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DIET OF JUVENILE *SILLAGO SIHAMA* (FORSKÅL) FROM INSHORE WATERS NEAR HSINCHU, TAIWAN

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ABSTRACT

Sin-Che Lee (1976). *Diet of juvenile sandborers* Sillago sihama *(Forskål) from inshore waters near Hsinchu, Taiwan.* Bull. Inst. Zool., Academia Sinica, **15**(2): 31-37 The juvenile sandborer feeds mainly on smaller benthos such as polychaetes, copepods, juvenile shrimps, juvenile crabs, amphipods, juvenile lamellibranchs and post larvae of its own species. Copepods were eaten intensively at the size of 30-40 mm, being gradually replaced by other food items as the fish grows. Some juveniles of other fishes in the same ecosystem consume food items similar to those for juvenile sandborer. The means of adaptation to avoid possible interspecific competition are discussed. The ecological role of the juvenile sandborer in the inshore ecosystem may be regarded as an intermediate predator in a food web connecting microbenthos or meiobethos with larger predatory fishes.

Five species of sandborers, *Sillago sihama* (Forskål), *S. maculatus* Quoy & Gaimard, *S. japonica* Temminck & Schlegel, *S. pavisquamis* Gill and *S. argentifaciata* Martin & Montalban, occur around Taiwan (Chen, 1967[1]; Shaw, 1976[2]). They are similar in external appearance but may be recognized by counting fin rays and vertebrae. *S. sihama* is a bottom-living fish in coastal waters on sand or muddy sand, and sometimes penetrates a certain distance into estuaries. This species is characterized by having 22-23 second dorsal rays, 21-22 anal rays, 32-34 (33) vertebrae and cycloid scales on cheek and interorbital. *S. sihama is* by far the commonest sandborer on the western coast-line of the Island. Fish of marketable size are usually caught either by hand-line or beam-trawl at some depth in the sea, and the examples obtained from the intertidal zone are almost all juveniles of less than one year old. Mature sandborers have never been found in the inshore area studied, and therefore, it may be presumed, like other species, to employ inshore waters as its nursery ground.

There are no earlier studies on the diet of Taiwan sandborers, and the present report may be regarded as a first attempt to elucidate predator-prey relationships between fishes and other organisms within a sandy inshore ecosystem.

MATERIALS AND METHODS

196 juvenile fish of 20.5-78 mm standard length, in 5 samples, were collected from tide pools of inshore sands near Hsinchu during the period from February to September 1975. Fish remaining in pool at low tide were anaesthesized by rotene when water level was at about 30 cm in depth. Specimens were preserved in 70% alcohol immediately after their capture. Guts (including stomach and intestine) were dissected

and examined under a microscope. The quantity of each food item was recorded by "the points method" (Hynes, 1950[3]), 20 points were given when the stomach was full, and 10 points for a full intestine. All the points gained from each food item were summed and then expressed as percentage of total points of the food of all the fish examined. Gut contents were dried in oven for 24 hours at 90°C and then weighed after cooling for about 12 hours in a desiccator.

HABITAT

The site chosen for this study is located at a beach beside the Nanliao Bathing Resort adjacent to the outlet of Touchen River, about 4 km to the north-west of Hsinchu city. Tide level is subject to fluctuations of about 2 m. The substrate exposed at low tide is mainly sandy, but sometimes covered by a thin layer of mud in lower parts of the pool, with hardly any vegetation except for sparse filamentous algae.

The benthic fauna frequently found included burrowing polychaetes, lamellibranchs, gastropods (mostly *Drupa*, Cerithids, *Mitrella bella*), crabs (*Matuta lunaris*, *Mictyris longicarps*), shrimps (mostly *Penaeus japonicus*), diogenid hermit-crabs, amphipods and others. The fish fauna consisted of *Albula vulpes*, *Pisoodonophis cancrivorous*, *Paraplagusia bilineata*, *Fugu niphobles*, *Platycephalus indicus*, *Liza carinata*, *L. parva*, *Sphyraena obtusa*, *Sillago pavisquamis*, *Gerres filamentous*, *Sparus latus*, *Lutjanus fulviflamma*, *Terapon jarbua*, *Leiognathus brevirostris*, *Callionymus richardsoni* and *Glossogobius giuris brunneus*. Several species of larger size become major catches of the stick-net fishery operated by local fishermen about 600 m farther off.

RESULTS

1. General composition of diet:

All the 196 sandborers examined had food in their guts. The food items are listed in detail as percentages of total points in Table 1. No sexual differences was observed in the diet of the sandborers so that the data for both sexes has been combined. The overall food composition is also expressed in food spectra (Fig. 1). Crustaceans formed by far the most important food. Among crustaceans, juvenile shrimps were most abundant and, with only a few exception, were all identified as the mysis stage of *Penaeus japonicus*, which occurred abundantly along the shore in this area. Copepods included pelagic calanoids and benthic harpacticoids, but were small in bulk despite their frequent occurrence in the guts (with an exception of February sample). Crabs found were small juvenile *Portunus* or megalopods of other species. Gammarid amphipods were found in a small proportion. Creeping diogenid anomurans, ostracods, cumaceans, isopods, caprellids, mysids, decapod zoea larvae, euphasia *Calytopsis* larvae and cirripedia larvae were eaten only occasional-

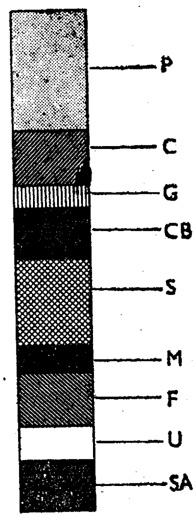


Fig. 1. Foop spectrum (% total points) of *S. sihama* based on combined data of different months.
P, Polychaetes (24.22%); G, Copepods (11.12%); G, Gammarid amphipods (4.56%); M, Molluscs (5.50%); CB, Crabs (9.70%); S, Shrimps (17.52%); F, Fishes (10.36%); U, Unidentified organic material (7.2%); SA, Sand (9.82%).

TABLE 1. Complete list of all food organisms found in the guts of juvenile *Sillago sihama* (% total points)

Food organisms \ Month	1975				
	Feb.	May	Jun.	Aug.	Sep.
Nematopoda	—	—	—	—	0.56
Polychaeta	—	48.31	13.45	9.29	18.94
Crustacea					
Ostracoda	—	—	0.42	0.13	0.19
Harpacticoid copepoda	0.36	11.09	2.97	0.45	2.41
Calanoid copepoda	37.46	0.59	0.53	0.64	15.23
Cirripedia cypris larva	0.36	0.05	—	—	—
Cumacea	1.08	—	—	—	—
Isopoda	—	—	1.69	—	—
Amphipoda					
Gammarid	14.34	6.52	5.08	0.64	0.74
Caprellid	—	0.09	—	—	—
Mysidacea	6.09	—	—	—	—
Euphasia: *Calyptopsis* larva	0.36	—	—	—	—
Juv. crabs including *Portunus*	—	—	20.76	—	—
Crab megalopa	4.66	12.68	3.6	0.89	6.22
Crab zoea larva	0.72	0.09	—	—	—
Juv. shrimps including mysis stage of *Penaeus japonicus*	7.89	3.83	—	55.92	9.66
Shrimp zoea larva	0.54	0.27	—	—	—
Anomura: Diogenidae	5.38	—	1.69	—	—
Decapoda indet.	—	—	0.85	—	—
Crustacean debris	—	—	1.48	—	5.66
Other arthropoda	—	—	—	—	0.56
Mollusca					
Juv. lamellibranchia	1.79	3.6	0.42	11.96	0.19
Cephalopoda mostly squids	11.83	—	—	—	—
Echinodermata: spines	—	—	—	—	0.19
Fish including juv. *S. sihama*	—	—	30.61	8.78	21.36
Algae	—	—	0.21	—	0.65
Diatoms	0.9	—	—	—	—
Eggs	—	—	0.21	—	0.09
Indet. materials	2.15	3.01	4.87	0.38	7.43
Sand	4.12	9.85	11.12	10.94	9.94
No. fish with empty guts	0	0	0	0	0
No. fish with food	30	75	37	54	54

ly. Of the polychaetes found in the guts, most were in fregments and this obviously raised a difficult problem in identification to the species level. Larval fishes, including postlarvae of sandborers, were eaten in relatively large quantity during June and September. Of molluscs, small juvenile clams occurred in nearly every month, but were unimportant in bulk; young squids were found on merely one occasion. Algae and diatoms were presumbly eaten by accident in association with some other food organisms. Sand was ingested in substantial amounts with benthic invertebrates particularily the infauna. Unidentified organic material shown in the above figure indicates digestion remains of food organisms.

2. Variation of diet with size of fish—quantitative and qualitative:

In order to demonstrate the relationship between change in diet and the growth of fish, data from 75 fish (20.5-56.5 mm in standard length) caught in May 1975 were divided into eight arbitrary length groups of 5 mm intervals. Mean dry weight of food was plotted against mean body length of the fish. The result (Fig. 2) reveals that food intake increases significantly with growth of fish.

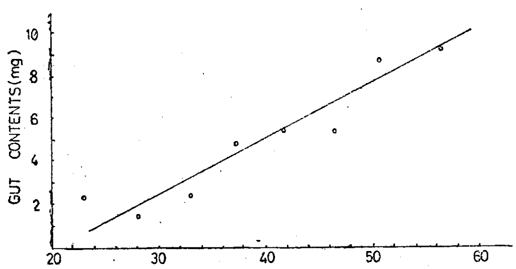


Fig. 2 Relationship between mean dry weight of food and standard length of *S. sihama* based on samples collected in May 1975 ($Y=-6.3840+0.3049X$, $r=0.9465$)

Fig. 3 shows that copepods were eaten intensively at the size of 30-40 mm but became less important with increasing fish size, while juvenile crabs, juvenile shrimps and post-larval

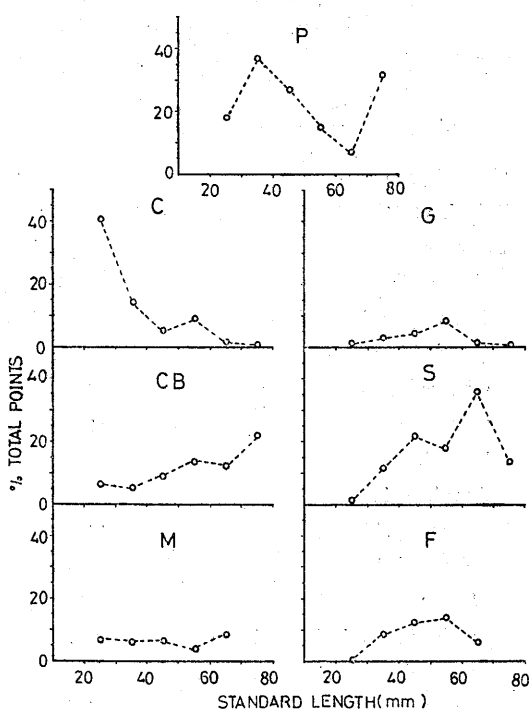


Fig. 3 Changes in the composition of food with change in standard length (% total points). P. Polychaetes; C, Copepods; CB, Crabs; S, Shrimps; G, Gammarid amphipods; M, Molluscs; F, Fishes.

fish became more important as the fish grow. Other food items such as polychaetes, molluscs and gammarid amphipods show no marked change in amount with increasing fish size.

3. Comparison of the diet of the sandborer with other species:

Among the fishes listed previously, *Liza carinata*, *Albula vulpes*, *Sparus latus*, *Callionymus richardsoni*, *Fugu niphobles* and *Terapon jarbua* were obtained in sufficient numbers to carry out diet comparison. Fig. 4 shows the food spectra of *Sillago sihama*, *Sparus latus*, *Albula vulpes* and *Callionymus richardsoni* caught in May 1975, from which some interesting differences are apparent. Polychaetes, juvenile crabs (including megalopa), copepods, gammarid amphipods, shrimps and lamellibranchs were major food items in both

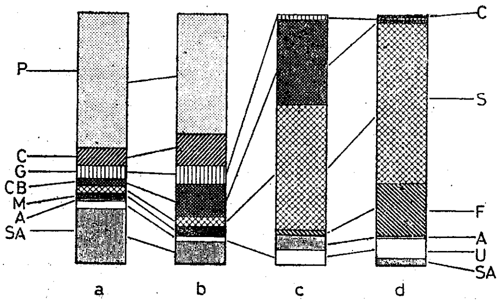
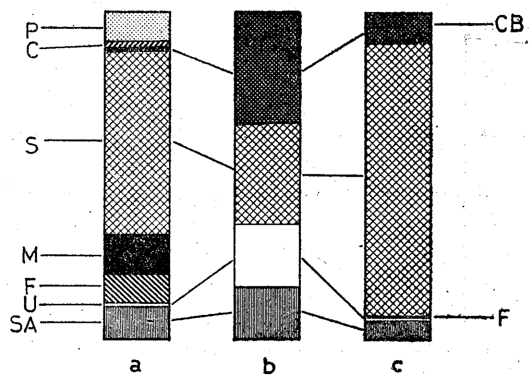


Fig. 4. Food spectra (% total points) of *C. richardsoni* (a), *S. sihama* (b), *Sp. latus* (c) and *A. vulpes* (d).
P, Polychaetes; C, Copepods; G, Gammarid amphipods; CB, Crabs; S, Shrimps; M, Molluscs; F, Fishes; A, Algae; U, Unidentified organic material; SA, Sand.



Fis. 5. Food spectra (% total points) of *S. sihama* (a), *F. niphobles* (b) and *T. jarbua* (c).
P, Polychaetes; C, Copepods; CB, Crabs; S, Shrimps; M, Molluscs; F, Fishes; U, Unidentified organic material and other recognizable food organisms; SA, Sand.

S. sihama ad *C. richardsoni*, other minor groups such as cumaceans, diatoms, ostracods, algae and cladocerans were occasionally eaten by both species. On the contrary, *Sp. latus* tended to eat larger organisms such as juvenile crabs (mainly *Matuta*) and shrimps, together with small amounts of gammarid amphipods, postlarval dragonets (*Callionymus*), diogenid hermit-crabs, stomatopods and algae. *A. vulpes* also consumed greater amounts of shrimps (mainly Segestidae) followed by postlarval sandborers, with minor food items being gammarid amphipods, crabs, copepods and algae. Besides this, another set of comparisons have been made for *S. sihama*, *F niphobles* and *T. jarbua* (Fig. 5) caught in August 1975. They present different feeding patterns, among which *F. niphobles* ate quite substantial amounts of crabs and shrimps of medium size as well as fragments of echinoderms (probably sand-dollars) which are included under the heading "unidentified organic material" in Fig. 5. *T. jarbua* consumed mysis and juvenile stages of shrimps (*P. japonicus*, with the maximum size of 7 mm wide and 40 mm long), followed by smaller young crabs and isopods. *S. sihama* on the other hand fed mainly on the mysis stage of *P. j. japonicus*, postlarvae of its own species, and some polychaetes. Finally, *Liza* carinata (not shown in the above figures) was found to eat exclusively diatoms mixed with sand or mud. Consequently, this species has significantly different feeding habits from those of *S. sihama.*

DISCUSSION

The site selected for this study is a typical inshore bay with a soft bottom where a flourishing fauna might be expected. Various food organisms for the demersal fishes may be classified as pelagic, epifaunal and infaunal according to different degree of dependance on the bottom. Thus, demersal fishes can then be classified into pelagic feeders, epifaunal feeders and infaunal feeders (Omori, 1975[4]). The diet of juvenile sandborers covered all three types stated above. In general, the food organisms found in the alimentary canals of fishes is related to fauna of its habitat. Many fishes consume similar food such as polychaetes and small crustaceans but they seem to experience no great pressure of food competition. Sandborers reach the shore in different size groups (Fig. 6) as a result of a long breeding season. Fishes of different size groups may show some degree of difference in size preference of food and could thus avoid possible food competition. *Liza carinata* is

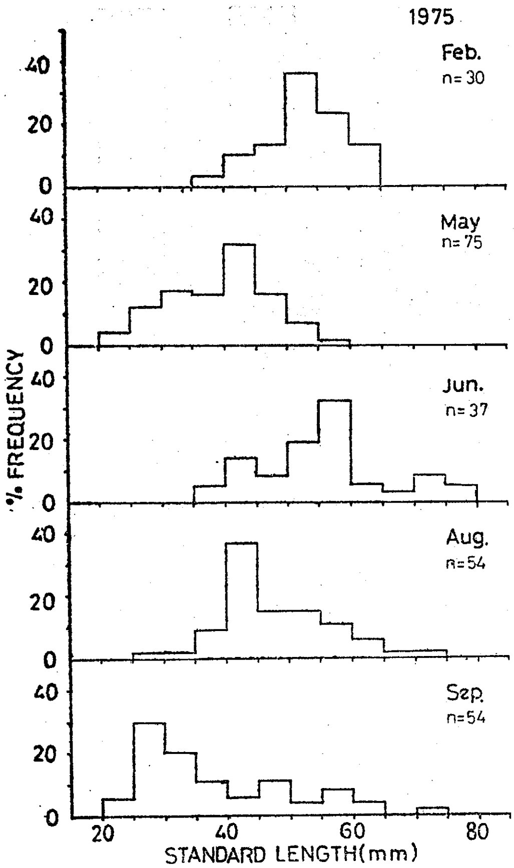


Fig. 6. Length-frequency histograms for each monthly sample of *S. sihama.*

adapted to take completely different types of food such as diatoms and other detritus and thus avoids competiting with other species.

Interspecific predation may remove some possible competitors and ease the competition pressures among the fishes of the same community. Thus, *Callionymus richardsoni* was eaten by *Sparus latus* and juvenile *Sillago sihama* by *Albula vulpes.* These juvenile fishes, including the sandborer itself, occurred in this area as primary prey for the more offshore species at higher trophic levels such as *Trichurus lepturus, Scomber spp., Decapterus maruadsi,* and *Apogon semilineatus* (Yokota, 1961[5]). The basic food of the primary prey is generally zooplankton, phytoplankton, larval decapods and polychaetes. As the sandborer grows and retreats to deeper offshore ground, its position in the food chain may change somewhat. Cannibalism has found among juvenile sandbores. Because of its long breeding season, juveniles of different broods may appear together at the same ground, and freshly hatched postlarvae will then be liable to predation by larger juveniles of the same species.

It is concluded that the ecological role of the juvenile sandborer in the inshore ecosystem is that of an intermediate predator in a food web connecting microbenthos or meiobenthos with larger predatory fishes.

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臺灣新竹沿岸沙鮻 (*Sillago sihama*) 幼魚之食物

李 信 徹

沙鮻幼魚主食小形底棲生物，如多毛類，橈脚類，蝦蟹類之幼體，端脚類，蛤類幼體，甚至同類之後期稚仔魚 (postlarvae) 亦所難免。小於 40 mm 之幼魚其餌料生物中橈脚類所佔之份量頗大，然於魚類生長過程中逐漸爲他種較大形之餌料生物所取代。在同一生態系中尚有他種魚類之幼魚出現，然彼此間尚能發揮特殊之適應力以避免種間過度之競食現象。在生態地位上，沙鮻之幼魚正好介於微細底生物 (microbenthos) 或小形底生物 (meiobenthos) 與大形魚食性魚類之間。