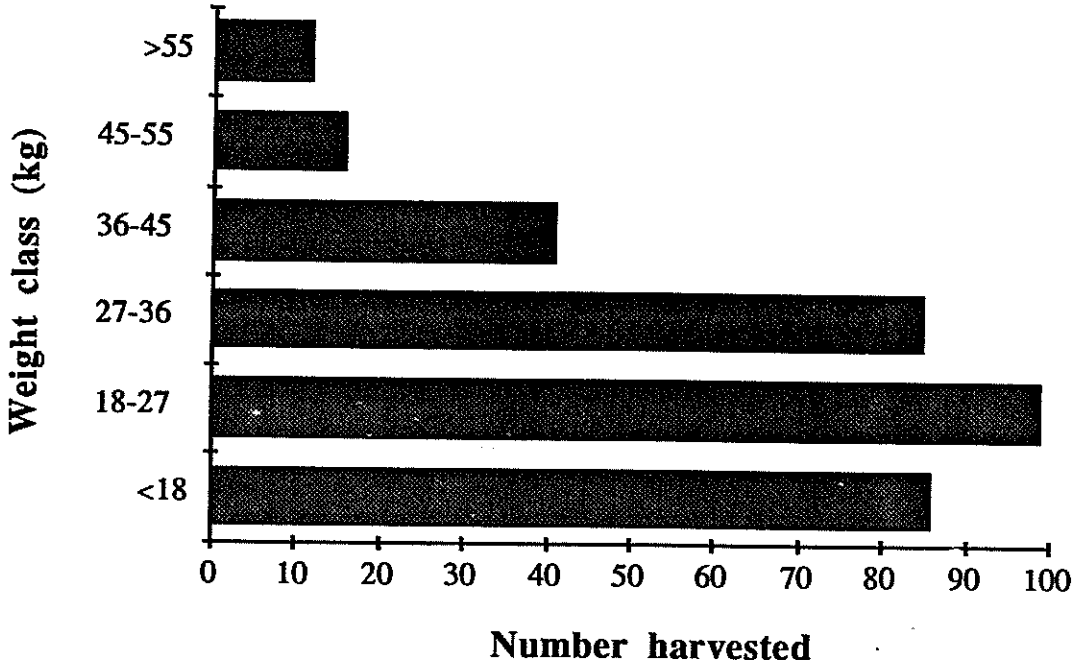


Figure 11. Size class structure of pigs harvested at Northwest Field and NAVCAMS during 1983 - 1985.

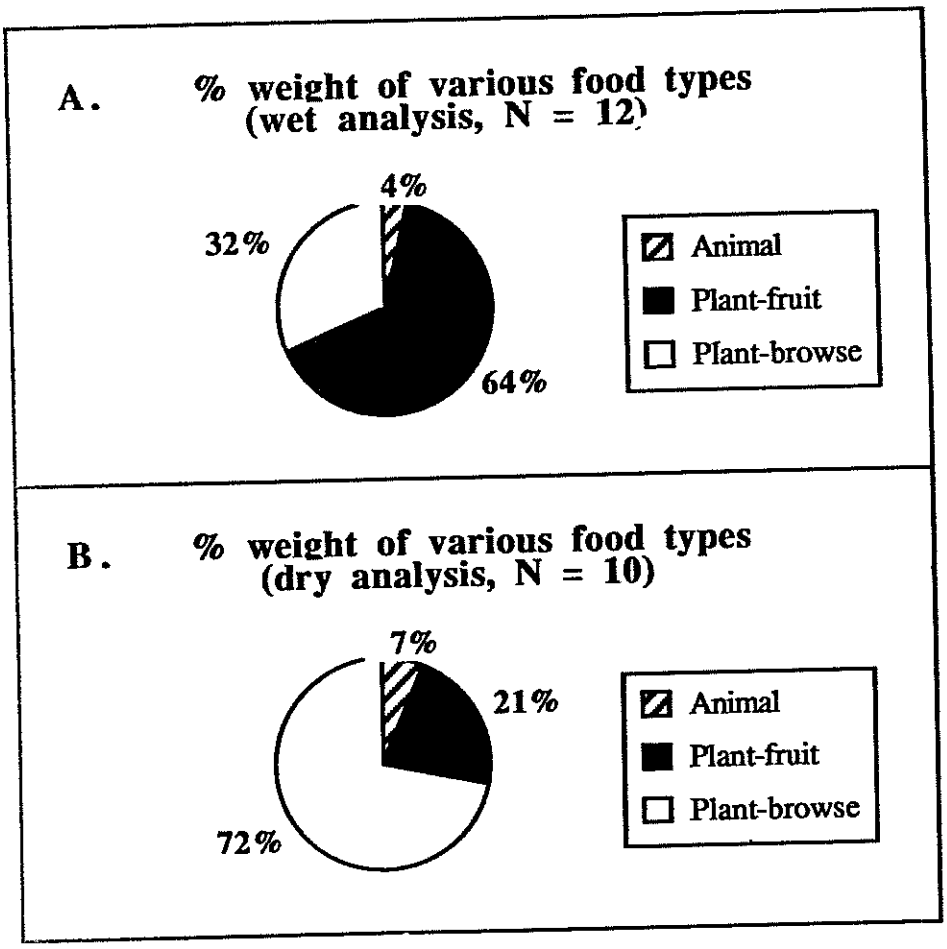


Figure 12. Percent composition of major food groups as determined by wet analysis (A) and dry analysis (B) in 22 stomachs of feral pigs harvested at Northwest Field during 1985 - 1987.

Table 6. Food items occurring in 22 feral pig stomachs obtained from hunters at Northwest Field during 1985 -1987. Abbreviations used in the table are FO = frequency of occurrence, F = fruit, L = leaf, and G = grass.

Food item	Food type	Dry analysis (n=10)				Wet analysis (n=12)				All (n=22)	
		No. FO	% FO	Wt (g)	% Wt	No. FO	% FO	Wt (g)	% Wt	No. FO	% FO
Animal Matter											
Caterpillar		1	10	0.1	0.1					1	5
Earthworm		5	50	2.8	2.8	7	58	41.1	3.3	12	55
Insects		3	30	0.3	0.3	3	25	0.3	0.0	6	27
Skink		1	10	0.1	0.1					1	5
Snail		1	10	0.5	0.5					1	5
Unknown vertebrate		1	10	3.0	3.0	2	17	10.7	0.9	3	14
Plant Matter											
Artocarpus mariunensis	F					1	8	12.3	1.0	1	5
Carica papaya	F	1	10	0.1	0.1					1	5
Cocos nucifera	F	1	10	0.7	0.7	5	42	14.8	1.2	6	27
Cycas circinalis	F	1	10	0.1	0.1					1	5
Flagellaria indica	F	2	20	2.1	2.1	3	25	2.5	0.2	5	23
Lucaena leucocephala	F, L					10	83	24.8	2.0	10	45
Morinda citrifolia	F	8	80	15.5	15.6	12	100	564.9	45.4	20	91
Pandanus spp.	F					4	33	202.7	16.3	4	18
Panicum maximum	F, G					1	8	0.4	0.0	1	5
Passiflora suberosa	F	5	50	0.8	0.8	8	67	3.7	0.3	13	59
Pennisetum polystachyon	F, G	1	10	0.1	0.1	1	8	5.4	0.4	2	9
Premna obtusifolia	F	1	10	0.1	0.1	2	17	1.0	0.1	3	14
Unknown bark		4	40	0.9	0.9	3	25	0.7	0.1	7	32
Unknown fruit		5	50	1.8	1.8					5	23
Unknown grass		1	10	0.2	0.2	7	58	19.4	1.6	8	36
Unknown leaves		10	100	68.7	69.1	12	100	329.5	26.5	22	100
Unknown root		3	30	1.3	1.3	2	17	9.4	0.8	5	23
Soil		1	10	0.2	0.2					1	5

the leaf crown of *Pandanus*, eating the slightly fleshy base of the leaves. Similarly, pigs feed on the fruit and also the fleshy inner parts of the trunk of *Cycas*. Heavy feeding on these two plants is readily apparent following strong storms when large numbers of trees are blown over (Fig. 13). Other important fruits consumed included tangantangan (*Lucaena leucocephala*), the inner meat of coconuts (*Cocos nucifera*), *Passiflora suberosa*, and breadfruit (*Artocarpus mariannensis*) (Table 6). Wild pigs have also been observed feeding on the fallen fruit of *Ficus* sp. in northern Guam (G. J. Wiles, pers. obs.).

Field observations of feeding sign indicated that some fruits such as breadfruit and pandanus may be consumed more frequently than indicated in these data. Breadfruit may be so thoroughly masticated or digested that it is not readily identified in stomach samples. Similarly, pigs chew and discard the fibrous nut-like seeds of pandanus, swallowing mainly the juice and fruit pulp. Some of the characteristic fruit fibers may be ingested but the amount is probably underrepresentative of the quantity of seeds actually fed on. Once consumed, the juice and pulp are quickly digested, leaving little evidence of pandanus in the stomach.

Animal matter occurred frequently in the diet but comprised only a small portion of matter consumed, 4% in wet analysis and 7% in dry analysis (Fig. 12). Earthworms (Lumbricidae) were present in 55% of the 22 samples examined and comprised the bulk of the invertebrates consumed. Other invertebrates eaten included a land snail and caterpillar. Vertebrates occurred less frequently in the diet (14% of the samples) and appear to be of minor importance. A skink (Scincidae) tail and unidentifiable tissue, possibly carrion, were the only vertebrate matter identified in the samples.

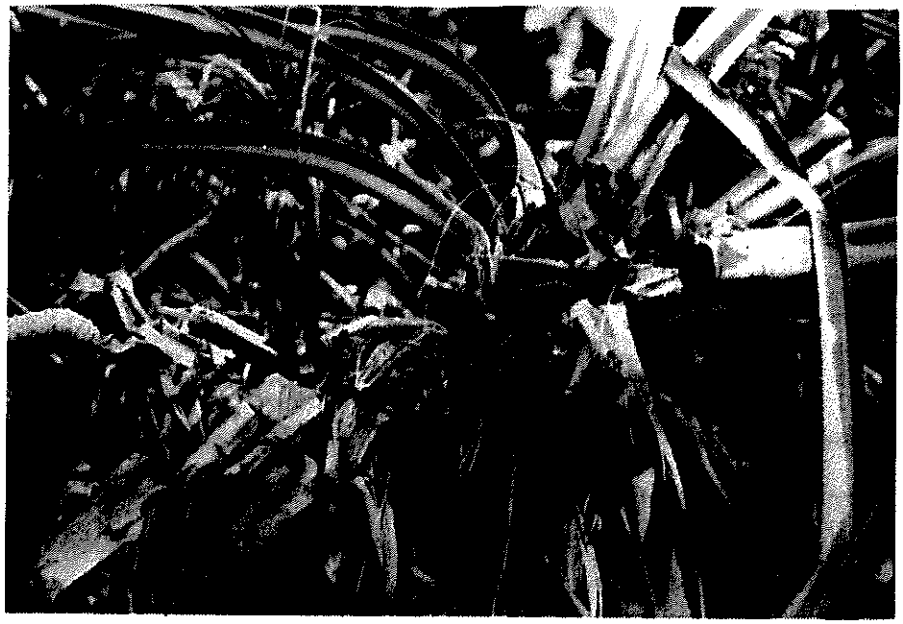
T. H. Fritts (pers. comm.) found brown tree snake (*Boiga irregularis*) scales and vertebrae in several pig droppings collected in northern Guam and concluded that pigs are occasional predators on snakes on the island (Fritts and Scott 1985). The extent to which pigs prey on snakes is of interest on Guam because of the extensive ecological problems that snakes have caused on the island. Snake remains were not identified in the small number of stomachs examined in this study. Based on pig feeding behavior elsewhere, it is reasonable to assume that pigs may consume both live and dead snakes. This behavior may be rare and restricted to older more aggressive individuals. Snake matter may not have shown up in this study because of the small sample size and the relatively young age of the pigs involved. Additional samples from adult animals may reveal more vertebrate matter in the diet.

Most other studies have also shown that pigs are highly omnivorous but feed primarily on plant matter (Henry and Conley 1972, Diong 1973, Barrett 1978, Giffin 1978, Wood and Roark 1980, Howe et al. 1981). Fruit is a major component of the diet in other areas (Henry and Conley 1972, Wood and Roark 1980) and its dietary importance has been linked with reproductive success (Barrett 1978, Baber and Coblentz 1986). Vertebrates such as snakes, lizards, birds, small mammals, and fish and carrion frequently occur on an occasional basis in the diets of wild pigs in other areas (Henry and Conley 1972, Diong 1973, Barrett 1978, Giffin 1978, Wood and Roark 1980) but were of little importance on Guam.

ABUNDANCE OF PIG SIGN IN SELECTED HABITATS

Surveys of pig sign were conducted in secondary forests at Northwest Field, savanna at Cross Island Road, and mixed savanna-agricultural habitat at Dandan. Pig sign was far more abundant in forest than savanna or mixed savanna-agricultural land. Some type of sign, either fresh or old, occurred in 79% of the plots sampled at Northwest Field, in 40% of the plots at Cross Island Road, and in 14% of the plots at Dandan (Table 7). Fresh sign was more abundant than old sign at Northwest Field but less common at the other sites (Table 7). Rooting was the most commonly encountered fresh sign in all habitats, trails and scats were the second and third most common indications of presence,

A



B

Figure 13. Photographs of pig feeding sign on (A) a *Pandanus* crown and (B) a *Cycas* trunk in secondary limestone forest at Northwest Field.

Table 7. Number and percent of study plots (10 x 2 m) containing various types of pig sign in secondary forest at Northwest Field, savanna at Cross Island Road, and mixed savanna-agricultural habitat at Dandan.

		Rooting	Trail	Scat	Wallow	Sighting	Any
Secondary Forest, Northwest Field (n = 1167 plots)							
Fresh sign	No.	547	50	92	3	4	588
	%	46.9	4.3	7.9	0.3	0.3	50.4
Old sign	No.	165	515	267	9	0	333
	%	14.1	44.1	22.9	0.8	0.0	28.5
Fresh or old	No.	712	565	359	12	4	921
	%	61.0	48.4	30.8	1.0	0.3	78.9
Savanna, Cross Island Road (n = 475 plots)							
Fresh sign	No.	47	5	0	0	0	48
	%	9.9	1.1	0.0	0.0	0.0	10.1
Old sign	No.	128	30	6	0	0	140
	%	26.9	6.3	1.3	0.0	0.0	29.5
Fresh or old	No.	175	35	6	0	0	188
	%	36.8	7.4	1.3	0.0	0.0	39.6
Mixed Savanna-Agricultural Habitat, Dandan (n = 147 plots)							
Fresh sign	No.	2	3	0	0	0	3
	%	1.4	2.0	0.0	0.0	0.0	2.0
Old sign	No.	13	7	1	0	0	17
	%	8.8	4.8	0.7	0.0	0.0	11.6
Fresh or old	No.	15	10	1	0	0	20
	%	10.2	6.8	0.7	0.0	0.0	13.6

and wallows and sightings the least common type of sign encountered.

Forested habitat was far more heavily used and important than savanna or agricultural land. Fresh sign was five times more common in forested habitat than in savanna and 25 times more common than in mixed savanna-agricultural habitats. When fresh and old sign are combined, the large differences in use of the various habitats are less pronounced but the relative ranking of importance remains the same.

These results should be used cautiously because of the limited scope of the surveys. Only three areas were surveyed and sampling intensity was light in agricultural habitats. In addition, sampling was done in the April-June dry season, which may have biased results toward use of forest habitat. During the dry season, wild pigs probably avoid the hot and shadeless agricultural lands and savanna during the daytime, using cooler forested areas instead. However, the relative occurrence of old sign in these habitats suggests that forests may be preferred even during the wet season. More surveys in additional areas and seasons are needed to verify these results.

Stone (1985b) and Barrett et al. (in press) have used similar surveys as an index to pig activity and density in other studies. Using 10 x 2 m plots, Stone (1985b) reported a pig activity index ranging from 0.5% to 58.1% in rain forest in Hawaii. In one intensively studied area, a pig activity index of 31% corresponded to density of 21 pigs/km^2. Barrett et al. (in press) used 10 x 10 m plots to survey pig sign in a 20 km^2 state park in California. They obtained a pig activity index of 25% for all types of sign which corresponded to a density of 5 pigs per km^2 in the park. In both of the above studies, environmental damage occurred at those levels of pig activity and density.

Indexes of pig sign in forested habitat in northern Guam are far higher than in the two studies reported above. The high incidence of pig activity at Northwest Field obtained in these surveys supports earlier conclusions based on harvest data that wild pigs are extremely abundant in forests of northern Guam. Although no specific studies have been conducted here, it is logical to associate serious environmental damage with high indexes of pig activity.

ECOLOGICAL IMPACTS

Pig rooting, trampling, and wallowing causes considerable soil disturbance and vegetation damage in some habitats (Bratton 1975, Ralph and Maxwell 1984, Singer et al. 1984, Stone 1985a). Pig rooting has been linked with reductions in understory plants (Bratton 1975, Singer et al. 1984) and declines of some surface dwelling vertebrates (Singer et al. 1984) in hardwood forest stands in southeastern USA. Feral pigs are the current major modifiers of Hawaiian forests (Stone 1985a). Pigs reduce the distribution and density of certain plants, particularly native ferns and certain other plants such as mints and orchids, and can affect forest composition, growth forms, and succession over large areas. Pig activity also enhances alien plant ingress into native ecosystems by creating open habitat through digging up, eating, and trampling native forest cover, by transporting alien plant propagules in their feces and pelage, and by increasing soil fertility via their droppings.

The extent and degree of damage that pigs cause in native forest ecosystems on Guam has not been studied. General observations and pig activity surveys indicate that wallowing, rooting, and trampling are common around much of the island (Fig. 14). Localized damage can be quite severe. A large complex of wallows and feeding area near Tarague Beach on AAFB measured in excess of 2.3 ha (Fig. 14). As is typical of damage that pigs can cause, this site was stripped of its ground cover, the soil was exposed to erosion, and no tree or shrub seedlings were regenerating. Evidence of pig damage has been observed in forests on Naval Magazine, NAVCAMS, Naval Facility, and AAFB. Less severe damage to forest and grasslands has also been observed on Government of

A

B

Figure 14. Photographs of understory vegetation damage in secondary limestone forest at the Conventional Weapons Storage Area (A) and in an abandoned coconut plantation (B) near Tarague Beach.

Guam Conservation Reserves at Anao Point, Mt. Bolanos, and Cotal in Yona. Deer and pig browsing on the seedlings of *Serianthes nelsonii* is also thought to be a factor in this endangered species' decline (USFWS 1987).

Pigs also damage agricultural crops on Guam. Over the past eleven years, GDOA has issued an average of 5 permits per year to control depredation on agricultural crops, particularly watermelon and taro. No doubt more farms sustain damage that goes unreported. Other crops damaged include honeydew melon, pineapple, cantaloupe, and tapioca. Damage to agricultural crops has been reported in Inarajan, Malojloj, Dandan, Talofofo, Bubulao, Yona, Barrigada, Dededo, and Yigo. Most recent complaints come from farmers in Dandan and Yigo. Pigs also cause damage in residential areas by rooting up lawns and gardens; this kind of damage has occurred at NAVCAMS housing at South Finegayan, AAFB housing, and the golf course on AAFB.

MANAGEMENT

Overall Management Strategy

The wild pig on Guam is a prolific renewable natural resource that provides a great deal of recreational hunting and meat for island sportsmen, but it can also cause extensive damage to native forests when it occurs at moderate to high densities. The strategy for managing this species is to maintain pig densities at a level to prevent serious large scale damage to native flora and fauna and agricultural resources. Certain areas on the island should be managed as native ecosystems and complete eradication or control of wild pigs will be necessary in these natural areas. The primary method to control pigs will be through recreational hunting. Additional methods of take will probably be necessary to completely eradicate or achieve a high level of control in these areas.

The second goal of management is to provide recreational hunting for island sportsmen. The need to control pig damage throughout most forested areas of the island should increase recreational hunting opportunities in the immediate future. Additionally, certain areas should be designated as wildlife management units and managed for increased recreational hunting. In such areas, efforts will be made to increase the quality of the hunting experience by managing pig populations to produce healthy animals for meat production and desirable trophies. Measures such as creating water developments and planting native fruit bearing trees in wildlife food plots are examples of management efforts that can be implemented to improve the quality of the game animal. The Cotal and Y-Piga Territorial Conservation Reserves are likely candidates for such habitat management.

The third goal in wild pig management is to work with private land owners, other Government of Guam departments, and the various military bases to identify and establish additional areas for recreational hunting. The Division is currently working with all military bases on the island to establish a program of scientific management for the wildlife species on their bases and to increase recreational hunting opportunities for residents. Similarly, efforts should be made in the near future to develop access to private land for sportsman. A number of approaches appear fruitful. The Guam Land Conservation Act, 5GC § 12600-12630, provides a process where private land owners can be compensated through a reduction in property taxes for putting their land into an agricultural preserve that open to public hunting. The law offers participants a deferral of 50% of the assessed value of their land in calculating property taxes.

Another measure that the Department of Agriculture can take to encourage more access to private lands is to sponsor legislation that would lessen the burden on private land owners that cooperate in the program. Appropriate legislation could include protection from liability for landowners that allow recreational use of their property without charge and legislation or regulations that strengthen measures to protect participating landowners from trespass and vandalism. In concert with the above efforts, the Division of Aquatic

and Wildlife Resources should undertake an aggressive educational and promotional campaign to sell the idea of a sportsman/landowner program and to improve the outdoor sportsmanship and ethics on the island. A cooperative working relationship already exists between the Division of Aquatic and Wildlife Resources, the Guam Soil Conservation Districts, Agricultural Extension Agents, and Sportsman's Clubs on Guam. These ties can be expanded to establish a landowner/sportsman program on Guam. The expertise in the various agencies and organizations involved should be able to develop a workable program that will meet the differing needs of both the landowners and sportsman on the island and promote greater public recreation.

Pig Hunting Regulations

Laws and regulations governing the harvest of wildlife on Guam have been in effect from as early as 1802 when Spanish administrators placed a prohibition against killing deer (Haswell 1917). Regulations specifically authorizing the harvest of wild pig have existed since the early American period in 1903 (U.S. Navy General Order No. 61). The tone and intent of early regulations treated the pig as an unprotected pest species and encouraged its control.

Public Law 6-87, promulgated in 1962, gave the Guam Department of Agriculture the authority to regulate hunting and fishing on the island and protected all wild animals with the exception of certain species such as the wild pig, which were classified as "unprotected wild animals". The hunting of pigs remained unrestricted through 1965 when Public Law 8-43 removed the wild pig from the unprotected list and made it a regulated game species. Department of Agriculture Regulation No. 25, promulgated in 1967, established a year-round season for wild pigs and established bag limits of one animal per day and no season limit. These restrictions stayed in effect until 1973 when the season was shortened to October-December (DOA Regulation No. 38). In 1978, bag limits were reduced to one pig per day and 10 per season (DOA Regulation No. 41).

Increasing pig populations warranted liberalized regulations in the 1980s. In 1983, the season was lengthened to October-March and hunters were allowed to kill two pigs per day and 20 per season (DOA Hunting Regulations, adopted June 24, 1983). Regulations were further liberalized in 1984 to year-round hunting in southern Guam and hunters could kill 30 pigs per season (DOA Hunting Regulation, Adopted September 20, 1984). The most recent regulations adopted in 1987 permitted year-round hunting over the entire island and set bag limits of 2 pigs per day and 40 per season (DOA Hunting Regulation, Adopted March 28, 1987).

Harvest Statistics and Hunter Habits

Pig hunting has long been a popular pastime with island sportsman. Between 300-600 hunting licenses have been sold annually on Guam since 1976 and 60-90% of those hunters that actively hunt report they hunt pigs (Fig. 15). Pig hunting appears to be gaining in popularity on the island. After a period of fluctuation during 1976-1981, participation has remained fairly stable at 80-90% of the active hunting public since 1984. The effort spent hunting pigs has also increased dramatically over that period from 1,256 eight-hr. days in 1976 to 5,444 eight-hr. days (8,710 hunter-days) in 1986 (Fig. 16). Hunter success has also increased from 40-56% during 1976-1982 to between 70-75% since 1986 (Fig. 17). With greater participation and success, annual harvests have increased nearly 600% from 217 pigs in 1976 to 1,273 pigs in 1986 (Fig. 18). Pig hunting is far more productive than deer hunting. In 1987, Guam hunters spent 8 days hunting per pig taken versus 123 days hunting per deer taken (DAWR 1987).

A harvest questionnaire distributed in 1986 queried island sportsmen about their hunting habits (DAWR 1986, 1987). Approximately 75% of the island's pig hunters reported they hunt with a shotgun. Archery hunting is next in popularity being used by

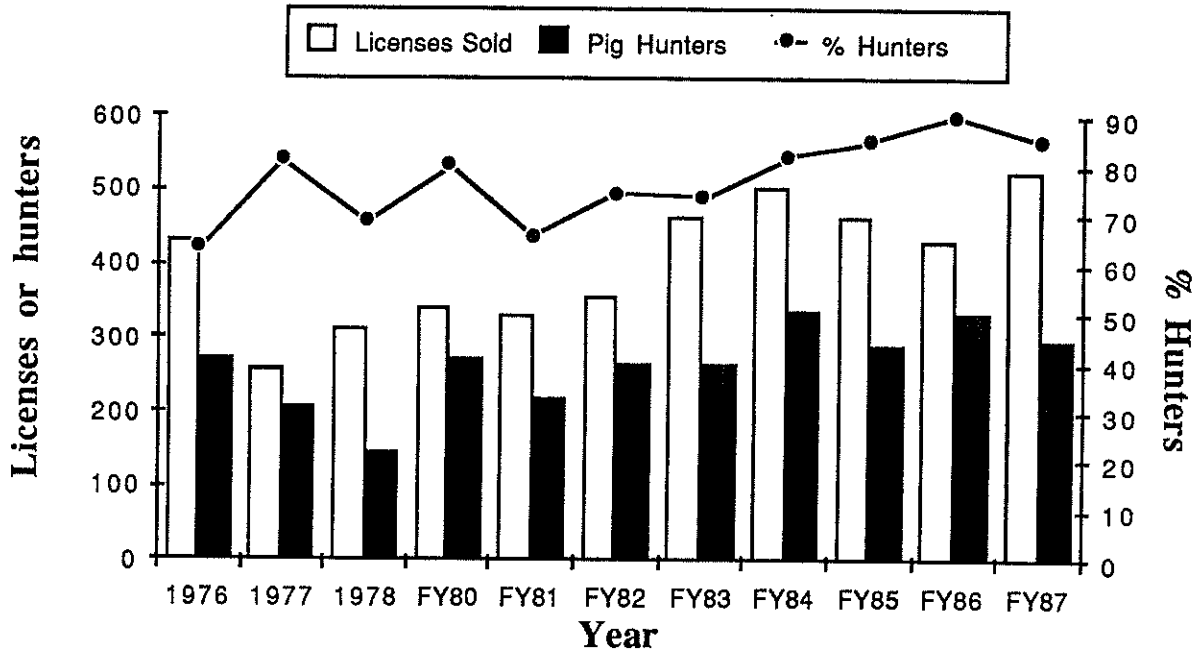


Figure 15. Number of hunting licenses sold, number of hunters that hunted pigs, and percentage of active hunters that hunted pigs on Guam during 1976-1987.

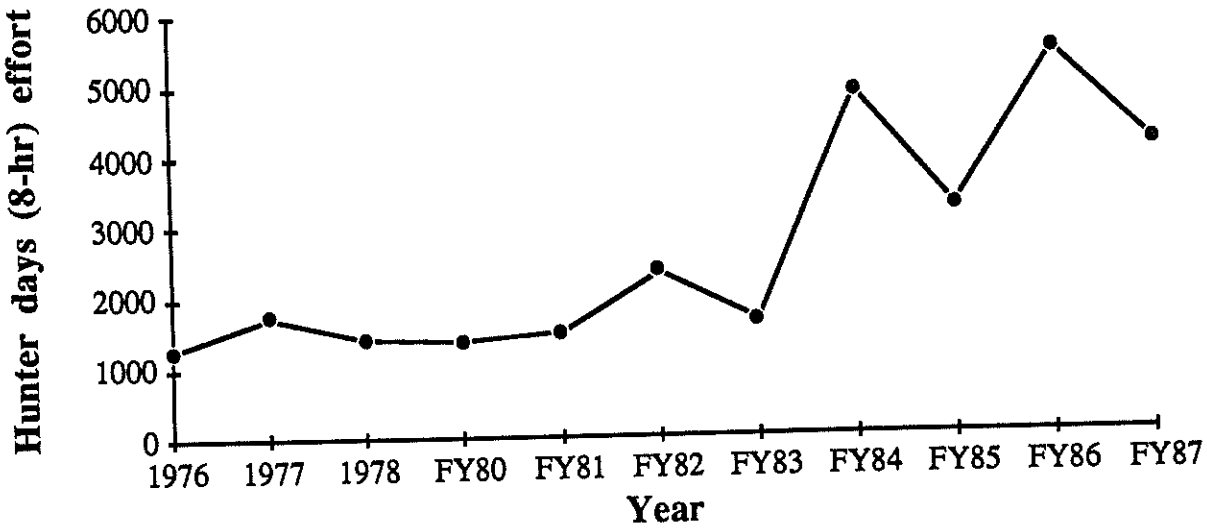


Figure 16. Estimated total annual effort spent hunting pigs by licensed hunters on Guam during 1976 - 1987 based on hunter questionnaire data.

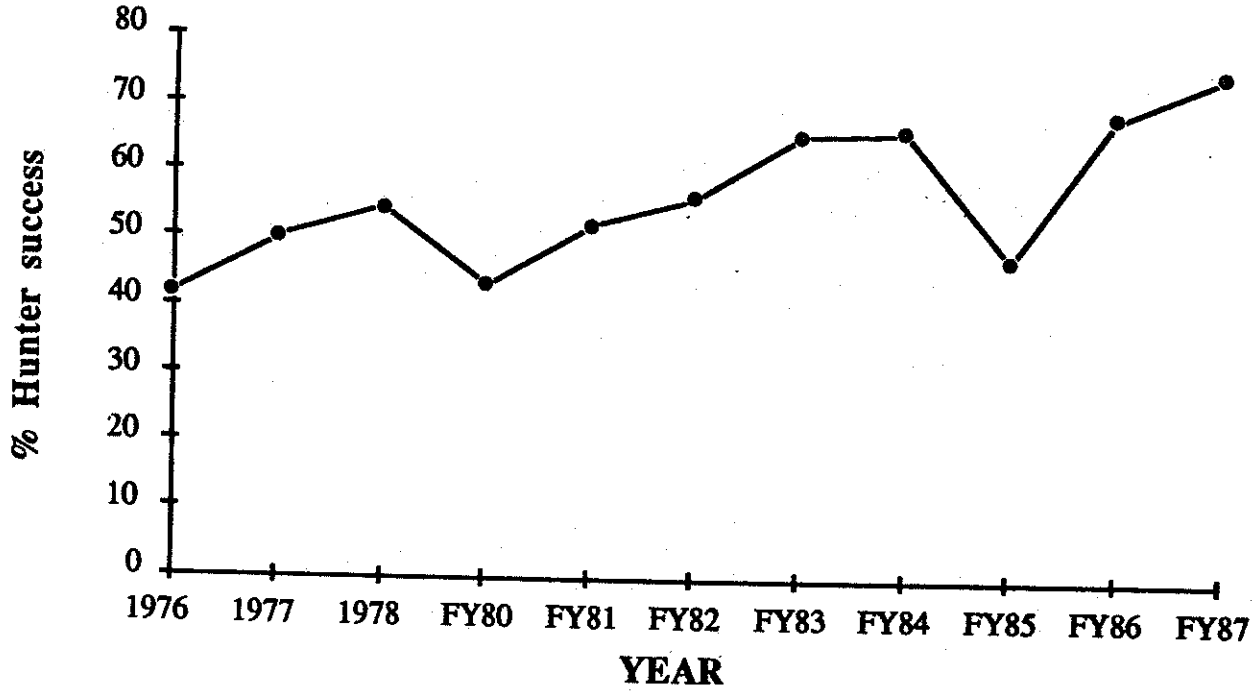


Figure 17. Trend in pig hunter success (i.e., the percent of hunters taking ≥ 1 pig per year) on Guam during 1976 - 1987.

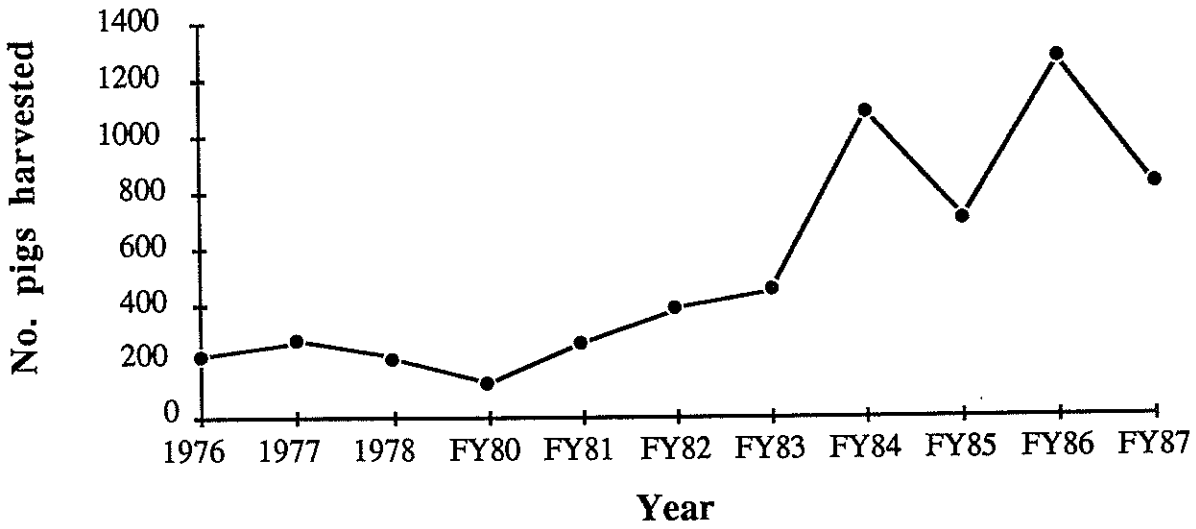


Figure 18. Estimated number of pigs harvested annually on Guam during 1976 - 1987 based on hunter questionnaire data.

21% of the reporting hunters. Handguns and rifles were used by fewer hunters, 14% and 4% respectively.

Most pig hunters report they hunt during the combined pig and deer season in October-December. Interest declines after the close of the deer season and 55% of those hunters that hunted at the beginning of the season continue to hunt pigs during January-March. Interest declines further after March and only 16% of the hunters that hunted at the start of the season hunt during April-September.

Twenty-one percent of the pig hunters responding to a harvest questionnaire (DAWR 1986) claimed to have taken at least one daily limit of two-pigs during the 1986 season. A few reported they took daily limits on a number of occasions. One percent of the island's pig hunters claim they killed their full season quota of 30 pigs in 1986.

The military bases on the northern end of the island are the most popular areas in which to hunt. Based on a 1984 hunter questionnaire, 51% of the island's pig hunters hunted at Northwest Field, 43% hunted at NAVCAMS, and 3% hunted at Naval Facility (DAWR 1984). These areas support some of the heaviest hunting pressure on the island. Hunting effort has varied from 720 hunter-days (1,470 hunter-sorties) in 1981 to 2,549 hunter-days (3,772 hunter-sorties) in 1987 (Fig. 19). Private property was hunted by up to 20% of the island's hunters and the Cotal, Anao, and Bolanos Territorial Conservation Reserves were hunted by between 5-15% of the responding hunters.

In general, access to hunting areas is a problem for all but a few hunters who have large private land holdings. Guam law requires that hunters obtain written permission prior to hunting on private property. The Government of Guam owns land that can be hunted by the public, notably the Anao, Cotal, and Bolanos Conservation Reserves. These and other government lands are open year-round to hunting but are often not clearly marked or adequately advertised. In addition, public lands are often land-locked by military or private holdings without marked boundaries, making ownership difficult to determine. On private land, there has been little interest on the part of private land owners to allow recreational hunting for the public. Because of these difficulties, many hunters chose to hunt on the military bases where hunting areas are clearly marked.

Northwest Field and NAVCAMS are popular hunting areas with island sportsman because of their established hunting program, large forested areas open to hunting, and abundance of pigs and deer. Both bases have hunting programs open to the public and can accommodate large numbers of hunters. Both areas have also produced large harvests of game in the past 10 years. For many hunters that do not have access to private property or know how to find Government of Guam land, military bases are the only lands available to hunt.

DISEASE

Wild pigs are carriers of serious diseases of public health and agricultural concern. Brucellosis, trichinosis, and leptospirosis have been confirmed in wild pigs on the island of Hawaii, with brucellosis infection rates of 60% of all animals examined from some areas (Giffin 1978). Hunters and their hunting dogs may be vulnerable to these diseases because of their close contact with wild game (Giffin 1978).

Little work has been done to screen wild pig populations for diseases on Guam. Four cases of brucelosis have occurred in the public over the past 15 years but none were linked with wild game. Leptospirosis is present in animal reservoirs on the island, primarily domestic dogs, but at relatively low levels (Ryu and Haddock 1972). Wild pigs are not considered a serious public health threat at present (pers. commun., Dr. R. Haddock, Territorial Epidemiologist).

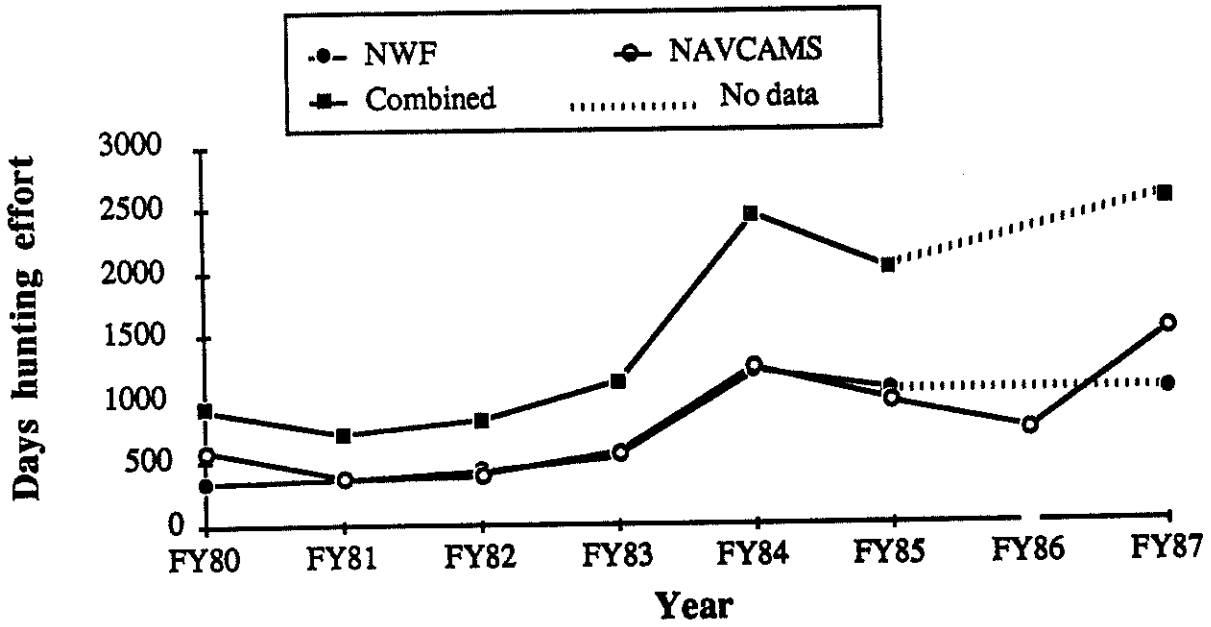


Figure 19. Hunting effort at military bases in nothern Guam during 1980 - 1987 based on mandatory hunter log books from each base.

PARASITES

Wild pigs necropsied at hunter check stations were grossly examined for ectoparasites and endoparasites. Most pigs had light to moderate numbers of the common cattle tick (*Boophilus annulatus*). Some individuals in poor condition exhibited extremely heavy infestations (Fig. 20). This tick is also a common pest of sambar deer (Wheeler 1979).

Internal parasites appeared to be a particularly severe problem in most pigs examined. Kidney worms (*Stephanurus dentatus*) occurred in most (88%, n=26) individuals over 6 months of age and were the most prevalent endoparasite found (Fig. 21). Kidney worms produce lesions and inflamation of the perirenal tissues, fibrosis of kidney, enlargement of ureters, enlargement of lymph glands, severe scarring in the liver, cirrhosis of the liver, and ascites (Lindquist 1964, Jones and Hunt 1983). The route of infection can be through penetration of the skin or oral ingestion of larvae (Lindquist 1964, Jones and Hunt 1983). The infective larvae of this parasite are vulnerable to changes in temperature, direct sunlight, and unusually dry conditions (Jones and Hunt 1983). Earthworms can serve as transport hosts for larvae, increasing the survivability of larvae during dry periods (Soulsby 1982).

Another common endoparasite of wild pigs was the lung worm (*Metastrongylus* sp.). Lung worms were usually found in the extremities of the lungs where they form hardened whitish plugs that blocked the distal bronchioles of the lung. Severe cases of lung worm infestation can cause a parasitic pneumonia that may be a serious problem in young animals (Lindquist 1964). *Metastrongylus* have an indirect life cycle that require earthworms (Soulsby 1982, Jones and Hunt 1983). Adult worms produce eggs and larvae in the lungs of the host that are coughed up by the infected animal, swallowed, and passed out of the body in the feces. The eggs or larvae are then picked up by earthworms that in turn are consumed by pigs, thus reinfecting the primary host (Lindquist 1964, Jones and Hunt 1983, Soulsby 1982). The eggs and larvae of this parasite are also vulnerable to environmental stresses such as temperature changes, direct sun light, and dry conditions (Lindquist 1964). Infective larvae can remain viable in earthworms for up to seven years (Soulsby 1982). Whipworms (*Trichuris suis*) and ascarid worms (*Ascaris lumbricoides*) have also been identified from wild pigs on Guam (Pers. commun., Dr. W. Mestanza, Territorial Veterinarian).

A team of U.S. Army Veterinarians examined 18 wild pigs killed by hunters at Northwest Field in 1987 and also found high infection rates of internal parasites (Pers. commun., Dr. L. E. Norman, U.S. Army Veterinarian Corps). Fifty percent of the animals examined were infested with kidney worms and 72% had lung worms. Lung damage was evident in 89% of the pigs examined, 83% had abnormal livers, 56% had extensively damaged livers, and 67% had abnormal kidneys. Roundworms were found in the stomach and intestines of five individuals and ova of unidentified hookworms and whipworms were found in two specimens. They concluded that wild pigs on Guam suffered from large parasitic burdens of lung and kidney worms.

In general, the parasite load observed in wild pigs on Guam caused a overall unthriftiness and probably made the host suceptible to mortality due to disease and other environmental stress. However, some pigs did develop parasite loads that were in themselves life threatening. Three animals were found dead of causes that probably resulted from heavy infestations of parasites. These animals were severely emaciated and had developed other complications as a result of chronic internal parasitism. In one case, kidney worm infestation was so severe that the ureters were blocked, the bladder and kidneys were enlarged, the bladder engorged with urine, and the animal was diagnosed as having died of uremia (Pers. commun., W. Mestanza, Territorial Veterinarian). The pigs in the other two cases died of verminous pneumonia caused by lung worms with verminous ureteritis, and fibrosis of liver related to kidney and lung worm infestation.

The annual loss to parasites and disease on Guam is unknown but may be a

A

B

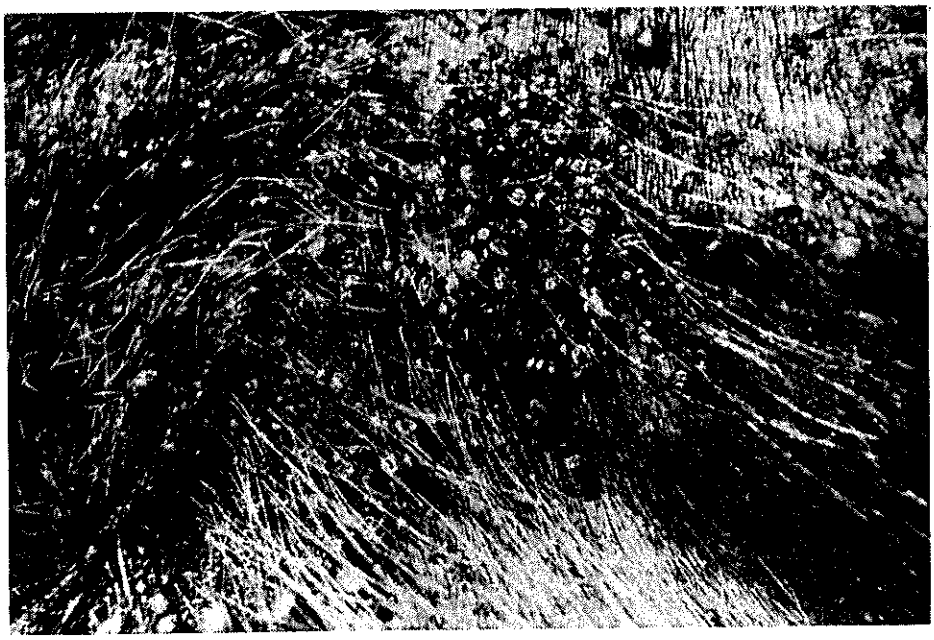


Figure 20. Photographs of a wild pig (A) with heavy tick infestation (B) harvested from Northwest Field.

Figure 21. Photograph of a kidney worm (*Stephanurus dentatus*) extracted from the perirenal tissue of a wild pig harvested at Northwest Field.

significant factor limiting the population, particularly where high densities of pigs occur. Giffin (1978) reported 13 types of internal and external parasites from wild pigs in Hawaii, with lung worms, intestinal worms, kidney worms, louse fleas and mites being the most common. He concluded that parasites did not seriously affect the health of host animals but may have contributed to mortality by lowering resistance to disease. Barrett (1978) reported a similar incidence of parasites in feral hogs in California but found no instances where parasite loads were so great that they were an important mortality factor. However, he believed that parasites could become a significant mortality factor in times of high densities and poor food availability.

The high occurrence of earthworms in the diet on Guam appears to have a link with the high incidence of internal parasites in wild pigs. Earthworms serve as a transport hosts for the kidney worm and an intermediate host for the lung worm. This food item likely facilitates the spread of both parasites through the population.

RECOMMENDATIONS

Although the wild pig has been the object of study on Guam for over 20 years, there is still much that is not known about its impact on the native forest ecosystem and how to best manage this resource. The most urgent need is to initiate studies of the impact of this species on the forest ecosystem and take measures to control damage that is now occurring. There is also a need to provide for increasing demand for the recreational use of this natural resource and obtain additional biological data for its management. It is recommended that the following measures be implemented to meet the management needs of this species.

1. Build exclosures to determine the extent and degree of vegetation damage that is caused by pigs in native forests.

2. Eradicate or control wild pigs in certain natural areas, conservation reserves, or other designated areas to prevent damage to native forest ecosystems. Control measures that may be necessary include recreational hunting and bounty hunting, and the use of snares, traps and toxicants. In areas where complete eradication is the goal, fences should be built to prevent immigration of pigs. All or parts of the Pati Point Natural Area Reserve, Haputo Ecological Reserve and the adjacent Government of Guam land at Falcona Beach, Anao Conservation Reserve and the adjacent Government of Guam land south to the Marbo Cave area, and the Almagoza Springs area of Naval Magazine are recommended for fencing and eradication of pigs. A high level of control is recommended where fencing is impractical.

3. Establish game management areas that will be managed for recreational hunting. Such areas should be managed to provide sustained recreational hunting and a desirable trophy. Existing hunting areas on Northwest Field, NAVCAMS, and Naval Facility and the Cotal and Bolanos Territorial Conservation Reserves are recommended for designation as such management areas.

4. Work with private land owners, other Government of Guam departments, and the various Military Commands to identify and establish additional areas to be management for recreational hunting.

5. The Department of Agriculture should sponsor legislation that would protect from liability those landowners that allow recreational use of their property without charge. Additionally, the Department should sponsor legislation or promulgate regulations that would strengthen measures to protect participating landowners from trespass and vandalism.

6. Continue surveys to monitor relative abundance and distribution of pig sign in selected habitats.

7. Investigate the relationship between hunting intensity and relative occurrence of pig sign and damage. A series of surveys in areas that are heavily hunted, lightly hunted,

and unhunted would provide comparative data on the level of hunting necessary to control pigs.

8. Continue investigations of wild pig biology. Focus on topics such as home range size, movements, and habitat use.

9. Continue to collect data on hunter effort and harvest in selected hunting areas and for the entire island. Relate harvest data to other indexes of pig population such as distribution and abundance of pig sign and vegetation damage.

10. Further investigate the incidence of disease and parasitism in wild pigs. Continue to conduct hunter check stations at Northwest Field and expand the program to include inspection of animals from other areas on the island.

11. Implement changes in hunting regulations to increase harvests of pigs. Suggested changes include the following:

a. Allow hunting with dogs during January-September.
b. Allow harvest via snares and live traps in selected areas that are closed to recreational hunting. This will involve the creation of a new type of license and license fee.
c. Liberalize bag limits to accommodate higher daily harvests with snares or live traps.

SUMMARY

Although commonly referred to as the wild pig or "Babui'n halomtano" (literally translated as "pig of the jungle"), the pig on Guam is the descendant of domestic stock brought to the island by the Spaniards. Early Spanish colonizers probably introduced pigs to the Marianas between 1672 and 1685 with the original stock thought to be domestic *Sus scrofa* from the Philippines. By 1772, a large feral population existed in forested areas of the island.

The feral pig on Guam displays characteristics of the Eurasian wild boar and domestic pig. Black is the dominant color (76%) but other combinations of brown, white, and red also occur. Adult males typically weigh between 23-55 kg and have body lengths between 117-165 cm. Adult sows weigh between 23-42 kg and have body lengths between 112-146 cm. A specimen of 139 kg has been verified by DAWR staff. Both sexes possess enlarged tusks in the upper and lower jaws. Tusks become particularly long in adult males and are highly prized as trophies by sportsmen. In a sample of 22 adult males, lengths of lower tusks varied from 0.5 to 9.0 cm. A large specimen in the DAWR collection had tusks that measured 9.2 cm.

Reproductive biology was studied on free-ranging and captive animals. Captive boars showed signs of sexual maturity at 6-7 months of age and bred successfully at an average age of 8.3 months (range = 7.8-11.1). Captive sows showed signs of sexual maturity at 5.6-7.8 months and bred successfully at an average age of 10.1 months (range = 6.8-21). The estrous cycle in captive sows varied from 18 to 25 days and averaged 20 days. Some free-ranging sows successfully bred as early as 6-9 months of age and most are probably pregnant by 9-10 months of age. The gestation period for captive sows varied from 112 to 115 days and averaged 113.5. The minimum birth interval is approximately 240 days if litters are weaned at 3 months or 270 days if litters are weaned at 4 months. Once reproductively active, sows can produce 3 litters every 2 years.

Litters were born throughout the year with two major peaks in activity, at the end of the dry season in April-May and at the end of the wet season in December. Prenatal litter size averaged 4.9 fetuses (range = 1-9) and did not significantly differ from litter size, which averaged 5.0 young (range = 1-10). The fetal pregnancy rate was 64.8% and intrauterine mortality 35.2%. Postnatal litters averaged 3.7 piglets (range of 1-6) suggesting a minimum mortality rate of 26% for piglets prior to weaning.

Certain areas of limestone forests in northern Guam support exceptionally high

densities, biomass, and harvests of pigs. Annual harvest at Northwest Field and NAVCAMS varied from 45 to 329 pigs during 1980-1987 and represented harvest density of 3.0-21.9 pigs/km^2. Harvest densities were generally higher at NAVCAMS (3.8-29.2 pigs/km^2) than Northwest Field (1.7-18.5 pigs/km^2). Estimates of population density for combined area of NAVCAMS and Northwest Field derived from harvest densities varied from a low estimate of 6 to 44 pigs/km^2 to a high estimate of 15 to 110 pigs/km^2. Densities at NAVCAMS may have reached 146 pigs/km^2 in 1987. Harvest biomass was estimated from harvest data and reached 877 kg/km^2 at NAVCAMS. Based on the high density estimate, biomass may have reached 4,387 kg/km^2 at NAVCAMS in 1987.

Pig numbers appear to have increased dramatically since 1980. Annual harvests on Northwest Field and NAVCAMS increased from an average of 67.5 (range = 45-90) pigs during 1980-1983 to 314.7 (range = 291-329) pigs during 1984-1987. The amount of effort expended per pig harvested decreased from 14.1 (range = 9.2-20.5) days/pig during 1980-1983 to 7.4 (range = 6.9-7.9) days/pig during 1984-1987, a further indication of increasing populations. This trend was consistent in data from the entire island.

Selected habitats on Guam had far higher indexes of pig sign than other locations. Some type of sign, either fresh or old, occurred in 79% of plots sampled in forested habitat at Northwest Field, 40% of plots in savanna habitat at Cross Island Road, and 14% of plots in mixed savanna-agricultural habitat at Dandan. Rooting was the most commonly encountered fresh sign in all habitats, trails and scats were the second and third most common, and wallows the least common type of sign encountered. General observations indicate that rooting and wallowing are common in most forested areas and can be quite severe locally. Controlling the effects of pig damage has been recognized as an important measure to protect native forest ecosystems.

Fruit was the most important component of the diet of wild pigs on Guam and it occurred in 100% of the stomachs examined. Fruits consumed included Indian mulberry, pandanus, coconut, breadfruit, tangantangan and *Passiflora suberosa*. Leaves occurred in 100%, grass in 50%, bark in 45%, and roots in 23% of the stomachs examined. Animal matter occurred frequently in the diet but comprised only a small portion by weight. Invertebrates that were consumed included earthworms, various insects, and land snails. A skink tail and unidentifiable tissue, possibly carrion, were the only vertebrate matter found in the diet. Earthworms occurred in 55% of the stomachs examined. Because earthworms can be an important intermediate host of kidney worms and lung worms, they may be an important link in the high incidence of these parasites in Guam's wild pigs.

Harvest statistics compiled since 1976 provided information on hunter participation, effort, harvest, and habits of island sportsmen. Between 80-90% of Guam hunters hunt pigs and between 60-75% of those hunters are successful in harvesting one or more pigs. Effort during the past five years has reached 5,444 eight-hr. days (8,710 hunter-days). Effort per harvest varied between 3.5-5.0 days/pig. Northwest Field and NAVCAMS are the most popular areas to hunt followed by private property and Government of Guam Conservation Reserves.

Little work has been done on the incidence of infectious disease in wild pigs on Guam and wild pigs are not currently considered a serious public health threat. Infestations of internal parasites appear to be severe problems in wild pig populations on the island. Kidney worms and lung worms infest all ages from 6-9 months to adults and occasionally cause lung, liver, and kidney damage that may be fatal. The common cattle tick is a common ectoparasite of pigs but does not appear to have a serious effect on individuals health or well being.

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