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Acta Zoologica Taiwanica 9(1): 59-66 (1998)

Diet Analysis of the Gray-cheeked Fulvetta (*Alcippe morrisonia*) at Fushan Experimental Forest in Taiwan

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Abstract

The Gray-cheeked Fulvetta (*Alcippe morrisonia*) is the most dominant bird species in Fushan Experimental Forest as well as in most forests below 1,000 m elevation in Taiwan. This paper presents the diet of this species based on 626 flushing gut contents from birds captured from July 1994 to April 1997. The diet of the Gray-cheeked Fulvetta is described through frequency of occurrence, relative volume, and a standardized index. The results reveal that the Gray-cheeked Fulvetta preys mainly on arthropods and less on plant matter. Seasonal change in diet composition between arthropods and plant matter is evident, with plant matter increasing sharply in fall and winter. Within the 18 orders of insects identified, Hymenoptera and Coleoptera contributed most in the diet of the Gray-cheeked Fulvetta. However, the former had the highest standardized index in fall and winter whereas the latter had this in summer. The high demand of arthropod food for nestlings in the breeding season and the increase of small fruits of various understory plant species in the nonbreeding season might account for the seasonal change in diet composition of the Gray-cheeked Fulvetta. However, seasonal variation of insect abundance might be the most influential factor leading to the observed result.

Key words: Gray-cheeked Fulvetta, *Alcippe morrisonia*, Diet analysis, Fushan.

INTRODUCTION

The Gray-cheeked Fulvetta (*Alcippe morrisonia*) is the most dominant bird species in Fushan Experimental Forest as well as in other forests at low elevations in Taiwan. However, information on the diet of the Gray-cheeked Fulvetta is scarce. According to observations of 549 feeding bouts at five nests, Lin (1996) found that adult fulvettas almost exclusively feed arthropods to nestlings. Except for one earthworm, 302 out of 303 identifiable prey were arthropods. Zhai (1977) considered the Gray-cheeked Fulvetta as an insectivorous species with a diet containing some vegetative food (20%, but sample size not available).

Fushan Experimental Forest has been a long-term ecological research site for more than 5 years with over 20 scholars involved. In order to understand the food web of this ecosystem, diet analysis of the Gray-cheeked Fulvetta was conducted. We document the diet of the Gray-cheeked Fulvetta based on gut contents and investigate the seasonal variation in diet composition.

METHODS

Fushan Experimental Forest is a research site of the Taiwan Forestry Research Institute. It is located at the border of Taipei and Ilan counties. This site is a moist subtropical forest at elevations of 670 to 1,100 m. Detailed description of the study site can be found in Lin *et al.* (1996). It was selected as one of five long-term ecological research sites in Taiwan in 1992.

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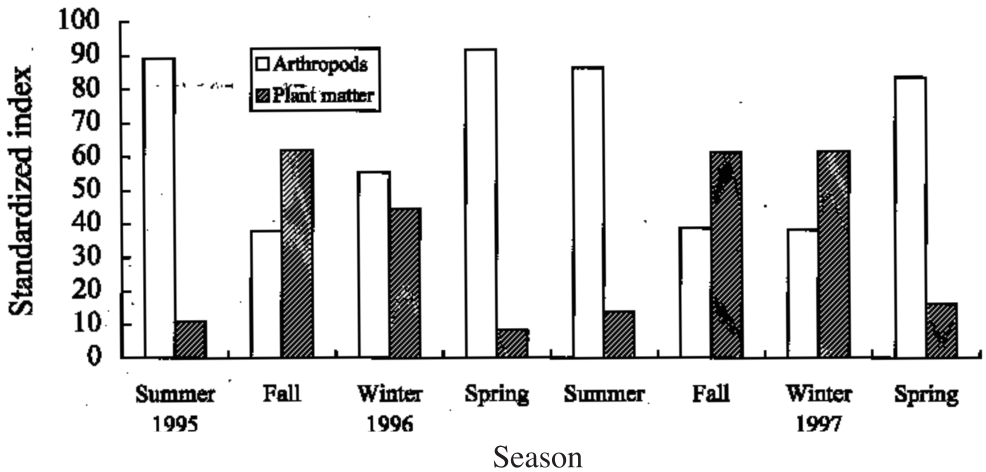

Figure 1. Seasonal change in standardized indices of arthropods and plant matter in gut contents of the Gray-cheeked Fulvetta during a 2-yr survey at Fushan Experimental Forest in Taiwan.

Gray-cheeked Fulvettas were captured using mist-nets at several selected sites in July 1994 and January 1995, then once a season from July 1995 to April 1997. When a bird was caught, it was ringed, and morphological characteristics were measured. Then, the bird was processed for flushing with a warm 1% saline solution using the method in Moody (1970). In short, one person held the bird and positioned the receptacle under the cloaca, and the other opened the bird's mouth, inserted the Vaseline-coated plastic tubing, and flushed saline solution into the bird's stomach. However, we made three minor modifications to the original method. First, we used a gardener's pump instead of a 10-cc disposable plastic syringe to shorten the process time. Second, we measured the approximate distance of the tubing needed to reach the stomach of the bird by taking the distance from the gape to the frontal end of the abdominal cavity of the bird. Then, we attached a stopper, which was made of a small piece of tape, onto the tubing to mark the distance. The tubing was inserted gently into the esophagus until the stopper rested upon either side of the gape. Therefore, we avoided inserting the tubing into the esophagus until the tip rested against the stomach by feeling as in Moody (1970). Third, besides a receptacle positioned under the cloaca, we put another one directly under the mouth for collecting any regurgitation from the bird.

It usually took 3-5 pushes, about 3 cc, for a bird to respond, and it needed only 1-2 min to finish the entire process. All gut contents were then collected and stored in a bottle with a 75% alcohol solution.

Diet samples were examined under a dissecting microscope by the third author. Residuals of arthropods, such as body segments, appendages, skeleton, or exoskeleton, were first separated from plant matter, and then identified to at least order level. Classification of insects followed Borror and White (1970). Occasionally, insects with whole body were found, and these were identified to genus or species level. We were unable to identify plant matter because of the lack of a collection of reference samples. Identified arthropods as well as plant matter were stored in 4-cc bottles by order, and volumetric measurement was taken for each diet category.

Volumetric measurement was determined as follows. Five levels were assigned according to the occupied underside area, about 95.03 mm^2 (r = 5.5 mm), of the bottle. Level one contained one to three small seeds or one small insect appendage, usually covering much less

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Table 1. Arthropod remains identified from 626 gut flushing samples of Gray-cheeked Fulvettas at Fushan Experimental Forest in Taiwan, July 1994-April 1997.

Arthropod category	Frequency of occurrence (%)	Relative volume (%)	Importance index[a]	Standardized Index[b]
Insecta				
Collembola	0.32	0.11	0.0004	0.0009
Ephemeroptera	0.16	0.11	0.0002	0.0004
Odonata	0.32	0.11	0.0004	0.0009
Plecoptera	0.16	0.11	0.0002	0.0004
Orthoptera	5.11	2.28	0.1165	0.2834
Dermaptera	0.32	0.22	0.0007	0.0017
Embioptera	0.16	0.11	0.0002	0.0004
Isoptera	0.16	0.05	0.0001	0.0002
Psocoptera	0.48	0.22	0.0011	0.0026
Mecoptera	0.48	0.16	0.0008	0.0019
Mallophaga	0.80	0.27	0.0022	0.0053
Homoptera	12.30	5.48	0.6740	1.6398
Hemiptera	11.82	5.26	0.6217	1.5126
Coleoptera	55.75	31.51	17.5668	42.7369
Tricopotera	0.16	0.11	0.0002	0.0004
Lepidoptera	18.53	10.14	1.8789	4.5711
Hymenoptera	56.87	32.21	18.3178	44.5639
Diptera	19.81	8.89	1.7611	4.2845
Arachnida	6.07	2.66	0.1615	0.3928

[a] Importance index was defined as the product of frequency of occurrence and relative volume.
[b] Standardized index is the standardized value of the importance index, and these values are summed to 100.

than 1/8 of the underside area of the bottle spatially. Level two included all the events from level one up to 1/4 of the underside area of the bottle. Thereafter, we assigned levels three to five as the proportion of underside area as 1/4 to 1/2, 1/2 to 3/4, or > 3/4 being occupied.

Frequency of occurrence, relative volume, and a standardized index are used to describe the diet of the Gray-cheeked Fulvetta. Importance index is defined as the product of frequency of occurrence and relative volume. Standardized index is the standardized value of the important index, and these values are summed to 100.

We first compared diet composition between arthropods and plant matter through the seasons, and then we concentrated on analyses of arthropod prey. For seasonal comparison of diet, we discarded data before July 1995 to keep two replications for each season.

RESULTS

The diet of the Gray-cheeked Fulvetta based on 626 samples of gut contents reveals that it preys primarily on arthropods and less on plant matter (overall standardized index = 67.99 and 32.01 for arthropods and plant matter, respectively). An obvious trend of seasonal change in the diet composition between arthropods and plant matter is shown in Figure 1. The Gray-cheeked Fulvetta preys predominantly on arthropods in spring and summer. However, the standardized index of plant matter increases several-fold from summer to fall, and even outnumbers the indices of arthropods in the fall of both years and the winter of 1996.

Within the 18 orders of insects and Arachnida identified from gut contents of the Gray-cheeked Fulvetta, Hymenoptera and Coleoptera occur most frequently and account for the largest volumetric importance (Table 1). Both orders contribute roughly equal

Table 2. Seasonal variation of main arthropod categories in gut contents of Gray-cheeked Fulvettas at Fushan Experimental Forest in Taiwan, July 1995-April 1997. Categories with small amount of food items were lumped into "Other insects."

	Spring (112)[a]			Summer (131)			Fall (118)			Winter (162)		
Food category	FO (%)[b]	RV (%)[c]	SI (%)[d]	FO (%)	RV (%)	SI (%)	FO (%)	RV (%)	SI (%)	FO (%)	RV (%)	SI (%)
Insecta												
Orthoptera	1.79	0.84	0.04	6.11	2.49	0.33	5.93	5.23	1.43	0.00	0.00	0.00
Homoptera	8.93	3.65	0.81	20.61	7.69	3.39	5.08	5.23	1.23	11.73	5.85	1.69
Hemiptera	10.71	5.34	1.42	16.03	5.61	1.92	9.32	7.56	3.24	6.17	2.93	0.44
Coleoptera	55.36	28.09	38.50	68.70	31.60	46.37	26.27	22.67	27.43	48.15	31.65	37.51
Lepidoptera	33.04	18.82	15.39	31.30	11.64	7.78	5.93	8.72	2.38	10.49	7.45	1.92
Hymenoptera	55.36	26.97	36.96	61.83	25.78	34.04	33.90	35.47	55.35	55.56	39.36	53.83
Diptera	22.32	11.24	6.21	22.90	8.11	3.97	14.41	13.37	8.87	18.52	9.31	4.24
Other insects	6.25	2.53	0.39	2.29	1.04	0.05	0.85	1.16	0.05	4.94	2.39	0.29
Arachnida	4.46	2.53	0.28	16.79	6.03	2.16	0.85	0.58	0.02	2.47	1.06	0.06

[a] Sample size.
[b] FO (%) = frequency of occurrence (%).
[c] RV (%) = relative volume (%).
[d] SI (%) = standardized index (%).

importance to the diet of the Gray-cheeked Fulvetta, their standardized indices being 44.56 and 42.74 for Hymenoptera and Coleoptera, respectively. In addition, Lepidoptera, Diptera, Homoptera, and Hemiptera attribute about 12% of the total standardized index. Insect remains that were identified to family level or below are listed in Appendix 1.

Frequency of occurrence for most arthropod categories has the lowest point in fall, increases through winter and spring, and reaches a peak in summer (Table 2). For the two main orders of arthropods, Hymenoptera and Coleoptera, the former has the highest standardized index in fall and winter, and the latter has this in summer. In addition, both orders have similar contributions in the diet in spring. On the other hand, Orthoptera is totally absent from the diet in winter.

DISCUSSION

Insects are predominant prey of the Gray-cheeked Fulvetta in the breeding season (spring and summer), whereas vegetative food increases sharply in the non-breeding season (fall and winter). Seasonal variation in insect abundance might be the most influential factor leading to the observed result. Nevertheless, the high proportion of insects in the diet of adults in the breeding season is probably related to the high demand of arthropod food by nestlings (Lin, 1996). On the other hand, the increase of small fruits of various understory plant species in fall and winter might also result in the high intake of plant matter by the Gray-cheeked Fulvetta. In short, diet analysis of gut contents is able to clearly reveal the shift in prey availability from season to season.

Different results of the two winters (Figure 1) might also be accounted for by yearly variation of food availability at Fushan. According to Lin (1996), the highest mortality rate occurs in winter. This indicates that the food resource is probably scarce during this time of year, thus the Gray-cheeked Fulvetta is probably more opportunistic and eats whatever it can find. In addition, because winter is the transition time between the dominance of plant matter and arthropod food, the sampling date could be another source of variation. Therefore, a greater variation in diet contents could appear in winter.

The lowest frequency of occurrence of most arthropod categories in gut contents occurs in fall instead of winter (Table 2). This may be due to the late sampling dates in winter. We did the sampling of both years in early February, when insects possibly start to emerge from the cold winter, since January is usually the coldest month at Fushan (Lin *et al.* 1996).

Although both Hymenoptera and Coleoptera occur all year round, the Gray-cheeked Fulvetta appears to select them differentially by season. Hymenoptera (ants, bees, wasps, and relatives) has the greatest standardized index in fall and winter (Table 2). In contrast, Coleoptera (beetles) is the most important arthropod food in summer. How do two such main insect orders contribute to the diet of the Gray-cheeked Fulvetta temporally? And to the extent that the variation of insect abundance through time affects the behavioral change in food selection of the Gray-cheeked Fulvetta deserves additional studies, especially from entomologists.

Although Lin (1996) reported that adult fulvettas almost exclusively feed arthropods to nestlings, we still found a small amount of plant matter in gut contents during the breeding season. This implies that adult fulvettas actually take vegetative food even though they feed only arthropods to nestlings. On the other hand, Lepidoptera larvae are important food items of nestlings (Lin, 1996); however, we did not find many of these in gut contents of adult fulvettas. Differential digestion rates among insect orders may account for such differences (Custer and Pitelka, 1974; Rosenberg and Cooper, 1990). Swanson and Bartonek (1970) found that soft-bodied insects can be digested completely in a short period of time, whereas hard seeds may persist for several days in gizzards of Blue-winged Teals (*Anas discors*). Therefore, it is likely that we may underestimate the importance of Lepidoptera in the diet of the Gray-cheeked Fulvetta.

Frequency of occurrence and volumetric measure are used in this analysis; either can reveal one form of information on diet, and combined they give a general interpretation of the data set. Most researchers recommend that more than one form of the diet data should be presented to portray a better picture of the diet of a certain species (e.g., Otvos and Stark, 1985; Rosenberg and Cooper, 1990). In addition, an importance index may be applied to give an overall value for each diet category (Hyslop, 1980). Frequency and weight are also used in the literature (e.g., Calver and Wooller, 1982; Castilla *et al.*, 1991); however, we found it difficult to reconstruct the prey from a mess of fragments due to the lack of a reference collection. Furthermore, plant parts were usually in a form from which we were unable to enumerate them. As a result, volumetric measure was adopted in this study.

The disadvantage of volumetric measure is that it will exaggerate the importance of large, mostly undigested food items (Hartley, 1948; Duffy and Jackson, 1986). For example, a large seed may reflect greater importance than 10 small seeds in a volumetric analysis although it may take more effort to pluck 10 small fruits than a large fruit. Moreover, larger remains of certain prey in the gut content do not necessarily imply higher energy intake of that item by birds (Rosenberg and Cooper, 1990), because prey remains and actual prey biomass digested by birds are different from one item to another. Rosenberg and Cooper (1990) also discussed the effect of digestion time, which is also a factor in this study. For example, the time in net and the process of banding, both induce variation in the degree of digestion of prey in the stomach.

Rosenberg and Cooper (1990) recommended the use of flushing, and avoiding chemical emetics to reduce the mortality of birds. Of 626 birds sampled, 11 (1.8%) died during or right after flushing. The mortality rate can be considered low compared to other studies using the same method (8.3% and 3.6% for Moody [1970] and Laursen [1978], respectively), and even lower than studies using emetics (often > 10%, e.g., Zach and Falls, 1976; Lederer and Crane, 1978). But Ford *et al.* (1982) reported virtually no mortality when using lukewarm water on Australian passerines.

This study contributes information to the structure of the food web of the Fushan ecosys-

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tem. The more we know about the diet of the most dominant bird species of Fushan, the more we feel the need to collaborate with entomologists and botanists to conduct further study in elucidating the complexity of the food web.

ACKNOWLEDGMENTS

We thank the National Science Council for providing research fund for this study, including projects NSC 84-2621-B-002-001-A07, NSC 85-2621-B-002-004-A07, and NSC 86-2621-B-002-016-A07. We are also indebted to the administration of the Fushan Experimental Forest for its great support during the study. We thank L. L. Yang, R. S. Lin, and H. F. Wu for their help in developing and executing the stomach flushing technique. A group of ringers led by C. W. Ouyang and J. F. Yeh are always helpful in the field; we are grateful for their efforts. And great help from A. F. Warneke, I. S. Hsu, and C. C. Lin for their expertise on the identification of insects.

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(Received Jan. 18, 1998; Accepted Apr. 6, 1998)

Appendix 1. Insect remains identified to family or below-family levels.

Order	Family	Species
Collembola	Entomobryidae	
Orthoptera	Acrididae	
	Tettigoniidae	
Isoptera	Rhinotermitidae	
Mallophaga	Menoponidae	
	Philopteridae	
Hemiptera	Miridae	*Lygocoris* sp.
	Reduviidae	
	Coreidae	*Cletus* sp.
	Scutelleridae	*Cantoa* sp.
	Pentatomidae	*Erthesina* sp.
		Gonopsis affinis
Homoptera	Membracidae	
	Cercopidae	
	Cicadellidae	
	Cixiidae	
	Psyllidae	
	Aphididae	*Aphis gossypii*
Lepidoptera	Arctiidae	*Spilarctia* sp.
	Eucleidae (caterpillar)	
	Nymphalidae (caterpillar)	
Coleoptera	Cicindelidae	*Cicindela* sp.
	Carabidae	
	Staphylinidae	
	Lycidae	
	Catharidae	
	Coccinellidae	*Leis dimidiata*
	Tenebrionidae	
	Anobiidae	
	Anthribidae	
	Cucurlionidae	*Euops chinensis*
		Anthonomis collaris
	Scolytidae	
	Chrysomelidae	*Arthrotus abdominalis*
		Gallerucida sp.
Hymenoptera	Formicidae	*Camponotus* sp.
		Crematogaster rogennoferi
		Honomorium intrudens
		Pheidole sp.
		Polyrhachis moesta
		Pristomyrmex pungens
		Technomyrmex albipes
		Tetramorium nipponense
	Ichneumonidae	
	Chrysididae	
Diptera	Bibionidae	
	Tipulidae	
	Culicidae	*Culex* sp.
	Chironomidae	
	Phoridae	
	Trypetidae	
	Drosophilidae	
	Calliphoridae	*Calliphora* spp.
	Hippoboscidae	