

Diets of 28 Fish Species from 12 Families at Kuchierabu - jima Island

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Abstract Stomach contents of 28 fish species from 12 families (Aulostomidae, Belonidae, Carangidae, Cirrhitidae, Fistulariidae, Lethrinidae, Mugiloididae, Scombridae, Scorpaenidae, Serranidae, Sphyracidae, Synodontidae) sampled from the coastal zone around Kuchierabu-jima Island, southern Japan, were analyzed. Of the 28 fish species having stomach contents, 75 % (21 species from 11 families) fed on various kinds of fish prey. Invertebrate prey such as crustaceans, echinoderms, and cephalopods were fed on by 57 % (16 species from 9 families). There are many primarily or secondarily piscivorous fishes that can feed on fish, which bring about complex predatory fish-prey fish interactions in the coral reef community.

Key words: coral reef fishes, food habits, stomach contents, piscivore

INTRODUCTION

During the last decade, numerous papers have been published dealing with the food habits of coral reef fishes. Details of when, where, how and what kind of prey a fish feeds on are still unclear for many species.

Especially, piscivorous fish that feed on other fish effect the survival, growth, and maturity of prey fish (Milinski, 1993; Carr and Hixon, 1995), and so play a significant role in the structuring of coral reef communities (Hixon, 1991). Therefore, it is important to confirm the level and intensity of predation by piscivores in coral reefs. A step to understand the predatory role of coral reef piscivores is to detail information on the identity and size of consumed prey by dietary analysis. However, although there are many reports about fisheries resources such as grouper and jack, there are not enough to reveal the diets of other coral reef fishes.

A large part of the ichthyofauna of Kuchierabu-jima Island consists of tropical species (Gushima and Murakami, 1976). This study was undertaken to provide information on the prey items of 28 fish species from 12 families along the coast of Kuchierabu-jima Island. The results were compared with diets of other population of these species.

MATERIALS AND METHODS

The fish samplings were conducted from the shore of Kuchierabu-jima (30° 28' N, 130° 10' E), southern Japan, from 0600 to 2000 during the periods of June-October 1997, May-November 1998, August-November 1999, June-August 2000, November 2001, June 2003, September-December 2004, and June-July 2005. A total of 147 specimens (28 species from 12 families; Table 1) were obtained using spears, spear guns, or by fishing.

Table 1. Family, species, abbreviation, number of specimens, and range of body size of specimens with stomach contents collected at Kuchierabu-jima island.

Family	Species	Japanese name	Abbreviation	No. of specimens with contents	Range of size (cm)
Aulostomidae	<i>Aulostomus chinensis</i>	Herayagara	Ac	12	45.2-77.5
Belonidae	<i>Tylosurus crocodilus crocodilus</i>	Okizayori	Tc	3	45.0-84.5
Carangidae	<i>Carangoides orthogrammus</i>	Nanyoukaiwari	Co	1	38.0
	<i>Caranx melampygus</i>	Kasumiaji	Cm	17	35.0-65.0
	<i>Seriola lalandi</i>	Hiramas	Sl	1	37.5
	<i>Seriola rivoliana</i>	Hirenagakanpachi	Sr	1	16.1
Cirrhitidae	<i>Cirrhitus pinnulatus</i>	Isogonbe	Cp	3	13.0-18.3
Fistulariidae	<i>Fistularia petimba</i>	Akayagara	Fp	1	80.0
Lethrinidae	<i>Lethrinus nebulosus</i>	Hamafuefuki	Ln	1	45.0
Mugiloididae	<i>Parapercis cephalopunctata</i>	Wanuketoragisu	Pc	8	16.1-18.4
Scombridae	<i>Gymnosarda unicolor</i>	Isomaguro	Gu	3	41.4-115.7
	<i>Katsuwonus pelamis</i>	Katsuo	Kp	8	27.0-55.0
	<i>Thunnus albacares</i>	Kihada	Ta	2	48.0, 49.0
Scorpaenidae	<i>Scorpaenopsis diabolus</i>	Niraikasago	Sd	1	14.7
Serranidae	<i>Cephalopholis argus</i>	Aonomehata	Ca	2	25.0, 33.0
	<i>Cephalopholis miniata</i>	Yukatahata	Ci	1	22.0
	<i>Cephalopholis urodeta</i>	Nijihata	Cu	1	16.5
	<i>Epinephelus caeruleopunctatus</i>	Hakutenhata	Ec	1	29.0
	<i>Epinephelus merra</i>	Kanmonhata	Em	1	15.0
	<i>Epinephelus fasciatus</i>	Akahata	Ef	2	24.0, 26.0
	<i>Epinephelus howlandi</i>	Hiregurohata	Eh	2	24.0, 25.0
	<i>Epinephelus tauvina</i>	Hitomihata	Et	1	34.0
	<i>Plectropomus leopardus</i>	Sujiara	Pl	5	28.0-50.0
<i>Variola albimarginata</i>	Ojjirobarahata	Va	1	33.0	
Sphyraenidae	<i>Sphyraena pinguis</i>	Akakamasu	Sp	11	27.0-31.0
Synodontidae	<i>Saurida gracilis</i>	Madaraeso	Sg	2	10.6, 20.5
	<i>Synodus ulae</i>	Akaeso	Su	14	9.5-19.8
	<i>Trachinocephalus myops</i>	Okieso	Tm	1	14.2

After collection, the specimens or stomachs were immediately preserved in 10% buffered formalin. Most specimens were measured as standard length (cm), but *Carangoides orthogrammus* and *Parapercis cephalopunctata* were measured as total length (cm). The stomach contents were classified to order, family, and where possible to species under a binocular microscope. The percentage frequency of occurrence for each prey item was calculated in each species. Empty stomachs were not included in the analysis.

RESULTS AND DISCUSSION

Of 147 specimens, 107 specimens contained stomach contents. Details of diets are as follows and in Table 2.

Table 2. Percentage frequency of occurrence calculated for each prey items in each diet of 28 fish species shown abbreviation.

Prey items	Ac	Tc	Co	Cm	Sl	Sr	Cp	Fp	Ln	Pc	Gu	Kp	Ta	Sd	
Teleostei	100	67	100	100	100	100	33	100	0	25	100	75	100	100	
Unknown	92	67	-	53	100	100	33	100	-	25	67	50	100	-	
Apogonidae	Apogonidae sp.	8	-	-	-	-	-	-	-	-	-	-	-	-	
Blenniidae	<i>Xiphasia setifer</i>	-	-	-	-	-	-	-	-	-	-	13	-	-	
Carangidae	Carangidae sp.	8	-	-	12	-	-	-	-	-	33	-	-	-	
Clupeidae	<i>Spratelloides gracilis</i>	-	-	-	41	-	-	-	-	-	-	13	50	-	
	<i>Spratelloides delicatulus</i>	-	-	-	6	-	-	-	-	-	-	-	-	-	
Labridae	Labridae sp.	8	-	-	6	-	-	-	-	-	-	-	-	-	
Monacanthidae	Monacanthidae sp.	-	-	-	-	-	-	-	-	-	-	-	50	-	
Pempheridae	Pempheridae sp.	-	-	-	-	-	-	-	-	-	33	-	-	-	
Pomacentridae	Pomacentridae sp.	-	-	-	24	-	-	-	-	-	-	-	-	-	
Scorpaenidae	<i>Scorpaenopsis cirrhosa</i>	-	-	-	6	-	-	-	-	-	-	-	-	-	
Serranidae	<i>Pseudanthias squamipinnis</i>	-	-	-	-	-	-	-	-	-	33	-	-	-	
Synodontidae	Synodontidae sp.	8	-	-	-	-	-	-	-	-	-	-	-	-	
Tetraodontidae	<i>Masturus lanceolatus</i>	-	-	-	-	-	-	-	-	-	-	13	-	-	
Tripterygiidae	Tripterygiidae sp.	-	-	100	-	-	-	-	-	-	-	-	-	100	
Crustacea	Crustacea	25	0	0	0	0	0	100	0	0	100	0	25	50	0
	Crustacea sp.	-	-	-	-	-	-	-	-	-	-	-	13	-	-
	Decapoda sp.	8	-	-	-	-	-	-	-	-	-	-	-	-	
	Brachyura sp.	-	-	-	-	-	-	33	-	-	88	-	13	-	-
	Xanthidae sp.	-	-	-	-	-	-	67	-	-	-	-	-	-	
	Macrura sp.	8	-	-	-	-	-	-	-	-	13	-	-	50	
	<i>Rhynchocinetes uritai</i>	8	-	-	-	-	-	-	-	-	-	-	-	-	
	Stomatopoda sp.	-	-	-	-	-	-	-	-	-	50	-	-	-	
Echinoidea	Echinoidea	0	33	0	0	0	0	0	0	100	0	0	0	0	
	Echinoidea sp.	-	33	-	-	-	-	-	-	-	-	-	-	-	
	<i>Diadema setosum</i>	-	-	-	-	-	-	-	-	100	-	-	-	-	
Ophiuroidea	Ophiuroidea	0	0	0	0	0	0	0	0	100	0	0	0	0	
	Ophiuroidea sp.	-	-	-	-	-	-	-	-	100	-	-	-	-	
Cephalopoda		0	0	0	6	0	0	0	0	0	0	13	0	0	

	Decapoda sp.	-	-	-	6	-	-	-	-	-	-	-	13	-	-
Gastropoda		0	0	0	0	0	0	0	0	100	0	0	0	0	0
	Patellogastropoda sp.	-	-	-	-	-	-	-	-	100	-	-	-	-	-

Table 2. Continued.

Prey items	Ca	Ci	Cu	Ec	Em	Ef	Eh	Et	Pl	Va	Sp	Sg	Su	Tm
Teleostei	50	100	0	0	0	0	50	0	100	100	100	100	100	0
Unknown	50	100	-	-	-	-	50	-	80	100	45	100	43	-
Acanthuridae	<i>Acanthurus pyroferus</i>	-	-	-	-	-	-	-	-	-	-	-	7	-
Blenniidae	Blenniidae sp.	-	-	-	-	-	-	-	-	-	-	50	-	-
Chaetodontidae	Chaetodontidae sp.	-	-	-	-	-	-	-	-	-	-	-	7	-
Clupeidae	<i>Spratelloides gracilis</i>	-	-	-	-	-	-	-	-	-	55	-	50	-
Labridae	Labridae sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Thalassoma amblycephalum</i>	-	-	-	-	-	-	-	20	-	-	-	-	-
Tripterygiidae	<i>Helcogramma sp.</i>	-	-	-	-	-	-	-	-	-	-	-	7	-
Crustacea		50	0	100	100	100	50	100	0	0	0	0	0	100
	Brachyura sp.	50	-	-	100	-	50	50	-	-	-	-	-	100
	<i>Thalamita picta</i>	-	-	-	-	100	-	-	-	-	-	-	-	-
	<i>Tetralia nigrolineata</i>	-	-	-	-	100	-	-	-	-	-	-	-	-
	<i>Percnon planissimum</i>	-	-	-	-	-	100	-	100	-	-	-	-	-
	Macrura sp.	-	-	100	-	-	-	-	-	-	-	-	-	-
	Stomatopoda sp.	-	-	-	-	-	-	50	-	-	-	-	-	-

Aulostomidae

In *Aulostomus chinensis* (n = 12, Ac), most of the prey items were fish, which accounted for 100 % by frequency of occurrence. The other prey items were several kinds of crustaceans such as decapods and macrurans (25 %). Maximum size of prey items was 14.5 cm BL of Carangidae sp. from one *A. chinensis* with 69.2 BL. Previous studies have been reported for this species (Indo-Pacific species) from Marshall Islands and Hawaii, and for congeneric species like *A. maculatus* (West Atlantic species) from the West Indies. In the previous study sites, this species mainly fed on two types of fishes as pelagic fish (e.g., Atherinidae, Carangidae) and reef fish (e.g., Acanthuridae, Tetraodontidae). Invertebrates were also present in the diet, but at a lower amount (Hiatt and Strasburg, 1960; Randall, 1967; Hobson, 1974; Parrish *et al.*, 1986). The high incidence of fish prey probably indicates that this species with size of 30-80 cm BL is primarily a piscivore.

Belonidae

Tylosurus crocodilus crocodilus (n = 3, Tc) fed on fish mainly. One specimen contained an invertebrate of an echinoderm. In the West Indies, Australia, and Solomon Islands, this species also fed on mostly two types of fishes as pelagic fish (*Spratelloides gracilis*, *Herklotsichthys* spp., *Stolephorus* sp.) and reef fishes (e.g., Acanthuridae, Gobiidae) (Randall, 1967; Blaber *et al.*, 1990; Salini *et al.*, 1990). It is considered that this species may not only move in surface waters, but also search for prey reef fish near the sea bottom. This species with 40-90 cm BL probably is primarily a piscivore.

Carangidae

In *Caranx melampygus* (n = 17, Cm), fish prey were the dominant prey category in 100 % by frequency of occurrence. Both types of fish prey as pelagic fish (Carangidae, *Spratelloides* spp.) and reef fish (e.g., Labridae, Scorpaenidae) were identified in their stomach contents. Invertebrate prey

such as cephalopod were also present in the diet of *C. melampygyus*, but with a lower frequency. In Hawaii and Solomon Islands, fish prey made up the principal dietary component of the *C. melampygyus* (Blaber *et al.*, 1990; Sudekum *et al.*, 1991; Meyer *et al.*, 2001). The single specimens of *Carangoides orthogrammus* (Co), *Seriola lalandi* (Sl), and *Seriola rivoliana* (Sr) also contained fish prey. Previous studies have shown that *C. orthogrammus* in Hawaii, *S. lalandi* in New Zealand, and *S. rivoliana* in the Azores fed on fish prey frequently (Russell, 1983; Meyer *et al.*, 2001; Barreiros *et al.*, 2003). The high incidence of fish prey probably indicates that these species are primarily piscivores.

Cirrhitidae

Cirrhitus pinnulatus (n = 3, Cp) fed on crustaceans such as brachyurans (Xanthidae) and fish prey. Parrish *et al.* (1986) has reported that fish prey of this species accounted for about 21 % by volume and 19 % by frequency. In Marshall Islands and Hawaii, this species fed mainly on various kinds of invertebrates such as brachyurans (Xanthidae), ophiuroids, and octopus (Hiatt and Strasburg, 1960; Hobson, 1974). The high incidence of crustaceans and fish prey probably indicates that it is primarily a carnivore and secondarily a piscivore.

Fistulariidae

One specimen of *Fistularia petimba* (Fp) was collected in depth of about 40 m by lure fishing. The specimen contained an unknown fish. In another site in Japan, one specimen of *F. petimba* was found to contain one *Sillago japonica* (Sillaginidae) (Takeuchi unpub. data). *F. petimba* is found throughout tropical Atlantic, Indo-West Pacific, and Hawaii along coastal areas with soft bottoms, usually at depths over 10 m (Fritzsche, 1976). This species perhaps is primarily a piscivore similar to congeneric species like *F. commersonii* (shallow reef species) (Takeuchi *et al.*, 2002).

Lethrinidae

One specimen of *Lethrinus nebulosus* (Ln) contained only invertebrate prey such as echinoderm, ophiuroids, and gastropod. In Australia, this species also fed on various kinds of invertebrates (e. g., annelids, brachyurans, stomatopods). In addition, fish prey such as Pomadasidae and Carangidae were also present in the diet of the population (50 % by frequency of occurrence) (Salini *et al.*, 1994). This species perhaps is primarily a carnivore and secondarily a piscivore.

Mugiloididae

In *Parapercis cephalopunctata* (n = 8, Pc), crustaceans as brachyurans and stomatopods were the dominant prey category in 100 % by frequency of occurrence. Fish prey were also present in the diets, but with a lower frequency (25 %). In Okinawa Island, the stomach contents of this species only contained invertebrate prey such as brachyurans and macrurans (Sano *et al.*, 1984). In the study site, Shibuno *et al.* (1996) has reported that this species with about 15-19 cm TL fed mostly on crabs (Portunidae, Grapsidae, Xanthidae) and stomatopods (Gonadactylidae), which account for about 78 % and 40 % by frequency of occurrence (fish prey account for 30 %). The small fishes of 9-15 cm TL fed on many fish prey and crabs, which account for 53 % and 53 %. Therefore, this species with 16-18 cm TL perhaps is secondarily a piscivore.

Scombridae

In *Gymnosarda unicolor* (n = 3, Gu), *Katsuwonus pelamis* (n = 8, Kp), and *Thunnus albacares* (n = 2, Ta), fish prey were the dominant prey category in 75-100 % by frequency of occurrence. Invertebrate prey such as crustaceans and cephalopod were also present in diet. Among the prey items of one *K. pelamis* with 60 cm TL was a specimen of sharptail mola *Masturus lanceolatus* (The National Science Museum, Tokyo, NSMT-P 68568, 4.8 cm SL) and two specimens of hairtail blenny *Xiphasia setifer* (24 cm TL, not measured). This represents an addition of a new prey item to the already diverse feeding habits of skipjack tuna. *G. unicolor* in Marshall Islands, *K. pelamis* in Solomon Islands, and *T. albacares* in French Polynesia also fed on mainly fish prey (Randall, 1980; Blaber *et al.*, 1990; Bertrand *et al.*, 2002). The high incidence of fish prey probably indicates that these species are primarily piscivores.

Scorpaenidae

One specimen of *Scorpaenopsis diabolus* (Sd) contained fish prey, Tripterygiidae sp.. Parrish *et al.* (1986) has reported that in Hawaii, fish prey in diets of this species was the dominant prey item, which accounted for 94 % by frequency of occurrence. Generally, stonefish and scorpionfish perform 'sit-and-wait' foraging and can catch mobile fish prey. The species perhaps is primarily a piscivore.

Serranidae

Of the 10 species, 5 species including *Cephalopholis argus* (n = 2, Ca), *Cephalopholis miniata* (n = 1, Ci), *Epinephelus howlandi* (n = 2, Eh), *Plectropomus leopardus* (n = 5, Pl), and *Variola albimarginata* (n = 1, Va) fed on fish prey such as Labridae. 6 species including *C. argus*, *Cephalopholis urodeta* (n = 1, Cu), *Epinephelus caeruleopunctatus* (n = 1, Ec), *Epinephelus merra* (n = 1, Em), *Epinephelus fasciatus* (n = 2, Ef), *Epinephelus tauvina* (n = 1, Et) fed on crustaceans such as brachyurans and macrurans. In Marshall Islands, Society Islands, Hawaii, Madagascar, Okinawa Islands, Red Sea, and Solomon Islands, three species of *Cephalopholis*, *E. merra*, *E. fasciatus*, *E. tauvina*, and *P. leopardus* fed on two types of fishes as pelagic fish (e. g., Clupeidae, Engraulidae) and reef fish (e. g., Blenniidae, Serranidae) (Hiatt and Strasburg, 1960; Randall and Brock, 1960; Hobson, 1974; Harmelin-Vivien and Bouchon, 1976; Randall, 1980; Sano *et al.*, 1984; Shpigel and Fishelson, 1989; Blaber *et al.*, 1990; Nakai *et al.*, 2001). Invertebrate prey such as crustaceans and cephalopods were also present in diets of these species frequently. Many species perhaps are primarily or secondarily piscivores.

Sphyraenidae

All *Sphyraena pinguis* (n = 11, Sp) fed on only fish prey such as pelagic fish *Spratelloides gracilis*, occurring in 55 % of stomachs. Little is known about the food habit of the species. It has been reported that the larvae of *S. pinguis* fed on *Podon* sp. and copepod nauplii (Kuwahara and Suzuki, 1982). In the study site, *S. pinguis* with over 10 cm BL usually form loose shoal and attack *S. gracilis* in the water column (Takeuchi unpub. data). The high incidence of fish prey perhaps indicates that it is primarily a piscivore.

Synodontidae

Saurida gracilis (n = 2, Sg) and *Synodus ulae* (n = 14, Su) fed on only fish prey such as pelagic fish, *Spratelloides gracilis* and reef fish, Acanthuridae and Bleniidae. One specimen of *Trachinocephalus myops* (Tm) contained crustacean such as brachyuran. *S. gracilis* in Marshall Island, Hawaii, Okinawa, and Kuchierabu-jima also fed on primarily fish prey (e.g., Aulostomidae, Atherinidae, *Spratelloides* sp.), secondarily crustaceans such as stomatopods (Hiatt and Strasburg, 1960; Hobson, 1974; Sano *et al.*, 1984; Parrish *et al.*, 1986; Shibuno *et al.*, 1996; Nakamura *et al.*, 2003). *S. ulae* in Hawaii also fed on mostly fish prey (Parrish *et al.*, 1986). Little is known about the food habit of *T. myops*. *S. ulae* and *S. gracilis* probably are primarily piscivores.

A total of 19 fish prey categories were identified. Of 28 species from 12 families having stomachs contents, 75 % (21 species from 11 families) contained fish prey. Of the 21 species, 7 species contained pelagic fish such as Carangidae and Clupeidae. Clupeidae *Spratelloides gracilis* and *S. delicatulus* were predated on by 5 species and are common pelagic prey. Reef fish such as Labridae and Tripterygiidae were predated on by 10 species from 7 families. Invertebrate prey such as crustaceans, echinoderms, and cephalopods were fed on by 57 % (16 species from 9 families). Shibuno *et al.* (1998) has reported that of 31 species, 12 species of piscivorous fishes at the reefs fed on mainly pelagic fish, *S. gracilis*. In the study site, carnivorous fishes such as Mullidae and Labridae can intentionally feed on pelagic fish by their skillful tactics (Takeuchi unpub. data). Therefore, their predation effects against fish may be underestimated. There are many primarily or secondarily piscivorous fishes that can feed on fish, which bring about complex predatory fish-prey fish interactions in the coral reef community.

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口永良部島における12科28魚種の食餌

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要旨 南日本にある口永良部島の沿岸域において採集した12科28種の魚類（ヘラヤガラ科，ダツ科，アジ科，ゴンベ科，ヤガラ科，フエフキダイ科，トラギス科，サバ科，フサカサゴ科，ハタ科，カマス科，エソ科）の胃内容物を分析した。胃内容物を含む28種のうち，75 %（11科21種）は様々な種類の魚類を食べていた。甲殻類，ウニ類や頭足類のような無脊椎動物は57 %（9科16種）によって食べられていた。魚類を主としてもしくは二次的に食べる魚類は多く存在し，それらはサンゴ礁群集において複雑な魚類捕食者・餌魚関係を生み出していると考えられる。

キーワード：サンゴ礁魚類，食性，胃内容物，魚食性