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SURVEY OF THE TERMITES (ISOPTERA: KALOTERMITIDAE, RHINOTERMITIDAE, TERMITIDAE) IN A FORMOSAN PANGOLIN HABITAT

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ABSTRACT

The Formosan pangolin, *Manis pentadactyla pentadactyla* Linnaeus, is an endangered species currently. To understand the termite species available as pangolin food sources, a field survey was conducted in a 120-ha habitat in Southeast Taiwan. One hundred and thirty three termite samples were collected, representing 7 species in 6 genera and 3 families. These were Kalotermitidae: *Glyptotermes fuscus* Oshima, *G. satsumensis* (Matsumura), and *Neotermes koshunensis* (Shiraki); Rhinotermitidae: *Reticulitermes flaviceps* (Oshima); Termitidae: *Nasutitermes parvonasutus* (Shiraki), *Odontotermes formosanus* (Shiraki), and *Pericapritermes nitobei* (Shiraki). Based on abundance, colony size, and lifetype, we concluded that *O. formosanus* and *R. flaviceps* are likely to represent the major termite species consumed by Formosan pangolins.

Key Words: termite survey, *Manis pentadactyla pentadactyla*, conservation, Taiwan

RESUMEN

El pangolín de Formosa, *Manis pentadactyla pentadactyla* Linnaeus es una especie en peligro de extinción hoy dia. Se realizó un estudio de campo en un hábitat de 120 hectáreas en el sudeste de Taiwán para determinar las especies de termitas disponibles como fuente alimenticia para el pangolín. Ciento treinta y tres muestras de termitas fueron recogidas, que representan 7 especies en 6 géneros de tres familias. Estas fueron Kalotermitidae: *Glyptotermes fuscus* Oshima, *G. satsumensis* (Matsumura) y *Neotermes koshunensis* (Shiraki); Rhinotermitidae: *Reticulitermes flaviceps* (Oshima); Termitidae: *Nasutitermes parvonasutus* (Shiraki), *Odontotermes formosanus* (Shiraki) y *Pericapritermes nitobei* (Shiraki). Basado sobre la abundancia, el tamaño de la colonia y la clase de vida, llegamos a la conclusión de que *O. formosanus* y *R. flaviceps* probablemente representan las especies de termitas principales consumidas por los pangolines de Formosa.

The Formosan pangolin, *Manis pentadactyla pentadactyla* Linnaeus (Fig. 1A), was once a commonly seen mammal in Taiwan. They were predominately found in mountainous areas, <1,000 m in altitude (Chao 1989). Due to habitat destruction and over hunting between the 1950s and 1970s (Chao 1989), the species is considered threatened to date (Duckworth et al. 2008) and protected by national law since 1989 (Wang 2008). Efforts have been made for pangolin conservation and fundamental biology in Taiwan (Chang 2003; Fan 2004; Wang 2006; Chan 2008; Wu 2008), but little is known about their food source and sustainable ecosystem.

Termites and ants are believed to be the major food source for all pangolin species. In mainland China, Wu et al. (2005) reported 6 termite species including *Coptotermes formosanus* Shiraki, *Macrotermes barneyi* Light, *Odontotermes formosanus* (Shiraki), *O. hainanensis* Light, *O. zunyiensis* Li et Ping, and *Pericapritermes nitobei* (Shiraki) and five ant species including *Camponotus* sp., *Odontomachus monticola* (Emery), *Paratrechina bourbonica* (Forel), *Pheidole* sp., and *Polyrhachis dives* Fr. Smith were food source of the Chinese pangolin, *Manis pentadactyla* Linnaeus. In Taiwan, several ant species including *Ca. friedae* Forel, *Crematogaster rogenhoferi* Mayr, *Cr. dohrni fabricans* Forel, *Ph. yanoi* Forel, and *Po. dives* have been found in their stomachs (Sonan 1912, 1941; Takahasi 1934), but the termite species consumed by Formosan pangolins has remained unknown. In the current study, a field survey of the termites was conducted in a Formosan pangolin habitat. The ecology of these termite species and their potential as a food source of the Formosan pangolins are discussed.

Materials and Method

Between 2009 and 2010, radio-tracking results of pangolins' activities at Song-Ling Village, Taitung County, Taiwan (Fig 1B) revealed the presence of 1 male and five females in a 120-ha area (Fig. 1C) (Lin 2011). Their habitat consisted of mosaic vegetation including secondary forest, tree plantation, bamboo forest, grassland, and orchards. A termite survey was conducted in this habitat on May 20 and 21, 2010. Termite samples were collected from soil, dead trees, decayed wood, and dead branches of living trees by using axes and aspirators, and preserved in 85% ethanol. Species identifications were made based on morphological descriptions (Shiraki 1909; Nawa 1911; Oshima 1912; Hozawa 1915) and keys offered by Chung and Chen (1994), as well as Li (2010). The voucher specimens will be deposited at the National Museum of Nature Science, Taichung, Taiwan. The lifetypes and feeding groups of the 7 species are summarized in Table 1 following the categories described by Abe (1987), Donovan et al. (2001), and Eggleton & Tayasu (2001).

Results and Discussion

One hundred and thirty three termite samples were collected from 17 localities (Fig. 1C), representing 7 species in 6 genera and 3 families (Table 1). The ecology of these termite species and their potential as a food source of Formosan pangolins are discussed below. Kalotermitidae was not as well represented in the current survey as Rhinotermitidae and Termitidae (Table 1). Two *Glyptotermes* species, *G. fuscus* Oshima and *G. satsumensis* (Matsumura), were found at five locations in secondary forests. Both species nested in dead trees or dead branches of living trees. Trees infested by several thousand individuals of *G. satsumensis* were found, but all *G. fuscus* colonies were small with <1,000 individuals. Exten-

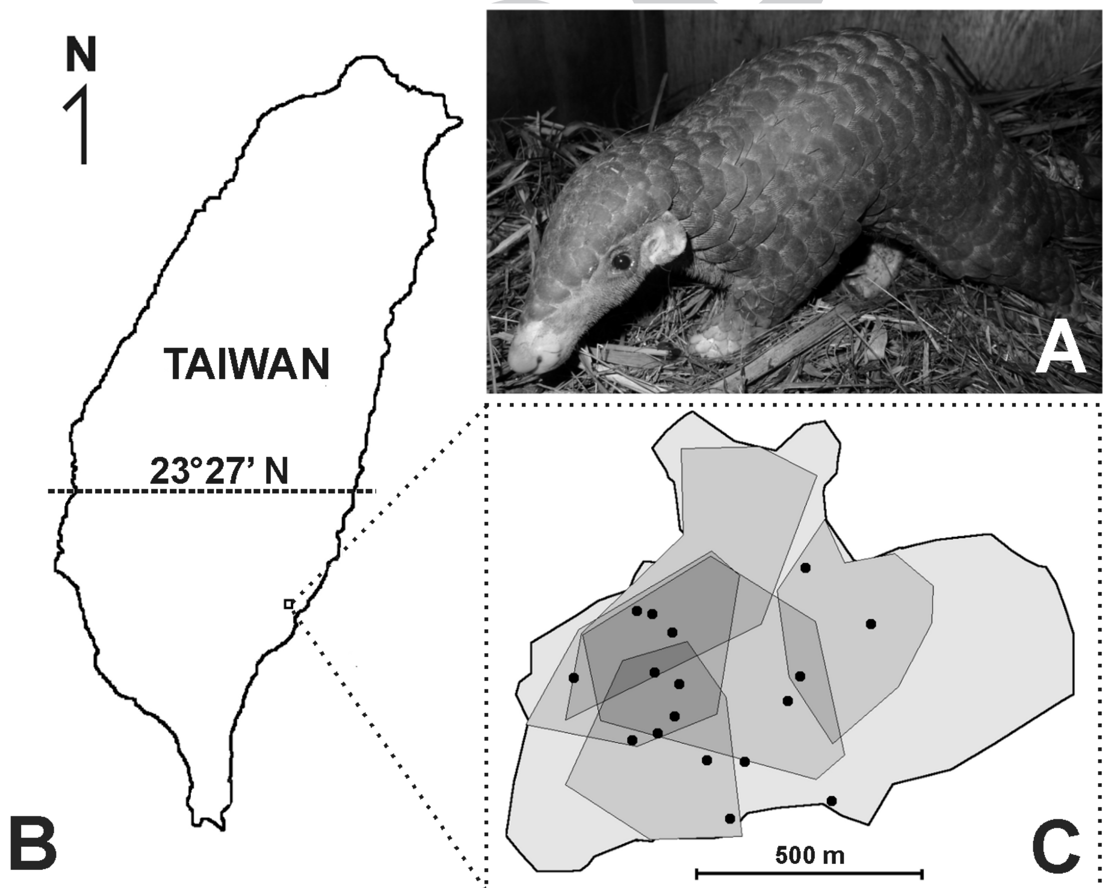

Fig. 1. Formosan pangolin, *M. pentadactyla pentadactyla* (A) is commonly found at Song-Ling Village in southeast of Taiwan (B); current termite survey was conducted in 6 pangolin habitats (C) (gray area). The largest territory occupied by a male pangolin overlapped with small territories of five female individuals. Closed circles represent termite collection sites.

TABLE 1. TERMITE SPECIES RECORDS FROM SONG-LING VILLAGE ALPHABETICALLY BY FAMILY.

Taxon	Lifetype[1]	Feeding group[1,2]	No. of colony samples/ collection sites
Kalotermitidae			
Glyptotermes fuscus Oshima	Single-piece nester	I. drywood	8/5
Glyptotermes satsumensis (Matsumura)	Single-piece nester	I. drywood	12/5
Neotermes koshunensis (Shiraki)	Single-piece nester	I. drywood	8/4
Rhinotermitidae			
Reticulitermes flaviceps (Oshima)	Intermediate nester	I. wood	37/12
Termitidae			
Nasutitermes parvonasutus (Shiraki)	Intermediate nester	II. wood	23/12
Odontotermes formosanus (Shiraki)	Separate-piece nester	II. wood, grass, fungus	40/12
Pericapritermes nitobei (Shiraki)	Soil feeder	III. soil	5/3

[1]Following the classification described by Eggleton & Tayasu (2001)

[2]I, lower termites that feed on wood, litter, and grass; II, higher termites that feed on wood, litter, and grass; III, higher termites that feed on very decayed wood and organic matter.

sive galleries of *G. satsumensis* were observed inside tree trunks, but *G. fuscus* typically excavates tunnels along the outer layers of tree trunks and branches. Another kalotermitid species, *Neotermes koshunensis* (Shiraki) was collected at 4 locations in abandoned orchards. Most colonies were found in dead plum trees with high moisture content. The colony size of *N. koshunensis* can be as large as several thousand individuals (Maki & Abe 1986). Kalotermitidae is a primitive termite family, and sound wood is their primary food source (Krishna 1961). An entire colony is usually restricted to a single piece of wood, hence, it is called a "single-piece nester" (Eggleton & Tayasu 2001). To collect kalotermitids, tools such as axes were usually required. Therefore, we speculated that it would be difficult for pangolins to excavate the infested dry wood for kalotermitids. Due to nesting in sound wood and their small colony size, the 3 kalotermitid species are less likely to be the food source of pangolins.

Reticulitermes flaviceps (Oshima) was the only rhinotermitid species found in the current survey, and it was collected from 12 of the 17 sites. This species was commonly discovered at the interface between decayed wood and wet soil. The colony size of *R. flaviceps* remains unknown, but *Reticulitermes* colonies containing several hundred thousand individuals is often reported (Howard et al. 1982; Su et al. 1993; Haagsma & Rust 1995; Haverty et al. 2000). The nest structure of most rhinotermitids consists of a subterranean main nest and some satellite nests located in infested wood or soil. This lifetype was classified as intermediate nester by Abe (1987) and Eggleton & Tayasu (2001). Because *R. flaviceps* nests in soil and is found in high abundance, it is likely to be a major food source of pangolins.

Three higher termite (Termitidae) species, *Nasutitermes parvonasutus* (Shiraki), *O. formosanus*, and *P. nitobei*, were found in the current survey, and their lifetypes and food sources are quite different (Table 1). *Na. parvonasutus* was collected at 12 of the 17 collection sites, usually in wooded areas. Shelter tubes made of mud on the surface of wood was observed for this species, and hence it was speculated that several nesting sites may be connected by forgaing tubes of a sigle colony. *Nasutitermes* were classified as intermediate nesters by Eggleton & Tayasu (2001). Even though *Na. parvonasutus* is abundant, it may be difficult for pangolins to excavate their nests from the infested wood. *O. formosanus* is the most abundant species found in the current survey. Forty colony samples were collected from 12 of the 17 collection sites. *O. formosanus* is a fungus growing termite species, and has a complex subterranean nest system consisting of a major chamber and multiple small chambers (Tsai 1965; Huang 2004). *O. formosanus* was found inside wood and in foraging tubes on the suface of tree trunks, dead grass, fallen tree branches, etc. *O. formosanus* does not nest in its food sources, hence, it belongs to a separate-piece nester classified by Eggleton & Tayasu (2001). The colony size of an *O. formosanus* can be as larage as 2,000,000 termite individuals (Huang et al. 1989). Because *O. formosanus* is the most abundant species with large colony sizes and a soil-nesting behavior, we speculate that *O. formosanus* is most likely a major food source of pangolins. Another termitid species, *P. nitobei*, is a soil feeding termite, only found at 3 of the 17 collection sites. This species built small soil chambers under stones and grass roots with < 100 individuals in each chamber. According to the observations by Tu (1954) and Hsueh (1998), these small chambers were interconnected with tunnels. The central chamber of a mature colony could be as deep as 1 m (Hsueh 1998), and no large colony exceeding a thousand individuals has ever been reported. Because *P. nitobei* feeds on organic matter close to the ground surface, pangolins should be able to excavate top-soil or flip over small stones to intercept *P. nitobei*. However, its low abundace would decrease the interception rate.

Based on abundance, colony size, and lifetype, we concluded that *O. formosanus* and *R. flaviceps* are likely to be the major termite species consumed by Formosan pangolins. The wood nesting species, including the 3 kalotermitids and *Na. parvonasutus*, are not likely to be available for pangolin predation.

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References Cited

Abe. T. 1987. Evolution of life types in termites, pp. 126-148 *In* Kawano, S., Connell, J. H., and T. Hidaka [eds.], Evolution and Coadaptation in Biotic Communities. University of Tokyo Press, Tokyo, Japan.

Chan, Y.-T. 2008. The breeding behavior study and mother-young relationship of captive Formosan pangolins (*Manis pentadactyla pentadactyla*). National Pingtung University of Science and Technology, Pingtung, Taiwan. (In Chinese).

Chang, C.-Y. 2003. Study on the apparent digestibility of diet on Formosan pangolin. National Taiwan University, Taipei, Taiwan. (In Chinese).

Chao, J.-T. 1989. Studies on the conservation of the Formosan pangolin (*Manis pentadactyla pentacactyla*) I. General biology and current status. Council of Agriculture, Taipei, Taiwan. (In Chinese).

Chung, C. H., and Chen, C. S. 1994. A review of Taiwanese termites (Insecta, Isoptera) with keys to adults and soldiers. Yushania 11: 193-203. (In Chinese).

Donovan, S. E., Eggleton, P., and Bignell, D. E. 2001. Gut content analysis and a new feeding group classification of termites. Ecol. Entomol. 26: 356-366.

Duckworth, J. W., Steinmitz, R., Pattanavibool, A., Zaw, T., Tuoc, D., and Newton, P. 2008. *Manis pentadactyla In* IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. www.iucnredlist.org. Downloaded on 28 Mar 2011.

Eggleton, P., and Tayasu, I. 2001. Feeding groups, lifetypes and the global ecology of termites. Ecol. Res. 16: 941-960.

Fan, C.-Y. 2004. Burrow habitat of Formosan pangolins (*Manis pentadactyla pentadactyla*) at Feitsui Reservoir. National Taiwan University, Taipei, Taiwan. (In Chinese).

Haagsma, K. A., and Rust, M. K. 1995. Colony size estimates, foraging trends, and physiological characteristics of the western subterranean termite (Isoptera: Rhinotermitidae). Environ. Entomol. 24: 1520-1528.

Haverty, M. I., Getty, G. M., Copren, K. A., and Lewis, V. R. 2000. Size and dispersion of colonies of *Reticulitermes* spp. (Isoptera: Rhinotermitidae) in a wildland and a residential location in northern California. Environ. Entomol. 29: 241-249.

Howard, R. W., Jones, S. C., Mauldin, J. K., and Beal, R. H. 1982. Abundance, distribution, and colony size estimates for *Reticulitermes* spp. (Isoptera Rhinotermitidae) in Southern Mississippi. Environ. Entomol. 11: 1290-1293.

Hozawa, S. 1915. Revision of the Japanese termites. J. Coll. Sci. Tokyo Imp. Univ. 35: 1-161.

Hsueh, W.-J. 1998. Development of castes in *Capritermes*, *Sinocapritermes*, and *Nasutitermes* in Taiwan. National Taiwan University, Taipei, Taiwan. (In Chinese).

Huang, C.-S. 2004. Nest and colony structure of *Odontotermes formosanus* (Isoptera: Termitidae), Tunghai University, Taichung, Taiwan. (In Chinese).

Huang, F.-S., Li, G.-X., and Zhu, S.-M. 1989. The taxonomy and biology of Chinese termites. Tianze press, Beijing, China. (In Chinese).

Krishna, K. 1961. A generic revision and phylogenetic study of the family Kalotermitidae (Isoptera). Bull. Am. Mus. Nat. Hist. 122: 303-408.

Li, H.-F. 2010. Identification and collection of termites in Taiwan, pp. 37-60 *In* Wu, W.-J. and Li, H.-F. [eds.], Proc. Symp.& Workshop on Termite Biology and Control in Taiwan, 1-2 October 2010, Taipei, Taiwan, Department of Entomology, National Taiwan University, National Science Council Research Promotion Center for Life Science, Taipei, Taiwan. (In Chinese).

Lin, J.-S. 2011. Home range and burrow utilization in Formosan pangolins (*Manis pentadactyla pentadactyla*) at Luanshan, Taitung. National Pingtung University of Science and Technology, Pingtung, Taiwan. (In Chinese).

Maki, K., and Abe, T. 1986. Proportion of soldiers in the colonies of a dry wood termite, *Neotermes koshunensis* (Kalotermitidae, Isoptera). Physiol. Ecol. Jpn. 23: 109-118.

Nawa, U. 1911. Two termite species from Taiwan. Insect World 15: 413-417. (In Japanese).

Oshima, M. 1912. The taxonomy and distribution of termites in Taiwan, pp. 54-94 *In* Oshima, M. [ed.], The Third Official Report on Termites. Taiwan Sotokufu, Taihoku, Japan. (In Japanese).

Shiraki, T. 1909. Japanese termites. Trans. Entomol. Soc. Japan 2: 229-242. (In Japanese).

SoNan, J. 1912. Pangolin and black-spiny ants. J. Nat. Hist. Soc. Taiwan 2: 215-219. (In Japanese).

Sonan, J. 1941. Study of pangolin's food. Science of Taiwan: 9: 9-10. (In Japanese).

Su, N.-Y., Ban, P. M., and Scheffrahn, R. H. 1993. Foraging populations and territories of the eastern subterranean termite (Isoptera: Rhinotermitidae) in southeastern Florida. Environ. Entomol. 22: 1113-1117.

Takahasi, S. 1934. Reexamination of pangolin's food. Kagaku 4: 370-371. (In Japanese).

Tsai, P.-H., Chen, N.-S., Chen, A.-K., and Chen, C.-H. 1965. Architecture and development of the termitarium of *Odontotermes* (*O.*) *formosanus* Shiraki. Acta Entomol. Sin. 14: 53-70. (In Chinese).

Tu, T. 1954. Ecological supplement to a Formosan termite, *Capritermes* (*Capritermes*) *nitobei* (Shiraki). J. Formos. Med. Assoc. 53: 225-235.

WANG, G.-B. 2008. Pangolin conservation in Taiwan, pp. 80-83 *In* Pantel, S. and Chin, S.Y. [eds.], Proc. Workshop on Trade and Conservation of Pangolins Native to South and Southeast Asia, 30 June-2 Jul 2008, Singapore Zoo.

WANG, P.-J. 2006. Application of wildlife rescue system in conservation of the Formosan pangolins (*Manis pentadactyla pentadactyla*). National Taiwan University, Taipei, Taiwan. (In Chinese).

WU, J.-H. 2008. The study on the establishment of pangolin scales DNA identification and the analysis of mitochondrial D-loop region. Central Police University, Taoyuan, Taiwan. (In Chinese).

WU, S., LIU, N., LI, Y., AND SUN, R. 2005. Observation of food habits and foraging behavior of Chinese pangolin (*Manis pentadactyla*). Chin. J. Appl. Environ. Biol. 11: 337-341. (In Chinese).