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Initial Investigation on the Diet of Eastern Grass Owl (*Tyto longimembris*) in Southern Taiwan

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ABSTRACT: This investigation, undertaken in the two regions of Nanshi and Yujing in Tainan County over the period of 2001 to 2003, included three nests belonging to the Eastern Grass Owl (*Tyto longimembris*). From these, we collected a total of 157 owl pellets. Analysis and examination of the pellets revealed 329 prey items. More in-depth investigation determined that 95.1% of the Eastern Grass Owl pellets collected consisted of mammal remains, while the remaining 4.9% were made up of bird remains. Of the various types of mammals consumed, rats made up the highest proportion, with a total of 285 rats, accounting for 86.6%. This was followed by 27 shrews and moles, accounting for 8.2%. Hares and birds were seldom caught and consumed. The findings suggested that rats are the main food source of the Eastern Grass Owl, with the Spinus Country-rat (*Rattus losea*) comprising the majority with 136 counted (41.3%), followed by the Formosan Mouse (*Mus caroli*) with 96 counted (29.2%). Regarding biomass, the reversion method was used to calculate that owls at the three nests consumed approximately 22,987 grams of mammal and 480 grams of bird, accounting for 98.0% and 2.0%, respectively. The biomass consumed for each pellet was approximately 149.5 g.

KEY WORDS: Eastern Grass Owl, *Tyto longimembris*, pellet, diet, biomass.

INTRODUCTION

The Eastern Grass Owl (*Tyto longimembris*) is distributed throughout India, Southeast Asia, southeast China, Taiwan, the Philippines, New Guinea and Australia. Formerly considered conspecific with the African Grass Owl (*T. capensis*), the two were subsequently classified as distinct species (the Eastern Grass Owl and the Western Grass Owl) on account of their different morph (del Hoyo et al., 1999; König et al., 1999). In the Tytonidae family, the Barn Owl (*T. alba*) has been extensively studied in terms of diet, breeding biology, survival status, movement and other aspects of its biology or ecology (Nagarajan et al., 2002; Altwegg et al., 2003; Meek et al., 2003; Álvarez-Castañeda et al., 2004; Bond et al., 2004; Durant et al., 2004; Roulin et al., 2004; Shifferman and Eilam, 2004). By contrast, research on other members of the Tytonidae family, including the Eastern Grass Owl studied here, is extremely scarce.

In the past, only scattered populations of Eastern Grass Owls were recorded in Taiwan. It was only in the year 2000 that relatively stable sightings were recorded. These included sightings in Yilan, Chiayi, Tainan, Kaohsiung, Pingtung, Penghu, and Kinmen, but the majority were recorded as being concentrated in the south of the island (Tseng, 2005). At present, most Eastern Grass Owl population counts rely on information on individuals caught in mist nets. These nets are mostly set up to prevent bird strikes or bird-damage to crops. A small part of percentage, however, are set up to catch birds. Based on the types of environment where these nets are erected, the Eastern Grass Owl inhabits mostly in the mosaic of grass and woodland area, arable farm land, orchards, airfields, etc. In addition, species distribution has also been recorded in hill-land and low-altitude mountain areas. Relatively little is known about the behavior of the Eastern Grass Owl, so there are huge gaps in our knowledge about ecology and status of the species in Taiwan. Furthermore, the information learned from individuals caught in mist nets in various regions is fairly limited.

During the period of 2001 to 2003, we found three Eastern Grass Owl nests by chance in Nanshi and Yujing in Tainan County. At the time the nests were discovered, both the adults and young had flown the nest; therefore, we were only able to collect post-fledging period pellets for analysis. This study, therefore, focus on an initial investigation of the composition of this owl diet based on the results of pellet analysis.

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MATERIALS AND METHODS

During the period of 2001 to 2003, we found three Eastern Grass Owl nests at Nanshi (23°10'45.1"N, 120°29'5.3"E) and Yujing (23°7'33.1"N, 120°27'42.3"E) in Tainan County in south Taiwan. The nests were uncovered inadvertently by local farmers during grass-cutting. At the time of their discovery, the nests were found to contain fully mobile juveniles ─ some had even reached the flight stage. After being disturbed by the farmers and their hay-making activities, the young and adults abandoned the nests. This meant that we could not conduct any further on-going studies of the birds. All that was left to study were the nest site itself, its environment, and a number of pellets.

Of the nest sites, the two at Yujing, at an altitude of 75 m asl., had been used over two years. The distance between the nests used each year was approximately 50 m. Half (50%) of the area surrounding the nest (measured in a 250-m radius from the nest center) was grassland composed primarily of large-sized shrubs and grasses. The predominant species were *Imperata cylindrical*, *Panicum maximum* and *Miscanthus floridulus*. Of the remaining habitat within the 250-m radius scope, 25% was paddy rice (*Oryza sativa*) and sugar cane (*Saccharum officinarum*) field, 20% was mango (*Mangifera indica*) orchard, 3% was bamboo forest, and 2% was human settlement or road. Only one nest site was found at Nanshi, in 2001, at an elevation of 180 m asl. The composition of the surrounding environment was made up as follows: 25% was predominantly *Imperata cylindrical* and *Miscanthus floridulus* grassland, 35% was paddy rice and sugar cane field, 35% was mango orchard, and 5% was betel nut plantation and bamboo forest. We defined the term 'nest site' as the area where grass had been trodden flat by the owls, which was surrounded by thick wild grasses and shrubs for camouflage. There were several obvious routes to the nests, each followed a winding path and was between two to eight meters in length. Both the nests and the routes to them contained owl down or flight feathers, as well as the pellets, large rodent and bird remains, and other information about the birds' diet.

The width, length, and depth of owl pellets collected were first measured using a vernier caliper (with an accuracy up to 0.05 mm). The samples were then weighed using electronic scales (with an accuracy up to 0.01 g). After allowing them to dry naturally for one week, the pellets were then carefully opened up using tweezers. During pellet examination, bones, feathers, fur and other parts were separated out first. Following the methods of Dickman et al. (1991), we used measurement values for the skulls and pelvic bones of various rodents from museums to help determine the types of rodent consumed by owls. Then the number of skulls, mandibles, limb bones, etc. were counted to calculate the number of animals consumed. The relevant processes were mostly in accordance with the methodology set out by Marti (1987) and Yalden (2003). The values for biomass within the pellets was calculated based on data from museums or the *in situ* capture of relevant species to determine mean average values as the basis for calculation. This procedure is called biomass reversion. The principles for this process are set out in numerous other literature (Marti, 1987; Holt et al., 1991; Holt, 1993; Denver and Leroux, 1996).

RESULTS

A total of 157 pellets were collected from the three Eastern Grass Owl nests. The average measurements of the pellets were 5.2 ± 2.6 cm in length, 3.8 ± 1.1 cm in width, 3.6 ± 1.3 cm in depth and 4.8 ± 1.9 g in dry weight. Following dissection and analysis, the pellets revealed a total of 329 prey items. On average, each pellet contained 2.1 prey items. It was not possible to identify the exact species of bird from the bird remains, which were documented simply as 'bird', however, nine mammal species were identified. The mammal remains included the Formosan Blind Mole (*Mogera insularis*), the House Shrew (*Suncus murinus*), Shrews (*Crocidura* spp.), the Bandicoot Rat (*Bandicota indica*), the Spinus Country-rat (*Rattus losea*), the Formosan Field Striped Mouse (*Apodemus agrarius*), the Formosan Mouse (*Mus caroli*), the Harvest Mouse (*Micromys minutus*), and the Formosan Hare (*Lepus sinensis formosus*). Of the 329 prey items, mammals accounted for 313 (95.1%), while birds accounted for only 16 (4.9%). Of the mammal remains, the proportion of rats was high, with 285 (86.6%) of all prey items. In second place were shrews and moles with 27 (8.2%). Only one record of Formosan Hare remains was made and this was found to be a juvenile. From pellet content analysis, it is evident that owl feeds mainly on rats and mice, with the Spinus Country-rat and the Formosan Mouse being the main species consumed, with 136 (41.3%) and 96 (29.2%) recorded, respectively. The third most commonly eaten mammals were the Formosan Field Striped Mouse, the Bandicoot Rat, and shrews, with 75 recorded (22.8%) (Table 1). Of these, most of the Bandicoot Rats consumed were juveniles.

Table 1. Diet composition in pellet of the Eastern Grass Owl.

Prey Item	Mid point of prey's weight	Nanshi (2001)		Yujing 1(2002)		Yujing 2(2003)		Total	
		Number (%)	Biomass (%)	Number (%)	Biomass (%)	Number (%)	Biomass (%)	Number (%)	Biomass (%)
Mammal									
Formosan Blind Mole (*Mogera insularis*)	45			1 (0.8)	45 (0.5)	1 (0.6)	45 (0.4)	2 (0.6)	90 (0.4)
House Shrew (*Suncus murinus*)	40			2 (1.6)	80 (0.8)			2 (0.6)	80 (0.3)
Shrew (*Crocidura* spp.)	9	4 (11.1)	36 (1.3)	11 (8.5)	99 (1.0)	8 (4.9)	72 (0.6)	23 (7.0)	207 (0.9)
Bandicoot Rat (*Bandicota indica*)(juvenile)	200	2 (5.6)	400 (14.8)	11 (8.5)	2,200 (23.3)	10 (6.1)	2,000 (17.7)	23 (7.0)	4,600 (19.6)
Spinus Country-rat (*Rattus losea*)	115	18 (50.0)	2,070 (76.4)	51 (39.5)	5,865 (62.2)	67 (40.9)	7,705 (68.1)	136 (41.3)	15,640 (66.6)
Formosan Field Striped Mouse (*Apodemus agrarius*)	25	1 (2.8)	25 (0.9)	6 (4.7)	150 (1.6)	22 (13.4)	550 (4.9)	29 (8.8)	725 (3.1)
Formosan Mouse (*Mus caroli*)	15	10 (27.8)	150 (5.5)	39 (30.2)	585 (6.2)	47 (28.7)	705 (6.2)	96 (29.2)	1,440 (6.1)
Harvest Mouse (*Micromys minutus*)	5					1 (0.6)	5 (＜0.1)	1 (0.3)	5 (＜0.1)
Formosan Hare (*Lepus sinensis*) (juvenile)	200			1 (0.8)	200 (2.1)			1 (0.3)	200 (0.9)
Bird	30	1 (2.8)	30 (1.1)	7 (5.4)	210 (2.2)	8 (4.9)	240 (2.1)	16 (4.9)	480 (2.0)
Total		36	2,711	129	9,434	164	11,322	329	23,467

Collectively, the five above-mentioned small mammal species accounted for 93.3% of owl's diet composition. The Eastern Grass Owl's consumption of these five key species was relatively stable year-to-year, with no significant difference in the amounts recorded for each year (Kruskal-Wallis H = 0.020; $p > 0.05$).

The biomass of the prey items caught and consumed by the Eastern Grass Owls varied from 5-200 g. Using biomass reversion, we estimated that the 157 pellets accounted for biomass of 23,467 g. Of this, mammals accounted for 22,987 g (98.0%), while birds accounted for just 2.0%. Of all the species consumed, the biomass contributed by the Spinus Country-rat was the highest with 15,640 g (66.6%) in total, followed by the Bandicoot Rat with 4,600 g (19.6%) in total. The biomass of the remaining species was less than 10.0% (Table 1). On average, each pellet represented biomass of 149.5 g. We subjectively classified the biomass consumed by owls into two categories: those >100 g and the others $\leqq 100$ g. By measuring the frequency of each of these two categories of prey item biomass in the pellets, it was found that 51.1% of the prey items consumed by owls had a biomass of over 100 g.

DISCUSSION

The prey items consumed by Eastern Grass Owls were found to be predominantly mammal species. This was similar to the results of other research on Barn Owls (Goodman and Thorstrom, 1998; Álvarez-Castañeda et al., 2004; Bond et al., 2004). However, no discovery was made of Grass Owls eating reptiles, insects or any other species recorded as prey items in other research (del Hoyo et al., 1999; Zhang, 1985). This may have been due to the limited number of pellet samples. Because the average weight of male Eastern Grass Owls in Taiwan is 450 g (n = 2) and around 500-550 g (n = 3) for females (Tseng, 2005), making them similar in size to Barn Owls, we suspect that both species catch similar size of prey. However, the result showed that the size of prey items caught by Eastern Grass Owls ranged from 5 g to 200 g and that over half (51.1%) were over 100 g. This was somewhat different from the results of past research, which showed that most of the prey items caught by Barn Owls are smaller than 100 g (Marti, 1974; Campbell et al., 1987; Andrew, 1990; Álvarez-Castañeda, 2004). Eastern Grass Owls caught prey weighing up to 200 g, including Spinus Country-rats and Bandicoot Rats. Most research suggests that raptors are opportunists, therefore, the availability of prey, their relative abundance, etc. are all factors deciding diet composition (Adams et al., 1986; Jones and Goetze, 1991; Jorgensen et al., 1998; Huebschman et al., 2000; Cameron, 2003). Within Taiwan's sugarcane fields, Bandicoot Rats and Spinus Country-rats are extremely numerous, as these are the predominant medium- and large-sized rat species (Wang, 1977). This could perhaps be the main reason why the Grass Owls studied caught a higher proportion of these species. Furthermore, the results of this research can only be used as reference about the Eastern Grass Owl's diets during the breeding season. It was not possible to determine the diet of the species outside the breeding season. Other

literature and research has revealed that some owl species show a marked preference for relatively large-sized prey during their breeding season (Belloca, 1998). Alternatively, it is possible that the margin of error for over-estimation of the number of large-sized prey items was due to certain factors concerning the pellets at the nest sites where collection took place (Evelyn et al., 1988).

The Grass Owl has been known to compete with other owl species. Western Grass Owl (*Tyto capensis*) numbers are tending to fall because the species competes for habitat with the Marsh Owl (*Asio capensis*) (del Hoyo et al., 1999). Although Barn Owls and Short-eared Owls (*Asio flammeus*) on Santa Barbara Island in southern California are sympatric, they are able to coexist because the Short-eared Owls on the island are smaller in relation to the Barn Owls there; therefore, there is differentiation in the size of the prey species caught by the two species (Drost and McCluskey, 1992). In Taiwan, Short-eared Owls live in environments inhabited by the Eastern Grass Owl. Although the two species feed predominantly on mammal prey species, the Short-eared Owl preys on mammals of a smaller size. Its prey species are mostly the Formosan Field Striped Mouse and the Formosan Mouse. The largest prey species caught by Short-eared Owls is the Spinus Country-rat (Lin and Yeh, 2002). This is substantially different from the Eastern Grass Owl, which feeds predominantly on the Spinus Country-rat and also preys on larger mammals like juvenile Bandicoot Rats and young rabbits. This means that there may have some slight differentiation in the two species' diet compositions.

The Eastern Grass Owl is by nature a very timid bird and its numbers in Taiwan are relatively few; therefore, research and data on the species is extremely limited. Furthermore, the Taiwan government's policy of conducting a nation-wide rodent extermination campaign in October each year via the widespread release of rat poison into the wild has caused the deaths of many species that feed on rats. These incidental victims, of course, include the Eastern Grass Owl. In addition to accidental poisoning, the Eastern Grass Owl's survival is also being threatened by measures to reafforested lowland areas, which are causing previously abundant and stable wild field rat populations to decline due to habitat loss. We believe that both the rat extermination and lowland reafforestation policies require immediate and in-depth review and investigation by the government to assess the negative impact and threats posed by such policies on other species.

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臺灣南部地區東方草鴞食性初探

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摘　　要

2001 至 2003 年研究期間，分別在台南縣楠西與玉井兩地，共發現三個東方草鴞 (*Tyto longimembris*) 的巢區，總共蒐集了 157 枚食繭。食繭內容物經分析鑑定共有 329 隻食餌包含其中，包括哺乳類與鳥類。東方草鴞的食繭中有 95.1%是哺乳類，其餘 4.9%是鳥類。哺乳類中又以囓齒目鼠類被捕捉比例較高，共有 285 隻，比例 86.6%。其次為食蟲目 27 隻，比例 8.2%。兔子與鳥類被捕食的情況較少。可以看出，鼠類是東方草鴞主要食物來源，其中又以小黃腹鼠 (*Rattus lo*sea) 被捕食的比例較高，共有 136 隻 (41.3%)。月鼠 (*Mus caroli*) 是被捕食第二多的哺乳類，共有 96 隻 (29.2%)。生物量部分，利用回推方式算出此三巢東方草鴞捕食的哺乳類約有 22,987 g，而鳥類有 480 g，所佔的比例分別為 98.0% 與 2.0%。每枚食繭約為消耗 149.5 g 的生物量。

關鍵詞：東方草鴞、食繭、食性、生物量。

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