Large Insect Diet of the Brown Hawk Owl *Ninox scutulata* in the Central Taiwan

台灣中部褐鷹鴞(*Ninox scutulata*)捕食大型昆蟲類食餌之研究

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Abstract

A total of 2,269 remains of large insects discarded aside by the brown hawk owl *Ninox scutulata* in its noctural feeding were collected at intervals of two weeks under the road lamps in three areas of the peripheral hills of the Central Mountain Range at elevations of 400-700m, November 1999 to December 2001. The results showed that in terms of number of the remains for the study period, insects of the order Coleoptera and Lepidoptera were the most dominant with 844 (37.2%) and 751 (33.1%), respectively. The second dominant group was Homoptera and Orthoptera with 249 (11.0%) and 188 (8.3%). In terms of biomass Coleoptera was the most dominant with a total net weight of 481.1g (37.5%), while Lepidoptera, Orthoptera and Homoptera had 262.9g (20.5%), 253.8g (19.8%), and 204.2g (15.9%). Phasmida, Odonata, Megaloptera, Neuroptera, Lepidoptera, and Homoptera had high utilization rates with 98.4%, 97.6%, 97.3%, 96.0%, 93.4%, and 91.4%. The above six orders of insects were highly utilized by the owl at levels higher than 90.0% of their body weight. The group with lower rates was made up of Coleoptera and Orthoptera at 73.0% and 70.6%.

摘　要

研究期間共蒐集2,269個褐鷹鴞捕食大型昆蟲後的食物殘餘，三樣區中以鞘翅目及鱗翅目昆蟲被捕食的數量最多，分別有844 (37.2%)與751 (33.1%)個食物殘餘。其次爲同翅目與直翅目昆蟲，分別有249 (11.0%)與188 (8.3%)個食物殘餘。褐鷹鴞捕食的大型昆蟲生物量以鞘翅目昆蟲最多，達481.1g (37.5%)。鱗翅目、直翅目與同翅目昆蟲居次，所提供之生物量分別是262.9g (20.5%)、253.8g (19.8%) 與204.2g (15.9%)。所有褐鷹鴞捕食的大型昆蟲之中，以竹節蟲目、蜻蛉目、廣翅

目、脈翅目、鱗翅目與同翅目的被利用率最高，利用率分別爲98.4%、97.6%、 97.3%、 96.0%、93.4% 與 91.4% ，這六目昆蟲被利用率均超過90%，可說是被褐鷹鴞利用最澈底的一群。鞘翅目與直翅目昆蟲的被利用率較低，分別只有73.0% 與 70.6%。

Key words : brown hawk owl, *Ninox scutulata*, food remains, large insect, diet

關鍵詞：褐鷹鴞、*Ninox scutulata*、食物殘餘、大型昆蟲、食性

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Introduction

The brown hawk owl (*Ninox scutulata*) is widely distributed in East Asia from the southern Siberia to the Java and Borneo islands of Indonesia. It was also recorded from the northern Australia (König *et al*. 1999; del Hoyo *et al*. 1999). It is composed of 11 geographical subspecies, of which *Ninox scutulata japonica* occurs in Taiwan (König *et al*. 1999; del Hoyo *et al*. 1999). Voous (1988) suggests that *N. s. japonica* is a common resident of Taiwan, but Yao (1995) indicates that it is an uncommon migratory bird wintering in Taiwan, while *N. s. tabago* is a rare resident on the Layun Island. According to our field observation and the bird-watch records of local bird associations of Taiwan, it seems that there are a rare resident population and an uncommon migratory (visitor) population of *N. s. japonica* in Taiwan. For the latter it is still unclear whether it has the wintering and summering populations. The resident population inhabits mainly in peripheral hills of the Central Mountain Range, while the migratory population is found in windbreak areas of the coastal plain from April to October, and each visitor usually stays for a few days.

It has been known that the brown hawk owl feds on large insects, such as beetles, grasshoppers, and cicada, and also, occasionally on small animals, such as mice, bats, birds, lizards, snakes, frogs, and crabs (McCann 1933; Ishizawa 1934; Kawaguchi 1937; Ikeda and Ishizawa 1949; Abe *et al*. 1979; Tomita 1990). The brown hawk owl prefers hunting near road lamps, since a substantial number of insects are attracted under light, their power box and power wire are convenient sites for the owl to perch with a good view, and the owl has an enough space for hunting (Abe *et al*. 1979; Oba 1996). When the owl catches a large insect, its tears it up and discards aside its hard parts, such as wings, wing sheaths, legs, and head, and eats the remaining soft part of the prey. The insect parts left under the road lamps provide evidence that the owl feeds on large insects (Taniguchi 1983; Tomita 1990).

Little is known about biology and the natural history of the brown hawk owl. Furthermore, it has been categorized as the

second-class preserve species defined as a valuable and scarce bird in Taiwan (Yao 1995). This study was intended to determine the kinds, biomass, utilization rates, and seasonal changes of large insects consumed by the brown hawk owl.

Materials and Methods

Three areas in the peripheral hills of the Central Mountain Range in the central Taiwan were studied: Dar-Ken (12048E; 267415N), Lain-Hwa-Chi (12055E; 264825N), and Wu-Fang (12047E; 266150N) at elevations of 400m, 750m, and 450m, respectively. The areas were covered with second growth forests mixing with some natural and man-made forests. Brown hawk owls in the areas apparently belonged to the resident population, and of ten perched nearby by road lamps to prey on insects and other animals attracted by the light. The observation could be conducted all the year round.

In each of the three study areas, a digital camera was used to monitor and to choose proper road lamps for the study, and we located three road lamps at each study areas for following research. The food remains of two pairs of the owls were collected, respectively, in Dar-Ken and Lain-Hwa-Chi from November 1999 to October 2000, and of one pair in Wu-Fang from January 2001 to December 2001. The collection was conducted once every two weeks at the end of the owls' daily nocturnal feeding activity, about an hour before sunrise (Voous 1988). In the reconnaissance phase of this study, the tape recorded by the digital camera revealed that some of food remains were left by small diurnal birds that were also attracted by the light, so that, we eliminated food remains before owl's activity period to assure that the collected food remains for data analysis were left only by the owls. The food remains collected were dried at 50℃ in an oven, and sorted according to their attributes, such as head, chest, paired legs, wings and wing sheaths. According to the method of reverse, the attributes were used to re-establish individual insects, identified to species, and weighed to estimate the biomass by family and order.

In order to estimate biomass and utilization rate of different kinds of insects consumed by the brown hawk owl, insects aggregated under the road lamps were also collected by the light-sucking trap. They were classified to family, dried, weighed, and combined by order. The reverse biomass (B) and utilization rate (U) for each order was estimated according to the following formula:

$$B = N \times W$$

$$U = (B - b) \times 100 / B$$

where N is the number of large insect remains of an order of insects; W is a mid point of average complete individual weight of insect in the order; and b is weight of remains of each order.

The seasonal percent compositions of large insects consumed by the owl were compared among the insect orders: March to May for spring, June to August for summer, September to November for fall, and December to January for winter.

Results

Large insects

A total of 2,269 large insect were collected in the three areas during the study period, consisting of 192 species, 44 families, and 10 orders. Lepidoptera was the most dominant and had 91 species and 18 families, in which 39 species belonged to Sphingidae and Noctuidae. Coleoptera was the second dominant group with 9 families and 51 species, in which 34 species were Scarabaeidae and Cerambycidae. The third largest group was Odonata and Orthoptera, that had 4 families, 17 and 13 species, respectively. The other orders were rare, each 1 to 3 families and 1 to 6 species.

The largest number of insects collected was Coleoptera and Lepidoptera, that had 844 (37.2%) and 751 (33.1%), respectively. The second large group was Homoptera and Orthoptera, with 249 (11.0%) and 188 (8.3%). The third large group was Odonata and Mantodea with 82 (3.6%) and 74 (3.3%). Blattaria, Megaloptera, Neuroptera and Phasmida had a few numbers: 45, 29, 5, and 2, respectively (about 2.0% to 0.1%)(Table 1). Scarabeidae of Coleoptera was the family that had the largest number, 533 individuals, consumed by the owl during study period (23.5%). It was followed by Cicadiae, Noctuidae, and Sphingidae with 11.0%, 9.8% and 9.0%, respectively.

Total biomass

Total biomass of large insects consumed by the brown hawk owl was 1,281.7g at the three study area during the study period. Coleoptera had the largest biomass with 481.1g (37.5%). It was followed by Lepidoptera, Orthoptera and Homoptera with 262.9g (20.5%), 253.8g (19.8%), and 204.2g (15.9%), respectively. Mantodea, Odonata and Blattaria had low biomass of 31.8g (2.5%), 27.9g (2.2%), and 12.6g (1.0%), while Megaloptera had 6.4g

Table 1. Number, biomass, and utilization rate preyed by the brown hawk owl (percent in parentheses)

Insect category	Number of large insect remains	Average biomass	Reverse biomass (B)	Weight of total remains (b)	Weight of utilization	Utilization rate (%)
Coleoptera	844 (37.2)	0.57±0.21	481.08 (37.5)	129.89	351.19	73.0
Lepidoptera	751 (33.1)	0.35±0.13	262.85 (20.5)	17.35	245.50	93.4
Homoptera	249 (11.0)	0.82±0.25	204.18 (15.9)	17.55	186.63	91.4
Orthoptera	188 (8.3)	1.35±0.84	253.80 (19.8)	74.62	179.18	70.6
Odonata	82 (3.6)	0.34±0.20	27.88 (2.2)	0.67	27.21	97.6
Mantodea	74 (3.3)	0.43±0.19	31.82 (2.5)	5.09	26.73	84.0
Blattaria	45 (2.0)	0.28±0.10	12.60 (1.0)	1.76	10.84	86.0
Megaloptera	29 (1.3)	0.22±0.09	6.38 (0.5)	0.17	6.21	97.3
Neuroptera	5 (0.2)	0.10±0.05	0.50 (<0.1)	0.02	0.48	96.0
Phasmida	2 (0.1)	0.31±0.12	0.62 (<0.1)	0.01	0.61	98.4
Total	2269		1281.71	237.13	1044.58	81.5

(0.5%). Phasmida and Neuroptera had the lowest rates of 0.6g and 0.5g (less than 0.1% in total), respectively (Table 1).

Utilization rate

Utilization of large insects by the brown hawk owl was highest for Phasmida at 98.4%. It was followed by Odonata, Megaloptera, Neuroptera, Lepidoptera, and Homoptera with the rates of 97.6%, 97.3%, 96.0%, 93.4%, and 91.4%, respectively. These six orders of insects were considered as the highest group with the utilization rate higher than 90.0%. The second high group was Mantodea and Blattaria with the rates at 84.0% and 86.0%, respectively. Coleoptera and Orthoptera had the lowest rates of 73.0% and 70.6%. The total remains of large insects was 237.1g, and total biomass utilized was 1,044.6g, so that average utilization of large insects by the brown hawk owl was estimated to be 81.5% (Table 1).

Seasonal changes

The major insect groups consumed by the brown hawk owl were Lepidoptera, Coleoptera, Homoptera, and Orthoptera. Lepidoptera and Coleoptera were consumed all the year round and composed of 64.0% to 78.1% of the total biomass of insects consumed by the owl. The highest rate was found in fall and the lowest rate in winter. The second dominant group was Homoptera and Orthoptera, that made up a total of 23.8%; the former had 20% and the latter had 3.8%. In winter Orthoptera constituted 28.3% and Homoptera 0%, while in spring and fall, they was fairly similar at the rates of 8.9% and 6.3%, respectively, in spring, and 5.5% and 6.1% in fall. For the orders other than those mentioned above, their percentage composition in the biomass of insects consumed by the owl was low, about 10.4% for all the year round.

The biomass of large insects consumed by the brown hawk owl was estimated as 186.2g in spring, 511.2g in summer, 367.5g in fall and 216.8g in winter. In spring, summer, and fall, 91.8% to 93.7% were made up of Lepidoptera, Coleoptera, Homoptera and Orthoptera, while in winter, Lepidoptera, Coleoptera and Orthoptera consitituted 96.3% of biomass, of which 54.9% was from Orthoptera. The orders other than those mentioned above had low biomass composition (Figs. 1 and 2).

Discussion and Conclusions

The brown hawk owl in the peripheral hills in the central Taiwan preyed on large insects, primarily Lepidoptera, Coleoptera, Homoptera, and Orthoptera. These four orders of insects constituted 89.6% in number and 93.7% in biomass of insects consumed by the owl. Lepidoptera and Coleoptera occurred all the year round and thus, they showed no seasonal change. Also, they were highly abundant, so that they provided the basic food source for the owl. In contrast, Homoptera and Orthoptera occurred seasonally (summer and winter), and their occurrence depended on weather conditions. For instance, cicadas were abundant in summer, and thus the brown hawk owl consumed more cicadas than any other kinds of insects in this period. In winter most insects were scarce with the exception of Orthoptera. The grasshopper such as *Chondracris rosea* became mature in this season and provided large biomass for the owl's consumption. The brown hawk owl also preyed

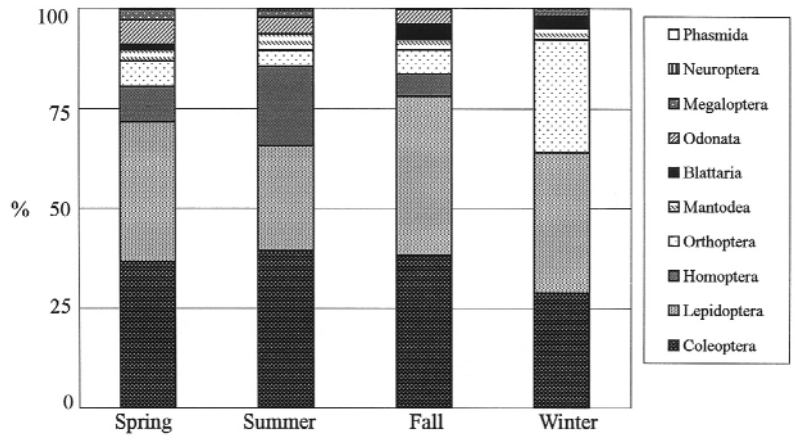

Fig. 1. Seasonal changes in the numbers of large insects consumed by the brown hawk owl.

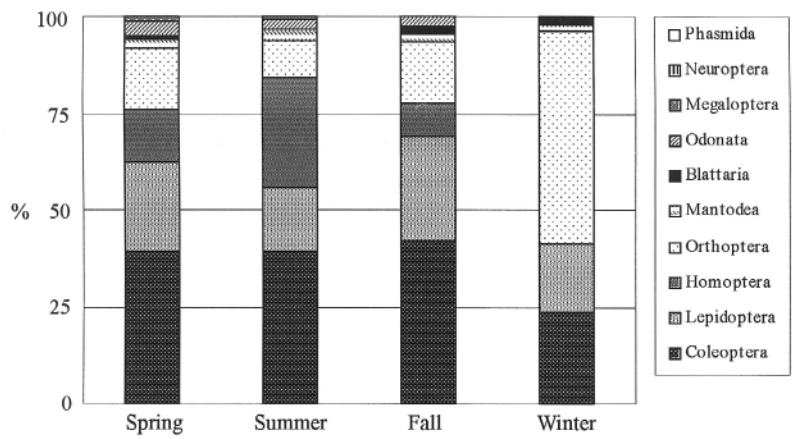

Fig. 2. Seasonal changes in the biomass of large insects consumed by the brown hawk owl.

on insects of Mantodea and Odonata, that supplied large biomass as food for the owl in spring and fall, but as compared to the above four groups, they were still the minor food sources for the owl.

The brown hawk owl consumed the soft parts of the insects, and discarded aside the hard parts, but with exception of some insects, of that entire bodies were swallowed by the owl. Although there were some remains, they were so little and so light that they were blown away, and could not recovered under the road lamps. Such case might occur for some insects of Lepidoptera, Neuroptera, Odonata, Blattaria, and Phasmida. Therefore, the biomass estimated by remains recovered might result in underestimation. In addition some insects have been known to be consumed by the owl, such as Pyralidae, Lymantriidae, Hesperiidae, Asilidae, and Tabanidae (Taniguchi 1983). However, they

were not found in this study.

The consumption of Lepidoptera, Homoptera, Odonata, Phasmida, Megaloptera, and Neuroptera was higher than 91.4%. Only their wings were torn apart and discarded aside by the owl, that occupied a very small part of the insects' body weight, so that their utilization rates estimated were very high. In contrast to the above insects, for Mantodea and Blattaria the owl did not utilize their wings and legs, and sometimes also discarded their whole thorax, so that their utilization rate was calculated to be low at 84% and 86%, respectively . For all insects that the owl consumed, the utilization rate was the lowest for Coleoptera and Orthoptera, since the owl only consumed their abdomens, and discarded head, thorax, wing-sheath, wings, and legs of beetles and wings, jumping legs of grasshoppers. Their abdomens occupied a very small part of total body weight, so that the utilization rates of these insects were low. However, because their biomass was large, they offered more energy than other insects, and constituted a high composition of the owls' diet.

The results obtained in this study were fairly similar to those obtained in Japan with a single peak of the insect consumption in the summer. However, there was longer food consumption period from June to August in Taiwan, but only a month from late June to mid July in Japan (Taniguchi 1983). The seasonal changes in the insect consumption by the owl is caused by increasing food demand of fledges (Taniguchi 1983). Why did it last for just a month in Japan but several months in Taiwan? Possibly, since the owl is a summering bird in Japan, and stays in Japan only for five to seven months. It starts breeding in April, incubates eggs in May, and fledges hatch in early June. The fledging period lasts for a month, and then they migrate to the south in late August or early September. Therefore, young fledges must grow and learn hunting techniques as quickly as possible, before migrate south. It has a short fledging period as compared to that of Taiwan. In Taiwan the owl is a resident in the hill and mountain areas and fledges have no pressure to migrate, and their food resources are plentiful all the year round, so that the parents may have more time to raise the youngs, leading to a longer fledging period.

Ishizawa (1934) used the stomach content analysis to prove that the brown hawk owl eats small insects, such as nocturnal moths, cranefly, and stonefly. Food remains of these small insects are minimal or even absent, because most of them in the stomachs were intact. Many medium or small birds such as the large-billed crow (*Corvus macrorhynchos*), Formosan blue magpie (*Urocissa carerulea*), red-headed babbler (*Stachyris ruficeps*), grey-eyed nun babbler (*Alcippe morrisonia*), lesser scimitar babbler (*Pomatorhinus ruficollis*), Chinese bulbul (*Pycnonotus sinensis*), black-naped blue flycatcher (*Hypothymis azurea*), pied wagtail (*Motacilla alba*), black drongo (*Dicrurus macrocercus*), and Chinese white-eye (*Zosterops japonica*) also hunt small insects and leave remains like owls, though they hunt in different time of a day. Therefore, it is essential to use the stomach content analysis to obtain more precise data on small insects preyed by the brown hawk owl. Raptor diet was usually studied by the method of fecal analysis, that examines prey's remains in its feces. However, this method allows only for identification of large items of

preys, often resulting in overestimation of large preys and underestimation of smaller ones (Redpath *et al*. 2001). This problem still remains for the food remain analysis, because small insects are often entirely consumed, such as case found for the brown hawk owl in this study.

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