On the Diet of Yellowfin Goby (*Acanthogobius flavimanus*) of a Mud Flat Area at the Mouth of the Kutanabe-gawa Brook, Yamaguchi

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Yellowfin goby(*Acanthogobius flavimanus*) is a dominant member of the fish assemblage around a mud flat area in the vicinity of the river mouth of the Kutanabe-gawa brook, which is located at the western Inland Sea, and it shows a tangible seasonal cycle in population structure. In order to disclose the productive process of this species, we conducted an analysis of the diet material which was recognized as the stomach contents, related to the change in population structure, as size composition.

We collected 3,614 specimens in all, having a median of 73 mm within the size range of 23-233 mm in total length. The size compositions of the population and those of the stomaching individuals, both of which have notable modes around the median, were monthly differentiated. However, although the diurnal differentiation in the population was significant, that in the stomaching individuals was undistinguished. The frequency of occurrence method revealed that the mode of the stomaching rate was developed in the larger size group.

The goby stomached polychaetes intensively, which was distincive in daytime. We showed, however, that this oligophagy may depend not upon the preference but upon the diet menu of the circumstances. Meanwhile in nighttime they diversified their diet materials such as fish, macrurans, copepods and polychaetes.

1 Introduction

Yellowfin goby (*Acanthogobius flavimanus*) is common among the species that dwell in the mud flat area of Japanese Archipelago.[1-3] This goby is a dominant member of the fish assemblage around a mud flat area in the vicinity of the river mouth of the Kutanabe-gawa brook, which is located at the western Inland Sea, and there shows a tangible seasonal cycle in population structure.[4] Thus, this area sustains the yellowfin goby of almost all the life history; therefore, it is interesting to demonstrate how this sedentary species is circumscribed by its ambience. To this end we conducted to analyze the diet material which was recognized as stomach contents, related to the seasonal change in population structure. It would be a help for comprehending the fish community of this

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mud flat area.

2 Materials and Methods

The specimens were collected in spring tide periods from September 1988 to December 1990. In each period we practiced two kinds of hauls; the daytime haul collected in flood tide of daytime, and the nighttime haul collected largely in flood tide of nighttime. The sampling gear we employed was a cod hoop net *fukuro-machi-ami*. Information as to gear design and its treatment is detailed in Takizawa (1994).[4] All the specimens were fixed in 10% formaline immediately after the landing operation.

The fish were measured to the nearest mm (total length: TL), and then the stomach was removed and the contents were taxonomically grouped depending upon Takizawa *et al.* (1990).[5] The importance of the different prey types in the diet was calculated using the prey frequency of occurrence with respect to the number of stomachs containing the prey.[6]

During the research period mentioned above the fish samples were obtained through 47 daytime hauls and 45 nighttime hauls. The time series of the fish number in each haul both of daytime and nighttime didn't show any long term tendency (t-test, $p > 0.05$) ; therefore, all the data were allocated monthly. Consequently, the main temporal change was hereafter analyzed based on the monthly CPUE (N/haul) value. Moreover, in order to ensure our inspection we introduced the experimental design methods,[7] and adopted the significance level of 5% at most in each case. The class interval of 50 mm TL was adopted to assess the population structure and the feeding traits.

3 Results and Discussion

Population Structure

We collected 2,227 yellowfin goby in the daytime hauls and 1,387 in the nighttime hauls. The median in TL for daytime was 73 mm and that for nighttime was 71 mm, respectively. The minima for daytime and nighttime haul were 23 mm and 26mm, and the maxima were 233 mm and 222 mm, respectively. The size compositions in each time phase were displayed monthly in Fig. 1, and Table 1 illustrated the results of the three-way layout method applied to these size compositions. They demonstrate:

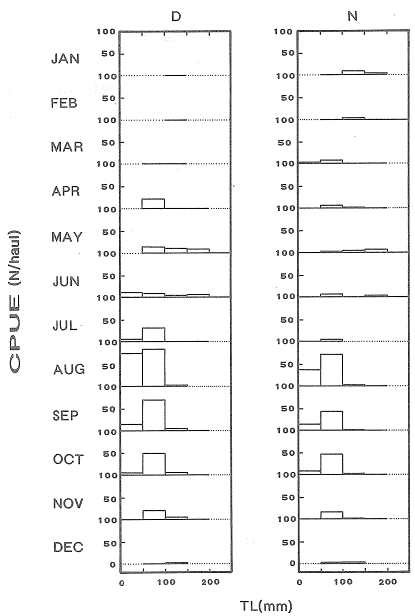

Fig. 1. Monthly change in the size composition of the yellowfin goby (*Acanthogobius flavimanus*) of the mud flat at the mouth of the Kutanabe-gawa Brook, Yamaguchi. D: daytime haul; N: nighttime haul.

Table 1. Results of analysis of variance for the size composition of yellowfin goby (*Acanthogobius flavimanus*).

Factors and interactions					
T+	M	L	T×M	T×L	M×L
**++	**	**		*	**

+T: time phase; M: month; L: length group; T×M, T×L, M×L: interactions among three main factors.
++*: $0.05>p>0.01$; **: $0.01>p$.

(1) the goby appeared more in daytime than in nighttime; (2) it appeard more during the late summer and/or early autumn (high water temperature period) than during the winter season (low water temperature period);[4,5] (3) individuals in 50-100 mm TL were overwhelming in number; (4) diurnal contrast in monthly fluctuation of occurrence was indistinctive; (5) the smaller individuals (than the median sized individual) appeared less in nighttime than in daytime and the larger appeared irrespective of time phase; (6) the dominant from winter to early spring consists of the larger individuals and that in late summer and/or early autumn, of the smaller, respectively.[7]

According to these results, the seasonal change of the yellowfin goby population is briefly construed as follows. The recruitment with the individuals of less than 50 mm TL began in early spring. This initial recruitment was in a small amount and was restricted in nighttime. The recruitment in daytime became perceptible in early summer and was enhanced and surpassed that in nighttime in late summer and/or early autumn. Then the recruitment seemed to almost finish by the time this mud flat area recorded the minimal water temperature.[4] Although the number of individual was reduced during the winter season, the goby represented to be more active in nighttime than in daytime, occupied mainly with the middle sized individuals of 100-150 mm TL, and having the occasional appearance of the largest. With the elevation of the ambient water temperature,[4] it increased in number and varied the size compositions. The largest group was recorded in early summer but disappeared immediately after that, both in daytime and in nighttime. Simultaneously, the second largest group also reduced in number or disappeared, and reappeard from late summer and/or early autumn to the winter season with reduction in number. One possible explanation for this discontinuity is the typical drop in the salinity of the ambient water which is brought about by freshet in the Japanese monsoon season. Thus, yellowfin goby appeared around this mud flat area, from autumn to winter, with the two different age groups at least, which has the accordance with the other observation.[1]

Feeding Habit and Diet Components

The number of the individuals whose stomach were vacant exceeded that of the individuals with any diet materials in daytime (59.0% to 41.0%), which became larger in nighttime (66.0% to 34.0%) (Table 2). Table 2 also indicates that the occupancy rates of the stomaching individual tends to have modes around the larger size group.

Main diet materials we recognized were tabulated in Table 3. The size compositions of the goby that fed on them in each time phase were displayed monthly in Figs. 2a-h. Other than these preys such as stomatopod larvae, chaetognnaths, Cumacea and bivalve larvae

Table. 2. The occupancy rates (%) of the individuals with any diet components on the division of TL size group.

Time phase	Size range (mm)					
	Total	-50	50-100	100-150	150-200	200-250
Daytime	41.0	29.3	41.9	65.4	46.9	12.5
Night time	34.0	13.6	36.5	50.4	55.7	0.0

Table 3. The frequency of occurrence of the stomach contents.

Diet items	CPUE
Fish	46.2
Brachyurans	16.2
Macrurans	46.3
Amphipods	49.0
Isopods	7.9
Copepods	38.2
Ostracods	3.0
Polychaetes	143.3

were found singly or so, but these singular componets were left out of account. In this context the maximum frequency was recorded in polychaetes and the minimum, in ostracods, respectively (Table 3). Among them, three taxa such as brachyurans, macrurans and polychaetes were mostly comprised of the individuals of their planktonic stages. We recorded the individuals which concurrently stomached more than two kinds of items and named them multi-feeder hereafter. They accounted for about one-tenth of all the goby in each time phase.

As mentioned above, the month-length interaction (denoted M × L in Table 1) in the population analysis detected the monthly alternation in size composition. This may bring about a significant influence on the diet analysis considering the size compositon, because a zero value of the frequency can be equivocally characterized, either no existence or no feeding (Figs. 1, 2a-h). Another point to ponder is the multi-feeders. Evidently the summation of the predator of each diet component, shown in Figs. 2a-h, exceeded the whole number of the individuals with any components. In order to examine the predation relatively to the population structure, the multi-feeder was scored with the reciprocal of the item number and was integrated into the concerned frequencies, otherwise the single-feeder was scored and integrated normally. This modification enabled us to evaluate the predator number coherently to the summation of the whole feeders; however it should be required to test whether or not it can operate reasonably. To this end we introduced chi-square tests to investigate how the modified histograms resembled to the original ones shown in Figs. 2a-h. In one case out of 84 which figures the total number of rectangles in Fig. 1, we detected the significant irregularity consequently, and we recognized the adequacy of the modification. Thus, we introduced two other three-way layout methods. One equips the factors of time phase, length and diet component and the other, of time phase, month and diet component (Tables 4, 5), respectively. Then we adumbrated the feeding trait of yellowfin goby, although three analyses deployed different factors each other and, to be exact, the results cannot be directly comparable.

Table 4 and Figs. 2a-h show that the median sized group fed most. Considering the feature on the population structure and the stomaching-vacant ratio analysis (Fig. 1 and Tables 1, 2), this suggests that there appeared numerously smaller individuals without any

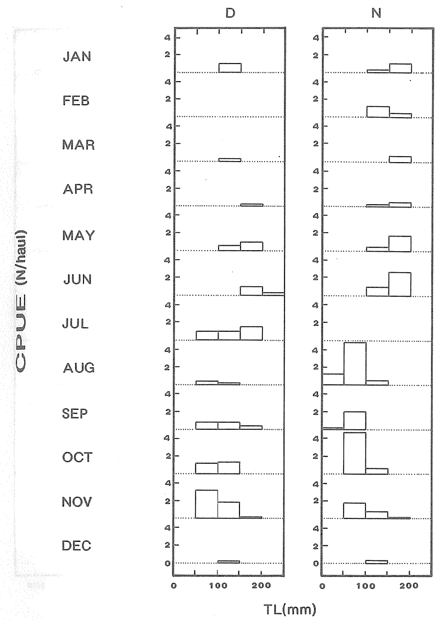

Fig. 2a. Monthly change in the size composition of the yellowfin goby who fed on fish. Refer to Fig. 1 on symbols.

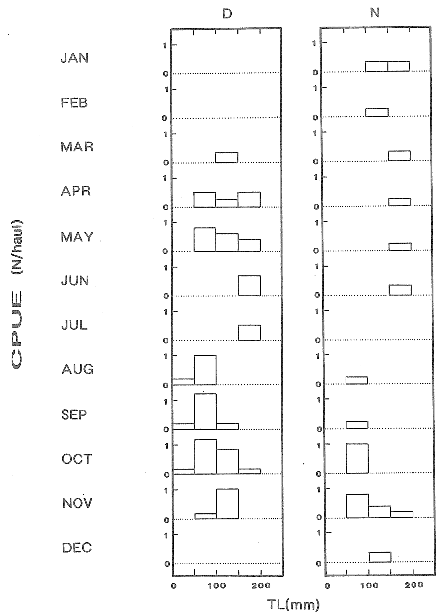

Fig. 2b. Monthly change in the size composition of the yellowfin goby who fed on brachyurans. Refer to Fig. 1 on symbols.

food. Within the stomaching individuals, there was no difference in number between daytime and nighttime, but the diet items were different between the time phases. Similar inconsisitency can be detected in the comparison of the TL distributions between the time phases (T×L interactions): The TL distributions of the stomaching individuals did not differ, but those of appearred did differ. This may indicate that there exists a characteristic nutritional relation such that this mut flat area provides a certain amount but different kind of prey between daytime and nighttime to a certain number of yellowfin goby. Thereby, the larger individuals may operate to collect prey items tactfully, and the smaller may remain in defect of them (Table 2).

They exclusively concentrated on polychaetes as mentioned, which was distinctive in daytime. Meanwhile in nighttime they diversified their diet materials such as fish, macrurans, copepods and polychaetes (Table 3 and Figs. 2a, c, f, h). Here the result that there were relatively large number of the polychaete feeders in autumn season is present, although it is not regarded as significant (Table 5). In this regard, the other studies revealed so far that in the surface layer of the offshore of this area in

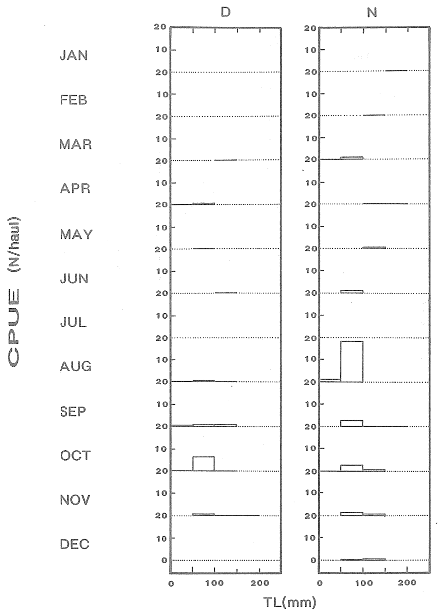

Fig. 2c. Monthly change in the size composition of the yellowfin goby who fed on macrurans. Refer to Fig. 1 on symbols.

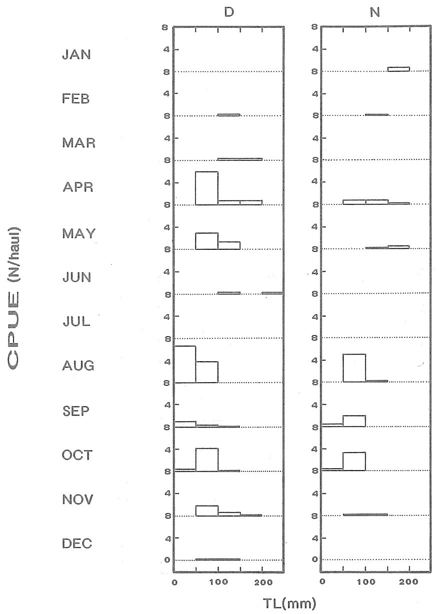

Fig. 2d. Monthly change in the size composition of the yellowfin goby who fed on amphipods. Refer to Fig. 1 on symbols.

autumn season polychaete larva occurred in not a small number,[5] and that on diurnal bases it phased in rather abundantly in the afternoon than in the morning (own observation). Thus, the polychaete larvae possibly bred in and migrated or was conveyed, by ebb tides, from this mud flat area. This implies that polychaete larva may be abundant there in daytimee during this season. If this is the case, then a substantial number of yellowfin goby depends upon the ubiquitous prey items indiscriminately.[1] As regards this, Zander (1982) revealed in another gobiid fish that the ingested food of *Gobius auratus* mainly reflects the composition of the benthos.[8] Additionally, the monthly imbalance of the stomaching yellowfin goby was significant; however, it proposed that the fluctuation in population more or less regulated it; morever, the goby did not show the alteration in diet components in consequence of the physical development or the monthly population structure as mentioned (Tables 4, 5). These may also confirm the opportunistic forage strategy of the yellowfin goby and its affinites. It will be ensured by some precise researches for the seasonal dynamics in zooplankton, the early life history of the invertebrates which produce the offspring of meroplankton type and the etholo-

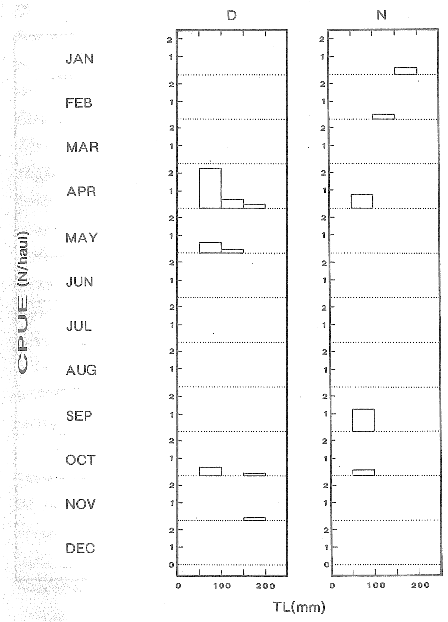

Fig. 2e. Monthly change in the size composition of the yellowfin goby who fed on isopods. Refer to Fig. 1 on symbols.

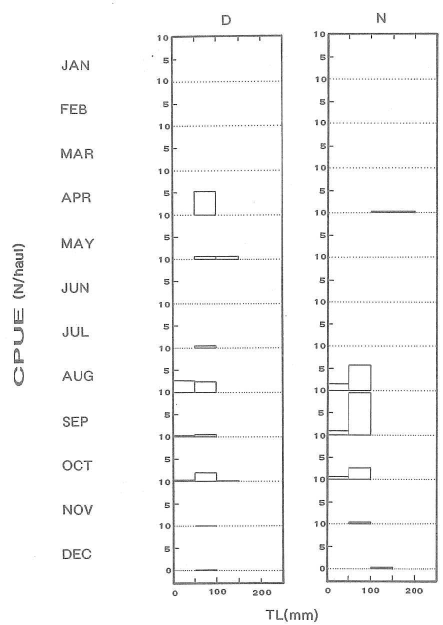

Fig. 2f. Monthly change in the size composition of the yellowfin goby who fed on copepods. Refer to Fig. 1 on symbols.

Table 4. Results of analysis of variance for the diet composition featuring its variety among TL size ranges.

Factors and interactions					
T+	L	D	T×L	T×D	L×D
	**++	*		*	

+T: time phase; L: length group; D: diet item; T×L, T×D, L×D: interactions among three main factors.
++*: $0.05>p>0.01$; **: $0.01>p$.

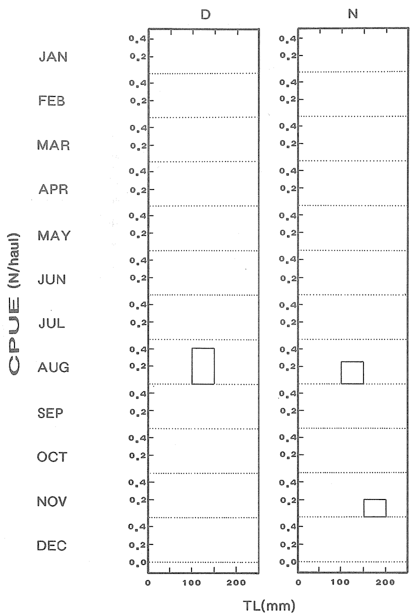

Fig. 2g. Monthly change in the size composition of the yellowfin goby who fed on ostracods. Refer to Fig. 1 on symbols.

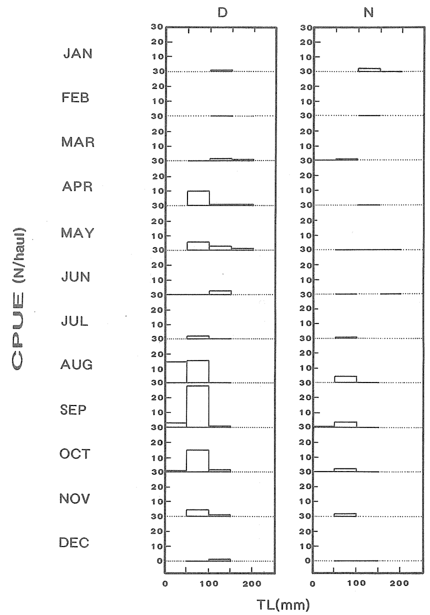

Fig. 2h. Monthly change in the size composition of the yellowfin goby who fed on polychaetes. Refer to Fig. 1 on symbols.

Table 5. Results of analysis of variance for the diet composition featuring its monthly change.

Factors and interactions					
T⁺	M	D	T×M	T×D	M×D
	**⁺⁺	**		**	

⁺T: time phase; M: month; D: diet item; T×M, T×D, M×D: interactions among three main factors.
⁺⁺**: $0.01 > p$.

gical patterns on the foraging on them. Another view point to discren the nourishment of the goby is how to evaluate the abundant occurrence of the recruitment or the smaller individuals, most of whose stomach were vacant. They might remain phytoplankton or some organic suspended matter, which we did not prepare to trace here, as unidentified miscellaneous medium staff. Pursuing this subject will, therefore, reval more ditailed features on the predation of the smaller individuals, which will enforce to disclose the productive process of the goby in the mud flat area. Admittedly, though, a better knowledge of these results will require a detailed analysis of the predation of the coexisting fishes there.

In order to formulate the nutrition dynamics under the influence of the seasonal change of population structure, here we employed the frequency of occurrence, because they are similarly concerned with the number of individual. So far there have been offered several methods to analyze the diet composition of fish, and they handle the number of individual, the weight of prey, or the number of predator.[6,8-10] Each device inherits advantage and inability for the analysis; therefore, the usage of them have been diversified. Moreover, some studies referred to them simultaneously and relatively.[6,8-10] These indicate the difficulty in demonstrating the virtual aspects of fish predation. Another nuisance is the multi-feeder. In order to investigate the selection or preference for several food items comparatively, we managed to modify "the frequency of occurrence" method as above mentioned. We do not conclude our procedure can satisfactorily function at any case; otherwise, we are sure it has enough room to be improved. We speculate that resolving such a complicated phenomenon can be achieved through how correctly we apprreciate the encounter of yellowfin goby with prey.

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百済部川河口域に棲息するマハゼ(*Acanthogobius flavimanus*)の食性について

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百済部川河口周辺域に周年出現するマハゼ(*Acanthogobius flavimanus*)個体群の食性変化を調べた。夜間に出現した小型個体の尾数は昼間よりも少なかったが，摂餌個体の昼夜比較では体長組成に変化は見られなかった。大型個体では，摂餌個体が出現個体群中に占める比率は高かった。胃内容物を調べたところ，多毛類を摂餌する個体が卓越し，この傾向は昼間採集群で著しかった。一方，夜間採集群のおもな胃内容物は魚類・長尾類・橈脚類・多毛類などに分散していた。また，胃内容物組成の成長にともなう変化や季節的変化は認められなかった。

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Edmund Talbotの3つの局面における精神的成長

——William Goldingの海洋小説3部作の一分析——

高　本　孝　子

Three Aspects of Edmund Talbot's Moral Growth
—An Analysis of William Golding's Sea Trilogy—

Takako Takamoto*

William Golding's sea trilogy, *Rites of Passage*, *Close Quarters* and *Fire Down Below*, is a typical buildungsroman in that it is focused on Edmund Talbot's mental growth, three aspects of which can be traced. First, Talbot becomes aware of the richness of his native language. Second, he realizes he possesses more romantic passion and idealism, particularly in terms of democracy, than he thought he did, and he no longer assumes common sense is the best component of one's personality. Third, he realizes that the conditions of human existence cannot be distinctly categorized into tragedies, comedies and farces; rather, these three are all entwined together.

Moreover, by presenting contrary views and values, Golding has also achieved the utmost of verisimilitude.

はじめに

William Goldingの*Rites of Passage*, *Close Quarters*, *Fire Down Below*のいわゆる海洋小説3部作は，主人公Edmund Talbotの精神的成長を中心として展開しているという点で，教養小説の一種だと言うことができる。オーストラリアへ行く船に乗り込んだ貴族階級の子弟トールボットは，初めは，階級制度やそれによって生じる差別・不正に対して何の疑問も持たず，特権階級にいる自分をひけらかす尊大で世間知らずの若者であったが，船の中でさまざまな経験をするうちに，人間として成長してゆく。その成長の過程は3つの局面において跡づけることができる。第1は，言葉に対する認識を深めたこと，第2には自己認識を深めたこと，第3には人間存在そのものに対する認識を深めたことである。本稿では，これら3つの局面に見られるトールボットの精神的な成長を検討することによって，海洋小説3部作におけるゴールディングの創作意図を考えてみたい。

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