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FOOD AND FEEDING HABITS OF RIBBONFISHES, *TRICHIURUS JAPONICUS* AND *T. LEPTURUS*

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Sin-Che Lee (1978) Food and feeding habits of ribbonfishes, *Trichiurus japonicus* and *T. lepturus*. *Bull. Inst. Zool., Academia Sinica* 17(2): 117-124. The stomach analyses of 832 *Trichiurus japonicus* and 677 *T. lepturus* revealed that both species fed mainly on other fishes (90% of total food weight or more). Other food items were shrimps, squids, mantis shrimps, euphasiaceans and isopods. A slight differences in composition of major food items occurred between the two species and could be attributed to the geographical variations. Occurrence of empty stomachs was found to increase with the size of fish. Diets of ribbonfishes also changed with size of fish: juvenile ribbonfishes fed intensively on young (including postlarval) and adult anchovies whereas larger adult ribbonfishes fed more on other bigger fishes such as Priacanthidae, Sphyraenidae and Sciaenidae and also on the ribbonfish itself. The changes in feeding habits coincided with the increase in hooked teeth as *T. japonicus* increased in size. A diurnal upward feeding movement of the adult ribbonfish in the evening also coincided with a diurnal vertical movement of zooplanktons, juvenile ribbonfishes and anchovies.

Trichiurus japonicus and *T. lepturus* occur in the muddy water or on the muddy-sand bottoms of the continental shelf of Taiwan. *T. japonicus* has greater commercial value and it inhabits more outer and deeper water than *T. lepturus* which is delimited in shallower inshore water. Both species occur in an accumulated muddy sediments between rocky substratum with depth ranging between 3 and 300 m. A habitat investigated off the coast of Chengkong has surface water temperatures between 22.2 and 29.8°C and the salinity between 33.2 and 35.2‰. The fish associates sharing a common environment are: *Carcharhinus melanopterus, Anago anago, Gymnothorax reticularis, Clupanodon thrissa, Stolephorus zollingeri, Engraulis japonicus, Saurida elongata, Sphyraena japonica, Sarda orientalis, Katswonis pelamis, Neopinnula orientalis, Upenus vittatus, Priacanthus macracanthus, Pseudopriacanthus niphonius, Atrobucca nibe, Lethrinus, Plectorhincus cinctus, Caranx armatus, C. ulva, C. equula, Decapterus russelli, D. kurroides akaadsi* and *Leiognathus.*

This study was based on the stomach analyses of ribbonfishes collected during the years 1976-1977 and on the direct observations of the diurnal feeding activities of the fishes.

MATERIALS AND METHODS

A total of 832 *Trichiurus japonicus* and 677 *T. lepturus* were sampled from catches of either trawlers or long-liners in the commercial fishing areas off the coast of Hualien, Tungkang and Kaohsiung (Fig. 1) between February 1976 and December 1977. The preanal length (tip of lower jaw to anus) and body weight for each individual fish were recorded. Stomach and intestine were removed and preserved in 10% formalin. The premaxillary and dentary bones were prepared when fresh by removing all attached tissue in boiling water. The proportion of hooked teeth to pointed teeth in the low jaw was expressed as:

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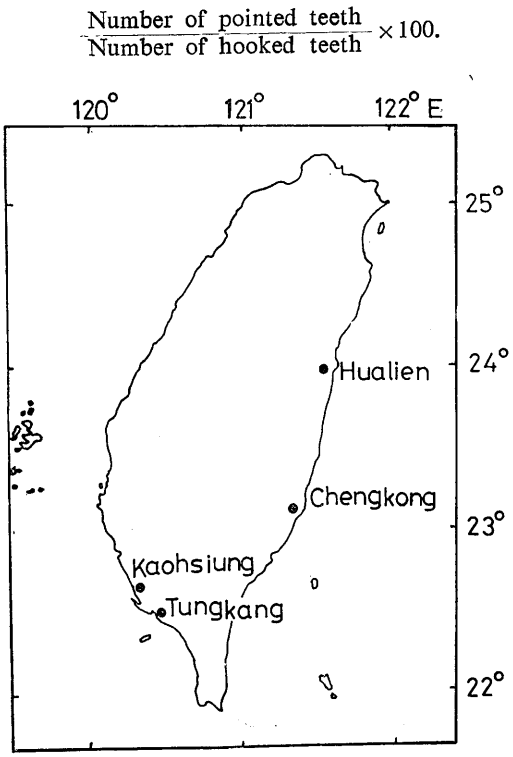

Fig. 1. Map of Taiwan.

Lengths of stomach and intestine were measured by vernier caliper and number of pyloric caeca was counted. Stomach contents were sorted with the aids of microscope and their weights were measured to the nearest 1 mg. The weight composition of each food species was expressed as the percentile of the total weight. The frequency of occurrence was expressed as the percentile of all feeding fish with particular food items. Fish finder was used to detect the vertical movement of fish school.

RESULTS

Digestive system

Mouth gap is rather wide in both species. The tips of both jaws possesses long inward-curved carniniform teeth to prevent the escape of forage prey. The rest of teeth on the dentary bone has slight differences in external feature, *i. e. Trichiurus lepturus* has higher proportion of hooked teeth than *T. japonicus*[5]. The number of hooked teeth on the dentary of *T. japonicus* increased with the growth of fish (Fig. 2). All the teeth along the linling of both jaws were well developed. Palatine teeth were villiform and were arranged in band. The vomer was toothless.

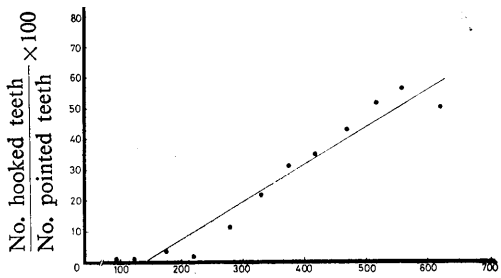

Fig. 2. The relation between the ratio of hooked-teeth numbers to pointed-teeth numbers on the dentary bone (*Y*) of *Trichiurus japonicus* and the preanal lengths (Pl) of *T. japonicus*. $Y=-0.168129+0.00121155$ Pl ($r=0.97$).

Young fishes of less than 100 mm preanal length had long striking gill rakers on the ventral half of the outermost gill arch than those of adults[4].

Stomach is extended into a long thick-walled cylinder of high distensibility, evidently to serve as a receptacle for bulky prey. Length of stomach is about 12% of total body length for both species. Intestine is about 22% of total body length for both species. Pyloric caeca located at the anterior part of intestine were 20–21 in numbers in *Trichiurus lepturus* and 19–22 in numbers in *T. japonicus*, respectively. Liver has two lobes: the right lobe is much shorter than the left one.

General food composition

Food items contained in the stomachs of *Trichiurus japonicus* and *T. lepturus* are shown in Table 1. No significant sexual differences in quantity or composition of food were found.

Trichiurus japonicus: Among 832 fish examined, 378 (45.43%) had food in their stomachs. From the overall composition summarised in Table 1 revealed that important fish items over 5% were: *Stolephorus zollingeri*, *Trichiurus*, *Saurida*, Priacanthidae and *Sphyraena*.

TABLE 1
List of food items contained in the stomachs of *Trichiurus japonicus* (*T. j.*) and *T. lepturus* (*T. l.*), expressed as % total food weights

Food items \ Locality / Fish species	Hualien	Chengkong		Tungkang		Kaohsiung
	T. j.	*T. j.*	*T. l.*	*T. j.*	*T. l.*	*T. l.*
Isopoda	0.05			0.26	0.01	0.03
Macrura (Shrimps):						
Leptochela gracilis, Heterocarpus sp. etc.	1.25	5.39	0.78			
Metapenaeus monoceros etc.				3.24	0.97	2.78
Stomatopoda:						
Squilla oratoria & *S. raphidea*			0.77			
Gonodactylus sp.	0.02					
Squilla alima larve				0.02		
Euphasiacea		0.13			0.07	0.03
Mollusca: *Loligo* sp. etc.	6.91	2.01	0.43		0.14	3.81
Pisces:						
Congridae		1.32				
Dussumieridae					0.99	
Clupeidae: *Sardinella* sp.	0.30		6.06		2.35	0.31
Engraulidae inc. *Stolephorus zollingeri, Engraulis japonicus* and *Thrissocles sectirostris*	33.05	2.81	3.53	7.00	2.56	79.04
Synodontidae: *Saurida* sp.				18.06		
Myctophidae; *Diaphus* sp. etc.	1.38	1.27		0.49	1.25	
Mugilidae: *Liza* sp.			5.07			
Sphyraenidae: *Sphyraena* sp.	5.90	5.18	5.62			
Scombridae: *Auxis* sp.	0.48				2.96	
Trichiuridae: *Trichiurus japonicus* & *T. lepturus*	9.51	11.29	8.67	45.71	58.94	
Priacanthidae		11.80			7.58	
Sciaenidae					4.81	
Sillaginidae: *Sillago sihama*						4.15
Caesionidae: *Pterocaesio tile*			15.08			
Carangidae: *Caranx* sp.	0.43				0.56	0.56
Menidae: *Mene maculata*	0.98	1.66				
Leiognathidae: *Leiognathus ruconius, L. rivulatus* & *L. brevirostris*			1.81		0.37	0.06
Indet. fish fragments	39.75	57.15	52.17	25.23	16.44	9.24
Total food weights in grams	769.06	1641.68	780.6	265.8	2026.67	354.48

Trichiurus lepturus: Among 677 fish examined, 390 (57.61%) had food in their stomachs. The important fish items over 5% shown in Table 1 were: *Stolephorus zollingeri, Trichiurus, Pterocaesio*, Priacanthidae, *Sphyraena* and *Liza.*

Variation with area

Food species eaten by the two species of ribbonfish differed in three sites, which was expected as fish fauna vary with habitats to some extent.

Trichiurus japonicus: T. japonicus from Tungkang area fed more upon the other ribbonfish (45.71%) than those caught from Hualien and Chengkong (9.51% and 11.29% respectively). *T. japonicus* from Hualien and Chengkong fed mostly on shrimps, *Leptochela gracilis* and *Heterocarpus*, while those from Tungkang fed on the other shrimp, *Metapenaeus monoceros.*

Trichiurus lepturus: Slipmouth, *Leiognathus* was found only in the stomachs of *T. lepturus* obtained from Kaohsiung and Tungkang (Table 1). Anchovies mostly *Stolephorus zollingeri* occupied a subtantial proportion in the food spectrum of *T. lepturus* from Kaohsiung. *Sillago sihama* was only found in *T. lepturus* from Kaohsiung. Shrimps eaten by the ribbonfish obtained from Kaohsiung and Tungkang were exclusively *Metapenaeus monoceros* which is rather abundant around the inshore water of those areas. *Metapenaeus monoceros* was replaced by other shrimp species in the east coast.

Variation in diet with size

Trichiurus japonicus: T. japonicus of the length between 200 and 500 mm fed on shrimps, mantis shrimps and squids more frequently than any other sizes. The postlarval anchovies were found to be an exclusive diet for the juvenile ribbonfish (up to 150 mm in length) and became a less important diet, as the size of *T. japonicus* increased. *T. japonicus* of less than 400 mm length fed on the postlarval or small juvenile ribbonfishes (hairtails), while the larger fish fed on the intermediate and larger ribbonfishes. Large sized fishes such as adult *Trichiurus*, Priacanthidae and *Sphyraena* were often taken by the fully grown ribbonfish of larger than 450 mm (Fig. 3).

Trichiurus lepturus: As shown in Fig. 4, *T. lepturus* of greater than 350 mm in length fed more on shrimps than *T. lepturus* of less than

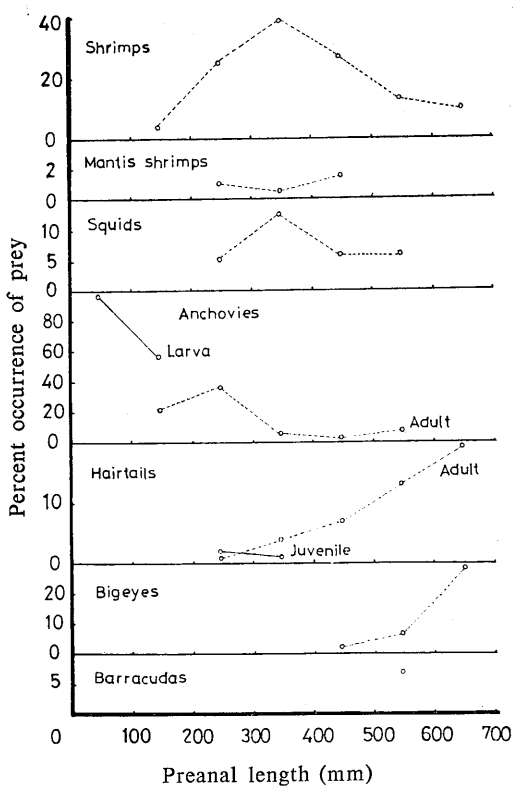

Fig. 3. % of food items in stomachs of *Trichiurus japonicus* in relation to preanal lengths of *T. japonicus*.

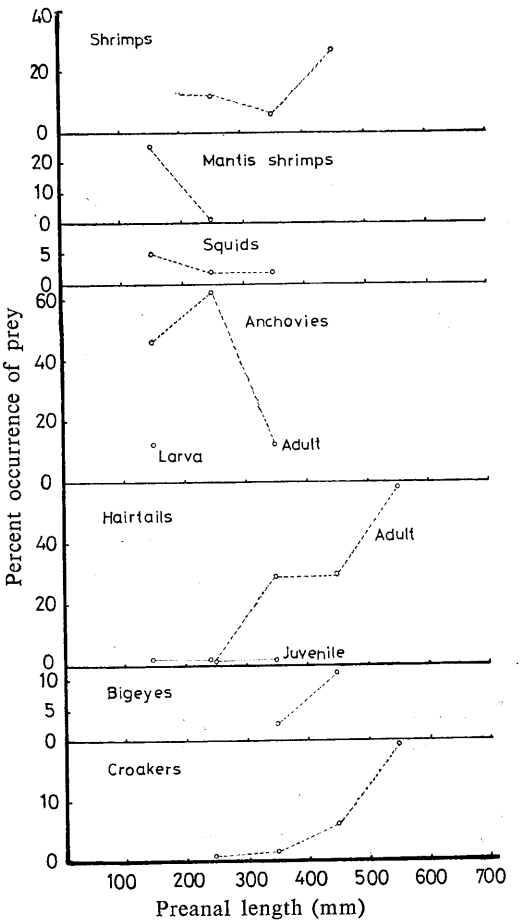

Fig. 4. % of food items in stomachs of *Trichiurus lepturus* in relation to preanal lengths of *T. lepturus*.

350 mm in length. *T. lepturus* of less than 200 mm in length mainly fed on young mantis shrimps. The small *T. lepturus* fed on anchovies and juvenile ribbonfishes whereas the larger fish increased their feeding on forage ribbonfishes, Priacanthidae and Sciaenidae.

Occurrence of empty stomachs increased with the size of fishes. The % of empty stomachs for the length range of 100-200 mm, 200-300mm and 300-400mm were 21% (n=38), 30% (n=185) and 43% (n=79) respectively. Diet of young fish were chiefly planktonic, therefore the small fish had greater availability for suitable forage animals than that of larger fish.

Variation in diet with different fishing methods

Food items of *Trichiurus japonicus* of the same size (200-300 mm) caught by different fishing gears differed. The fish caught by the long-liners ate bottom living organisms such as shrimps, squids, adult *Trichiurus* and *Sphyraena* while those by the beach seiners from the shallower water near water surface fed enitrely on anchovies.

Variation with season

Among the major food items of both species, proportion of forage fishes, shrimps and squids in food spectrum did not vary from season to seasons (Tables 2-3). However, it appeared that the forage anchovies had a quite interesting seasonal patterns; *Trichiurus japonicus* (Table 4) from Chengkong ate anchovies with higher frequency during March through May. *T. lepturus* (Table 5) caught from Kaohsiung were found feeding intensively on the anchovies all year round at the water depth of about 20 m.

TABLE 2
Seasonal variations in the major food items of *Trichiurus japonicus* from Chengkong (expressed as % of total food weights)

Food items	Seasons								x^2
	Mar.-May (n=16)		Jun.-Aug. (n=72)		Sept.-Nov. (n=73)		Dec.-Feb. (n=38)		
	wt. (g)	%	wt .(g)	%	wt. (g)	%	wt. (g)	%	
Shrimps	5.3	8.45	28.61	6.23	24.61	5.04	29.90	4.73	1.397 NS
Squids	0	0	19.51	4.25	11.10	2.28	2.30	0.36	6.689 NS
Fishes	57.4	91.55	410.80	89.52	452.15	92.68	597.90	94.58	0.146 NS
Total food wt. (g)	62.7		458.92		487.86		632.20		

TABLE 3
Seasonal variations in the major food items of *Trichiurus lepturus* from Tungkang (expressed as % of total food weights)

Food items	Seasons								x^2
	Mar.-May (n=45)		Jun.-Aug. (n=39)		Sept.-Nov. (n=12)		Dec.-Feb. (n=34)		
	wt. (g)	%	wt. (g)	%	wt. (g)	%	wt. (g)	%	
Shrimps	3.12	0.22	12.70	4.31	3.60	3.07	0.20	0.11	6.848 NS
Fishes	1423.95	99.78	280.30	95.21	113.50	96.93	184.85	98.27	0.116 NS
Others	0	0	1.40	0.48	0	0	3.05	1.62	
Total food wt. (g)	1427.07		294.40		117.10		188.10		

TABLE 4

Seasonal variations in the forage anchovies taken by *Trichiurus japonicus* of Chengkong (expressed as % of total food weights)

Food items	Seasons								x^2
	Mar.-May (n=16)		Jun.-Aug. (n=72)		Sept.-Nov. (n=73)		Dec.-Feb. (n=38)		
	wt. (g)	%	wt. (g)	%	wt. (g)	%	wt. (g)	%	
Anchovies	22.0	35.09	22.0	4.79	0	0	0	0	85.9226**
Total food wt. (g)	62.7		458.92		478.0		632.20		

** Significant at 1% level.

TABLE 5

Seasonal variations in the forage anchovies taken by *Trichiurus lepturus* of Kaohsiung (expressed as % of total food weights)

Food items	Seasons								x^2
	Mar.-May (n=17)		Jun.-Aug. (n=64)		Sept.-Nov. (n=29)		Dec.-Feb. (n=39)		
	wt. (g)	%	wt. (g)	%	wt. (g)	%	wt. (g)	%	
Anchovies	22.80	96.20	89.60	87.93	53.40	81.22	123.37	75.63	2.767 NS
Total food wt. (g)	23.70		101.90		65.75		163.13		

Diurnal feeding activity

The ribbonfishes stayed inactive on the bottom surface during the day and moved upward in the early evening. This vertical movement was recorded from the fish finder which showed initially with very few individuals at the depth of 30 m at 7 PM, and then the fish shoaled at 7 m (zooplankton layer) an hour later. It was proved by a result of the operation of stick-held dipnet at 8 PM when members of an entire food chain including zooplanktons, larval fishes, anchovies, juvenile ribbonfishes, adult ribbonfishes were caught together at the same time. This demonstrated that the ribbonfishes searched for food more actively during the evening. Therefore, the diurnal feeding activity of the ribbonfishes may be correlated with the availability of food. During the early evening the zooplanktons and forage fishes *i. e.* fish larvae, anchovies and juvenile ribbonfishes began their upward movement and subsequently attracted the large ribbonfishes. All of them migrated downward in the early morning, resulting a downward movement of larger ribbonfishes to a certain depth of preferred lower illuminations.

DISCUSSION

No significant difference is found in the diet composition between *Trichiurus japonicus* and *T. lepturus*. The minor divergence in food items appears to be the results of the geographical variations. Sufficient data from *T. japonicus* demonstrates that its diet composition changes with the size of the fish. Although it is difficult to determine the exact degree of preference for one type of food over another, it is apparent that the planktonic larval fishes and pelagic anchovies constitute the main food items for the juvenile ribbonfish whereas other larger fishes such as adult *Trichiurus*, Priacanthidae and *Sphyraena* are main food items for the adult ribbonfish. The food spectrum of the adult ribbonfish alone covers both benthic and midwater organisms; this suggests that the adult ribbonfishes may eat the organisms encountered during the course of their vertical movement. Since postlarval and small juvenile *T. lepturus* are not

available for this study, the tentative conclusion is based upon the data of *T. japonicus* obtained from Chengkong. It is pointed out that a tendency of change from juvenile diet to adult agrees with the increase in the number of hooked-canine teeth on the dentary bone. This agrees with Hanabuchi's findings on *T. lepturus* off Tsushima, Japan[3]. Hanabuchi has pointed out that the young and immature fish of less than 230 mm have pointed teeth and are plankton feeder whereas the adult has a tendency of increasing hooked canine teeth and is mostly piscivorous.

It appears that both species feed on the food items such as anchovies, other ribbonfishes, Priacanthidae and other fishes at different depths in the same environment. Simply because they are present in great abundance. Both phytoplanktons and zooplanktons constitute a major item of food for anchovies[6] and fish larvae including postlarval ribbonfishes. Anchovies and other larval fishes may, in turn, serve as major food sources for the juvenile ribbonfish. The latter is frequently ingested by *Mola mola*, Priacanthidae, dolphin-fish, *Auxis rochei*[1], *Decapterus russelli* and *D. kurroides akaadsi*[2], *Argyrosomus argentatus*[7] as well as adult ribbonfish itself. The adult ribbonfishes consume anchovies, Priacanthidae, *Sphyraena* and other fishes at the same habitat. However, they are, in turn, preyed upon by dolphins and sharks of higher trophic level. Thus, the trophic level occupied by the adult ribbonfishes in the marine ecosystem is the one just below sharks and dolphins. Intraspecific cannibalisms of the ribbonfishes may be an ecological adaptation to ease the possible competition for space and food.

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瘦帶 (*Trichiurus japonicus*) 與肥帶 (*T. lepturus*) 之食性

李 信 徽

由 832 尾瘦帶 (*Trichiurus japonicus*) 及 677 尾肥帶 (*T. lepturus*) 之胃內容物之分析結果顯示，二者均以魚類爲主食（超過胃內容易重量組成之 90%），此外尙捕食少量之蝦、魷、蝦蛄、磷蝦及等脚類。二種帶魚間餌料生物組成並無顯著之差別，其所呈現之微細差異，乃屬地理差異而已。空胃率隨帶魚之成長而有增加之趨勢。帶魚所捕食之餌料生物種類亦隨魚之成長而有變化：幼魚多以鯊類之稚仔魚及成魚爲食，而大帶魚則多食較大形之大眼鯛、金梭、石首魚及帶魚等。上述帶魚食性之改變，實與牙齒形態之變化有關，例如瘦帶下頷鈎狀齒 (hooked teeth) 之數目有隨魚之成長而增加之趨勢。大帶魚常有夜間湧上海水表層捕食之習性，且與浮游動物，鯊魚甚或帶魚幼魚之垂直上升運動有密切之關連。