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FEEDING ATTRACTANTS FOR AQUATIC ANIMALS - VI

ATTRACTANT STRUCTURE - ACTIVITY AND APPLICATION TO FISHERY

Katsuhiko HARADA*

The feeding attractants for aquatic animals were compiled in previous reports[222)&232)]. Those studies pointed out that an attractant that is common to aquatic animals is the amino acid, with a possibility that nucleic acid related compounds might also be a candidate. Furthermore, it was also stated in these reports that, in the case of the mollusks, the gastropods, in particular, besides these attractants the glucides also play a major role. In addition to these findings, it was made apparent that the attraction activities can be increased by the effective combination of compounds, thus resulting in a synergistic effect.

In this article, which forms the conclusion of the series, the relationship of the structure of the attraction

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compounds to their activity will be outlined followed by their application to the fishery.

7. THE STRUCTURE AND THE ACTIVITY OF FEEDING ATTRACTANTS

In order to uncover the activity site of attraction compounds, the attraction activities of the derivatives, isomers or homologues of these compounds have been examined from the standpoint of behavioural science as well as that of electrophysiology. They were roughly classified into the results of either behavioural science or physiology, and then the test animals were compiled according to taxonomy. As given in Table 15, the aquatic animals examined from the standpoint of behavioural science and physiology numbered 14 species and 9 species, respectively, for a total of 22 species. A report in which the study is conducted using the methods of both behavioural science and physiology is only found in the study of attraction properties of the glycine isotopes for a species of white trout <u>Coregonus</u> <u>clupeaformis</u>[233]. On the other hand, with regard to the attractants studied, many are on the amino acid related compounds, reflecting the results of the past studies[222]&[232] and this trend is especially pronounced with the research in the field of electrophysiology. However, in the field of behavioural science, examples of research on the diversity of related compounds such as nucleic acids, fatty acids including organic acids, and glucides are found in addition to the studies of amino acids, though they are limited in number.

The first study that uncovered the relationship between the structure and the activity of the compounds that are effective as feeding attractants is found in the research that examined the effects of the homologues of amino acids and other compounds on a species of goby <u>Gobiosoma bosci</u>[32]. As a result, it was demonstrated that only amino acids having a short normal chain and 2 to 5 carbons are effective. The relationship between the structure and activity repellents, in contrast to the attractants, was demonstrated in a study conducted previous to the one just mentioned on salmonids <u>Oncorhynchus kistch</u> and <u>Oncorhynchus tshawtscha</u>[238)&239]. In other words, it was observed that the water that was used to rinse such things as a person's hands caused a repellent reaction in salmon that were in the act of ascending the river in their regular course, forcing them to stop the river ascending behaviour temporarily. As a result of chemical analysis, it was ascertained that L-Ser was the effective compound whereas D-Ser and other L-amino acids were noneffective, and it is considered to be the first report that proved the presence of the chemical specificity using optical isomers. As is apparent in Table 15, there was a historical development that took place after this in which the activities of the optical isomers of amino acids were demonstrated by studies in electrophysiology for a species of rainbow trout <u>Salmo salar</u>[173] and a species of catfish <u>Ictalurus catus</u>[174].

It is the intention of the author to explain the relationship of the structure of feeding attraction compounds to their attraction activities in detail from the standpoint of behavioural science around the findings[217] of this author. This relationship concerning amino acids was investigated for oriental weatherfish Misgurnus anguillicaudatus, yellowtail Seriola quinqueradiata and black abalone Haliotis discus. The results of the study are summarized in Table 16. There are three things to note as demonstrated in the table: both functional groups of the α-amino radical and carboxyl radical, as well as carbons having short normal chains, are responsible for the manifestation of the attraction activities with the carboxyl radical more so than the α-amino radical. The fact that both functional groups are essential is also apparent from the results of the behavioural study conducted on red sea bream Chrysophyrys major[102] as well as those of the studies in electrophysiology conducted on rainbow trout Salmo gairdneri[181)&237]. Although the importance of the carboxyl radical, that is the knowledge that the α-carboxyl radical is more important to the attraction activities than the α-amino radical, is not found in the existing research examples in the field of behavioural science, the importance of the α-carboxyl radical has been confirmed in studies in electrophysiology conducted on rainbow trout Salmo gairdneri[181)&237]. Furthermore, there is an evidence that the α-carboxyl radical also contributes greatly to the activities of acidic amino acids, which are the repellent, in contrast to the attractant[299]. However, the findings of the study obtained with a species of catfish Ictalurus punctatus[184] do not demonstrate the importance of the α-carboxyl radical. This is a problem likely arising from the fact that the amino acid derivatives have not been studied systematically. The fact that amino acids having a short normal chain carbon are effective attractants has been agreed upon by the findings of numerous studies in the field of both behavioural science and physiology.

With the isomers of amino acids, although the attraction activities are observed with the L-isomers, the D-isomers either exhibit no activities or else very weak activities. These are findings that are consistent among studies in the field of behavioural science as well as in that of electrophysiology[102,119,173,174,186,189&234]. However, according to the results of the study in electrophysiology conducted on a wide range of concentrations, the above findings are not applicable at high concentrations[173]. These findings indicate that the concentration dependency is a major characteristic of the L- and D-type isomers. In addition, there are some interesting research that examined the attraction activities of ^{1}H-Gly and ^{2}H-Gly (deuterated) for a species of white trout Coregonus clupeaformis from the standpoint of physiology and behavioural science[233]. Whereas in the electrophysiology fairly similar concentration-response curves can be obtained at 10^{-8} to 10^{-4} for both substances, contrasting behaviour that is reciprocal 58 at 10^{-7} to 10^{-5} is observed in behavioural science studies, showing an attraction effect with the non-deuterated Gly and repellent effect with the deuterated Gly. The reason for the manifestation of this behaviour is presumed to be the involvement of the molecular properties of these compounds.

On the basis of the attraction effects of phospholipids, the derivatives of phosphatidylcholine (lecithin) in particular, the relationship of their structure to their activities is given in Table 17[217)]. It is apparent from this table that, in general, the greater attraction activities seem to be observed with the increase in the number of carbons that are present in fatty acids that are bonded in the manner of lecithin. On the other hand, with the amine related compounds that are bonded to the phosphate radical of the phosphatidic acid, it is clear that the lecithin type amine having bonded choline exhibits a strong activity. Since no other research examples on the relationship of the structure and activity of phospholipids are found, no comparison can be made with the above mentioned results obtained by this author. However, concerning fatty acids, which are the lipid related compounds, behavioural studies have been conducted on the invertebrates[52),55)&62)]. Since strong attraction activities have been observed with oleic acid ($C_{18:1}$)[52)] for a species of sea hare <u>Aplysia</u> <u>kurodai</u>, with octanonic acid ($C_{10:0}$)[55)] for a species of oishinomigai* Bulinus rohlfsi and with propionic acid ($C_{3:0}$)[62] for a species of kawanejigai* Biomphalaria glabrata, it is assumed that these activities vary greatly depending on the species of the gastropods concerned, these results are due to the high attraction activities exhibited by the fatty acids having the highest number of carbons among those fatty acids examined. These findings indicate a possibility that an increase in the activity will be observed with an increase in the number of carbons.

Nucleic acid related compounds, whose importance as the feeding attractants is next to the amino acids will be discussed now. Just as was done in the case of amino acids, the author has examined the attraction activities of nucleic acid related compounds for oriental weatherfish Misgurnus anguillicaudatus, yellowtail Seriola quinqueradiata and black abalone Haliotis discus[216]. On the basis of the findings of this study, it was decided to use the nucleotide adenylic acid (AMP) as the basic type and the relationship between the structure and activity thus obtained is given in Table 18. It was inferred that this relationship is involved mainly with three requirements. In other words, it is thought that the purine base is essential and the maintenance of one phosphate bond and ribose are important. Before this author's study, detailed studies were conducted on this subject using a species

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* Translator's note: Japanese names transliterated.

of flatfish *Scophthalmus maximus*[90] and a species of prawn *Palaemonetes pagio*[104] and similar results were obtained. 59

Besides these behavioural science studies, there are physiological studies examining the structure and activities of nucleic acid related compounds for a species of spiny lobster *Panulirus argus* by the olfactory receptors[118&202]. There are the P_1- and P_2-type purine acceptors, and whereas the response of the former type is in the order of AMP>ADP>ATP≥adenosine the latter type has the response that is in total contrast to the former in the order of ATP>ADP>AMP. With regard to the former type of acceptor, these findings have been confirmed by studies in the behavioural science as well. On the other hand, besides the receptors of nucleic acid related compounds, the fact that a number of varieties exist for the receptors of amino acids, which are feeding attractants, has been reported by physiological studies conduced with rainbow trout *Salmo gairdneri*[240~242] and crucian carp *Cyprinus carpio*[243]. It was demonstrated that the receptors that bond Thr, Ser and Ala, as well as the receptors that bond the Lys, both associated with the olfactory chamber and cilia of rainbow trout, produce competitive inhibition with other amino acids[242]. As demonstrated by these findings, it is becoming clear that the receptors of attractants are many from the physiological standpoint, however, we will have to wait for future studies to find out what roles they are playing in the manifestations observed by behavioural studies. Although there are many instances in which the increase in the attraction effect can be observed for oriental weatherfish, yellowtail and abalone by combining feeding attractant compounds, in some instances a decrease in this effect has been observed[215]. It seems that the decrease in this attraction effect can also be explained if we were to assume that the behavioural manifestations are regulated by a number of receptors.

The relationship between the structure and the activity of attraction compounds, and to some extent the receptors, have been explained so far, but it seems that in a general way the whole picture is starting to emerge as far as this relationship is concerned with regard to the related compounds of amino acids and nucleic acids. However, there are not many studies of this subject concerning phospholipids, and this is also true for the studies of proteins, glucides and other attractants that bear relation to the invertebrates. For this reason, there is a need to examine in a systematic way the activities of these chemical compounds as well as their derivatives, isomers and homologues in order to clarify the relationship between their structure and activity.

8. APPLICATION TO FISHERY

The application of this relationship in fisheries is for the purpose of artificial feed in the roughly divided categories of use in angling, the fishing industry and culturing. In any case, when the importance of olfaction is considered, the first thing that is needed is the addition of feeding attractants, or feeding activators. It is obvious that the development of this artificial feed will bring about a great benefit of practical as well as economic value. Furthermore, it will probably be possible to anticipate a wave effect of keeping environmental pollution to a minimum by the use of this feed.

Although this involves only a small sector of fisheries, the subject of the artificial feed for angling is discussed here. Although the artificial feed is being used at present by the anglers at large, it is hardly being used by professional fishermen using single rods or longline. The reason for this is the use of live and fresh natural feed such as shrimps among the rod fishing operators in the entire area of the Western Japan[244]. The investigation of commercially available artificial feed that is designed for fishing revealed nearly 50 varieties, including similar products. Representative products were selected from these and listed in Table 19. The display stating that the product possessed attraction effect was found on some of these products, and, though not indicated in the table, there are some products that has a feeding attractant or feeding promotor added to them. The presence of such displays is a phenomenon that was not observed in the past and seems to be proof that the outcome of basic research is being reflected indirectly. However, the contents of these products are industry secrets and it is difficult to find out what they are. It is assumed that their main ingredients are probably the powdered or extracts of natural feed that have been proven in practice to be greatly effective in catching fish or as feeding attractants or the chemically or enzymatically treated materials of such natural feed. Moreover, in addition to these products, in some of the stores that sell fishing bait their own fishing bait or ground bait are being prepared. In other countries, too, the feed is being developed by the addition of feeding attractants in baits for sports fishing. As demonstrated in Table 19, fishing bait tends to be frozen products whereas ground bait tends to be products stored at room temperature. The presence of several companies in the industry that are manufacturing these products with consideration given to environmental pollution is desirable commercial ethics and it seems to demonstrate the stand that should be taken by the industry in the future.

The subject of artificial feed intended for use in the fishing industry will be discussed next. Although the utilization of the knowledge gained on the relationship between the structure of feeding attractants and their activities in the preparation of such artificial feed is the most desired of the applications of this knowledge to the field of fisheries, this is lagging behind. The results of research on this subject are compiled in Table 20. Of the literature that we were able to obtain, all, with the exception of two cases, were the findings of Japanese investigators. Although the number of species of aquatic animals studied was small when compared to the one studied in the investigation of feeding attractants[222)&232)], many cases of research can be found on the subject of the relationship between oil and the feed materials, either as attractants or as the activator. Furthermore, in many reports, the effectiveness (of oil) has been confirmed. This seems to reflect the historical background in which the bait preserved in oil had been developed independently in Japan[16)] from long ago.

The improvement made on the trap fishing method of a invertebrate gastropod conch Babylonia japonica will be introduced. This research[245)] was conducted by focusing on the two aspects of improvement, the physical improvement of the cage and the improvement of the bait. The results thus obtained were compiled in Table 21. As demonstrated by this table, it was found that more fish entered the traps baited with fresh mackerel preserved in the oil of the sand launce, rather than conventionally used fresh mackerel, and that even more fish entered the traps baited with komai (a species of small cod) preserved in the same oil. From the consideration of the cost, too, it was discovered that good results are obtained at half of the previous cost. The following three points have been cited as the advantages of the oil-preserved komai samples: whereas the smell of the fresh bait preserved in oil changes, the smell of komai does not change; because its skin is tough, the bait does not fall off; and because dried komai is used, it absorbs oil well and keeps the smell so that it can be reused 2 or 3 times. In this manner, it is obvious that this bait has the advantage of not only obtaining a better trap entry rate of fish than the conventional bait but also excellent incidental characteristics. On the other hand, the results of the similar experiments conducted on Charybdis miles and Ovalipes punctatus[246] indicate that the number that enter the traps becomes reversed depending on the living density of these species of crabs.

The results of the development of artificial feed for the vertebrate selachian sharks are introduced here. This research[248] was conducted with the aim of developing artificial feed intended for longline fishing that is readily obtainable, easy to store and is highly functional in catching fish, with the attention focused on two senses, the olfactory and the visual, in regard to the function of the bait to attract the fish being studied to the fishing hook. Using the five varieties of feed to be tested, the average fishing rate was obtained from the experiment conducted seven times. The results thus obtained are given in Table 22. The total number of fishes caught was 493 comprising of 22 species, with 389 sharks accounting for 79% of the total. As demonstrated in the table, the catching rate was extremely poor when only soaked in feed oil (a mixture of cod liver oil and squid oil) but the bait made of this with squid slices and fluorescence added to it is most appropriate. From this it was concluded that the fluorescence and smell were responsible in raising the rate of catch. Since the uptake of urethane into the mouth cavity and subsequent physical stage of consumption differ from those of squid slices, further investigation is required on this matter. In cases such as this where artificial material is used as the feed base, it is thought that the physical factor plays a major role in the stage of consumption. In fact, when fishing for tuna, the use of sponge gives inferior results to those obtained using saury[254]. Concerning these relations, it is thought that the development of artificial feed intended for use in the fishing industry, in longline fishing in particular, must proceed in a comprehensive manner with consideration given to the involvement of the tactile sensation in addition to the attraction capacity.

The feeding attractants were discussed in previous
reports[222]&[232], however, it seems that hardly any of the 65
findings of these reports are being utilized in the development of artificial feed intended for the fishing industry. There is a particular need to work on the utilization and application of amino acid and nucleic acid related compounds. In fact, the effectiveness of the amino acids has been proven by the field experiment[147]. By releasing a variety of amino acid solutions into the ocean water, the species as well as the number of fishes that collect around the opening of the release are studied by television camera. As a result, the following results were uncovered: Gly>Ala>Met>Aspn>Cys>Glu>Leu for a species of flatfish Pseudopleuronectes americanus; γ-butyl

butyric acid (GABA)>Ala=His>Gly for a species of medaka <u>Fundulus heteroclitus</u>; and Ala>Met>β-Ala>Thr for a species of togoro iwashi* <u>Menidia menidia</u>. The author and his colleagues have also demonstrated the ability of amino acid rich krill extract to attract fish in a preliminary experiment using vertical sonar[300].

On the subject of artificial feed for fish culture, the research has been limited to the study of useful aquatic animals, as in the case of feed for the fishing industry, and most of the findings are those made by Japanese investigators. The existing studies were compiled and shown in Table 23. Abalone, <u>Penaeus</u>, Japanese common eel, yellowtail and red sea bream account for the majority of studies. For the materials used as bait, many of the old studies were concerned with natural feed or feed based on fish powder, as well as substitute protein materials, however, in recent years, some studies concerned with the involvement of chemical stimulants, i.e. feeding attractants or feeding activators, are appearing.

Of the studies[265),271),272),277),283),284),287),289)&290)] dealing with the chemical involvement of attractants or activators, the effect of the addition of amino acid and UMP on Japanese common eel <u>Anguilla japonica</u>[272] and yellowtail <u>Seriola quinqueradiata</u>[287] will be introduced here. Feed (the

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* <u>Translator's note</u>: Japanese name transliterated, found in coastal waters of Southern Japan.

sample specimen) prepared by adding feeding activators* (Ala, Gly, His, Pro and UMP) to whitefish meal based feed (the control specimen) was given to Japanese common eel for a duration of 25 days and the changes in the body weight thus obtained were given in Table 24. On the basis of findings showing that the weight gain obtained with the sample specimen was twice that obtained with the control specimen, as demonstrated in the table, it is possible to state that amino acids and UMP play a major role. Furthermore, an increase in the physiological activities is suggested by these activators. Such findings were substantiated by similar results obtained with yellowtail. In addition, it was found that Met[265)] was effective for Penaeus japonicus and basic amino acids[277)] for silver salmon Oncorhynchus kisutch. On the other hand, there are reports that are in contrast to them demonstrating that 19 varieties of amino acid mixtures are not effective for carp Cyprinus carpio[282)] and bullhead Silurus asotus?[282)]. Although the composition is unknown, the effect of the addition of oil has been confirmed to be similar to what was obtained with the study of baits for the fishing industry[266),273),288),289)&291)].

As demonstrated by the above, the results of feeding attractants or feeding activators are being reflected in the studies concerning feed for culturing, as compared with those

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* Although these were entered as feeding promoter in the original article, as it was explained in the previous report[16)], it should be noted that they manifested themselves to be activators.

concerned with baits for angling and the fishing industry, but it still is not sufficient. It is necessary to conduct the research and development further focusing on the substitute protein materials and chemical stimulants while consulting the results of the studies mentioned above. The basic research concerning the ingredients of feed is also important in addition to this for the breeding and rearing of healthy fishes and shellfishes.

In concluding this article, the summary of feeding attractants will be presented. When feeding attractants are viewed as a whole, there is a possibility that the amino acid and nucleic acid related compounds play the main role in the attraction activities while lipids, basic amines or proteins play a supporting role.

The subject of feeding attractants was considered from both scientific and practical perspectives since they have a close correlation.

From the scientific perspective, there is a need to promote further research concerning aquatic animals other than the mollusks, gastropods and vertebrates. There is a possibility that such research might lead to the discovery of new physiological activators. Since we are at a stage where receptors having specificity are being uncovered by physiological studies, it is important to examine the synergistic effect of these with respect to their involvement in a systematic manner from the standpoint of physiology and behavioural science in order to uncover their relationship. In addition, the relationship between the structure of attractants and their receptors is extremely important.

From the practical standpoint, the development of baits for the fishing industry including angling and of feed for culture is lagging, this being especially true in the case of the former, consequently, the findings of the basic research are not being reflected in this area sufficiently. In addition, the research findings that contribute to the cultivation of seaweed beds and marine pasture will also be desirable.

Of the 83 million tons of fish caught in the world, the Japanese catch is 12 million tons, accounting for about 15% of the world catch, whereas the population of Japan is 120 million, which accounts for only about 2.5% of the world total population of 480 millions. It is not possible to think that the rest of the world will allow such allocation of exploitation to continue indefinitely. Of the 12 million tons of catch, 3.8 million tons, about 32%, are being used for domestic consumption as feed and bait, and sardines are largely being relied on to fill this purpose. From the global perspective, there is a need to consider their value as food, especially as the source of protein. In order to accomplish this, it is my belief that importance must be placed on the development of feed by treating this subject in a comprehensive manner by searching for material among not yet utilized aquatic animals or land-produced protein sources and by adding feeding attractants as well as viewing the matter from the perspective of physiological and nutritional science, while consulting the findings of basic scientific research.

表15 水産動物における摂餌誘引化合物の誘導体・異性体・同族体

1. 水産動物*1	2. 試験水	3. 代表尺度 (cm, g)	4. 使用個体数	5. 研究法	6. 誘引物質*2	7. 濃度 (M)
8 (行動学)						
9. 無脊椎動物						
10. クロアワビ *Haliotis discus*[216]	11 海水	12 殻長2.8	50	13. 探索行動	14 アミノ酸誘導体	10^{-3}
15 オオイシノミガイの一種 *Bulinus rohlfsi*[62]	16 淡水	17 体重0.002 −0.005	100	13. 探索行動	18 有機酸・脂肪酸同族体	10^{-2}
19. アメフラシ *Aplysia kurodai*[52]	11 海水	17 体重5 −70	32	20. 摂餌量	21. 脂肪酸同族体†	10^{-3}
22. カワネジガイの一種 *Biomphalaria glabrata*[17]	16 淡水	17 体重0.01 −0.015		13 探索行動	23. アミノ酸・有機酸・アミド・アミン・アルコール・テトロース同族体	10^{-1}
〃 [55]	16 淡水	17 体重0.05 −0.35		13 探索行動	21 脂肪酸同族体	10^{-1}
〃 [66]	16 淡水	17 体重0.25 −0.35		24 索餌行動	25. 糖質異性体†	10^{-2}
26. テナガエビの一種 *Palaemonetes pugio*[10]	11 海水		18	13 探索行動	27. タンパク質同族体	(0.1 − 1.5 mg/ml)
〃 [101]	11 海水	28 体長1.5 −3.0	18	13 探索行動	29. 核酸誘導体	10^{-7} − 10^{-1}
30. アステリアスの一種 *Marthasterias glacialis*[119]	11 海水			13 探索行動	31. アミノ酸誘導体・異性体, 有機酸異性体	10^{-8} − 10^[illegible]
32. 脊椎動物						
33. シロマスの一種 *Coregonus clupeaformis*[233]				34. 滞留時間	35. グリシン同位体	10^{-8} − 10^[illegible]
36. ドジョウ *Misgurnus angillicaudatus*[217]	16. 淡水	28. 体長10.1	60	13 探索行動	14. アミノ酸誘導体	10^{-3}
37 ブリ *Seriola quinqueradiata*[217]	11 海水	38 尾叉長5.4	<126	13 探索行動	39. アミノ酸・脂質誘導体	10^{-1}
40 スズキの一種 *Dicentrarchus labrax*[234]				20 摂餌量	41. アミノ酸異性体†	
42. マダイ *Chrysophyrys major*[102]	11 海水			13 探索行動	43 アミノ酸誘導体・異性体	10^{-2}
44 ハゼの一種 *Gobiosoma bosci*[32]	11 海水		14 − 20	24 索餌行動	45. アミノ酸同族体	
46. カレイの一種 *Scophthalmus maximus*[10]	11 海水	体長6 − 10	10	20. 摂餌量	29. 核酸誘導体	(10^{-6}M/g)
47. カの幼虫 *Culex pipens*	16. 淡水	48 幼虫		24. 索餌行動	29. 核酸誘導体	10^{-5} − 10^{-3}
49. (生理学)						
9. 無脊椎動物						
50. イセエビの一種 *Panulirus argus*[118]	11 海水			51. スパイク	52 核酸同族体	10^{-3}

1. 水産動物*1	2. 試験水	3. 代表尺度 (cm, g)	4. 使用個体数	5. 研究法	6. 誘引物質*2	7. 濃度 (M)
〃 [203]	11. 海水			53 インパルス	29. 核酸誘導体	10^{-4}
54 ワラジムシの一種 *Hemilepistus reaumuri* [236]	55 空気			56 電位	57. アミン・脂肪酸同族体	10^{-2}
32. 脊椎動物						
58. ウナギの一種 *Anguilla rostrata* [189]	16 淡水	17 体重200−700		EOG, NTR, MNR	59. グルタミン異性体	10^{-4}
60. ニジマス *Salmo gairdneri* [181]	11 海水	体長18−22		61 嗅球応答	14. アミノ酸誘導体	$10^{-5}-10^{-4}$
〃 [237]	11 海水	体長18−22		61 嗅球応答	14. アミノ酸誘導体	10^{-5}
62. ニジマスの一種 *Salmo salar* [173]	16 淡水	体長15−18		51 スパイク	41. アミノ酸異性体	10^{-4}
33. シロマスの一種 *Coregonus clupeaformis* [233]				61 嗅球応答	35. グリシン同位体	$10^{-7}-10^{-4}$
63 ナマズの一種 *Ictalurus catus* [174]	11 海水			51 スパイク	41. アミノ酸異性体	
63 ナマズの一種 *Ictalurus punctatus* [184]	16 淡水	17 体重70−200		EOG	14. アミノ酸誘導体	10^{-4}
63 ナマズの一種 *Arius felis* [186]	11 海水	17 体重75−250		EOG	41. アミノ酸異性体	10^{-4}

*1 文献に記載された学者；*2 誘引物質を含む活性物質。

Table 15: The derivatives, isomers and isotopes of feeding attractant compounds for aquatic animals.

1. aquatic animals*
2. water tested
3. typical length or weight (cm. or g.)
4. number of individuals used
5. research method
6. attractants**
7. concentration (M)
8. (behavioural science)
9. invertebrates
10. black abalone
11. sea water
12. shell length
13. exploratory behaviour
14. amino acid derivatives
15. a species of oishinomigai
16. fresh water
17. body weight
18. homologues of organic acids and fatty acids
19. sea hare

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* Investigators mentioned in the article.

** Active substances including attractants.

20. the amount of feed consumed
21. fatty acid homologues
22. a species of kawanejigai
23. homologues of amino acids, organic acids, amides, amines, alcohols and tetrose
24. feeding behaviour
25. glucide isomers
26. a species of prawn
27. protein homologues
28. body length
29. nucleic acid derivatives
30. a species of Asteridae
31. amino acid derivatives and isomers, and organic acid isomers
32. vertebrates
33. a species of white trout
34. stopping time
35. glycine isotopes
36. oriental weatherfish
37. yellowtail
38. length to the fork of the tail
39. amino acid and lipid derivatives
40. a species of sea bass
41. amino acid isomers
42. red sea bream
43. amino acid derivatives and isomers
44. a species of goby
45. amino acid homologues
46. a species of flatfish
47. mosquito larva
48. larva
49. (physiology)
50. a species of spiny lobster
51. spike
52. nucleic acid homologues
53. impulse
54. a species of sow bug
55. air
56. electrical potential
57. amine and fatty acid homologues
58. a species of common eel
59. glutamine isomers
60. rainbow trout
61. olfactory bulb response
62. a species of rainbow trout
63. a species of catfish

表16 アミノ酸の構造と誘引活性

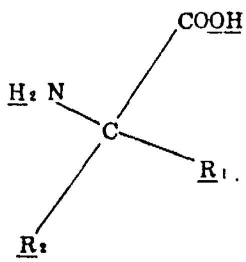
1. 構造	2. 置換部位	3. 誘引活性
	H	H>CH_3 >C_2H_5
	OH	4. OH>ニトロアニリン，アミノ
	H	5. H>ベンゾイル
	R_1	H>CH_3
	R_2	H>C_2H_5，C_3H_7

Table 16: The structure and attraction activities of amino acids.
1. structure
2. substitution site
3. attraction activities
4. H > nitroaniline and amino
5. H > benzoyl

表17 リン脂質の構造と誘引活性

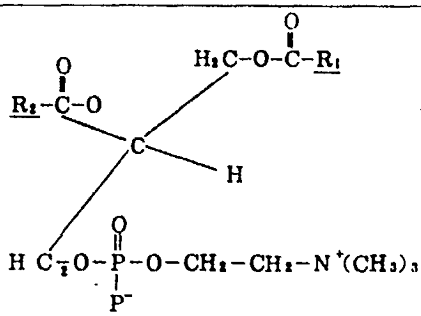
1. 構造	2. 置換部位	3. 誘引活性
	R_1	4. ジプロピオイル>ジパルミトイル>ジラウロイル，5. ジベヘノイル>ジステアロイル>ジパルミトイル．
	R_2	6. パルミトイル / リノレオイル > パルミトイル / ステアロイル > パルミトイル / オレオイル
	$(CH_3)_3$	$(CH_3)_3$ > $(CH_3)_2$，H>CH_3，H_2>H_3

Table 17: The structure and attraction activities of phospholipids.
1. structure
2. substitution site
3. attraction activities
4. dipropioyl > dipalmitoyl > dilauroyl
5. dibehenoyl > distearoyl > dipalmitoyl
6. palmitoyl / linoleoyl > palmitoyl / stearoyl > palmitoyl / oleoyl

表18　核酸関連化合物の構造と誘引活性

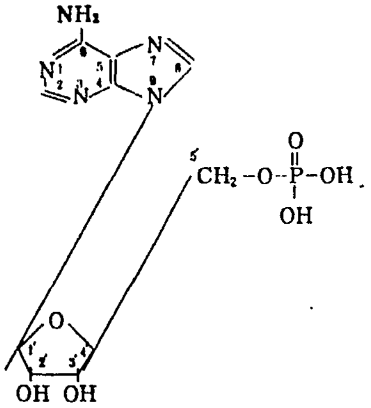
1、構　　造	2. 置換部位	3 誘　引　活　性
	4. プリン	5.アデニン>グアニン
	6. リン酸	AMP>ADP>ATP
	7. D-ライボース	8. ライボーズ>デオキシライボース

Table 18: The structure and attraction activities of nucleic acid related compounds.

1. structure
2. substitution site
3. attraction activities
4. purine
5. adenine > guanine
6. phosphate
7. D-ribose
8. ribose > dioxyribose

表19 釣り用市販人工餌料

1. 商品名	2. 素材	3. 効果	4. 対象魚	5. 備考
6. つりダンゴ	7. 特別調製	8. 集魚(釣り・撒餌)	9. チヌ・メジナ・タイ・イサキ・ボラ・アジ・タナゴ	10. 冷凍，生ウニ・にんにく入り
11 生ミック	12. 生きたエサをすりつぶしてミックス	8. 集魚(釣り・撒餌)	13. クロダイ・メジナ・アイゴ・イサキ・カレイ・ハヤ・ワカサギ・コイ	14. 冷凍，防腐剤添加無し
15 エース	16. 生エビ他魚の好物をミックス	17. 寄せ(釣り・撒餌)	18. チヌ・メジナ・バリ・ボラ・アジ・タイ・タナゴ	19. 冷凍，生ニンニク・酒粕入り
20 サナギ粉	21 サナギ	22 誘引（撒餌）	23 クロダイ・ボラ・コイ・ハヤ	24 室温
25 酵母荒びき	26 酵母	27 集魚（撒餌）	28. チヌ・メジナ・コイ・ヤマベ・ハヤ	24 室温
29 集魚ロック		27 集魚（撒餌）	30. すべての魚種	24 室温
31. ウミッコ	32. オキアミ・エビ粉・イカワタ・アサリ他10種	27 集魚（撒餌）	33 タイ・チヌ	34. 室温，海洋汚染なし
35. ジャンボマキエ	36. 麦	27 集魚（撒餌）	37 クロ・チヌ・イサキ・ボラ	24 室温

Table 19: Commercially available artificial bait for angling.

1. product name
2. material
3. effect
4. intended fish
5. notes
6. Tsuri Dango (anglers' dumpling)
7. specially prepared
8. collects fish (angling and ground bait)
9. black porgy, opaleye, sea bream, grunt, mullet, saurel and bitterling
10. frozen, contains fresh sea urchin and garlic
11. Nama Mikku (fresh mix)
12. ground and mixed fresh baits
13. black porgy, opaleye, aigo*, grunt, flatfish, dace, freshwater smelt and carp
14. frozen, no preservatives added
15. Ace
16. mixture of fresh shrimps and other feed favoured by fish
17. to attract (angling and ground bait)
18. black porgy, opaleye, bari**, mullet, saurel, sea bream and bitterling.
19. frozen, contains fresh garlic and sake lees

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* Translator's note: Japanese name transliterated. Possibly a species of Siganus. *Siganus fuscescens* (Houttuyn)

** Translator's note: Japanese name transliterated. English name unknown.

20. Sanagi-ko (chrysalis powder)
21. chrysalises
22. attractant (ground bait)
23. black porgy, mullet, carp and dace
24. room temperature
25. Kobo Arabiki (coarsely ground yeast)
26. yeast
27. collects fish (ground bait)
28. black porgy, opaleye, carp, yamabe* and dace
29. Shugyo Rokku (fish collecting rock)
30. all species of fishes
31. Umikko
32. krill, shrimp powder, the innards of squid, short-necked clam and ten other species
33. sea bream and black porgy
34. room temperature, free of ocean pollutants
35. Janbo Makie (jumbo ground bait)
36. wheat
37. black porgy, grunt and mullet

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* Translator's note: Japanese name transliterated. A dialect meaning either a species of masu trout or a species of carp, depending on the region of Japan.

表20　漁業用人工餌料

1. 水産動物*1	2. 研究法	3. 餌料素材及び効果
4. 無脊椎動物		
5.（腹足類）		
6. バイ *Babylonia japonica*[245]	7. 入籠数	8. コマイのコウナゴ油漬＞生サバのコウナゴ油漬＞生サバ
9.（甲殻類）		
10. イセエビの一種 *Panulirus interruptus*[156]	7. 入籠数	11. アワビ・サバ筋肉
12. ウミザリガニの一種 *Homarus gammarus*[298]	7. 入籠数	13. アミノ酸・4級アンモニウム塩基・核酸関連化合物・乳酸・TMAの練り石こう＞塩漬サバ
14. アカイシガニ *Charybdis miles*[246]	7. 入籠数	15. サバをイカナゴ油・アネトール・非イオン活性剤浸漬＞サバ（生棲密度の大きい場合），
16. ヒラツノガニ *Ovalipes punctatus*[246]	7. 入籠数	サバをイカナゴ油・アネトール・非イオン活性剤浸漬＜サバ（生棲密度の小さい場合）
17. ベニズワイガニ *Chinoecetes japonicus*[247]	7. 入籠数	18. ズワイガニエキス固形化，魚類・ズワイガニエスキ固形化あるいは魚類エキス固形化＜冷凍サバ
19. 脊椎動物		
20 タロウザメ *Centrophorus acus*[248]	21 釣獲数	22 イカにフィードオイル含浸蛍光ウレタン装着＞イカに蛍光ウレタン装着＞イカにフィードオイル含浸ウレタン装着＞イカ＞フィードオイル含浸蛍光ウレタン
23 モミジザメ *Centrophorus squamosus*[248]	21 釣獲数	
24 ユメザメ *Centroscymnus owstoni*[248]	21 釣獲数	
25 ブリ *Seriola quinqueradiata*[249]	21 釣獲数	26 イワシ肉にサツマイモ澱粉滓・イカ肝油・大豆レシチン添加の練餌＞イワシ（撒餌）
27 イラ *Choerodon azuri*[250]	21 釣獲数	29 生イソメ＞生イカ＞フイッシュソルブル・アミ練餌（釣餌）
28 ササノハベラ *Psuedolabrus japonicus*[250]	21 釣獲数	
30 キュウセン *Halichoeres poecilepterus*[250]	21 釣獲数	
31 マダイ *Chrysophyrys major*?[251]	21 釣獲数	32 イカナゴ油にミリン添加＞イカナゴ油／イワシ・イカナゴ油混合＞イワシ油＞サメ油／イカナゴ・サメ油混合／イワシ・サメ油混合
33 マサバ *Scomber japonicus*?[137]	21 釣獲数	34 イワシ油にサツマイモ澱粉滓・イカ肝油・大豆レシチン添加の練餌＞イワシ（撒餌）
33 マサバ *Scomber japonicus*?[252]	21 釣獲数	35 冷凍魚腸・冷凍イワシ・粉末飼料の練餌＝冷凍イワシ（撒餌）
33 マサバ *Scomber japonicus*?[253]	21 釣獲数	36 フイッシュソルブル・乳タレ油・大豆レシチン・小麦粉の練餌（フイッシュソルブルの質で異なる）（撒餌）
37 マグロ（学名不明）[254]	21 釣獲数	38 マグロ肉・小麦粉の練餌＜サンマ
37 マグロ（学名不明）[254]	21 釣獲数	39 魚油含浸スポンジ＜サンマ
37 マグロ（学名不明）[255]	21 釣獲数	40 サンマ肉・ポリビニルアルコールの練餌≒サンマ

*1　文献に記載された学名。

Table 20: Artificial feed for the fishing industry.

1. aquatic animals*
2. study methods
3. feed materials and their effects
4. invertebrates
5. (gastropods)
6. conch
7. number of fish entering the cage
8. komai preserved in the oil of sand launce > fresh mackerel preserved in the oil of sand launce > fresh mackerel
9. (crustaceans)
10. a species of spiny lobster
11. abalone and mackerel meat
12. lobster
13. the kneaded plaster of amino acid, quaternary ammonium base, nucleic related compounds, lactic acid and TMA > mackerel pickled in salt
14. Akaishi** crab
15. mackerel impregnated with the oil of sand launce, anethole and non-ionic activator > mackerel (when the living density is high); mackerel impregnated with the oil of sand launce, anethole and non-ionic activator < mackerel (when the living density is low)
16. hiratsuno** crab
17. beni-zuwai*** crab *Chionoecetes opilio* (O. FABRICIUS)
18. solidified extract of zuwai*** crab; solidified extract of zuwai crab or that of fishes < frozen mackerel
19. vertebrates
20. taro** shark
21. number caught
22. squid with fluorescent urethane device containing feed oil > squid with fluorescent urethane device > squid with urethane device containing feed oil > squid > fluorescent urethane containing feed oil
23. momiji** shark
24. yume** shark
25. yellowtail
26. sardine meat kneaded with sweet potato starch dregs, squid liver oil, and soybean lecithin > sardine (ground bait)
27. ira****
28. sasanoha bera****

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* Scientific names given in articles.

** <u>Translator's note</u>: Japanese name transliterated.

*** <u>Translator's note</u>: Japanese name transliterated. a species of spider crab.

**** <u>Translator's note</u>: Japanese name transliterated. A species of wrasse.

29. fresh Lumbriconereis heteropoda > fresh squid > kneaded fish solubles and mysid (angling bait)
30. puddingwife
31. red sea bream
32. oil of sand launce with the addition of mirin (sweet sake) ≧ oil of sand launce and the mixture of sardine oil and oil of sand launce > sardine oil > shark oil, the mixture of the oil of sand launce and shark oil and the mixture of sardine oil and shark oil
33. mackerel
34. sardine oil kneaded with sweet potato starch dregs, squid liver oil and soybean lecithin > sardine (ground bait)
35. bait made by kneading together frozen fish intestines, frozen sardines and powdered feed = frozen sardine (ground bait)
36. bait made by kneading together fish solubles, Nyutare* oil, soybean lecithin and wheat flour (differs depending on the quality of fish solubles used) (ground bait)
37. tuna (scientific name unknown)
38. bait made by kneading tuna meat with wheat flour < mackerel
39. sponge soaked impregnated with fish oil < sardine
40. bait made by kneading mackerel meat with polyvinyl alcohol ≒ mackerel

* Translator's note: Japanese word transliterated. Meaning uncertain.

表21　籠及び人工餌料の種類によるバイの平均入籠重量（g）

1. 籠	2. 餌料			
	3. 人工臭*	4. 生サバ	5. コウナゴ油漬生サバ	6. コウナゴ油漬コマイ
7. 2方入口	0	500	600	650
8. 3方入口	0	650	700	800
9. 4方入口	0	800	900	1000

*バター状で飴色をした魚臭をつけた製品で成分不明。

Table 21: Average trap entry weight (g) of conch and the trap and artificial bait varieties.

1. trap
2. bait
3. artificial scent*
4. fresh mackerel
5. fresh mackerel preserved in the oil of sand launce
6. komai preserved in the oil of sand launce
7. entrances on two sides
8. entrances on tree sides
9. entrances on four sides

* a product having fish odour, of a caramel colour, having the consistency of butter, and of unknown composition.

表22 延縄漁における人工餌料のサメ釣獲率

1. 人工餌料	2. 実験*							3. 相対値平均
	I	II	III	IV	V	VI	VII	
4. イカ切身	13.3 (1.0)	21.1 (1.0)	7.5 (1.0)	10.3 (1.0)	13.6 (1.0)	8.1 (1.0)	20.0 (1.0)	(1.0)
5. イカ切身にフィードオイル含浸蛍光ウレタン装着	26.7 (2.0)	48.9 (2.3)	23.3 (3.1)					(2.5)
6. イカ切身にフィードオイル含浸ウレタン装着			13.9 (1.9)	11.3 (1.1)	20.0 (1.5)	8.8 (1.1)	32.0 (1.6)	(1.4)
7. イカ切身に蛍光ウレタン装着			16.9 (2.3)	24.0 (2.3)	38.6 (2.8)	10.0 (1.2)	55.0 (2.8)	(2.3)
8. フィードオイル含浸ウレタン			2.5 (0.2)	1.7 (0.1)				(0.1)

* 括弧内はイカ切身の釣獲数を1とした相対値である。原報[248]では小数第3位まで記載されているが，四捨五入して小数第1位まで求めた。

Table 22: Catch rate of shark using artificial bait and longline.

1. artificial bait
2. experiments*
3. mean relative value
4. squid slices
5. squid slices with feed oil impregnated fluorescent urethane device
6. squid slices with feed oil impregnated urethane device
7. squid slices with fluorescent urethane device
8. urethane impregnated with feed oil

* The relative value obtained by setting the number of fish caught with squid slices as 1 is given in the parenthesis. Although the values were given to the third decimal place in the original article[248], they are rounded up to the first decimal place here.

表23 増養殖用人工飼料

1. 水産動物*1	2. 研究法	3. 飼料素材及び効果
4. 無脊椎動物		
5. (腹足類)		
6. クロアワビ *Haliotis discus* [256]	7. 増重量	8. アルギン酸基本飼料にクロレラ添加>カジメ
〃 [257]	9. 日殻長伸率	10. 小麦粉基本飼料に魚粉あるいは植物性蛋白添加≒アラメ
11. エゾアワビ *Haliotis discus hannai* [258]	12. 成長率	13. カゼイン基本飼料>アラメ>魚粉基本飼料
〃 [259]	12. 成長率	14. カゼイン基本飼料>魚粉基本飼料
〃 [260]	12. 成長率	15. 未加熱カゼイン・魚粉基本飼料>加熱カゼイン・魚粉飼料
16. アメフラシ *Aplysia kurodai* [261]	7. 増重量	17. 寒天基本飼料に各種試料添加，アナアオサ>アナアオサ成分>アミノ酸欠アナアオサ成分>寒天
18. アメフラシの一種 *Aplysia dactylomela* [262]	7. 増重量	19. 炭水化物基本飼料にアミノ酸添加>アオサ
20. (甲殻類)		
21. クルマエビ *Penaeus japonicus* [263]	22. 摂餌料	23. ニホンアミ>アサリ>オキアミ>カタクチイワシ
〃 [264]	7. 増重量	24. イカミール基本飼料にグルコサミン添加>アサリ
〃 [265]	7. 増重量	25. イカミール基本飼料にメチオニン添加>アサリ
〃 [266]	7. 増重量	26. イカミール基本飼料にイカ肝油あるいはコレステロール>イカミール基本飼料
27. ウシエビ *Penaeus monodon* [267]	7. 増重量	28. 各種配合試料<アサリ
29. 脊椎動物		
30. (硬骨魚類)		
31. ウナギ *Anguilla japonica* [268, 269]	7. 増重量	32. 北洋魚粉基本飼料に加工糖添加≒基本飼料
〃 [270]	7. 増重量	33. 北洋魚粉基本飼料に酵母添加≒基本飼料
〃 [271]	7. 増重量	34. 市販配合飼料にアミノ酸・UMP添加>市販配合飼料
〃 [272]	7. 増重量	35. 北洋魚粉基本飼料にアミノ酸・UMP添加>基本飼料
36. ヨーロッパウナギ *Anguilla anguilla* [273]	7. 増重量	37. 市販配合飼料にフィードオイル添加≒市販配合飼料
〃 [274]	7. 増重量	38. ホワイトフイッシュミール基本飼料に脱脂大豆添加≦基本飼料
39. アユ *Plecoglossus altiveris* [275]	40. 日間成長率	41. 魚粉基本飼料に酵母添加≦基本飼料

水産動物[*1]		研究法	飼料素材及び効果
〃	[276]	40日間成長率	42魚粉基本飼料にレシチン添加>基本飼料
43 ギンザケ *Oncorhynchus kisutch*	[277]	44 増重率	45.カゼイン基本飼料にアミノ酸添加>基本飼料
46.ニジマス *Salmo gairdneri*	[278]	7.増重量	47魚粉基本飼料にリーフプロティン添加<基本飼料
〃	[279]	7.増重量	48ペルミール基本飼料≒基本飼料に大豆粉添加≒市販ニジマス用飼料
49 シロマスの一種 *Coregonus lavaretus*	[281]	50.生長	51酵母基本飼料≒アルテミア
52 コイ *Caprinus carpio*	[282]	7.増重量	53カゼイン・ゼラチン基本飼料にアミノ酸添加<基本飼料
〃	[280]		54北洋魚粉基本飼料>スクラップミール基本飼料
55 アメリカナマズ *Silurus asotus*	[282]	7.増重量	56カゼイン・ゼラチン基本飼料にアミノ酸添加<基本飼料
57.ブリ *Seriola quinqueradiata*	[283]	58官能検査	59.アミ>人工飼料にアミノ酸添加>人工飼料
〃	[284]	7.増重量	60市販配合飼料に冷凍イワシ・フイッシュソルブル添加<冷凍イワシ
〃	[285]	7 増重量	61.カゼイン・ゼラチン基本飼料>マサバ
〃	[286]	7 増重量	62カゼイン・ゼラチン基本飼料にデキストリン添加<基本飼料
〃	[287]	7.増重量	63魚粉基本飼料にアミノ酸・IMP添加>冷凍イカナゴ
〃	[288]	7 増重量	64魚粉基本飼料にカツオ油添加≒冷凍イカナゴ
〃	[289]	7 増重量	65.カゼイン・ゼラチン基本飼料に各種油添加,カツオ油>イカ・イワシ油>ニシン油>タラ肝油
〃	[290]	7 増重量	66カゼイン・ゼラチン基本飼料にアミノ酸添加>基本飼料
67 カワスズメの一種 *Tilapia nilotica*	[291]	7.増重量	68カゼイン基本飼料に各種油添加,コーン油・大豆油>タラ肝油・牛脂・トリグリセリド
69.マダイ *Chrysophrys major*	[292]	7.増重量	70.魚粉基本飼料>市販配合飼料
〃	[293]	7.増重量	71 市販ウナギ用飼料にオキアミミール添加>市販ウナギ用飼料
〃	[294]	7.増重量	72魚粉基本飼料にオキアミ抽出液添加>基本飼料
〃	[295]	7.増重量	73魚粉基本飼料にワカメあるいはアスコフィルム添加>基本飼料
〃	[296]	7.増重量	74魚粉に蒸煮発酵サバ荒粕>発酵サバ荒粕>サバ荒粕
〃	[297]		75.カゼイン・ゼラチン基本飼料にアナアオサ添加≒基本飼料
76.ササウシノシタの一種 *Solea solea*	[48]		77,カゼイン基本飼料にイガイ成分添加>基本飼料にイガイ筋肉添加

[*1] 文献に記載された学名。

Table 23: Artificial feed designed for culturing.

1. aquatic animals*
2. study method
3. feed material and their effectiveness
4. invertebrates
5. (gastropods)
6. black abalone
7. weight gain
8. the addition of chlorella to the feed of alginic acid base > kajime**
9. daily growth in shell length
10. the addition of fish powder or vegetable protein to the wheat flour based feed ≒ arame**
11. Ezo*** abalone
12. growth rate
13. casein based feed > arame > fish powder based feed
14. casein based feed > fish powder based feed
15. feed based on unheated casein and fish powder > heated casein and fish powder feed
16. sea hare
17. agar based feed with the addition of various samples, and ana-aosa**** > ana-aosa constituents > ana-aosa constituents lacking amino acids > agar
18. a species of sea hare
19. carbohydrate based feed with amino acid added > aosa****
20. (crustaceans)
21. prawn
22. the amount of feed consumed
23. Japanese mysid > short-necked clam > krill > anchovy
24. squid meal based feed with glucosamine added > short-necked clam
25. squid meal based feed with methionine added > short-necked clam
26. squid meal based feed with squid liver oil or cholesterol > squid meal based feed
27. ushi-ebi***
28. various blended samples < short-necked clam
29. vertebrates
30. (teleost)
31. Japanese common eel

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* Scientific names given in the reference articles.

** Translator's note: Japanese word transliterated. A kind of kelp, possibly *Eisenia bicyclis*.

*** Translator's note: Japanese name transliterated.

**** Translator's note: Japanese name transliterated. A species of sea lettuce.

32. north-sea fish powder based feed with processed sugar added ≒ base feed
33. north-sea fish powder based feed with yeast added ≒ base feed
34. north-sea fish powder based feed with amino acid and UMP added > commercially available blended feed
35. north-sea fish powder based feed with amino acid and UMP added > base feed
36. European eel
37. commercially available blended feed with feed oil added = commercially available blended feed
38. whitefish meal based feed with the de-fatted soybeans added ≲ base feed
39. ayu
40. daily growth rate
41. fish powder based feed with yeast added ≲ base feed
42. fish powder based feed with lecithin added > base feed
43. silver salmon
44. the rate of weight gain
45. casein based feed with amino acid added > base feed
46. rainbow trout
47. fish powder based feed with leaf protein added < base feed
48. permeal based feed ≒ base feed with soybean flour added ≒ commercially available feed for rainbow trout
49. a species of white trout
50. growth
51. yeast based feed ≒ artemia
52. carp
53. casein and gelatine based feed with amino acid added < base feed
54. north-sea fish powder based feed > scrap meal based feed
55. bullhead
56. casein and gelatine based feed with amino acid added < base feed
57. yellowtail
58. organoleptic test
59. mysid > artificial feed with amino acid added > artificial feed
60. commercially available blended feed with frozen sardine and fish solubles added < frozen sardine
61. casein and gelatine based feed > mackerel
62. casein and gelatine based feed with dextrin added < base feed
63. fish powder based feed with amino acid and IMP added > frozen sand launce
64. fish powder based feed with bonito oil added ≒ frozen sand launce
65. casein and gelatine based feed with various oils added and bonito oil > squid and sardine oils > herring oil > cod liver oil
66. casein and gelatine based feed with amino acid added > base feed

67. a species of tilapia
68. casein based feed with various oils added, corn oil and soybean oil > cod liver oil, beef tallow and triglycerides
69. red sea bream
70. fish powder base feed > commercial blended feed
71. commercial eel feed with krill meal added > commercial eel feed
72. fish powder based feed with krill extract added > base feed
73. fish powder based feed with wakame seaweed or asukofirumu* added > base feed
74. fish powder and steam cooked fermented sardine scraps > fermented sardine scraps > sardine scraps
75. casein and gelatine based feed with ana-aosa added ≒ base feed
76. a species of sole
77. casein based feed with constituent substances of hard-shelled mussel added > base feed with muscles of hard-shelled mussel added

* Translator's note: Transliteration of the Japanese rendition of a foreign word. Meaning uncertain.

表24 摂餌活性物質添加によるウナギの体重の変化

1.飼料		2.活性物質 3.添加	4.無添加
5.使用尾数		30	30
6.平均体重(g)	7.開始時	77.6	77.7
	8.25日間後	93.3	80.6
9.全増重量(g)		489.0	201.2

Table 24: Changes in the body weight of eels obtained by the addition of feeding attractants.

1. feed
2. activators
3. added
4. not added
5. number of fish used
6. mean body weight (g)
7. at the start
8. after 25 days
9. total weight gain

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* Translator's note: possible typographical error. probably should be 1974.

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