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Diel Feeding Patterns of the Congiopodid Fish *Hypodytes rubripinnis* in Aburatsubo Bay, Japan

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Abstract Diel changes in the feeding intensity and diet composition of the congiopodid fish *Hypodytes rubripinnis* were studied in Aburatsubo Bay, Miura Peninsula, Japan, on July 24 and 25, 1985. In samples taken at night, the ratio of stomach content weight to body weight was high and the frequency of occurrence of fish with empty stomach was very low, while the reverse was the case in the daytime, suggesting that this species feeds intensively at night, instead of during the day. Gammarids were the most dominant prey and isopods and caprellids were next important. These three prey items accounted for 91% of the total diet by number. The proportion of isopods in the total diet showed the most remarkable diel change. They amounted to about 30% at night, but were not consumed in the daytime.

Hypodytes rubripinnis is a small congiopodid fish which is commonly found and coexists with many other fishes in *Zostera* beds in southern Japan and Korea (e.g., Kikuchi, 1966). To examine the interspecific competition between the fishes which share the same habitat, the study on food habit and feeding time is essential. The food habits of *H. rubripinnis* were briefly referred to in the studies on the animal communities in *Zostera* beds (Fuse, 1962a; Kitamori, 1963; Kikuchi, 1966; Imabayashi et al., 1975; Kimura et al., 1983; Shiobara and Suzuki, 1985). However, a study on the feeding time has not been conducted. The purpose of the present study is to clarify the diel changes in feeding intensity and in diet composition of *H. rubripinnis*.

Materials and methods

The study was carried out in Aburatsubo Bay situated at the south of the Miura Peninsula (35° 10′N, 139°38′E), central Japan, on July 24 and 25, 1985. Fish were collected from *Zostera* beds and adjacent areas, which are at the deepest 4 m, at 4 hour intervals throughout a 24 hour period using a small beach seine and dip nets. Samples were preserved in 10% sea water formalin immediately after collection. Table 1 shows the number of fish collected at each sampling time. After measuring the standard length (SL), total body weight and wet weight of the stomach contents, prey species in the stomach contents were identified under a binocular microscope and the number of individuals of each prey species was counted. The percentage ratio of the stomach content weight to the body weight (SCW/BW) was calculated for each specimen. In case of the specimen with empty stomach, the ratio was regarded as 0%. From these, a mean was calculated for each sampling time. The percentage ratio of the number of empty stomachs to the total number of stomachs examined at each sampling time was also calculated. From the changes of these two ratios with time, the diel changes in feeding intensity were determined. To describe the diet composition, two methods were used. One was

Table 1. Number of specimens of *Hypodytes rubripinnis* collected at each sampling time in Aburatsubo Bay on July 24 and 25, 1985.

	Sampling time						Total
	13:00	17:00	21:00	01:00	05:00	09:00	
No. of fish collected	13	18	35	51	34	27	178
No. of fish containing food	6	5	30	45	34	22	142
No. of fish with empty stomach	7	13	5	6	0	5	36

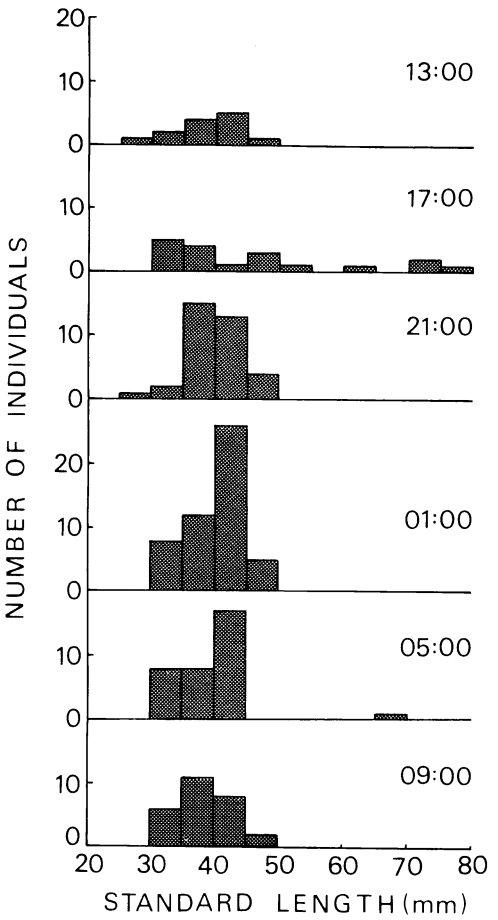

Fig. 1. Frequency distribution of standard length of *Hypodytes rubripinnis* collected at each sampling time in Aburatsubo Bay.

the percentage composition by prey number and the other was the percentage of frequency of occurrence (Hyslop, 1980).

Results

Length frequency distribution. Fig. 1 shows the length frequency distribution for each sampling time. The standard length ranged from 25.9 to 76.4 mm, but that of most fish collected (96% of all the specimens) fell into the range between 30 and 50 mm SL and the number of fish of 30–40 mm SL is nearly equal to that of fish of 40–50 mm SL at each time. Thus, there was little difference among the length frequency distributions with sampling time.

Since the ratio of stomach content weight to body weight (SCW/BW) might vary with the body size of fish, mean ratio of SCW/BW should be calculated for each size group and compared among the groups (Keast and Welsh, 1968). In the present study the samples for each sampling time were divided into two size groups, i.e. length ranges of less than 40 mm SL and more than this. At any sampling time, however, the comparisons between two size groups showed little difference in SCW/BW and diet composition. Therefore, the samples for each time were treated as one size group for later analysis.

Diel changes in feeding intensity. Fig. 2 indicates the diel changes in the mean SCW/BW and the empty stomach ratio. Of all the specimens examined, 20% had empty stomachs and 74% had

Table 2. Diet composition of *Hypodytes rubripinnis* collected from the *Zostera* area in Aburatsubo Bay. N(%), percentage composition by number; F(%), percentage of frequency of occurrence.

Prey item	N(%)	F(%)
Polychaeta	2.1	16.9
Mollusca		
Gastropoda	0.5	4.2
Bivalvia	0.1	0.7
Crustacea		
Ostracoda	0.3	2.1
Copepoda	1.0	5.6
Nebaliacea	0.3	2.1
Mysidacea	0.1	0.7
Cumacea	0.2	0.7
Tanaidacea	1.6	7.7
Isopoda		
Dynoides dentisinus	16.7	32.4
Paranthura japonica	0.2	1.4
Idoteidae	0.1	0.7
Sphaeromidae	0.2	0.7
Cirolanidae	0.1	0.7
Other Isopoda	0.3	2.1
Gammaridea	65.1	88.7
Caprellidea	8.6	35.2
Decapoda		
Natantia	0.5	4.2
Brachyura		
Pinnixa haematosticta	0.4	3.5
Grapsidae	0.2	1.4
Megalopa larvae	0.2	1.4
Other Brachyura	0.3	2.1
Other Crustacea	0.4	3.5
Osteichthyes	0.2	1.4
Algae	0.5	4.2
Others	0.1	0.7

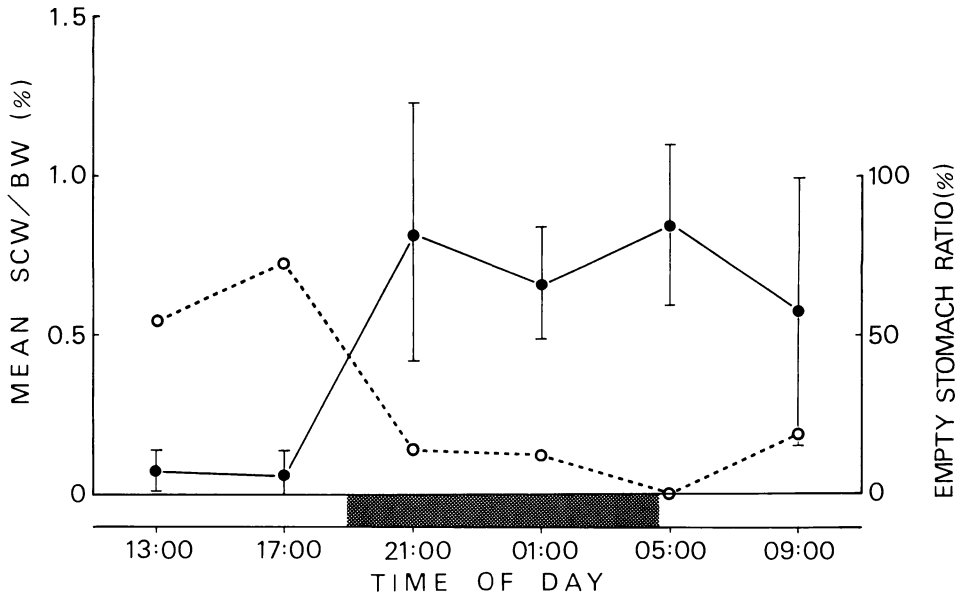

Fig. 2. Diel changes in mean ratio of stomach content weight to body weight (mean SCW/BW) and in empty stomach ratio of *Hypodytes rubripinnis* in Aburatsubo Bay. Solid line indicates the mean SCW/BW (with 95% confidence intervals) and broken line shows the empty stomach ratio. Shadowed area represents the nighttime.

SCW/BW value of less than 2%. The highest value of SCW/BW was 6.5% in a specimen of 21:00. Mean values of SCW/BW at 13:00 and 17:00 were 0.08% and 0.06% respectively, indicating very low food uptake rates. These values were much lower than those in the nighttime.

Diel changes in the empty stomach ratio were reciprocal of the mean SCW/BW. The empty stomach ratios at 13:00 and 17:00 were high, 54% and 72% respectively, while those at night were low (Fig. 2).

Dominant prey items and the diel changes in diet composition. Table 2 shows the diet composition of *H. rubripinnis*. Gammarids were the most dominant prey accounting for 65% of the total diet by number. Isopods and caprellids were next in abundance making up 17% and 9% respectively. Most of the isopods were *Dynoides dentisinus*. These three prey items constituted 91% of the total number of individuals of all prey items consumed. Furthermore, the percentage of frequency of occurrence also indicated the importance of these prey items. Gammarids occurred in 89% of all the fish examined and caprellids and isopods were next, occurring in 35% and 32% respectively. Other than these prey items, polychaetes and decapods appeared in more than

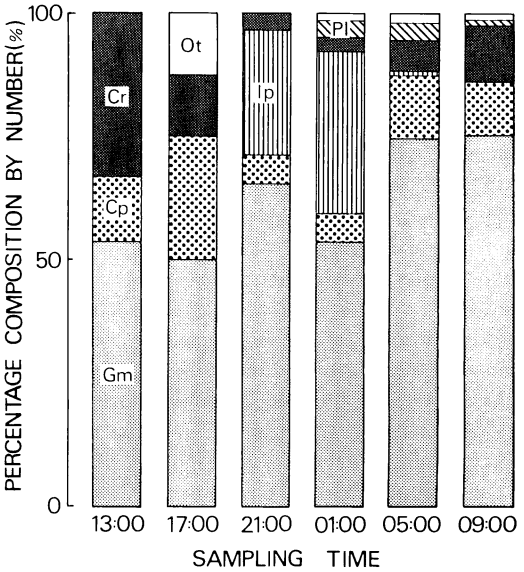

Fig. 3. Diel changes in diet composition of *Hypodytes rubripinnis* in Aburatsubo Bay expressed as percentage composition by number. Gm, Gammaridea; Cp, Caprellidea; Ip, Isopoda; Cr, Crustacea; Pl, Polychaeta; Ot, others.

10% of all the fish, indicating a significant role in the diet. Molluscs (gastropods and bi-

valves), fishes and algae also occurred in stomachs, but these prey items were relatively unimportant as indicated by both the percentage by number and frequency of occurrence.

Fig. 3 shows the diel changes in the diet composition. Prey items occurring in the stomachs were grouped into six dominant groups, gammarids, caprellids, isopods, other crustaceans, polychaetes and others, and the composition is expressed as percentage by number. Gammarids were the most dominant prey at any sampling time, always accounting for more than 50% of all the prey consumed. Caprellids were also present in stomachs at any time, but their percentage compositions were different between night and day. They made up more than 10% in the daytime, although they decreased to 6% in the nighttime. On the contrary, isopods constituted 25% and 33% in the nighttime, while they scarcely appeared in stomachs in the daytime.

Discussion

In the present study, 96% of all the specimens of *H. rubripinnis* examined were shown to fall into a length range from 30 to 50 mm SL and only a few larger specimens were collected. About 90% of the samples collected from Ago Bay, Mie Pref. in July had total lengths ranging between 40 and 60 mm (Kimura et al., 1983). Considering the difference in the measuring methods employed, i.e. the standard length in our study and the total length in Kimura et al. (1983), the results of these two studies are similar to each other. Very few large mature fish had been collected in our July study, although the spawning season of *H. rubripinnis* is from May to July (Kikuchi, 1966; Suzuki et al., 1981). Fukuda (1934–35) and Kikuchi (1966) observed that the mature large individuals were caught at depths of greater than 15 m instead of in shallow *Zostera* beds and accordingly considered that the adult and sub-adult fish migrated into the deeper zone during the spawning season and returned to the *Zostera* beds in autumn. As our sampling area was at deepest 4 m, the length frequency distribution in the present study may have reflected that of the non-spawning population of mostly 1 year old fish (Kikuchi, 1966).

Although food uptake rate and prey organisms consumed are generally considered to vary with the size of predators (Keast and Welsh, 1968; Tyler, 1972), size related changes in SCW/BW and in diet composition were not observed in the present study. This may be attributed to the narrow length range of the specimens collected (mainly 30–50 mm SL).

Diel changes in the SCW/BW ratio and the empty stomach ratio were apparent. Although the SCW/BW was very low in the afternoon (13: 00 and 17: 00), it increased drastically toward nighttime and higher values were maintained until dawn (05: 00). Subsequently, the value decreased slightly toward the morning (09: 00), but still remained high. Also, diel changes in the ratio of empty stomachs were the reciprocal of the SCW/BW; very high in the afternoon and decreasing greatly at night, becoming 0% at dawn followed by the slight increase in the morning. These observations suggest that *H. rubripinnis* feeds more intensively at night and little during daytime. Taking into account the high SCW/BW value and low empty stomach ratio at 09: 00, this species may continue feeding for a while after sunrise and cease to feed gradually toward noon or the food ingested at night may still remain in the stomachs at 09: 00.

Jenkins and Green (1977) pointed out confusing terminology used in the studies which intended to determine fish feeding periodicity. According to their definition, "periodicity", "rhythm" and "cycle" should be used only when feeding is cyclic, while it is appropriate to use "chronology" or "pattern" when it is not certain that feeding is cyclic. They also noted that the cyclic nature in feeding behavior could be determined only after long term experimental analysis, not by sampling only a few 24-hour periods. We sampled only one 24-hour period, which could not confirm cyclic feeding of *H. rubripinnis*, and hence we used the term "feeding pattern." But we feel sure that the nocturnal feeding is a commonly observed behavior of this species from the present study and our preliminary investigations.

Main food items were gammarids, isopods, caprellids, polychaetes and decapods. These prey items were common in other reports, which, however, differed in the degree of importance of each prey. For example, Kikuchi (1966) reported that decapods (shrimps) were important, and small crustaceans such as gammarids and isopods were less important in summer but that in winter the reverse was the case. Imabayashi et al. (1975)

reported that shrimps were the most important prey, followed by small crustaceans and polychaetes. These differences in the importance of each prey among localities and seasons may reflect the prey availability in each environment. Takama (1980) studied the seasonal variation of the phytal animal community in *Zostera* beds and suggested that the composition and seasonal changes of phytal animals as prey affected the feeding habits of the fishes.

The proportion of isopods in the stomachs showed the most remarkable diel change. At night these prey items occurred frequently in stomachs, while they were not found in daytime samples. Fuse (1962b) noted that the diet composition of some fishes in *Zostera* beds changed between night and day. Such dietary changes with time may be related to the diel changes in availability of prey organisms and isopods might be available to *H. rubripinnis* in the nighttime.

In *Zostera* beds several fishes such as *Hexagrammos otakii* and *Pseudoblennius cottoides* utilize the same food as *H. rubripinnis* and have the specific feeding time (Kitamori and Kobayashi, 1958). For example, *H. otakii* feeds intensively at sunset and *P. cottoides* feeds at both sunrise and sunset. Our study showed that *H. rubripinnis* fed throughout the night. These differences in feeding time of coexisting species may play an important role in reducing the competition for food and in making coexistence possible. Therefore, the further study on food habit and feeding periodicity is required to examine the interspecific competition among coexisting species in *Zostera* beds.

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三浦半島油壺湾におけるハオコゼの日周摂餌様式

馬場　治・佐野光彦

三浦半島の油壺湾において，ハオコゼを一昼夜にわたって採集し，本種の摂餌時刻と胃内容物組成の経時変化を調査した．夜間の調査個体においては，体重あたりの胃内容物重量の比率は高く，空胃率はきわめて低かった．一方，昼間には夜間とはまったく逆の傾向が認められた．このことから本種は昼間よりも夜間に活発に摂餌を行うものと考えられた．本種の餌生物としてはヨコエビ類が最も重要であり，次いで等脚類やワレカラ類が多く出現し，この 3 種類の餌生物だけで全餌生物中の 91% (個体数百分率) を占めた．胃内容物中に占める割合の昼夜変化が最も大きかった餌生物は等脚類であり，昼間にはほとんど出現しないが，夜間には全餌生物中の約 30% を占める重要な餌生物となっていた．

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