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The Diet of Fairy Pitta *Pitta nympha* Nestlings in Taiwan as Revealed by Videotaping

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Ruey-Shing Lin, Cheng-Te Yao, and Pei-Fen Lee (2007) The diet of Fairy Pitta *Pitta nympha* nestlings in Taiwan as revealed by videotaping. *Zoological Studies* **46**(3): 355-361. The nestling diet of the Fairy Pitta (*Pitta nympha*) in west-central Taiwan was studied by videotaping 8 broods from 2000 to 2002. Adults usually brought 1-3 items at each feeding visit to nestlings, and the prey sizes were usually in 2-10 cm in length. The total number of food provisionings to provide food for nestlings was estimated to be around 900-1000 based on a brood observed for the entire nestling period. Earthworms were the most important food item for all broods and occurred in more than 73% of the adult's feeding visits. However, the occurrences of earthworm decreased with nestling age in 1 brood which was observed during drought conditions, possibly due to a decline in earthworm abundances during this dry period. More information on the effects of earthworm abundances on the breeding performance of the Fairy Pitta and relationships with habitat characteristics is needed to ensure the future conservation of this vulnerable species. http://zoolstud.sinica.edu.tw/Journals/46.3/355.pdf

Key words: Food, Earthworm, Videotaping, Reproduction, Endangered species.

The Fairy Pitta (*Pitta nympha*) is listed as being in a vulnerable C1 status according to IUCN criteria (BirdLife International 2001). It is migratory, breeds in forest habitats of southern Japan, South Korea, southeastern China, and Taiwan, and resides mainly on the island of Borneo in winter (Lambert and Woodcock 1996, Erritzoe and Erritzoe 1998). Habitat loss, illegal trapping, and human disturbance are major threats (BirdLife International 2001). The birds are highly susceptible to habitat deterioration that may result from timber clearance, agricultural practices, degradation and fragmentation of subtropical and tropical forests, as well as poaching (Severinghaus 1991). BirdLife International (2001) estimated that its population may be less than 10,000 individuals worldwide. Our understanding of the Fairy Pitta is rather limited due to its elusive lifestyle, making detection in the field difficult. For conservation of this threatened species, ecological studies on its breeding habitat requirements are essential (BirdLife International 2001).

In Taiwan, the species is distributed along hill slopes below 1300 m elevation (Severinghaus et al. 1991). Most of the birds arrive in Taiwan during mid- to late Apr. (RS Lin unpubl. data). The breeding season begins in late Apr. when adults engage in singing. Adults lay the 1st eggs in mid- to late May or early June (Lin et al. 2002). The clutch size ranges from 3 to 5, but 3 is rare. Most young birds are observed from early June to late July (RS Lin unpubl. data). Although it is assumed that they leave Taiwan around Sept.- Oct. (BirdLife International 2001), both the young and adults are difficult to observe in the field once the young become independent (RS Lin unpubl. data).

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Fairy Pittas search for food under leaves on the ground and feed on insects and their larvae, such as ants, snails, beetles, earthworms, and centipedes (BirdLife International 2001). Nestlings are mainly fed earthworms, and occasionally insects and small crabs (Lin et al. 2002, Okada 1999). It has been reported that both parents contribute toward the rearing of their nestlings (Severinghaus et al. 1991, Liu et al. 1996, Okada 1999). Four to 5 d prior to fledging, the nestlings may consume 70-80 earthworms daily (Okada 1999), but there are no other quantitative data on the food of nestlings.

The breeding success of the Fairy Pitta probably depends on the availability of suitable nesting habitat that can provide adequate food for nestlings. Therefore, identification of the diet of nestlings is important for developing conservation strategies to improve habitat quality (Moreby and Stoate 2000). In this study, we collected quantitative data on the nestling diet of the Fairy Pitta in central Taiwan, where a dam construction project, initiated in 2002, has threatened a local population of this species in recent years.

METHODS

Study area

This study was conducted at Linnei, Yunlin County in west-central Taiwan (120°37'E, 23°44.5'N, Fig. 1) from Apr. 2000 to July 2002. The hilly area is about 2200 ha with elevations ranging from 50 to 500 m. It was designated an Important Bird Area (IBA) mainly for the conservation of the Fairy Pitta by the Wild Bird Federation of Taiwan (2001) which was later endorsed by BirdLife International. Cultivated Taiwan giant bamboo (*Dentrocalamus latiflorus*) is dominant and occupies more than 50% of the area. Secondary broadleaf trees are common on sides of ravines and ridges, and in some abandoned bamboo plantations. Fruit orchards and betel nut (*Areca catechu*) plantations are sparsely distributed in the area.

The study area has a subtropical climate with a cool, dry winter and a hot, wet summer. In general, the wet season runs from Apr. to Sept. with total seasonal precipitation of about 1500 mm. The dry season runs from Oct. to Mar. with total precipitation of < 400 mm (Fig. 2). A severe drought occurred in Oct. 2001 to May 2002, when little precipitation was recorded.

Videotaping

In our study area, the Fairy Pitta arrived in mid-Apr. and began actively singing in late Apr. (Lin et al. 2002). Most (79%) nests were built on the ground on a steep slope, often on the sides of gullies, with some nests occasionally placed in forks of trees (RS Lin unpubl. data). We located nests by searching potential nesting sites at locations with previous playback response records (Lin et al. 2002, 2007), or by following adults which were foraging or collecting nesting materials.

We recorded nesting activities with camcorders (Canon LX-1 and XL1, Tokyo, Japan; and

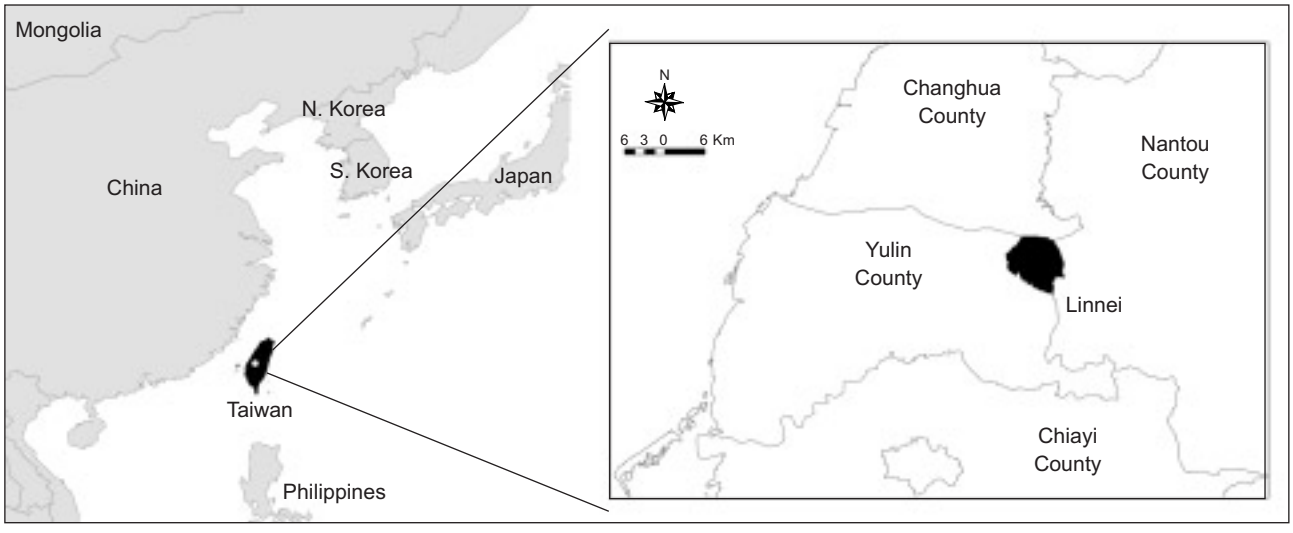

Fig. 1. Map of the study area in west-central Taiwan.

Sony DCR-PC5, Tokyo, Japan) in 2000 and 2001, and with a miniature camera (Watec WAT202B, Tsuruoka, Yamagata, Japan) and video recorder (Mitsubishi HV-S606KG, Tokyo, Japan) in 2002. Eight broods were monitored for a total of 214 h (Table 1). In the 2000 and 2001 seasons, we taped 7-d-old nestlings from 06:00 to 12:00 to minimize the potential disturbance and to avoid adults abandoning the nests; we were also working under a manpower shortage. The nestlings left their nests on the 13th-14th day after hatching (n = 11). To monitor an entire nestling period, we set up a video device for a brood 4 d before they hatched in 2002. The equipment was operated during the daytime to capture the entire nestling period. No nest abandonment was observed.

For each of the broods, each visit by a parent was recoded, and the number, size, life stage (larval or adult), and type of prey delivered to the nestlings were recorded. The length of the prey was determined by comparing its exposed portion with the birds' bills, which measured about 2 cm (19.8 ± 0.8 mm) on 46 banded bird specimens from museums. Because we were unable to determine the number of items in some of the feeding visits due to light conditions and interrupted views, the percentage occurrence of each prey type to the total nest visits by parents was used for comparisons. To compare potential differences in nestling periods, we divided this period into 2

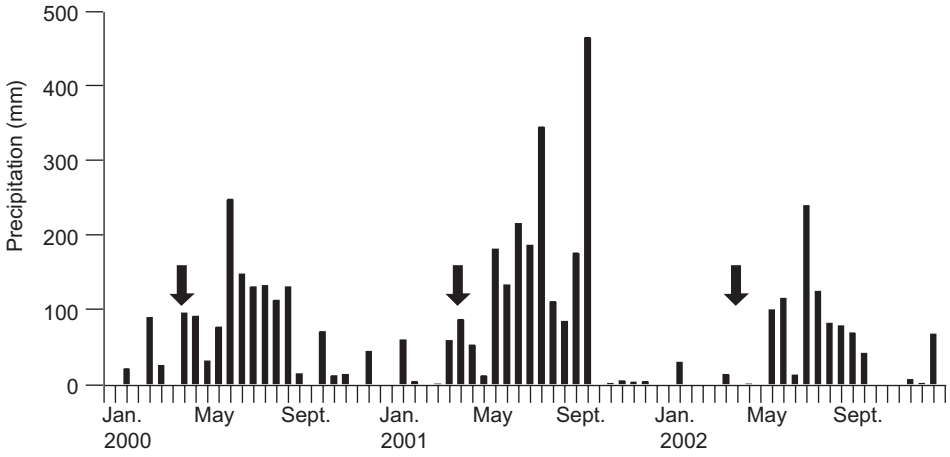

Fig. 2. Semi-monthly precipitation at Linnei, Yunlin County in west-central Taiwan from Jan. 2000 to Dec. 2002. The arrows indicate the dates the Fairy Pitta arrived.

Table 1. Summary of 8 Fairy Pitta broods studied at Linnei, Yunlin County in west-central Taiwan during the breeding seasons in 2000-2002

Year and nest no.	Number of nestlings hatched	Number of young fledged	Hatching date	Total observations (h)
2000				
#1	unknown	4	May 26	2
2001				
#1	3	1	May 25	3.5
#2	5	5	May 27	6.5
#3	4	0*	June 9	4
#4	5	5	May 27	8
#5	4	4	June 10	8
#6	4	4	July 7	13
2002				
#1	5	4	June 10	169

* Nest failed due to human disturbance on the day before fledging occurred.

halves: the 1st period when nestlings were younger than 7 d, and the 2nd one when they were older than 7 d.

RESULTS

Diet items

In total, 1062 feeding visits were recorded for the 8 broods during the study period. Of these, food items were clearly identified on 661 visits. Approximately 20% of the observations belonged to the same type (but was not an earthworm) that could not be identified. Earthworms of several species were the most common food item for nestlings, averaging 73% of all items for the 8 broods (Table 2). Lepidopteran larvae were the 2nd largest identifiable food item, comprising 8.6% of observations. Lepidopteran adults and likely their pupae occupied 11% of the nestling diet. The remaining invertebrate taxa were only rarely recorded, including slugs, snails, spiders, Plecoptera, Scutigeromorpha, dipteran larvae, freshwater crabs, praying mantis (Mantodea), dragonflies (Odonata), centipedes (Scolopendromorpha), whip scorpions (Thelyphonidae), beetle adults and larvae (Coleoptera), and grasshoppers, katydids, and crickets (Orthoptera). Vertebrate dietary items (n = 24) included frogs, lizards, small snakes, and a small shrew, occupying only 4% of the nestlings' diet.

For the 2002 brood, the occurrence of earthworms in the nestling diet decreased with the age of the nestlings (r^2 = 0.77, n = 14, p < 0.001; Fig. 3). The mean occurrence of earthworms in the diets decreased from 0.72 (SD = 0.15, n = 7) in the 1st half to 0.41 (SD = 0.13, n = 7 d) in the 2nd half. The mean occurrence of earthworms in the other 7 broods (in 2000 and 2001) that were taped during the 2nd half of the nestling period was 0.76 (SD = 0.18).

Number of food items per visit

Among 661 nest visits by adults, we were able to identify 610 prey items. For each visit, adults brought 1 to 6 items, but usually fewer than 4 items. Based on the 4 broods with more than 20 observations each, the mean prey number per visit was 1.8 (SD = 0.39), and only 1 item was carried on 43% of the feeding visits (Fig. 4). The number of prey items per visit was affected by the food

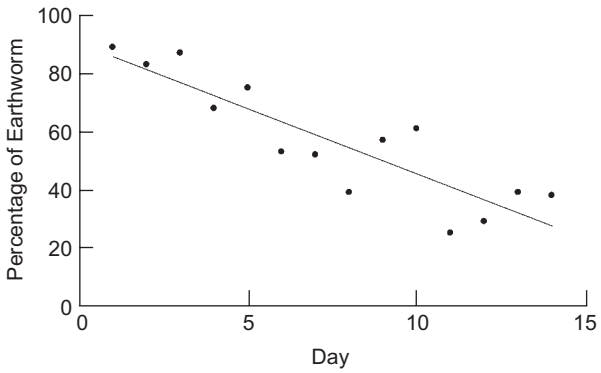

Fig. 3. Percentage of earthworm occurrence in the diet of nestlings. It was found to have significantly decreased with nestling age for a brood videotaped in 2002. The day of hatching was designated day 1.

Table 2. Percentage occurrence and mean of food items for 8 Fairy Pitta broods at Linnei, Yunlin County in west-central Taiwan during the nesting seasons in 2000-2002. The number in parentheses indicates the number of feeding visits when the food item could clearly be identified

Food items	Percentage (%) of food items							
	2000 #1 (8)	2001 #1 (7)	2001 #2 (23)	2001 #3 (16)	2001 #4 (32)	2001 #5 (26)	2001 #6 (52)	2002 #1 (497)
Earthworms	75.0	85.7	73.9	62.5	46.9	100.0	88.5	52.9
Uncertain items but not earthworms	0	28.6	26.1	12.5	46.9	15.4	7.7	24.3
Lepidopteran larvae	25.0	0	4.3	12.5	15.6	0	1.9	9.6
Beetle adults	12.5	0	13.0	0	3.1	0	0	0.8
Insect pupae	0	0	0	6.3	0	7.7	7.7	1.0
Other arthropods	12.5	0	0	0	0	3.8	3.8	12.6
Small vertebrates (frogs, snakes, lizards, and shrews)	0	14.3	8.6	6.3	0	0	0	4.2
Snails and slugs	0	0	0	0	0	0	1.9	0.4

type; the number of earthworms per visit (mean ± SD, 1.7 ± 0.95; n = 181) was significantly higher than the number of other food items per visit (1.0 ± 0.19; n = 165) (the Mann-Whitney U test, p < 0.001).

Prey size

The estimated mean food length of 759 items was 6.4 cm (SD = 0.55), and 93.4% of the food items were smaller than 10 cm, but a few large items were observed (Fig. 5). The longest prey was a lizard (*Japalura swinhonis*) at 20 cm in length. Other food items longer than 12 cm were vertebrates, large caterpillars, and earthworms.

Food provisioning rates

For a brood in 2002, 881 total feeding visits were recorded. Five nestlings were hatched, but only 4 successfully fledged. During this period, the daily observation length was 13 h (05:00-18:00), except for 1 d with 10 h. Although adults provided food to their nestlings up to 19:00, light conditions in the early morning and early evening (after 18:00) made it difficult to discern food items. We estimated that the total number of feeding visits for this particular brood was between 900 and 1000.

The daily (05:00-18:00) provisioning rate increased from 2.2 to 6.2 visits/h during the first 7 d, remaining relatively high until the young fledged, although it dropped after the 9th d (Fig. 6).

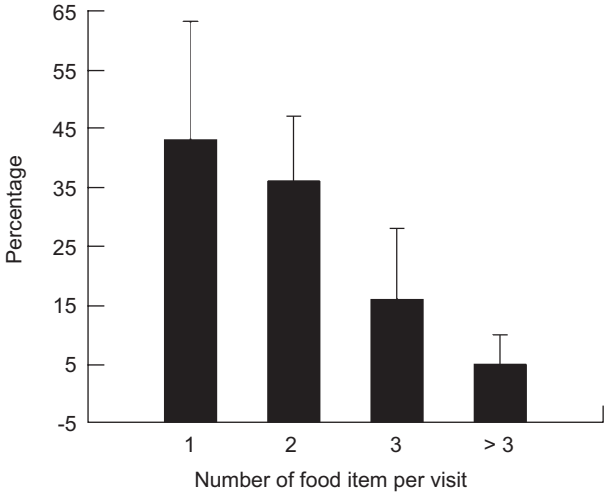

Fig. 4. Mean (± SD) percentage of the number of food items carried by an adult in each feeding visit. Data are from 4 broods with more than 20 observations each in 2001 and 2002.

DISCUSSION

We found that earthworms comprised the largest component of the diet of nestling Fairy Pittas, occurring in 73% of parental feeding visits; this supports previous claims and observations (Severinghaus et al. 1991, Okada 1999, BirdLife International 2001). The high percentage of earthworms in the diet also indicates that this food item is easy to procure during the wet season. Earthworms have also been found to be the common food item for other pitta species: 63% for the Rainbow Pitta (*P. iris*) (Zimmermann 1996, Zimmermann and Noske 2003), 73-79% of identified prey items in the diet of nestling Gurney's Pitta (*P. gurneyi*) (Round and Treesucon 1986, Gretton et al. 1993), and over 30% of the nestling diet for the Giant Pitta (*P. caerulea*) (Round et al. 1989).

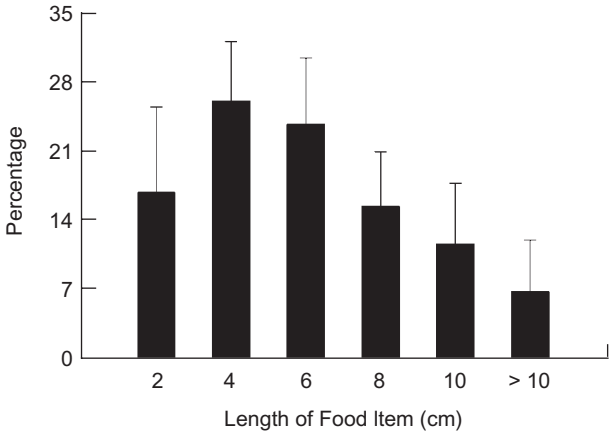

Fig. 5. Mean (± SD) percentage of the length of food items based on 5 broods with more than 20 observations each in 2001 and 2002.

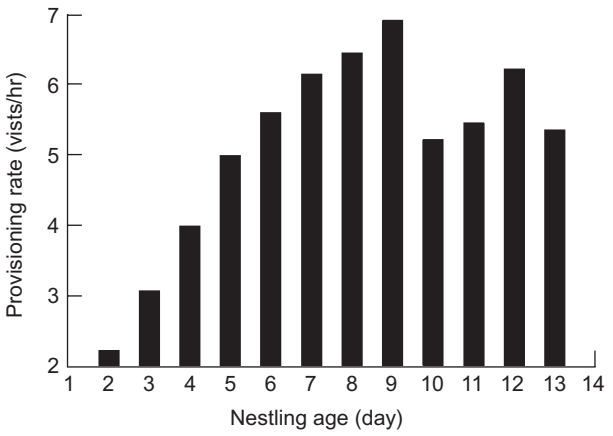

Fig. 6. Trend of the provisioning rate with nestling age for a brood studied in 2002. The day of hatching was designated day 1.

Apparently, the Fairy Pitta prefers to feed its nestlings earthworms (Severinghaus et al. 1991, Liu et al. 1996, Okada 1999), even when other food items are available. Moreover, non-earthworm items may be more difficult to handle when the adults carry more than 2 items simultaneously.

In addition to earthworms, arthropods (such as spiders, centipedes, several kinds of insects, whip scorpions, freshwater crabs, and scutigeromorphs) were also an important part of the diet items for nestlings, although they comprised < 30% of the diet items. One photographer captured an adult bringing a cicada to its young in central Taiwan (http://www.birdingintaiwan.com/Birdsintwn/FairyPitta.htm).

In this study, an unexpected component of the diet of nestlings was vertebrates, such as frogs, lizards, snakes, and shrews. To our knowledge, this is the 1st observation of Fairy Pittas feeding on vertebrates. However, adult Rainbow Pittas (*P. iris*) were found to feed on small vertebrates, such as frogs, lizards, and snakes (Zimmererermann 1996, Erritzoe and Erritzoe 1998). In this study, adult Fairy Pittas brought vertebrate items for the young only during the late nestling period (≥ 6 d old). In other passerines, larger prey items are brought to older nestlings possibly because they can handle larger prey better than can younger nestlings (Knapton 1984, Van Horne and Bader 1990, Haggerty 1992). Similarly, vertebrate prey might be too large (11.1 ± 2.4 cm, n = 24) for recently hatched nestlings.

In our study, we found that adult Fairy Pittas made over 70 visits during the daytime. In contrast, Liu et al. (1996) reported 35-52 feeding visits from 05:00 to 19:00 for a brood with 5 fledglings older than 6 d in Anhui Province, China. The number of feeding visits may be strongly affected by environmental conditions, and the size and density of prey items available (Naef-Daenzer and Keller 1999, Naef-Daenzer et al. 2000, Grieco 2002). A direct comparison cannot be made, because the methodology and nestling diet were not detailed by Liu et al. (1996).

In 2002, there was an unexpected trend of a decrease in earthworms in the diet with an increase in nestling age. Several factors have been proposed for the dietary shift, such as individual differences in selecting food types by parent birds (Grundel 1990), foraging skills of the parent birds (Lemmon 1993), habitat and territory quality (Hess and James 1998), nestling age, and time of day or year (Grundel and Dahlsten 1991). However, the low rainfall in 2002 might have been responsible for a reduction in earthworm abundances. There was a severe drought from Oct. 2001 to early May 2002 (Fig. 2). In drought conditions, earthworms may enter a resting stage deep underground where they become motionless, and probably do not feed, grow, or breed (Lee 1985). This situation made it difficult for the adults to collect enough earthworms for the nestlings. Earthworm scarcity during the breeding season not only forced the adults to search for alternative foods, but also caused the breeding season to be postponed for at least 2 wk in 2002. Between the breeding seasons of 2000 and 2003, 40 nests within the study area were located (RS Lin, unpubl. data). In normal years, the breeding season usually begins on about 10 May, but in 2002 it did not begin until 23 May. Food abundance constrains the breeding performance of adults, and affects annual fecundity (Holmes et al. 1992, Siikamaki 1998, Rodriguez-Estrella 2000). Zimmermann and Noske (2003) found that the breeding period of the Rainbow Pitta coincided with the wet season, and the start of the breeding season varied annually with rainfall.

In conclusion, earthworms were the main food item for Fairy Pitta nestlings. When there was a scarcity of earthworms due to a severe drought, adults shifted to other food sources. Because of the importance of earthworm availability for the diet of the Fairy Pitta, further studies should address to the relationship between their abundances and habitat characteristics, such as land cover types, leaf litter, and soil moisture, as well as seasonal variations. Finally, food quality and availability may vary among habitats or even territories in the same habitat, affecting territorial occupancy and breeding performance of adult Fairy Pittas. Understanding the responses of the Fairy Pitta to fluctuations in food availability, especially under different climate scenarios, will provide useful data for the conservation of this species. Only if combined with adequate habitat protection will we truly be able to protect this endangered species.

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REFERENCES

BirdLife International. 2001. Threatened birds of Asia: the BirdLife International Red Data Book. Cambridge, UK: BirdLife International.

Erritzoe J, HB Erritzoe. 1998. Pittas of the world. Cambridge, UK: Lutterworth Press.

Gretton A, M Kohler, RV Lansdown, TJ Pankhurst, J Parr, C Robson. 1993. The status of Gurney's Pitta *Pitta gurneyi*, 1987-1989. Bird Conserv. Int. **3:** 351-367.

Grieco F. 2002. Time constraint on food choice in provisioning Blue Tits, *Parus caeruleus*: the relationship between feeding rate and prey size. Anim. Behav. **64:** 517-526.

Grundel R. 1990. The role of dietary diversity, prey capture sequence and individuality in prey selection by parent Mountain Chickadees (*Parus gambeli*). J. Anim. Ecol. **59:** 959-976.

Grundel R, DL Dahlsten. 1991. The feeding ecology of Mountain Chickadees (*Parus gambeli*): patterns of arthropod prey delivery to nestling birds. Can. J. Zool. **69:** 1793-1804.

Haggerty TM. 1992. Effects of nestling age and brood size on nestling care in the Bachman's Sparrow (*Aimophila aestivalis*). Am. Midl. Nat. **128:** 115-125.

Hess CA, FC James. 1998. Diet of Red-cockaded Woodpecker in the Apalachicola National Forest. J. Wildlife Manage. **62:** 509-517.

Holmes RT, TW Sherry, PP Marra, KE Petit. 1992. Multiple brooding and productivity of a Neotropical migrant, the Black-throated Blue Warbler (*Dendroica caerulescens*), in an unfragmented temperate forest. Auk **109:** 321-333.

Knapton RW. 1984. Parental feeding of nestling Nashville Warblers: the effects of food type, brood-size, nestling age, and time of day. Wilson Bull. **96:** 594-602.

Lambert F, M Woodcock. 1996. Pittas, broadbills and asities. Sussex, UK: Pica Press.

Lee KE. 1985. Earthworms: their ecology and relationships with soils and land use. Sydney, Australia: Academic Press.

Lemmon WC. 1993. Heritability of selectively advantageous foraging behaviour in a small passerine. Evol. Ecol. **7:** 421-428.

Lin RS, PF Lee, TS Ding, YK Lin. 2007. Effectiveness of playbacks in censusing the Fairy Pitta *Pitta nympha* during the breeding season. Zool. Stud. **46:** 242-248.

Lin RS, PH Liu, FH Hsu, CH Hsu, PF Lee. 2002. Effectiveness of tape playback in censusing the Fairy Pitta *Pitta nympha* during the early breeding season. *In* ML Hsueh, eds. Proceeding of Biodiversity Symposium 2002. Nantou, Taiwan: Endemic Species Research Institute, pp. 248-258 (in Chinese with English abstract)

Liu X, C Gu, S Zheng, H He, S Liu. 1996. Studies on the breeding ecology of Blue-winged Pitta. *In* GM Zheng, ZM Zhang, ZW Yan, ML Zeng, eds. Studies on Chinese ornithology. Beijing: China Forestry Publishing House. (in Chinese)

Moreby SJ, C Stoate. 2000. A quantitative comparison of neck-collar and faecal analysis to determine passerine nestling diet. Bird Study **47:** 320-331.

Naef-Daenzer B, LF Keller. 1999. The foraging performance of Great and Blue Tits (*Parus major* and *P. caeruleus*) in relation to caterpillar development, and its consequences for nestling growth and fledgling weight. J. Anim. Ecol. **68:** 708-718.

Naef-Daenzer L, B Naef-Daenzer, RG Nager. 2000. Prey selection and foraging performance of breeding Great Tits *Parus major* in relation to food availability. J. Avian Biol. **31:** 206-214.

Okada M. 1999. Fairy Pitta at the environs of River Shimanto-gawa. Birder **13:** 54-57. (in Japanese)

Rodriguez-Estrella R. 2000. Breeding success, nest-site characteristics, and diet of Swainson's Hawk (*Buteo swainsoni*) in a stable population in northern Mexico. Can. J. Zool. **78:** 1052-1059.

Round PD, U Treesucon. 1986. The rediscovery of Gurney's Pitta *Pitta gurneyi*. Forktail **2:** 53-66.

Round PD, U Treesucon, JC Eames. 1989. A breeding record of the Giant Pitta *Pitta caerulea* from Thailand. Forktail **5:** 35-47.

Severinghaus LL, CT Liang, SR Severinghaus, LC Lo. 1991. The distribution, status and breeding of Fairy Pitta (*Pitta nympha*) in Taiwan. Bull. Inst. Zool. Acad. Sin. **30:** 41-47.

Siikamäki P. 1998. Limitation of reproductive success by food availability and breeding time in Pied Flycatchers. Ecology **79:** 1789-1796.

Van Horne B, A Bader. 1990. Diet of nestling Winter Wrens in relationship to food availability. Condor **92:** 413-420.

Wild Bird Federation Taiwan. 2001. Important bird areas in Taiwan. Taipei, Taiwan: Wild Bird Federation Taiwan.

Zimmermann UM. 1996. Ecology of the monsoon-rainforest endemic Rainbow Pitta *Pitta iris*. PhD thesis, Northern Territory University, Darwin, Australia.

Zimmermann UM, RA Noske. 2003. Breeding biology of the Rainbow Pitta, *Pitta iris*, a species endemic to Australian monsoon-tropical rainforests. Emu **103:** 245-254.