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Food Habits of the Sea Snake, *Laticauda semifasciata*

Yeng Su[1], Sun-Chio Fong[2], and Ming-Chung Tu[3,*]

[1]*Department of Marine Sports and Management, National Penghu Institute of Technology, Makung, Penghu, Taiwan 880, R.O.C.*
[2]*Institute of Marine Biology, National Sun Yat-sen University, Kaohsiung, Taiwan 804, R.O.C.*
[3]*Department of Life Science, National Taiwan Normal University, No. 88, Sec. 4, Taipei, Taiwan 116, R.O.C.*

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Yeng Su, Sun-Chio Fong, and Ming-Chung Tu (2005) Food habits of the sea snake, *Laticauda semifasciata*. *Zoological Studies* **44**(3): 403-408. We collected specimens of *Laticauda semifasciata*, a dominant species of sea snake at Orchid I., and dissected them to investigate their food habits. In total, 219 snakes were dissected. Most of them (67%) had no food in their stomachs. We found more individuals with empty stomachs in a snake cave than from any other place. This was probably because the snake cave was a place used for reproduction. We found that 73 (33%) snakes had food in their stomachs, and identified 16 fish families among the food items. Hatchling snakes ate only the Mugiloididae, while subadult and mature snakes fed mainly on the Emmelichthyidae, Acanthuridae, and Pomacentridae. We found a greater variety of fish families in the stomachs of mature males (15 families) than in those of adult females (6 families). Male snakes ate more frequently on the Emmelichthyidae (35%) and Acanthuridae (19%). Females preyed more frequently on the Acanthuridae (25%) and Pomacentridae (25%). http://zoolstud.sinica.edu.tw/Journals/44.3/403.pdf

Key words: Diet, Feeding, Reptile, Taiwan.

The study of an animal's food habits is important for understanding its relationship with other organisms within an ecosystem. The diets of many sea snakes have been reviewed in a few papers (Voris and Voris 1983, Heatwole 1999), but neither of those included *Laticauda semifasciata*. This sea snake is distributed from the Philippine Is. and Moluccas to the Ryukyu Is. of southern Japan (Smith 1926). Although *L. semifasciata* is a common species in various islands such as Gato Islet, Philipians (Bacolod 1983), Orchid I., Taiwan (Wang 1962, Tu et al. 1990), and the Ryukyu Is. (Takahashi 1984), research of its ecology is still limited. Research on this species has mainly focused on its toxicology (Tu 1959, Takashi et al. 1970, Harvey et al. 1978, Harvey and Rodger 1978, Tamiya and Takasaki 1978, Gerencser and Loo 1982, Nishida et al. 1985). Of ecological research, only reproduction has been studied very thoroughly (Herre and Rabor 1949, Gorman et al. 1981, Bacolod 1983, Nakamoto and Toriba 1986, Toriba and Nakamoto 1987, Tu et al. 1990). Its activity period (Dunson and Minton 1978, Heatwole et al. 1978), diving (Pickwell 1972), shedding (Mays and Nickerson 1968), aggressiveness (Tu and Su 1991), and feeding (Pickwell 1972, Bacolod 1983) have also been studied. Pickwell (1972) described its feeding behavior in an artificial tank. It reacted to fish smells such as killifish, *Fundulus parvipinnis*, and the mud sucker, *Gillichthys mirabilis*. It would search for them in every nook and cranny of the laboratory tank. Bacolod (1983) only gave a short statement on its diet. He described females as always having eels and other types of fish in their stomachs. As the diet of *L. semifasciata* remains unclear, we conducted this study to investigate its food habits, and to compare it with the diets of other sympatric sea snakes published elsewhere.

*To whom corresponding and reprint requests should be addressed. Tel: 886-2-29336875 ext. 321. Fax: 886-2-29312904. E-mail: biofv026@cc.ntnu.edu.tw

MATERIALS AND METHODS

Orchid I. (Lanyu in Chinese), located about 64 km off the southeastern coast of Taiwan, is a tropical volcanic island with an area of approximately 46 km^2. The Kuroshio Current passes through this area giving an average water temperature of 26 (range, 21~29) °C. From Mar. 1986 to March 1987, we visited Orchid I. monthly and collected snake specimens. We used scuba diving to collect sea snakes in nearby coastal waters during the day. At night, we searched for them in the intertidal zone with flashlights. We also visited a snake cave, and collected snakes there in the day and at night. The snake cave is located at the southwestern part of the island. The cave opens into a tidal pool, withing which there was a round rock with a diameter of about 0.8 m. The sea snakes usually hid underneath this rock before entering the cave or crawling back to the sea during low tide. At high tide, the tidal pool is full of water, and the entrance to the cave is partially submerged under the water. A pool of water, approximately 1.2 m deep remained in the cave even at low tide. Therefore, the relative humidity within the cave was nearly 100% at all times. Another description of the cave can be found in Tu et al. (1990). We recorded the latency time, defined as the time from when the snakes were caught to when they were put into a freezer. Generally, the snakes were frozen within 3 h after having been placed in the freezer. The frozen snakes were brought back to the laboratory where they were thawed and weighed before dissection. We measured the snout-vent length (SVL), tail length (TL), and body weight of the snakes. We determined the sex through dissection. We also measured the weight of the food and recorded its direction in the stomach of the specimen sea snake. The food, mainly fish, was preserved in 10% formalin for further study. Other than food content, we measured the gonads to study the reproductive cycle of these snakes (Tu et al. 1990). The dissected snakes were preserved in 10% formalin, and deposited in the Taiwan Museum (specimen nos., TMRS0384 ~TMRS0480). We followed Colewell and Futuyama (1971) in quantifying the extent of diet overlap between different groups of snakes. The niche overlap index (NOI) can vary from 0 when the diets have no overlap to 1 when the diets are exactly the same between compared groups.

RESULTS

We dissected a total of 219 sea snakes. Of these, only 73 individuals (33%) had food inside their stomachs. None of the other 146 individuals (67%) had any food, but 2 snakes had small pieces of stone in their stomachs. The weight of those stones was < 1.8 g. The percentage of snakes with empty stomachs was 87% (n = 87) among the snakes caught at the snake cave. For snakes captured from other places the percentage was 54% (n = 132). Snakes from the snake cave had a significantly higher (X^2 = 27.31; p < 0.001) percentage of individuals without food compared to those from other places. This phenomenon was true for mature male and female snakes as well as for immature snakes (Table 1). When we examined the most-freshly treated samples (n = 86), i.e., those with a latent time of < 2 h, we also found similar results. Among snakes collected from the snake cave, 89% (n = 36) of individuals had empty stomachs, while among snakes collected from other areas, 50% (n = 50) of individuals had empty stomachs. Therefore, the latency time was not a cause for snakes from the snake cave having a very high percentage of individuals with empty stomachs.

Table 1. Comparison of the sampled numbers and percentages of *Laticauda semifasciata* with empty stomachs between the snake cave and in other areas

	Snake cave				In other areas				X^2	p
	Stomach with food	Empty stomach	Sum	Percent with an empty stomach	Stomach with food	Empty stomach	Sum	Percent with an empty stomach		
Mature males	9	31	40	77.5	39	47	86	55	6.04	0.014
Mature females	2	28	30	93.3	18	18	36	50	12.57	< 0.001
Immature snakes	0	17	17	100.0	5	5	10	50	6.95	0.0084
Sum	11	76	87	87.3	62	70	132	53	27.31	< 0.001

The extent of food digestion was correlated with the latency time. We were able to identify the food to family level if the latency time was < 20 h. When the latency time was > 20 and < 66 h, we could still find food items in the stomachs of the snakes, but could not identify them to the family level. No food was found in snakes with a latency time of > 66 h. The sample size of snakes that had food which could be identified to the family level was 44. The mean food ratio of those samples was 3%, and the largest food ratio was 32%. Most of the food, mainly fish, was swallowed head first, while 14% of what the snakes consumed was done so tail first.

Other than 2 invertebrates of the Isopoda found in 1 snake's stomach, all the other food items consisted of coral fish. We found a total of 16 fish families eaten by *L. semifasciata*. Only 1 family (Balistidae) belongs to the Tetradontiformes. The other 15 families belong to the Perciformes (Table 2). The most-frequent prey item of *L. semifasciata* was the Emmelichthyidae, totaling 132 fish in 15 snakes. Acanthuridae was the second most frequent prey of *L. semifasciata*, with 36 Acanthuridae fish in 10 snakes. By ranking the food by total mass, however, the Acanthuridae (133.1 g) was first, the Pomacentridae (98.1 g) was second, and the Emmelichthyidae (94.4 g) became third (Table 2).

Two fish families, the Emmelichthyidae and Mugiloididae, were found in the stomachs of immature snakes. They were eaten by 50% of the immature snakes. When immature snakes were divided into 2 groups of hatchlings (SVL < 45 cm, n = 3) and subadult snakes (54 < SVL < 70 cm; n = 3), the latter ate only the Emmelichthyidae while the former ate only the Mugiloididae, which was eaten by only 1 adult snake (SVL > 70 cm; n = 38). Male snakes tended to eat a greater number of families of fish than did females (Fig. 1). Fifteen and 6 families of fish were found in the stomachs of male and female snakes, respectively. The most-common fish families in stomachs of mature male snakes were the Emmelichthyidae (29%) and Acanthuridae (21%). The most-common fish families in stomachs of mature females were the Acanthuridae (25%) and Pomacentridae (25%). The NOI of immature and mature snakes was 0.28, and that of mature male and female snakes was 0.58.

Table 2. Fish species and families found in stomachs of *Laticauda semifasciata*

	Family			
Species name	Family name	Total no. of individuals	Total weight (g)	Total no. of snakes with this prey
Dipterygonotus sp.	Emmelichthyidae	132	94.4	15
Acanthurus sp.	Acanthuridae	36	133.1	10
A. bleekeri				
Ctenochaetus striatus				
Pseudanthias sp.	Serranidae	7	27.7	5
Halichoeres trimaculatus	Labridae	6	12.5	4
Thalassoma sp.				
T. amblycephalum				
Abedefduf sexfasciata	Pomacentridae	4	98.1	3
Chromis sp.				
Parapercis sp.	Mugiloididae	4	5.5	4
P. clathrata				
P. schauinslandi				
Caesio diagramma	Nemipteridae	3	37.6	1
Chirrhitichthys aprinus	Chirrhitidae	2	10.0	2
Siganus sp.	Siganidae	2	1.6	1
Grammistes sexlineatus	Grammistidae	1	18.1	1
	Eleotridae	1	5.1	1
	Pentacerotidae	1	1.4	1
	Apogonidae	1	1.2	1
	Haemulidae	1	1.1	1
Centropyge heraldi	Chaetodontidae	1	0.9	1
	Balistidae	1	1.3	1

DISCUSSION

Snakes are quite different from the closely related lizards that frequently eat small meals. The average percentage of lizards with empty stomachs is low (13.2%). Although certain species of lizard may have 66% of individuals with empty stomachs (Pianka and Vitt 2003), this ratio is still lower than that for snakes. The percentage of individuals with empty stomachs may exceed 70% in quite a few taxa of snakes. In *Acrochordus arafurae*, the percentage may reach 95% even in freshly caught snakes (Shine 1986). The high number of snake species that have a high proportion of individuals with empty stomachs may due to their low energetic requirements (Bennett and Dawson 1976, Gans and Pough 1982, Pough 1983), and the habit of eating a few large meals (Mushinsky 1987). *Laticauda semifasciata* like many snakes as well as the congeneric snake, *L. colubrina* (Pernetta 1977), also had a high percentage of individuals with empty stomachs, especially for the samples collected from the snake cave.

The reason why snakes from the snake cave had an extraordinarily high percentage of individuals with empty stomachs was not due to the latency time. It was probably due to a reproduction effect. The snake cave is the place where *L. semifasciata* and *L. laticaudata* come for reproduction. Samples caught in the snake cave were mostly in the reproductive season (Tu et al. 1990). During gestation, especially in the latter part of pregnancy, female snakes and lizards tend to reduce their food intake (Shine 1979). Mature female snakes in the snake cave had a higher percentage of individuals without food than did females from other places. However, mature males and immature snakes also had significant effect on this phenomenon.

Most species of sea snakes have specialized food habits. Some of the specialists may prey on only 1 or 2 families of fishes (Glodek and Voris 1982). Others even eat several families of fish if the prey items have a common morphology. For example, some specialize on eels or goby-like fishes (Takahashi 1981, Glodek and Voris 1982, Voris and Voris 1983, Heatwole 1999), while others specialize on fish eggs (Voris 1966, Heatwole et al. 1978, Glodek and Voris 1982, Voris and Voris 1983). Only a few sea snake species are generalists (Voris and Voris 1983, Heatwole 1999), preying on several families of fish. For example, *Aipysurus laevis* is known to take 12 fish families, while *Lapemis hardwickii* was found to prey on 31

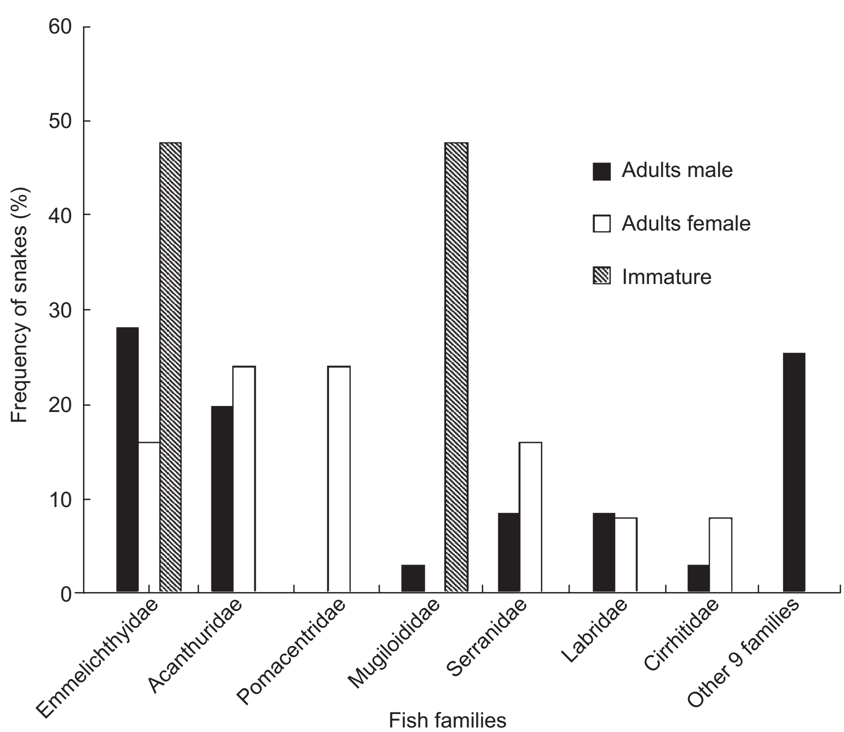

Fig. 1. Frequency of adult males, females, and immatures of *Laticauda semifasciata* that preyed on each fish family. The other 9 families include the Nemipteridae, Siganidae, Grammistidae, Pentacerotidae, Eleotridae, Chaetodontidae, Apogonidae, Haemulidae, and Balistidae. The frequency was 2.94% for each of these 9 families.

fish families and squid (Voris and Voris 1983). As we found 16 families of fish in the stomach of *L. semifasciata*, it is clearly a generalist.

Sympatric sea snakes frequently have very little diet overlap (Glodek and Voris 1982, Voris and Voris 1983). This also seems true for the species around Orchid I. Four species of sea snakes, *Emydocephalus ijimae*, *L. colubrina*, *L. laticaudata*, and *L. semifasciata* are found around this island. The 1st 3 species are specialists, *E. ijimae* eats only fish eggs (Voris 1966), while *L. colubrina* and *L. laticaudata* specialize on eels (Bacolod 1983, Voris and Voris 1983, Heatwole 1999). Although Bacolod (1983) stated that females of *L. semifasciata* feed on eels and other types of fish, we found no eels in their stomachs. We did, however, find 16 fish families. Obviously, there was only diet overlap in *L. colubrina* and *L. laticaudata* in our study area. These 2 species also co-occur in New Caledonia, where they show different activity peaks (Shine et al. 2003). Whether *L. colubrina* and *L. laticaudata* around Orchid I. use the same strategy to avoid competition merits further investigation.

Resource competition within the same species is normally more severe than that between different species. Consequently, it is not surprising to find an ontogenetic shift of diet (Plummer and Goy 1984, Mushinsky 1987, Arnold 1993, Nogueira 2003) or divergent food habits between the sexes (Shine 1991 1993). We found that all hatchlings ate only the Mugiloididae, but only 1 mature snake had any Mugiloididae in its stomach. Mature snakes tended to prey on the Emmelichthyidae, Acanthuridae, and Pomacentridae while immature snakes ate only the Mugiloididae and Emmelichthyidae. The NOI of immature and mature snakes was only 0.28. The NOI of mature male and female snakes was 0.58, which was higher than that of immature and mature snakes. This showed that there was a higher diet overlap between sexes than between ages. However, the NOI of mature male and female snakes was still much less than 1. Therefore, like other snakes, *L. semifasciata* may have an ontogenetic shift in diet as well as differences in the diet between the sexes. The food diversity of males was greater than that of females, and the dominant food item also differed between sexes. The Pomacentridae was one of the most-common fish families consumed by females, but was not found in the diet of males. On the other hand, males fed most frequently on the Emmelichthyidae, which was not the most-frequent food of the females. The Acanthuridae was the only fish family frequently preyed on by both sexes.

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