

Manis pentadactyla. By Martha E. Heath

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***Manis* Linnaeus, 1758**

- Manis* Linnaeus, 1758:36. Type species *Manis pentadactyla* Linnaeus.
- Pangolinus* Rafinesque, 1821:214. Type species *Manis pentadactyla* Linnaeus.
- Phataginus* Rafinesque, 1821:214. Type species *Manis tricuspis* Rafinesque.
- Phatages* Sundevall, 1843:258. Type species *Manis laticaudata* Illiger (= *Manis crassicaudata* Gray).
- Smutsia* Gray, 1865:369. Type species *Manis temminckii* Smuts.
- Triglochipholis* Fitzinger, 1872:65. Type species *Manis tricuspis* Rafinesque.
- Paramanis* Pocock, 1924:722. Type species *Manis javanica* Desmarest.
- Uromanis* Pocock, 1924:722. Type species *Manis longicaudata* Brisson (= *Manis tetradactyla* Linnaeus).

CONTEXT AND CONTENT. Order Pholidota, Family Manidae. There are seven extant species of *Manis*, three Asian and four African (Simpson, 1945; Ellerman and Morrison-Scott, 1951). Pocock (1924) suggested the species represented three subfamilies and six genera, but Emry (1970) and Patterson (1978) feel this division is excessive. These latter investigators agree that the Asian and African pangolins differ enough to warrant subdivision at either the subfamily or generic level. Also, the differences between the African tree pangolins and ground pangolins warrant further subdivision at the generic or subgeneric level (Patterson, 1978). This account follows the convention of assigning all seven species to the genus *Manis*. A key to extant *Manis* follows:

- 1 Ear pinna present; hair bristles occur between scales; dorsal medial row of scales extends to end of tail; fifth digit of hind foot as large as first digit; xiphisternum relatively short and expands into spade-shaped plate Asian species 2
- Ear pinna absent; no hair between scales; dorsal medial row of scales splits in tail region into two rows of alternating asymmetrical scales; xiphisternum elongated dividing into two branches and extending to the level of the caudal ribs African species 4
- 2 Ear pinna pronounced; no pads on soles of forefeet; tail length divided by total length <0.42; dorsal scales well separate from nostrils; depression in skin caudal to anus; narrowing near distal end of tail *M. pentadactyla*
- Ear pinna small; no depression in skin behind anus 3
- 3 Tail ends in a scale *M. crassicaudata*
- Ear pinna only ridges; pads on soles of forefeet; tail ends in an unscaled fleshy pad; tail length divided by total length >0.42; dorsal scales extend almost to nostrils *M. javanica*
- 4 Tail longer than head and trunk combined; first digit of fore and hind limbs smaller than fifth digit; tail ends in unscaled terminus; hair is present on upper sides of feet; lacrimal bone present; epitympanic recess inflated laterally and posteriorly in the squamosal bone 5
- Tail shorter than head and trunk combined; first and fifth digits of hind limb are of similar size; tip of tail not naked on lower surface; upper surface of fore feet scaled to claws 6
- 5 Scales on shoulder are few and large; 10-13 rows on body; tail about twice as long as head and body; belly dark brown *M. longicaudata*
- Scales on shoulder are many and small; 19-32 rows on body; tail about 1.5 times the length of head and body; belly white *M. tricuspis*
- 6 Entepicondylar foramen of humerus absent; head and body <700 mm; tail <700 mm (Meester, 1971); tail tip rounded; 11-13 rows of body scales; mass <18 kg *M. temminckii*

Head and body >700 mm; tail >500 mm; tip of tail pointed; 17 rows of body scales; 15-18 scales on margin of tail; mass >18 kg *M. gigantea*

***Manis pentadactyla* Linnaeus, 1758**

Chinese pangolin

- Manis pentadactyla* Linnaeus, 1758:36. Type locality, Formosa (=Taiwan).
- Manis brachyura* Erxleben, 1777:98. No locality given, but presumably Formosa (=Taiwan).
- Manis auritus* Hodgson, 1836:234. Type locality, Nepal.
- Manis (Pholidotus) dalmanni* Sundevall, 1843:256. Type locality, near Canton, China.
- Pholidotus assamensis* Fitzinger, 1872:49. No locality given, but presumably India: Assam.
- Phatages bengalensis* Fitzinger, 1872:72. No locality given, but presumably India: Bengal.
- Manis pusilla* J. A. Allen, 1906:465. Type locality, Hainan Island, China.
- Pholidotus kreyenbergi* Matschie, 1907:234. Type locality, Nanking, Kiangsu, China.

CONTEXT AND CONTENT. Context in generic account above. Three subspecies are recognized (Ellerman and Morrison-Scott, 1951):

- M. p. aurita* (Hodgson, 1836:234), see above (*auritus* Hodgson, *dalmanni* Sundevall, *assamensis* Fitzinger, *bengalensis* Fitzinger, and *kreyenbergi* Matschie are synonyms), from mainland Asia.
- M. p. pentadactyla* (Linnaeus, 1758:36), see above (*brachyura* Erxleben and *pentadactyla* Linnaeus are synonyms), from Formosa.
- M. p. pusilla* (Allen, 1906:465), see above, from Hainan Island.

One contradiction to the reported distribution of subspecies is a specimen (115628) at the American Museum of Natural History that is identified as *M. p. aurita* and reported as being from Formosa.

DIAGNOSIS. *Manis pentadactyla* is distinguished from the other Asian species by larger ear pinna, a post-anal depression in the skin, and a narrowing near the distal end of the tail (Pocock, 1924). *M. pentadactyla* has smaller scales than *M. crassicaudata* (Jentink, 1882), and lacks the pads on the soles present in *M. javanica*. These are important distinctions since the range of *M. pentadactyla* partially overlaps that of the other two Asian species.



FIG. 1. Adult male pangolin from China. Photo by S. L. Vanderlip, taken at University of California, San Diego.

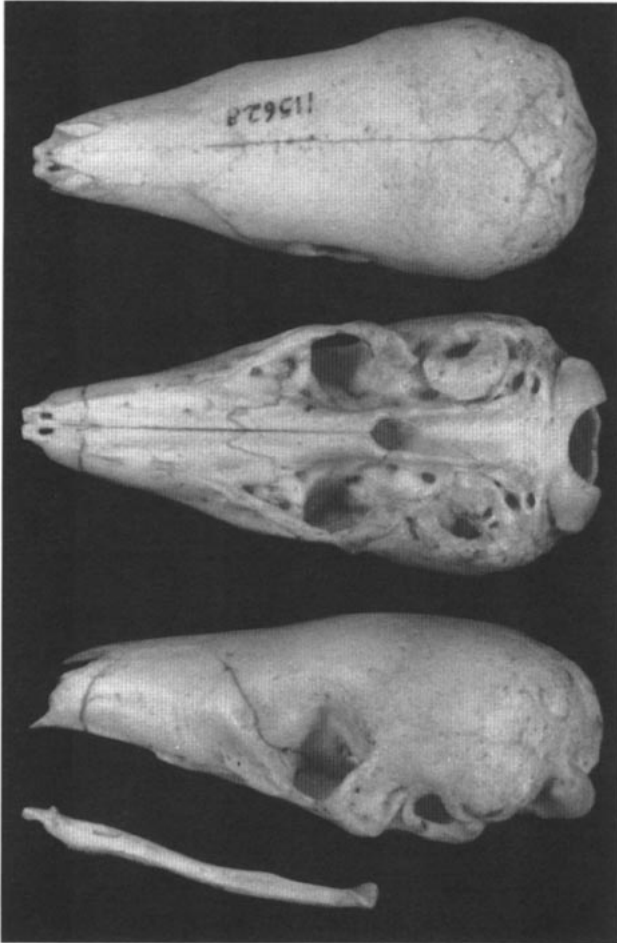


FIG. 2. Dorsal, ventral, and lateral views of the cranium, and lateral view of the mandible of a female *Manis pentadactyla* (American Museum of Natural History, New York, 115628, from the east coast of Formosa). Greatest length of the cranium is 83.6 mm.

GENERAL CHARACTERS. *Manis pentadactyla* (Fig. 1) has a streamlined elongate body and tail covered with large (2–5 cm diameter), rounded, overlapping scales formed from fused hair. Scales are dark brown or yellow-brown in color and cover everywhere except the ventral head and trunk and the inner surface of the limbs, and the foot pads. Chinese pangolins roll into a ball as a defense. In this configuration all soft tissues are hidden or protected by scales (see Fig. 2 in Heath and Vanderlip, 1988).

Manis pentadactyla has anatomical adaptations for feeding on ants and termites. A tongue that is long (16–40 cm), thin, and conical is used to lap up prey into a toothless mouth (Fig. 2). The forelegs are powerful with long, robust claws, resembling those of anteaters from South America. The central three front claws are up to 5-cm long and used to tear apart ant and termite nests and to dig burrows. Chinese pangolins walk quadrupedally on their knuckles or wrists by curling their long front digging claws inward and backward. The shorter and stouter hindlegs have short claws. The long tail is thick, dorsally rounded and ventrally flattened, prehensile, and very muscular (Grassé, 1955).

Males are larger than females. Adult body mass ranges from 2.35 (young, sexually mature female) to 7.0 kg (fat male). Total length and tail length range from 545 and 260 mm (young female) to 795 and 347 mm (male; Heath and Vanderlip, 1988). Measurements (mm) of specimens from southeast Asia were: total length, 700–850 mm; length of tail, 280–340 mm; length of hind foot, 65–85 mm; and length of ear, 20–26 mm (Van Peenan et al., 1969).

DISTRIBUTION. *Manis pentadactyla* extends (Fig. 3) throughout the provinces in China south of the Yangtze River: Yunan, Guangxi, Guangdong, Hainan Island, Fujian, Zhijiang, Hu-

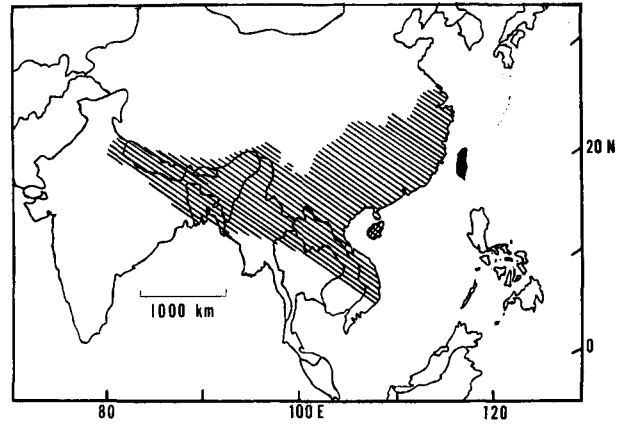


FIG. 3. The present distribution of *Manis pentadactyla* is represented by the hatched area. *M. p. aurita* occurs on mainland Asia (hatched shading); *M. p. pentadactyla* occurs on the island of Formosa (=Taiwan) to the east of China (shaded black); and *M. p. pusilla* occurs on Hainan Island to the south of China (cross-hatched shading).

nan, and Taiwan (Fang and Wang, 1980) and extends as far north as Kiangsu (Jiangsu) and the southern regions of Japan (perhaps meaning Taiwan which was once a part of Japan; Ellerman and Morrison-Scott, 1951). *M. pentadactyla* also occurs in northern India to the Himalayan foothills, Nepal, Sikkim, the Nega Hills in Assam, Pegu and Mount Popa in Burma, and in Laos (Ellerman and Morrison-Scott, 1951). *M. pentadactyla* is reported from northern regions of Vietnam, Laos, and Thailand (Lekagul and McNeely, 1977) and South Vietnam and southern Laos (Van Peenan et al., 1969; locality records: Quang Tri Province: Khe Sanh; Tuyen Duc Province: Riong Cohia). *M. pentadactyla* is sympatric with *M. javanica* in parts of the Malaysian peninsula (Lekagul and McNeely, 1977; Van Peenan et al., 1969) and with *M. crassicaudata* in northern India and Nepal (Van Peenan et al., 1969). There is no fossil record for *M. pentadactyla*.

FORM. Scales on the Chinese pangolin originate from their thick skin and continue to grow from the base throughout life, thereby compensating for wear at the outer edge. Trunk scales are arranged from the dorsal mid-line outward, scales on the forelegs are horizontal, and scales on the hind legs are vertical (Fang and Wang, 1980). The edge of the tail is defined by sharp scales folded along their mid-line. These pointed scales can injure anything trying to grasp the tail. The ventral surface of the head and trunk is covered with sparse white hair. The skin and scales make up about 25% of their total body mass (Kingdon, 1974) and thus represent a large investment physically and energetically. Scales provide little insulation or protection from external parasites, but require no grooming, and afford effective protection for the skin against scratches from underbrush or sharp rocks along burrow walls and from predators. Scale size, shape, and ridge pattern are different for each species of pangolin (Grassé, 1955; Kuehn, 1986). The number and pattern of scales on the tail, head, and trunk region vary intraspecifically (Jentink, 1882). *M. pentadactyla* normally have a layer of subcutaneous fat up to 1-cm thick (Fang, 1981). This could provide a significant degree of insulation. Chinese pangolins have anal glands which can exude an obnoxious odor (Grassé, 1955).

The head is cone shaped and small compared to the body. The eyes are very small and of limited use, but the olfactory sense is extremely good and used for spatial orientation and identification of prey. *M. pentadactyla* has well-defined pinna (Pocock, 1924).

The mouth of *M. pentadactyla* is small and toothless. They have only thin jawbones (Fig. 2). Prey are ingested with a long, thin, cone-shaped tongue that can be extended 8–10 cm beyond the lips. The tongue folds into a sheath in the throat when it is retracted. A complicated system of muscles controls tongue movement. The tongue divides caudally into two musculotendinous roots, the sterno-glossus, in the posterior part of the pharynx (Grassé, 1955; Kuehn, 1986). These roots start from a fibrous sheath that originates from the mylohyoid and runs adjacent to the esophagus and ends at the xiphisternum (Grassé, 1955; Griner, 1983). The spade-shaped xiph-

sternum is formed from the last pair of cartilaginous ribs, which have lost their attachment to the vertebra and migrated ventrally. Large salivary glands located in the pharyngeal and cervical regions extend almost to the shoulder. A tenacious mucus (pH = 9–10; Fang, 1981) secreted into the tongue sheath and onto the tongue helps to gather prey (Griner, 1983; Kuehn, 1986).

Food is macerated in the stomach which has two chambers. The first compartment makes up about 80% the total size, is thin-walled, and functions as a storage chamber. A gland of approximately 35 mm by 25 mm by 10 mm, located at the bottom of this chamber, secretes fluid (pH = 6) of unknown function (Fang, 1981; Gu et al., 1983). The second, smaller chamber has thick muscular walls with many rugae on the inner surface. A rough hard spherical tissue mass (described by the Chinese as litchi-like) near the upper part of the pylorus grinds or macerates food before it passes to the intestine (Fang, 1981; Grassé, 1955). About 0.5 kg of food was found in the stomach of a 4.5-kg individual (Fang, 1981).

The skull is conical (Fig. 2). The greatest length in specimens from southeast Asia was 85–95 mm (Van Peenan et al., 1969). Interparietal, jugal, and lacrimal bones are absent. Frontal bones are larger than the parietals. The nasals and supraoccipital are large, the palate is long and narrow, and the pterygoids are separate and external to the bulla. A small median vertical crest descends from the center of the lambdoid crest (Emry, 1970; Grassé, 1955). The lambdoid crest is present only posteriorly.

The orbital and temporal fossae are confluent. A foramen between the petrosal and basisphenoid traverses the median aspect of the otic cavity and through which the inferior petrosal sinus probably passes. Medially and anteriorly to this foramen is a groove that marks the path of the vidian branch of the seventh nerve (Emry, 1970).

The posterior lacerate foramen is slightly anterior and lateral to the condylar foramen. A groove marking the path of either the median entocarotid artery or the inferior petrosal sinus is clearly visible on the basioccipital. The median lacerate foramen is only a slit. The second branch of the trigeminal, which usually traverses the foramen rotundum (absent in *Manis*), traverses the anterior lacerate foramen in *Manis* (Emry, 1970).

The tympanic bone forms the bulla, which consists of loosely attached crescentic tympania. The small mandible is without angular processes and shows only slight contact with the ventro-medial aspect of the zygomatic process (Fig. 2; Emry, 1970). The zygomatic arch is incomplete, consisting of the maxillary bone, connective tissue bridge, and squamosal bone.

The *Manis* skull and its development are described by Parker (1885). A detailed comparison of skulls from the different extant species of pangolins is unavailable, however, Emry (1970) compared skulls and skeletal features between *Patriomanis*, an extinct pangolin genus, and *M. pentadactyla* and other extant *Manis* species.

Manis pentadactyla have 7 cervical, 16 thoracic, 6 lumbar, 3 sacral and 27 caudal, for a total of 59 vertebrae (Jentink, 1882). Lumbar vertebrae have well-developed concave zygapophyses anteriorly but supplementary articular process (Humphry, 1870).

The carpal and ray elements are in the usual number except that the scaphoid and semilunar bones are fused into a single scapholunar bone. The first phalanges bones are short and articulate closely with the second phalanges bones in the third and fourth digits. The terminal phalanges are long and bifid (Humphry, 1870).

The facial muscles of *M. pentadactyla* include seven associated with the auricle: auricularis superior, auriculo-occipitalis, auricularis anterior, and three unnamed muscles associated with the tragus, sphincter colli, and platysma. Three muscles are associated with the eye: orbicularis oculi, a muscle at the inner canthus that contributes to opening the eye-lid, and the orbito-auricularis (Imai, 1978).

The masseter has two bellies; the superficial containing 48 muscle spindles, and the profound containing 34 spindles. It arises from the incomplete zygomatic arch and passes ventrally and caudally to the mandible. The temporalis has small vertical belly containing 11 spindles. It begins at the posterior part of the zygomatic arch and the wall of the temporal fossa and inserts into the jaw bone above the mandibular foramen. The pterygoides lateralis lacks spindles and arises from the wall of the infratemporal fossa, passing caudally to the condyle. The pterygoides medialis is absent. The intermandibularis is devoid of spindles, but well developed and forms the floor of the mouth (Yeh, 1984). Spindles in the masticatory muscles show a tendency toward atrophy (Yeh et al., 1984).

The retractor plicae alaris and a dozen associated unnamed

muscles control the plica alaris, which is a fold of tissue in the nasal passage that closes during feeding to keep ants and termites out of the passage. The plica oralis and plica buccalis are two folds of skin in the oral cavity that inhibit the escape of ants or termites. Nine muscles control the plica oralis. Six muscles control the plica buccalis. In addition, eight muscles control the upper lip, seven control the lower lip, two control the corner of the mouth, three occur in the skin covering the bottom of the oral cavity, and one is in the mucus membrane of the lining of the oral cavity (Imai, 1978).

The digastric inserts in the mandible half way to the symphysis. There is no sterno-maxillaris. The stylo-hyoid, glossus and pharyngeus are present. Omo-hyoid, cleido mastoid, and scaleni are absent. The omo-trachealian is attached to the mastoid rather than the atlas (Windle and Parsons, 1899).

Dermal muscles are well developed along the flanks to support and control the skin and scales. The panniculus has the normal mammalian arrangement. The rectus thoracis lateralis, which occurs only in edentates and pholidotes, attaches to the first and third-seventh ribs. Recti capitis dorsales and splenius colli are absent, but the splenius capitis is present. The subclavius is absent. The deltoid has the usual three parts, but whereas the cephalo-humerus is well defined, the acromial and spinous are not always separate. Only the gleno-ular part of the biceps muscle is present. There are four lumbricales. The pronator quadratus is absent in *Manis* and the supinator longus is present (Windle and Parsons, 1899).

The extensors carpi radiales longior and brevior are absent. The tendon of extensor communis digitorum passes to the medius, and the extensor minimi digiti is present, but is inserted into the fifth metacarpal bone instead of the normal attachment to phalange. The extensor incidis alone is present. Palmaris brevis is absent (Windle and Parsons, 1899).

Retia mirabilia are present in axis of the limbs. Several parallel blood vessels are adjacent to the spinal cord and run the length of the body, but their purpose is unknown (Kingdon, 1974).

Manis pentadactyla does not show pronounced cerebralization and the cerebral hemispheres do not overlap either the olfactory bulbs or the cerebellum. Thus, the brain from a lateral view has a simple serial configuration of its three major parts. The olfactory lobes are short, level with the cerebral hemispheres, and without neural fibers protruding dorsally. The cerebellum is relatively large and well differentiated with the vermis and lateral lobes of the cerebellum being of similar size. Hackethal (1976) suggests, from morphological investigations of the brain, that the Asian species of pangolin are more primitive than the African species.

The penis is well developed. The testes do not descend into a scrotum, though they do pass through the inguinal canal at sexual maturity and enlarge in a fold of skin in the groin. Female Chinese pangolins have two pectoral mammae with nipples 5–8 mm (Kuehn, 1986). The uterus is bicornuate and the placenta is diffuse and nondeciduate (Grassé, 1955; Kowalski, 1971).

FUNCTION. *Manis pentadactyla* regulates body temperature at 33–34.5°C and has an average resting metabolic rate of 3.03 ml O₂ kg⁻¹ min⁻¹ (range: 1.5–4.8 ml O₂ kg⁻¹ min⁻¹; Heath and Hammel, 1986). At ambient temperatures <25°C the Chinese pangolin increases metabolic rate to maintain body temperature (Heath and Hammel, 1986).

The O₂ affinity of the blood and hemoglobin is greater in *M. pentadactyla* than in non-burrowing mammals of similar size (Weber et al., 1986). This suggests adaptation to prolonged stays in hypoxic environments as may exist in burrows, particularly if the entrance has been sealed with dirt as reported (Lekagul and McNeely, 1977). The higher O₂ affinity is attributable to a lower ratio of diphosphoglycerate (DPG) to hemoglobin than is normally found in mammals. There is no significant difference in the intrinsic O₂ affinity, in hemoglobin sensitivity to temperature, or erythrocyte DPG in pangolins compared to other mammals. Newborn and adult individuals have similar O₂ affinities and pH and DPG sensitivities. Adult Chinese pangolins have two types of hemoglobins and newborns have only one. This contrasts with the more typical mammalian scheme in which fetal blood has two or more hemoglobins and some of these are lost after birth (Weber et al., 1986). *M. pentadactyla* can survive 1 h of forced submersion in water (Fang, 1981).

Resting *M. pentadactyla* have heart rates of 80–86 beats/min. Respiration is somewhat apneic with frequency varying from 14–20 to 42–53 breaths/min in the same individual over a 2–5-min period (Heath and Vanderlip, 1988). Chinese pangolins can be

anesthetized for about 15 min by administering 18–25 mg/kg body mass of Ketamine HCl intramuscularly (Heath and Vanderlip, 1988).

ONTOGENY AND REPRODUCTION. Oestrus occurs in late summer and early autumn in mature females (Fang and Wang, 1980). Length of gestation is undocumented, but may be similar to that for *M. temminckii*: 139 days (van Ee, 1966). Births to captive *M. pentadactyla* have been reported on 25 December 1965 at the Ueno Zoo, Tokyo (Masui, 1967), on 14 November 1984 to a mature female, and on 5 February 1985 to a yearling female (Heath and Vanderlip, 1988). Females reach reproductive maturity in their first year, but mate later in the year than older females, in late autumn, and give birth in winter (Fang and Wang, 1980). The mass of two females at parturition was 3 kg and the mass of their young was 92 and 93 g (Heath and Vanderlip, 1988). Two female Chinese pangolins observed in the field also weighed 3 kg at term (Fang and Wang, 1980). A placenta found after the birth of the Chinese pangolin at the Ueno Zoo weighed 13 g and measured 24 cm long and 3–6.5 cm in diameter (Masui, 1967).

Chinese pangolins spend winter months in deep burrows (Fang and Wang, 1980; Shi and Wang, 1985). Females give birth to a single offspring and nurture it through the winter in the burrow. Because winter burrows are excavated next to termite nests, they also provide a source of food. Young pangolins emerge with the mother in spring. Offspring hold onto the dorsal part of their mother's tail near its base or very young babies hold onto the underside of their mother. The young forage with the mother, but are not weaned until later (Fang and Wang, 1980).

There is some contradiction in the literature about the degree of development of newborns. Heath and Vanderlip (1988) document photographically that young are born 20–21 cm long, with eyes open, scales that are soft, with hairs present between scales, and strong forelegs ending in long, well-developed claws. In contrast, Masui (1967) reported that newborn offspring were about 15-cm long, with hair appearing when 7 days old, eyes not opening until 9 days old, and ridges developing when 14 days old on the previously soft scales. The mother's mammary glands were dry 86 days post-partum and keepers force-fed the young Chinese pangolin a mixture of 8% Esbilac in water until it freely drank the mixture 3 days later. The diet was later changed to raw horse meat, raw egg yolk, and Esbilac and the quantity increased. When 6 months old the offspring weighed 2.7 kg (Masui, 1967).

Mothers are protective toward their offspring in captivity to the extent that they hold their young to their ventral surface and curl into a sphere around them to sleep. Motor coordination is good and newborn pangolins are very active climbing on their mothers and throughout the brood enclosure (Heath and Vanderlip, 1988). Females do not retrieve offspring that wander off (Heath and Vanderlip, 1988). In the closed winter burrow the young remain in a brood chamber (Fang and Wang, 1980). Thus, it may not be possible for the baby to wander away from the mother. Young pangolins have been observed suckling even while seemingly sleeping. Orphans may be fostered by other female pangolins (Fang and Wang, 1980).

ECOLOGY. There is little information about the actual size of the present population of *M. pentadactyla* or the amount of habitat available to this species. The Chinese pangolin population has been dramatically reduced due to poaching (Jiang et al., 1988).

Chinese pangolins are important to the Chinese because they prey on termites which cause damage to man-made structures. *M. pentadactyla* is listed as a second-class protected animal in China. In spite of this, they are hunted and killed in excess (Fang and Wang, 1980). In northern parts of Fujian Province where Chinese pangolins are common, it is traditional to hunt them when they emerge from their winter burrows in the spring and to keep them alive until sold at market. Then they are killed by crushing the skull, after which the tongue is quickly cut and bled. The warm blood is drunk as a tonic. Chinese pangolin meat is a delicacy and believed to give energy or refresh people weakened by illness, to fight fever, and to stimulate milk production and secretion in human mothers. Scales are used whole to scratch over mosquito bites or to rub over injuries as protection against infection, to eliminate pus, and to reduce swelling. Scales are also ground into a powder and used as an aphrodisiac, or medicinally as an antipyretic, to increase leukocytes, to stimulate circulation of blood, and to fight diseases such as amenorrhoea and rheumatism (Fang and Wang, 1980). It was estimated that, between 1958 and 1964, over 60 tons of *Manis crassicaudata* scales were legally exported from Sarawak to China (Lekagul and McNeely, 1977).

Field studies of *M. pentadactyla* have been carried out in the Nanping, Jianyang, and ChongAn districts in the northern part of Fujian Province (about 27°30'N and 118°E; Fang and Wang, 1980) and in Jiangxi Province (Shi and Wang, 1985). In these provinces Chinese pangolins inhabit mountainous regions at or about 1,500 m elevation where the soil is acidic and yellowish red. Winter is short; there are only 3 months with mean temperatures <10°C. Summer is long, hot, and damp. Rainfall is >150 cm/year. The flora in this region includes forest of coniferous and evergreen trees and bamboo. Lush growth of bushes and weeds occurs at the edge of the forest, in canyons, and on mountain slopes (Fang and Wang, 1980). In contrast, an immature Chinese pangolin in South Vietnam excavated its burrow in clay soil at 400 m elevation at the edge of a coffee plantation (Van Peenan et al., 1969).

Burrows of Chinese pangolins are primarily on slopes of 20–40° facing south or southeast, therefore having the most direct and longest exposure to the sun (Fang and Wang, 1980). Few burrows are dug in steep slopes and none are dug in level ground or in hard soil (Jiang et al., 1988). Burrows have only one opening, about 15–20 cm in diameter, that widens into larger chambers behind the opening. There are mounds of freshly dug soil outside the burrow (Fang and Wang, 1980; Jiang et al., 1988) and walls of dirt at frequent intervals within summer burrows (Jiang et al., 1988).

Chinese pangolins eat mostly black ants (species unidentified) and a few termites found in surface detritus in summer. In winter they eat two types of termites located in deep nests (Shi and Wang, 1985): the white *Macrotermes barneyi* and an unidentified black species. These termites build a large nest 1–2 m underground with many passages radiating out to other smaller nests or to the surface (Shi and Wang, 1985). Chinese pangolins use these passages to find the termite nest by olfaction. They can apparently judge the relative distance to the nest and abandon openings where nests were >4 m away but dig up nests which were <2.5 m away (Shi and Wang, 1985). Chinese pangolins feed mainly on the imagoes, then larvae, eggs, adults, some wood powder nest material, and excrement of the ants or termites (Fang and Wang, 1980). They eat most of the termites in an average-size nest in 30 min. If the termite nest is exceptionally large (90 cm in diameter), the Chinese pangolin will eat its fill on the first occasion, reseal the nest, and return the next day (Shi and Wang, 1985). Chinese pangolins can go without food for 10 days in winter and for 5–7 days in summer (Shi and Wang, 1985).

Apparently, burrows are dug while foraging for termites and thus differ in summer and winter due to the seasonal differences in termite distribution. Winter burrows follow the subterranean meanderings of the termite nest passages to more than 2 m below the surface where the main termite nest is located. The chamber used for sleeping and rearing the infant is mid-way along the burrow, about 1 m from the main termite nest and is lined with weeds for insulation. Winter burrows are inhabited by one adult, either a male or a female with infant. Chambers in the burrow may be as much as 2 m in diameter (Fang and Wang, 1980). It is not clear whether Chinese pangolins use just one such burrow throughout a winter or if they move and excavate more than one burrow. It is also unclear whether they stay in the burrow throughout the winter or leave periodically to forage for other sources of termites. One pangolin can eat all the termites in the main termite nest in one or two feeding sessions (Shi and Wang, 1985).

Summer burrows are more numerous but shorter (80–100 cm long) with nests only 15–50 cm below the surface (Fang and Wang, 1980; Jiang et al., 1988). This burrow parallels the movement of termites toward the surface in the warmer seasons when nests are smaller and more diffusely distributed.

During summer, individual Chinese pangolins have a wide range and may move from one hillside to another during one night (Fang and Wang, 1980). Two Chinese pangolins were tracked with radio-telemetry for 16 days in May after being released in unfamiliar territory in the Dinghu Mountain region of China (Jiang et al., 1988). The animals stayed in burrows throughout the day and began foraging around 1700 h. They foraged in an area 50–100 m in circumference around their burrow for several days until food became scarce. They moved some distance to a new site, usually in the early morning hours, and established a new burrow. One of the pangolins used 3 burrows in 16 days, the other used 7 burrows in 15 days. They normally stayed in burrows for 2–7 days, sometimes longer (Jiang et al., 1988).

Parasites include three species of nematode found in *M. pentadactyla* from Taiwan: *Manistongylus meyeri*, *Necator americanus*

us, and a unidentified larval ascarid (Cameron and Myers, 1960). *Strongyloides* and a new nematode, *Leiperinema leiperi*, were reported in *M. pentadactyla* from northern India (Singh, 1976). Parasites found in *M. pentadactyla* from mainland China included *Strongyloides* and hookworm within the intestine, nematodes (*Cylicospirura*) in the esophagus, stomach, and peritoneum, and filarial nematodes in the dermis (Heath and Vanderlip, 1988).

BEHAVIOR. Chinese pangolins are solitary, sleep in a burrow during the day, leave the burrow in early evening (1900 h) to forage, and return around 2200 h (Fang and Wang, 1980). Captive *M. pentadactyla* are nocturnal; they never leave the nest box before 1600 h, emerge intermittently for variable lengths of time (30 s–1.5 h), and end their active period by 0200 h. Total time spent out of the nest on any given night differed among individuals but ranged from 2.9% to 7.6% (average = 5.6%) of a 24-h period (Heath, 1987; Heath and Vanderlip, 1988).

Chinese pangolins walk quadrupedally, putting weight on the knuckles of their forefeet and curling their nails inward and caudally, like South American anteaters. Their head sways from side to side and their tail leaves a trail in the substrate. They normally walk slowly but can move quickly, walking bipedally by balancing on their hindlegs and tail. Chinese pangolins are capable swimmers and climbers. They ascend and descend trees by using their prehensile tail to support their mass while repositioning their other limbs to move along the trunk (Fang, 1981).

Chinese pangolins dig burrows with their front legs while their tail is inserted into the ground for support. They push the dirt backward under their bodies. While digging they move their body from side to side excavating both sides and the roof of the passage. When loose soil is accumulated they move it to the burrow entrance using both front and hind feet as they back up. The dirt is thrust out of the entrance for a meter or more. They excavate at a rate of 2–3 m/h (Fang and Wang, 1980; Shi and Wang, 1985). Captive Chinese pangolins move nest material into their nest box by gathering it into a pile with their forefeet and pulling it toward their ventral surface as they back into the nest (Heath and Vanderlip, 1988).

Chinese pangolins have two defense postures. They respond to noise by putting their head between their hind legs and presenting the scales of the dorsal region to predators. They roll into a sphere if they are disturbed directly (Heath and Vanderlip, 1988). Pangolins sleep on their side curled into a sphere or with their back upward and the head and forelegs rolled to the chest. Captive pangolins housed together either curled into a sphere as individuals or one around another to sleep. Captive individuals are not aggressive (Heath and Vanderlip, 1988), but males put together in the field fight (Fang and Wang, 1980).

When more than one male is in the presence of a female in estrus, the males fight violently until all but one leaves. A female in estrus mates outside the burrow with a single male repeatedly over a 3–5-day period. The male and female lay together on their sides, embracing with their forelimbs and swaying their heads. The male coils his tail about that of the female with his pelvis to one side of the base of her tail. Copulation lasts for 3–5 min (Fang and Wang, 1980).

Manis pentadactyla dig a hole to deposit urine and feces, and then cover it with earth. The hole is dug either with the forefeet or by placing the head between its legs and dragging it forward along the ground so the scales in the neck region excavate dirt from between its legs. This is repeated several times until a hole 5–10 cm deep is made.

GENETICS. Diploid number of chromosomes in *M. pentadactyla* has been reported as 36 (Aswathanarayana and Prakash, 1976; Matthey, 1970; Ray-Chaudhuri et al., 1969), 38 (Chakrabarti et al., 1982), 40 (Quan et al., 1984), or 42 (Makino and Tateishi, 1951). The study of Chakrabarti et al. (1982) is the most convincing. It is based on two specimens of each gender collected in West Bengal and Tripura. In contrast, the paraffin sectioning method used by Makino and Tateishi (1951) had limitations in determining the exact number of chromosomes from clumped chromatin mass. Also, Ray-Chaudhuri et al. (1969) may have been working with another species (see note added in proof, Chakrabarti et al., 1982). None of the papers state what precautions were taken to identify correctly the species under study. This is a problem because the range of *M. pentadactyla* overlaps with that of *M. crassicaudata* and *M. javanica*. Interspecific comparisons can not be made because karyotypes have not been reported for other pangolin species.

REMARKS. Chinese pangolins are mentioned in Chinese literature early in the Sung Dynasty, 960–1279 A.D. (Fang, 1981). The Chinese Mandarin name for pangolins is *Ling-li* and translates as hill carp. This is probably due both to their covering of scales and because the yellowish-brown scales are the same color as carp in China. The Chinese Cantonese name for Chinese pangolins translates as animal that digs through mountain, and the name *Chun-shau-cap* translates as scaly hill-borer. A Chinese legend that pays tribute to their ability to excavate tunnels says that pangolins travel all around the world underground.

The nomenclature associated with pangolins includes: Pholidota from the Greek words *pholis* or *pholidos*, meaning horny scale; Manidae and *Manis* from the Latin word *manes*, meaning spirit of the dead or ghost and used because of the pangolin's secretive nocturnal habits; *pentadactyla* from the Greek words *penta*, meaning five, and *daktulos*, meaning finger. The term pangolin comes from the Malayan word *peng-goling*, meaning a roller (Gotch, 1979).

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- Editors of this account were TROY L. BEST, GUY N. CAMERON, and KARL F. KOOPMAN. Managing editor was CRAIG S. HOOD.
- M. E. HEATH, RESEARCH LABORATORY, BOX 38, DEPARTMENT OF REHABILITATION MEDICINE, COLLEGE OF PHYSICIANS AND SURGEONS, 630 WEST 168th STREET, NEW YORK, NEW YORK 10032.