J. Fac. Appl. Biol. Sci.,
Hiroshima Univ. (1994), 33 : 159～166

Feeding Habits of Moray Eels (Pisces: Muraenidae) at Kuchierabu-jima

Hideki YUKIHIRA*, Takuro SHIBUNO
Hiroaki HASHIMOTO and Kenji GUSHIMA

Faculty of Applied Biological Science. Hiroshima University, Higashi-Hiroshima 724, Japan

Received October 25, 1994

Abstract The gut contents of 14 species of tropical moray eels, *Strophidon ui, Gymnothorax eurostus, G. rueppelliae, G. flavimarginatus, G. melanospilus, G. thyrsoideus, G. fimbriatus, G. javanicus, G. albimarginatus, Echidna polyzona, E. nebulosa, Gymnomuraena zebra, Uropterygius macrocephalus* and *U. tigrinus,* plus unidentified young morays in shallow reef water around Kuchierabu-jima Island, southern Japan, were analyzed. These morays were carnivorous, feeding on crabs, shrimps, stomatopods, amphipods, gastropod snails, sea urchins and fishes. Among the available prey their most important food was crabs, in particular, grapsid crab, *Percnon planissimum,* living in shallow water along rocky shores. The larger specimens of the genus *Gymnothorax,* frequently fed on crabs and fishes. The fish of the genus *Echidna* fed mainly on crabs and the genus *Gymnomuraena* fed on crabs, gastropod snails and sea urchins with hard shells. Small young morays (<100 mm TL) primarily fed on amphipods.
Key words: feeding habits, *Gymnothorax* morays, *Echidna* morays, *Gymnomuraena* morays, Kuchierabu-jima

INTRODUCTION

Moray eels are common coral reef fishes and are distributed widely throughout temperate waters. Most of them remain secreted in reef crevices (HOBSON, 1974; HIATT and STRASBURG, 1960). HOBSON (1974) observed they foraged prey not only at night but also during the daytime. They consume benthic invertebrates and fishes (SUYEHIRO, 1942; HIATT and STRASBURG, 1960; RANDALL, 1967). From a morphological point of view, their foods are limited by the length of the mouth cleft and the shape of dentition (SCHULTZ *et al.*, 1953; BLACHE, 1967; RANDALL, 1967).

In the subtropical region of Japan little attention has been given to the feeding habits of morays except for *Gymnothorax kidako* (SUYEHIRO, 1942). In this study the feeding habits of 14 species of morays and unidentified young morays distributed along the coast of Kuchierabu-jima were examined and compared with those of tropical species.

* Present address: IC Net Ltd. 3-6-7-301, Shirahata, Urawa, Saitama 336, Japan

MATERIALS AND METHODS

All of the field work was conducted on the shallow reef habitat of Kuchierabu-jima Island (30° 28' N, 130° 10' E), southern Japan, between 1981 and 1990 (Fig. 1). The fish used for dietary analysis was collected by spears, long lines and crab trap cages at reefs in Honmura and Nishiura Bays. After the collections, samples were preserved in 10% solution of buffered formaldehyde with their abdomens deeply incised. In the laboratory, total lengths were measured. The guts were removed and prey items in the gut contents identified under a binocular microscope. The body sizes (length, width and height) of the prey were measured, and the percentage of the latter in the diet volume (the total volume of gut contents in all specimens) calculated. Centrifuge tubes were also used for estimating the volume of the fragments of animal. The empty guts rate for each species was calculated as (number of specimens with empty guts/number of all specimens) ×100.

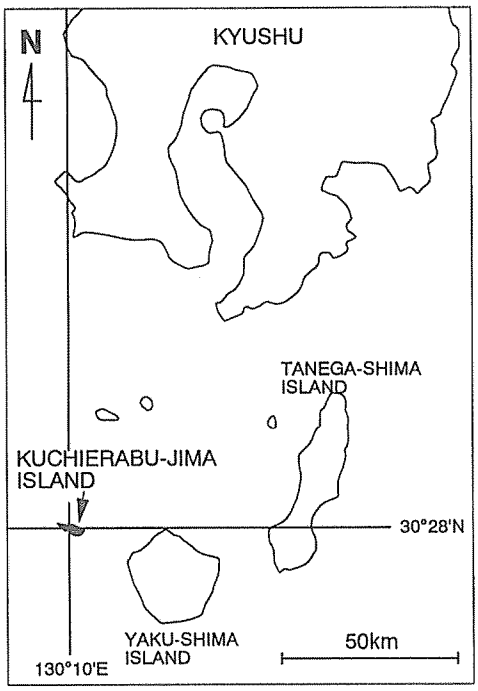

Fig. 1. Location of Kuchierabu-jima Island.

In the species of *Gymnothorax eurostus* the percentage frequency of occurrence for each food item and the numerical percentage of each food item of the total number of all food items were also culculated. This species was separated into five size classes such as 9.4-20 cm, 20-30 cm, 30-40 cm, 40-50 cm and 50-65.5 cm in total length and ontogenetic changes in diet investigated.

RESULTS AND DISCUSSION

A total of 178 specimens, including 14 species and four unidentified young morays, were collected. Their size range, the number of specimens, the number of empty guts and the empty guts rate of each species are shown in Table 1. The details of gut contents are as follows.

1 ***Strophidon ui*** TANAKA

This species contained unidentified crab fragments in the gut.

2 ***Gymnothorax eurostus*** (ABBOTT) (Table 2)

This species attains a maximum length of about 650 mm TL. Seventy-eight of the 97 specimens had gut contents. Table 2 shows gut contents in each size class. All food items were benthic except for yellow wrasse *Thalassoma lutescens* (about 13 cm TL) found in a single specimen (385 mm TL). Throughout all of the size classes, decapods were the dominant prey (69.8% to 75.8% in volumetric percentage). The numerical percentage of decapod crabs for the five size classes, 9.4-20 cm, 20-30 cm, 30-40 cm, 40-50 cm and

Table 1. List of moray eels and specimen numbers collected at the reefs of Kuchierabu-jima Island. Size range (mm TL), numbers of empty guts and empty guts rate are also given.

Species	Japanese name	No. of specimens	Size range (mm TL)	No. of empty guts	Empty guts rate (%)
Strophidon ui	Take-utsubo	1	700	0	0.0
Gymnothorax eurostus	Waka-utsubo	97	94-655	19	19.6
G. rueppelliae	Kurakake-utsubo	1	492	1	100.0
G. flavimarginatus	Goma-utsubo	4	100-241	0	0.0
G. melanospilus	Nisegoishi-utsubo	3	890-1500	2	66.7
G. fimbriatus	Herigoishi-utsubo	18	206-920	13	72.2
G. thyrsoideus	Sabi-utsubo	8	105-460	3	37.5
G. javanicus	Doku-utsubo	7	263-1030	2	28.6
G. albimarginatus	Herishiro-utsubo	3	750-955	3	100.0
Echidna polyzona	Simaarashi-utsubo	6	183-600	0	0.0
E. nebulosa	Kumo-utsubo	13	145-640	0	0.0
Gymnomuraena zebra	Zebura-utsubo	8	555-1000	0	0.0
Uropterygius macrocephalus	Hoshikikai-utsubo	4	177-340	1	25.0
U. tigrinus	Moyoukikai-utsubo	1	1210	1	100.0
Unidentified young morays		4	34.8-72.0	0	0.0

50-65.5 cm in total length, were 77.8%, 72.7%, 74.2%, 100% and 100%, respectively. Therefore, crabs were the most important food item for this species at Kuchierabu-jima. Two species of grapsid crabs, *Percnon planissimum* and *Plagusia tuberculata,* living in holes, crevices or coral- or stone-heads, were most frequently found in the guts of specimens (>300 mm TL). HOBSON (1974) reported that *G. eurostus* captured caridean shrimps and xanthid crabs during the day. The important point to note is that a single young specimen (142 mm TL) fed on amphipods, while any other larger specimens did not feed on amphipods.

3 *Gymnothorax rueppelliae* (McCLELLAND)

The gut of the specimen was empty.

4 *Gymnothorax flavimarginatus* (RÜPELL) (Table 3)

All of the four specimens had gut contents. Crabs were consumed by each of the four specimens. A benthonic fish *Eviota abax* (41.8 mm TL) was consumed by a single specimen (213 mm TL).

5 *Gymnothorax melanospilus* (BLEEKER)

One of the three specimens fed on an unidentified shrimp.

6 *Gymnothorax thyrsoideus* (RICHARDSON) (Table 4)

Three of the eight specimens contained foods. The main food item of this species was crabs (72.2% in volumetric percentage). Octopods and fishes were also consumed. A single specimen (366 mm TL) fed on portunid crabs *Thalamita admete* (11.2 mm and 11.9 mm in carapace width) and *Thalamita* sp. (11.9 mm in carapace width).

Table 2. Volume (%), frequency (%) and number of food animals in each size class of *Gymnothorax eurostus*.–: not consumed.

Size class (TL)	9.4–20 cm			20–30 cm			30–40 cm			40–50 cm			50–65.5 cm		
No. of specimen	11			14			26			19			8		
Food items	Vol.	Freq.	No.	Vol.	Freq.	No.	Vol.	Freq.	No.	Vol.	Freq.	No.	Vol.	Freq.	No.
Decapods	74.9	81.8	9	74.6	71.4	11	69.8	84.6	31	75.8	73.7	19	72.5	50.0	6
Crabs															
Tiarinia spinigera											5.3	2			
Majid fragments					7.1	1									
Thalamita sima								3.8	1						
T. prymna								3.8	1						
Portunid spp.					7.1	1		3.8	1		10.5	2		12.5	1
Metopograpsus messor		9.1	1												
Grapsus albolineatus		9.1	1					3.8	1		5.3	1			
Percnon planissimum					7.1	1		30.8	10		21.1	6		12.5	1
Plagusia tuberculata								3.8	1		21.1	4		25.0	2
Xanthid fragments					7.1	1									
Unid. spp.		45.5	5		28.6	4		30.8	8		21.1	4		25.0	2
Shrimps															
Macrobrachium japonicum							3.8	1							
Alpheid sp.					7.1	1									
Palaemon ortmanni								3.8	2						
Rhychocinetes uritai								3.8	1						
Stenopus hispidus								3.8	1						
Macrobrachium sp.		9.1	1												
Caridean sp.		9.1	1												
Unid. spp.					14.3	2		7.7	2						
Hermit crabs								3.8	1						
Stomatopods	11.1	18.2	2	—			—			4.5	5.3	1	7.3	12.5	1
Gonodactylus chiragra											5.3	1		12.5	1
Unid. spp.		18.2	2												
Amphipods	1.5	9.1	1	—			—			—			—		
Octopods	—			—			10.7	7.7	2	—			—		
Fishes	7.4	9.1	1	16.1	14.3	2	14.2	23.1	6	0.3	5.3	1	16.2	12.5	1
Thalassoma lutescens								3.8	1						
Gobid sp.								3.8	1						
Blenniid sp.		9.1	1												
Balistid sp.								3.8	1						
Unid. spp.					14.3	2		11.5	3		5.3	1		12.5	1
Unid. fragments	5.1	18.2		9.3	28.6		5.4	15.4		19.4	47.4		4.0	25.0	

7 *Gymnothorax fimbriatus* (BENNETT) (Table 5)

This species attains a large size (>900 mm TL). Five of the 18 specimens contained foods. The main food item of this species was fishes (65.1% in volumetric percentage). A single specimen (920 mm TL) contained two species of fish, a scarid fish *Scarus* sp. and a

Table 3. Volume (%) and number of food animals from guts of *Gymnothorax flavimarginatus*

Food item	% Volume	Number
Crabs	11.1	
Portunidae		2
Unid. sp.		2
Shrimps	71.6	
Rhynchocinetes uritai		1
Fishes	17.3	
Eviota abax		1
Unid. sp.		1

Table 4. Volume (%) and number of food animals from guts of *Gymnothorax thyrsoideus*

Food item	% Volume	Number
Crabs	72.2	
Thalamita admete		2
Thalamita sp.		1
Unid. sp.		1
Octopods	21.4	1
Unid. fishes	4.0	1
Unid. fragments	2.4	1

Table 5. Volume (%) and number of food animals from guts of *Gymnothorax fimbriatus*

Food item	% Volume	Number
Unid. crab fragments	12.4	1
Fishes	65.1	
Scarus sp.		1
Unid. fish fragments		4
Unid. fragments	22.5	2

Table 6. Volume (%) and number of food animals from guts of *Gymnothorax javanicus*

Food item	% Volume	Number
Crabs	5.2	
Percnon planissimum		1
Thalamita admete		1
Unid. crab fragments		1
Fishes	82.7	
Uropterygius macrocephalus		1
Unid. fragments	12.1	2

herbivorous fish species, which were identified from an observation of their pharyngeal teeth. The total length of this *Scarus* sp. was estimated to be between 10 and 15 cm TL by the size of the pharyngeal bone. Another specimen (206 mm TL) fed on two unidentified fishes (33.3 mm and 29.0 mm TL). Three other specimens contained unidentified fishes and their fragments.

8 *Gymnothorax javanicus* (BLEEKER) (Table 6)

This species attains a very large size (>1000 mm TL). One of the 5 specimens (700 mm TL) fed on a grapsid crab *Percnon planissimum* and a moray *Uropterygius macrocephalus* (280 mm TL), which was swallowed wholle head first. Another specimen (263 mm TL) consumed a portunid crab *Thalamita admete* (14.3×9.6 mm in carapace width).

9 *Gymnothorax albimarginatus* (TEMMINCK *et* SCHLEGEL)

The guts of all three specimens were empty.

10 *Echidna polyzona* (RICHARDSON) (Table 7)

All of the six specimens contained crabs and a single specimen (183 mm TL) contained a shrimp. All of the gut contents examined were crushed by the pavement-like teeth. HIATT and STRASBURG (1960) reported that a single specimen collected from the Marshall Islands contained a large shrimp *Saron marmoratus*, which habitually secludes itself under

Table 7. Volume (%) and number of food animals from guts of *Echidna polyzona*

Food item	% Volume	Number
Crabs	99.7	
Percnon planissimum		2
Shizophrys aspera		4
Tiarinia spinigera		1
Majid fragments		2
Parathenoid fragments		2
Portunid spp.		3
Xanthid spp.		3
Shrimps	0.2	
Alpheid sp.		1

Table 8. Volume (%) and number of food animals from guts of *Echidna nebulosa*

Food item	% Volume	Number
Crabs	71.9	
Percnon planissimum		2
Majid spp.		2
Portunid sp.		1
Grapsid sp.		1
Xanthid spp.		3
Unidentified crabs		6
Stomatopods	4.4	
Odontodactylus japonicus		1
Unid. sp.		1
Unid. fragments	23.7	

Table. 9. Volume (%) and number of food animals from guts of *Gymnomuraena zebra*

Food item	% Volume	Number
Crabs	78.3	
Tiarinia comigera		1
Unid. majid spp.		4
Percnon planissimum		3
Unid. grapsid sp.		1
Unid. xanthid spp.		2
Gastropods	11.6	
Peribolus (Arabica) arabica		1
Cypraenid sp.		1
Unid. sp.		1
Urchins	10.1	
Eucidaris metularia		2
Unid. sp.		1

rocks and ledges.

11 *Echidna nebulosa* (AHL) (Table 8)

All of the thirteen specimens which had food in their guts fed mainly on crabs such as grapsid crab *Percnon planissimum*, and majid and xanthid crabs. The carapaces of some large crabs found in the guts were crushed by their teeth. Two of the thirteen specimens contained stomatopods, including *Odontodactylus japonicus*.

12 *Gymnomuraena zebra* (SHAW) (Table 9)

The main food item of this species was crabs. Gastropods and sea urchins were also consumed. Crabs found in the guts of six specimens were majid, grapsid and xanthid crabs, all of whose carapaces were crushed by the molariform teeth of this species. Two of the eight specimens had consumed three crushed gastropods. A single specimen fed on *Peribolus (Arabica) arabica* and *Cypraenidae sp.*, and other unidentified gastropods. Other three specimens contained crushed gastropod shells and the spines of sea urchins, *Eucidaris metularia* and another unidentified species. HIATT and STRASBURG (1960) reported that this species consumed xanthid crabs and a rock dwelling sea urchin which is usually difficult to extricate from its tightly fitting depression.

13 *Uropterygius macrocephalus* (BLEEKER) (Table 10)

Three of the four specimens fed on gastropods and crabs. With regard to the gastropods, only their operculums and soft bodies were found, their shells were not found.

Table 10. Volume (%) and number of food animals from guts of *Uropterygius macrocephalus*

Food item	% Volume	Number
Unid. crab fragments	5.3	1
Unid. gastropods	94.7	3

14 *Uropterygius tigrinus* (LESSON)

The gut of the specimen was empty.

15 Unidentified young morays

All of the four unidentified specimens contained only amphipods. Young specimens (<100 mm TL) could not capture large decapods and heavily armored prey. As mentioned above, a small *G. eurostus* also fed on amphipods. The feeding habits among small morays (<100 mm TL) have never yet been examined in the world. But it seems to be obvious that small morays can not catch large or hard bodied prey due to their short mouth cleft and weakly developed dentition.

The primary food items of *Gymnothorax* morays were crabs and fishes. In particular the grapsid crab, *Percnon planissimum,* was frequently consumed, as seen in the case of *G. eurostus.* The species which attained a large size fed on fishes, such as *G. javanicus* and *G. fimbriatus. Gymnothorax eurostus* fed on a wide variety of animals, as the size-related analysis demonstrates, and the smaller fish of *G. eurostus* also consumed amphipods.

Unlike *Gymnothorax* morays, as reported in *Echidna leucotaenia* (HIATT and STRASBURG, 1960) and *E. catenata* (RANDALL, 1967), *Echidna* morays consumed only crustaceans. Crabs were the food item most frequently taken by *Echidna* morays at Kuchierabu-jima, as RANDALL (1967) reported in *E. catenata* of the West Indies.

The feeding habits of the *Gymnomuraena* moray are distinctive. Unlike other genera of muraenid fishes at Kuchierabu-jima, this moray consumed crabs, sea urchins and gastropod snails with hard shells. Since this moray is a slow swimmer, its prey seems to be limited to a sluggish type. What is more this moray seems to capture and crush the hard shells of sea urchins and gastropod snails by its strong molariform dentition. These prey animals were never consumed by other muraenid fishes at Kuchierabu-jima.

Acknowledgments We thank Shunpei KAKUDA for valuable advice. We are also grateful to the people of Kuchierabu-jima Island for permission to work in their waters.

References

BLACHE, J. 1967. Contribution à la connaissance de poissons anguilliformes de la côte occidentale d'Afrique. *Bull. Inst. Fond. Afri. Noire, ser. A,* 29 (1): 163-217.

BLACHE, J. 1967. Contribution à la connaissance de poissons anguilliformes de la côte occidentale d'Afrique. *Bull. Inst. Fond. Afri. Noire, ser. A,* 29 (2): 695-709.

BLACHE, J. 1967. Contribution à la connaissance de poissons anguilliformes de la côte occidentale d'Afrique. *Bull. Inst. Fond. Afri. Noire, ser. A,* 29 (3): 1122-1187.

HIATT, R. W. and D. W. STRASBURG. 1960. Ecological relationships of the fish fauna on coral reefs of the Marshall Islands. *Ecol. Monogr.,* 30: 65-127.

HOBSON, E. S. 1974. Feeding relationships of teleostean fishes on coral reefs in Kona, Hawaii. *Fish. Bull. U. S.,* 72 (4): 915-1031.

RANDALL, J. E. 1967. Food Habits of reef fishes of West Indies. *Stud. Trop. Oceanogr.*, 5: 665-847.

SCHULTZ, L. P., E. S. HERALD, E. A. LACHNER, A. D. WELANDER, and L. P. WOODS. 1953. Fishes of the Marshall and Mariana Islands. Families from Asymmetrontidae to Siganidae. *U. S. Nat. Mus. Bull.*, 202, (1): i-xxxii+1-685, pls. 1-74.

SUYEHIRO, Y. 1942. A study of the digestive system and feeding habits of fish. *Japan. J. Zool.*, 10 (1): 1-303, pls. 1-15.

口永良部島におけるウツボ科魚類の食性

行平　英基*・渋野　拓郎
橋本　博明・具島　健二

広島大学生物生産学部，東広島市 724
*現勤務先：IC Net (株)，浦和市白幡3-6-7-301 336

南西諸島の口永良部島の磯水域において，熱帯性ウツボ科魚類14種，タケウツボ *Strophidon ui*，ワカウツボ *Gymnothorax eurostus*，クラカケウツボ *G. rueppelliae*，ゴマウツボ *G. flavimarginatus*，ニセゴイシウツボ *G. melanospilus*，サビウツボ *G. thyrsoideus*，ヘリゴイシウツボ *G. fimbriatus*，ドクウツボ *G. javanicus*，ヘリシロウツボ *G. albimarginatus*，シマアラシウツボ *Echidna polyzona*，クモウツボ *E. nebulosa*，ゼブラウツボ *Gymnomuraena zebra*，ホシキカイウツボ *Uropterygius macrocephalus*，モヨウキカイウツボ *U. tigrinus* と，未同定のウツボ幼魚の胃内容物を調査した。これらは肉食性で，カニ類，エビ類，シャコ類，ヨコエビ類，巻貝類，ウニ類，魚類を摂餌していた。利用する餌の中で最も重要なものは，特に浅い所に生息しているトゲアシガニ *Percnon planissimum* などのカニ類であった。ウツボ属 *Gymnothorax* では，大型個体はカニ類と魚類を主に摂餌していた。アラシウツボ属 *Echidna* は甲殻類，特にカニ類を摂餌していた。ゼブラウツボ属 *Gymnomuraena* は固い殻を持つカニ類，巻貝類，ウニ類を摂餌していた。小型のウツボ幼魚 (<100 mm TL) は基本的にはヨコエビ類を摂餌していた。

キーワード：食性，口永良部島，ウツボ属 *Gymnothorax*，アラシウツボ属 *Echidna*，ゼブラウツボ属 *Gymnomuraena*