水産動物に対する釣り餌の摂餌誘引活性

誌名	水産増殖 = The aquiculture
ISSN	03714217
著者	原田, 勝彦 宮崎, 泰幸 佐藤, 浩司
巻/号	45巻3号
掲載ページ	p. 351-356
発行年月	1997年9月

(水産増殖 45巻3号 351−356
SUISANZOSHOKU (1997-H9))

Attractiveness of Fishing Baits for Aquatic Animals*

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Abstract

The effectiveness of a variety of fishing baits to attract aquatic animals was statistically estimated adopting the attraction indices *a* and *gr* as a preliminary approach to search for possible new attractants for fish feeds. The abalone *Haliotis discus*, the oriental weatherfish *Misgurnus anguillicaudatus* and the yellowtail *Seriola quinqueradiata* were used in the experiments. Water soluble extracts from twelve species of baits distributed over a variety of phyla were examined. Attractivity for abalone was stronger in extracts of limpet > Japanese pilchard > sea cucumber > others. For oriental weatherfish, the order of preference was earth worm > Japanese pilchard > barnacle followed by the others whereas yellowtail preferred Japanese pilchard > silkworm pupa > limpet > others. The efficiency of the extracts of these baits was clearly concentration-dependent. The effective baits common to the three test animals were Japanese pilchard, whiskered velvet shrimp, and sea cockroach although their attractivity varied to some extent depending on the test animals.

A variety of organisms-with both aquatic and terrestrial origin-has been widely used as bait to commercial and leisure fishermen worldwide since ancient times.[1,2] Baits used nowaday are the results of a long time selection.

The function of fishing baits depends on their feeding attractants and/or stimulants. In the last decades, studies on the attractants and/or stimulants for fishes and shellfishes[3,4] have advanced remarkably.

Among crustaceans which are the class of animals most widely used as bait, a diversified species of shrimps are used regardless of the target species in both commercial and leisure fishing. In contrast, sea cockroach is used specially for a few limited species only by leisure fishermen in some area.[5,6] Even within the same taxonomic group, preference diversifies tremendously among target species as well as between commercial and leisure fishing.[5,6] Therefore a detail comparison of the attractivity of known baits may prpvide us a clue in searching for new or novel feeding attractants other than amino acids and nucleic acid related compounds. In fact, the terrestrial origined stevioside[7] and β-elemene[8] have been verified as new attractant to abalone *Haliotis discus*, oriental weatherfish *Misgurnus anguillicaudatus* and *yellowtail Seriola quinqueradiata*. Here we chose 12 species of

Received : January 22, 1997
Key words: attractivity, bait, behavior, aquatic animal
* Studies on the Feeding Attractants for Fishes and Shellfishes-XXXII.

organisms with both aquatic and terrestrial origin including rarely used species to search for new attractants.[5,6] As a result, sea cockroach was found to be one of the best new feeding attractants by using attraction indexes, either *a* or *gr*, through the 4-canal experiments.

Materials and Methods

Test animals

Young black abalone (1.5 cm in average shell length at the initial of experiment) were afforded by the Yamaguchi Prefecture Gaikai Fisheries Experimental Station. Fifty were used in each test. Adult oriental weatherfishes (8.2 cm in average body length) were supplied by a private aquaculture farm in Shiga Prefecture and 60 were used in each test. Juvenile yellowtail (4.9 cm in average fork length) were offered by an aquaculture farm of Senzaki Cooperative in Yamaguchi Prefecture. Fifty were accommodated in a single test tank. During the experimental period, 30 individuals were successively removed as they grew too big for tank test. Maintenance of test animals and the procedures of the experiments were the same as described in the previous papers.[9-11]

Table 1. List of baits tested

Bait materials*1	Tissues used	Main target fishes*1
(Oligochaete)		
Earth worm-"Futsuumimizu"-*Pheretima communissima**2	Whole body	Crucian carp-"Funa"-*Carassius auratus*, Common carp-"Koi"-*Cyprinus carpio*, Japanese eel-"Unagi"-*Anguilla japonica*
(Gastropod)		
Limpet-"Bekkohgasagai"-*Cellana grata**3	Muscle	Red sea bream-"Madai"-*Pagrus major*
(Cephalopod)		
Squid-"Surumeika"-*Todarodes pacificus**2	Muscle	Red sea bream-"Madai"-*Pagrus major*, Amberjack-"Hiramasa"-*Seriola aureovittata*, Yellowtail-"Buri"-*Seriola quinqueradiata*
(Crustacean)		
Barnacle-"Kamenote"-*Mitella mitella**3	Muscle	Rock bream-"Ishidai"-*Oplegnathus fasciatus*, Rock porgy-"Ishigakidai"*Oplegnathus punctatus*
Sea cockroach-"Funamushi"-*Ligia (Megaliga)exotica**3	Whole body	Black porgy-"Kurodai"-*Acanthopagrus schlegeli*, Japanese parrotfish-"Budai"-*Calotomus japonicus*, Japanese sea perch-"Suzuki"-*Lateolabrax japonicus*
Whiskered velvet shrimp-"Akaebi"-*Metapenaeopsis barbata**2	Muscle	Red sea bream-"Madai"-*Pagrus major*, Japanese sea perch-"Suzuki"-*Lateolabrax japonicus*, Japanese stingfish-"Mebaru"-*Sebastes inermis*
Mask crab-"Heikegani"-*Dorippe japonica**3	Whole body	Black porgy-"Kurodai"-*Acanthopagrus schlegeli*, Rock bream-"Ishidai"-*Oplegnathus fasciatus*, Marbled rockfish-"Kasago"-*Sebasticus marmoratus*
(Holothurian)		
Sea cucumber-"Manamako"-*Stichopus japonicus**3	Muscle	Red sea bream-"Madai"-*Pagrus major*
(Teleost)		
Japanese pilchard-"Maiwashi"-*Sardinops melanosticta**2	Muscle	Tunas-"Maguro"-*Thunus* spp., Skipjack-"Katsuo"-*Euthynnus pelamis*, Common Japanese mackerel-"Masaba"-*Scomber japonicus*
Japanese river goby-"Mahaze"-*Acanthogobius flavimanus**3	Muscle	Japanese sea perch-"Suzuki"-*Lateolabrax japonicus*, Japanese flounder-"Hirame"-*Paralichthys olivaceus*
(Insect)		
Silkworm pupa-"Kaikosanagi"-*Bombyx mori**2	Whole body	Black porgy-"Kurodai"-*Acanthopagrus schlegeli*, Common carp-"Koi"-*Cyprinus carpio*
(Phaeophycean)		
Brown alga-"Habanori"-*Endarachne binghamiae**3	Thallus	Japanese parrotfish-"Budai"-*Calotomus japonicus*, Rudder fish-"Isuzumi"-*Kyphosus lembus*

*1 Common name-"Japanese name"-Scientific name; *2 Popular bait; *3 Special bait.

Test samples

The twelve species of bait materials[5,6] with their tissues used and their main target species are listed in Table 1. The tissue used , *i. e.*, muscle or whole body, of each bait material was thoroughly chopped into small pieces and homogenized with a homogenizer in an equivolume of deionized water. Trichloroacetic acid (20%) was also added to a concentration of 5%. After being incubated at room temperature for over 30 min, the homogenate was centrifuged for 15 min at 8,000× *g* below 5℃. The pH of supernatant was adjusted to 6.5 by adding diluted sodium hydroxide or hydrochloric acid solution. This extract was stored at -40℃ before use. The 10, 2, or 1-fold diluted solution was used for the test of concentration dependency.

Estimation of attractivity by attraction index

Attraction index, either the A.I.*a* for both abalone and oriental weatherfish or the A.I.*gr* for yellowtail, was estimated by the methods described in previous papers.[9-11] Briefly the estimation of A.I.*a* was based on applying the remained time-course obtained from a behavioral experiment to a logistic curve $y=g/\{1+\exp[-r(x-a)]\}$, while A.I.*gr* on either the entered or left one. Practical phenomenal meanings of A.I.*a* and A.I.*gr* are the average remained time (min) and the numbers of locomotive fish at the coefficient *a*, respectively. Out of the 12 test baits, three were chosen arbitrarily as a group for evaluating A.I.*a* or A.I.*gr*, and then set in the compartment arbitrarily selected three channels out of the total four in the test tank (a dummy was set into the rest channel as control). Three pieces of crumpled gauze (a sheet of 25×25 cm) each absorbed with 7.5 ml of a different kind bait extract and a dummy were set into the four compartments (10×30 cm, 10×30 cm, and 20×40 cm for abalone, oriental weatherfish, and yellowtail, respectively) at the innermost end of the channels of the test tank. For estimating A.I.*a* or *gr*, the number of individuals either remained, entered or left was counted in 10 min at 1 min intervals for oriental weatherfish and yellowtail or 20 min at 2 min intervals for abalone, and their behaviour was also recorded during counting. The experiments were carried out duplicately for each group of test samples, twice a day at 10:00 a.m. and 15:00 p.m., using a method similar to the Latin-square method of allocating test samples to compartments.

Results and Discussion

The results of attraction index of eadh bait material for the three tested animals are shown in Table 2. Test samples with attraction index higher than that of the dummy (control) are regarded as being effective in attraction. The ettective baits in attraction did not induce any unusual behavior during the experiment, and the test individuals swam into and away from the test compartment as it was in the previous report.[7-11] For abalone,the following 8 bait samples showed attractive effect: Japanese pilchard, squid, whiskered velvet shrimp, Japanese river goby, sea cucumber, barnacle, sea cockroach, and limpet (order the same as that in Table 2). Among them, Japanese pilchard, sea cucumber, and limpet showed the highest A.I.*a* for each related group. For oriental weatherfish, all the bait samples except limpet showed attractive effect. Among them, Japanese pilchard, barnacle, and worm showed the highest A.I.*a*. For yellowtail, the following 6 bait samples showed attractive effect: Japanese pilchard,

Table 2. Attractivity of baits

Test No.	Baits	Attractivity* Abalone (A.I.*a*)	Oriental weatherfish (A.I.*a*)	Yellowtail (A.I.*gr*)
1	Dummy (Control)	3.4†	1.9†	154.7†
	Japanese pilchard	15.2†	3.3†	210.1†
	Squid	5.6†	2.7†	155.3†
	Whiskered velvet shrimp	11.2†	2.7†	169.8†
2	Dummy (Control)	2.5†	1.8†	111.2†
	Japanese river goby	5.5†	2.3†	79.7†
	Sea cucumber	8.6†	2.1†	73.3†
	Barnacle	6.2†	5.2†	93.2†
3	Dummy (Control)	7.1†	2.0†	61.4†
	Sea cockroach	7.6†	2.7†	67.0†
	Mask crab	6.7†	2.4†	55.9†
	Silkworm pupa	4.8†	2.8†	76.1†
4	Dummy (Control)	6.8†	2.6†	8.1†
	Limpet	9.8†	2.3†	26.4†
	Brown alga	3.1†	3.9†	8.9†
	Worm	6.0†	4.3†	9.5†

* For the attractivity see details in Materials and Methods; †$\Pr\{\chi^2>\chi^2_{0.100}\}>0.100$; †?$\Pr\{\chi^2>\chi^2_{0.100}\}<0.100$.

whiskered velvet shrimp, sea cockroach, silkworm pupa, limpet, and worm. Among them, Japanese pilchard, silkworm pupa, and limpet showed the highest A.I.*gr*. The common effective bait samples for all the three test animals were Japanese pilchard, whiskered velvet shrimp, and sea cockroach.

Furthemore, to determine the most effective bait for each test animal, the attractivities of the above three baits were compared to each other in the combination test (test No.5 for abalone, No.6 for oriental weatherfish, and No.7 for yellowtail). The results showed that limpet, worm, and Japanese pilchard were the most effective one for abalone, oriental weatherfish, and yellowtail, respectively (Table 3).

Next we examined whether the attractivity of the above three baits were concentration dependent. Samples of different concentrations were dipped on the gauze and their A.I.*a* or A.I.*gr* were evaluated. Figure 1 showed that the efficiency of the extracts of these bait was clearly concentration-dependent within the tested concentration range.

Among the 12 baits tested, we concluded that 8 of them could be regarded to be effective to abalone, 11 to oriental weatherfish, and 6 to yellowtail. It is very interesting that some organisms, which were hardly regarded as daily food of the test animals, are also included. These results suggested the presence of uncommon attractant (s) in the bait in the habitat of target animals.

A variety of human food materials has been tested for searching attractants and/or stimulants for fishes and shellfishes.[3,4] It is well-known that fish can be classified into plankton feeder, herbivorous, omnivorous, carnivorous, *etc.* The natural foods of carnivorous and omnivorous fishes are mainly the muscle of diverse fishes, crustaceans, bivalves, cephalopods, and oligochaetes. Among the above 12 baits, the following 5 were reported to be common attractants for the 3 species of test animals: silkworm pupa, worm, barnacle, whiskered velvet shrimp, and Japanese pilchard.[9-11] Silkworm pupa strongly elicited the apetite of carp *Cyprinus carpio*[12] and sea bream *Chrysophrys major*.[13]

Table 3. Comparison of attractivity of the selected baits

Test No.	Baits	Attractivity*	Test No.	Baits	Attractivity*	Test No.	Baits	Attractivity*
For abalone		(A.I.*a*)	For oriental weatherfish		(A.I.*a*)	For yellowtail		(A.I.*gr*)
5	Dummy (Control)	4.5†	6	Dummy	1.1†	7	Dummy	14.5†
	Japanese pilchard	8.8†		Japanese pilchard	3.1†		Japanese pilchard	19.4†
	Sea cucumber	8.3†		Barnacle	2.7†		Silkworm pupa	18.9†
	Limpet	11.7†		Worm	3.5†		Limpet	15.6†

*,† See footnote in Table 2.

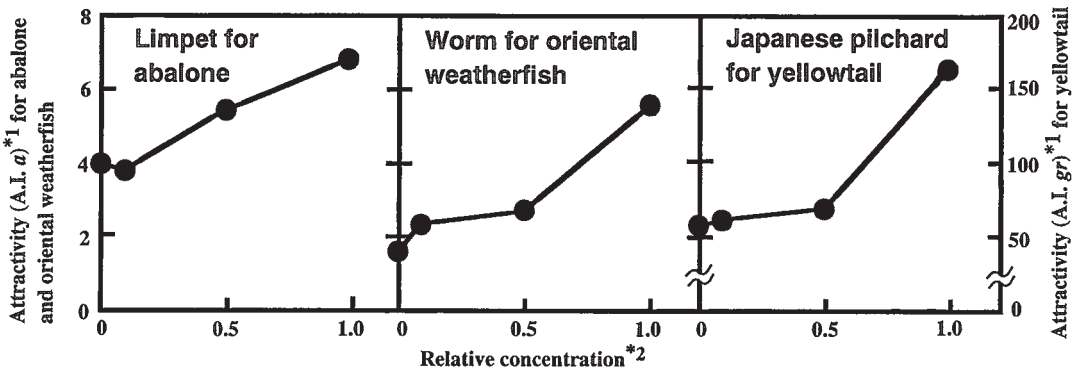

Fig. 1. Effect of concentrations on attractivity. *1 For the attractivity see details in Materials and Methods. *2 Concentration of the original extract was set at 1.0.

In those reports, it was shown that the amino acids in the pupa appeared to play an important role on it. As to carp, un-identified substances also seemed to stimulate its feeding behavior. The attractivity of worm and whiskered velvet shrimp for the oriental weatherfish, and that of barnacle, whiskered velvet shrimp, and Japanese pilchard for yellowtail was previously tested.[11,14] Our results here are consistant with the previous one.

We are the first who reports the attractive effect of sea cockroach. Sea cockroach is a kind of crustaceans dwells on the splash zone or upper part of intertidal zone. It is a common attractive bait for reef creeping shell, freshwater and pelagic fish but not commonly found in the habitat of the three test animals. As the next step, we will try to identify the effective substances to see whether it is a new attractant.

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水産動物に対する釣り餌の摂餌誘引活性

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漁業者並びに遊漁者が半経験的に用いている釣り餌素材の中から摂餌誘引活性を示す新たな物質を含む可能性を調べるため，一般的並びに特殊な釣り餌素材12種を選び，それら水抽出液に対するクロアワビ稚貝，ドジョウ成魚とブリ稚魚の索餌行動から誘引活性を調べた。クロアワビに対してはマイワシ，マナマコとベッコウガサガイが，ドジョウに対してはマイワシ，カメノテとフツウミミズが，ブリに対してはマイワシ，カイコサナギとベッコウガサガイが強い誘引活性を示した。これらの中でベッコウガサガイがクロアワビに，フツウミミズがドジョウに，マイワシがブリに対して最強の誘引活性を，さらにその活性が濃度依存性を示すことを明らかにした。また試験動物3種に対して共通の誘引性を示した餌素材はマイワシ，アカエビとフナムシであった。特にフナムシは試験動物3種のいずれの生息域にみられないことから，新たな誘引物質を含む可能性がある。