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# Predation of Bivalves by Sea Stars, with Special Reference to the Predation of *Pseudocardium sybillae* and *Mactra chinensis* by *Luidea yesoensis*

by Noriyoshi TAKAMARU (Kushiro Fisheries Experimental Station)
and Ichio SATO (Notsuke Fishermen's Cooperative Association)

Sea stars are generally carnivorous, and are known to be predators of bivalves in particular[1) ~ 6)], they cause considerable damage to fishing grounds for useful bivalves[7)], and are a factor causing large decreases in the numbers of seed *Anadara broughtonii* and *Patinopecten yesoensis* immediately after their release[8)9)]. Therefore, in order to shed light on the movement of bivalve populations, it is necessary to determine the quantities eaten by sea stars. In addition, when creating fishing grounds for useful bivalves or releasing seeds, one should first have an understanding of the distribution and predatory behaviour of sea stars in the sea area concerned.

This time, the distribution and the stomach contents of sea stars were observed along the shore of Notsuke Peninsula at Bekkai-chō and on the Ryūjin Bank, which are fishing grounds for Pseudocardium sybillae and Mactra chinensis, and greater understanding of the predation of P. sybillae and M. chinensis by Luidea yesoensis in particular was obtained.

Before proceeding with this report, the authors would like to express their gratitude to persons connected with the Notsuke Fishermen's Cooperative Association, the Nemuro North Guidance Centre for the Dissemination of Fisheries Technology, and the Bekkai-chō Fisheries Section who cooperated in this survey.

## Survey Methods

The sea areas surveyed were the area along the shore of Notsuke Peninsula in the central part of the Nemuro Strait and the vicinity of the Ryūjin Bank, 2 to 5 m deep, situated to the southeast of it (Fig. 1). This sea area is a fishing ground for P. sybillae and M. chinensis with a depth of 5 m and a substrate of fine sand.

The sea stars were collected on November 10, 1981 by means of a dredge net (width of beam 2 m, mesh 6 cm) for the extermination of sea stars - modified from a P. yesoensis dredge net - which was towed 250 m parallel to the shoreline in the Notsuke Peninsula fishing ground (st. 1 to 17) and in an east-west direction in the Ryūjin Bank fishing ground (st. 18 to 25). The sea stars collected were sorted by species and counted, and for some of the specimens the length of the arms, the wet weight and the contents of the stomach were determined. In the case of L. yesoensis in particular, 20 individuals collected at each

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point were fixed in 10% Formalin and brought to the laboratory, where the stomach contents were observed. The stomach contents were sorted by species and counted, and for P. sybillae and M. chinensis the shell length was measured by means of a sliding caliper.

In addition, in order to determine the distribution of juvenile P. sybillae and juvenile M. chinensis at the time of this survey, samples of the substrate were obtained by means of a Smith-McIntyre bottom sampler (collection area: 0.05 $m^2$), and the P. sybillae and M. chinensis were separated from the substrate by means of a 1 mm mesh sieve. These were collected, and the shell length of the P. sybillae and the M. chinensis was measured by the above-mentioned method.

## Results

### 1. Distribution of Sea Stars

The sea stars collected during this survey belonged to the following seven species: Asterias amurensis, Distolasterias nippon, Lysatrosoma anthostictha, Luidea yesoensis, Certonardoa semiregularis, p. 129 Asterina pectinifera and Solaster borealis.

The densities and the percentages accounted for by the various species of sea stars in the Notsuke Peninsula fishing ground and the Ryūjin Bank fishing ground are shown in Table 1. The density of the sea stars was 0.397 individuals/$m^2$ in the Notsuke Peninsula fishing ground and 0.168 individuals/$m^2$ in the Ryūjin Bank fishing ground. In both fishing grounds the density of A. amurensis and L. yesoensis was high, and that of D. nippon and A. pectinifera was low. The other three species of sea stars were excluded from this table because their combined density was less than 0.001 individual/$m^2$. With regard to

the percentages accounted for by the various species of sea stars in the Notsuke Peninsula and Ryūjin Bank fishing grounds, A. amurensis constituted 59.9% and 65.4% respectively, and L. yesoensis 34.3% and 31.0%. These two species accounted for more than 90% of the total. D. nippon constituted 3.0% and 1.8% respectively, and A. pectinifera 2.8% and 1.8%.

Fig. 2 shows the distribution of sea stars. Sea stars were found over the entire sea area surveyed, and at many of the survey points there were 0.1 to 0.3 individuals/$m^2$, but there was a high-density area with more than 0.3 individuals/$m^2$ to the east of the Notsuke Peninsula fishing ground. At the centre of the Ryūjin Bank the density was less than 0.1 individual/$m^2$. The density of L. yesoensis was 0.1 to 0.3 individuals/$m^2$ on the western side of the Notsuke Peninsula fishing ground and on the southwestern side of the Ryūjin Bank fishing ground, in the area between the two fishing grounds it was less than 0.1 individual/$m^2$, and on the eastern side of the Ryūjin Bank fishing ground, no individuals were collected. The density of D. nippon and A. pectinifera was low - less than 0.1 individual/$m^2$ - but these species were widely distributed over the sea area surveyed, with the exception of the eastern side of the Ryūjin Bank. Because the numbers of individuals collected of the other species of sea stars were small, they are not shown in the table, and only one individual S. borealis each at st. 10 and st. 13 and one individual each of L. anthostictha and C. semiregularis at st. 10 were collected.

Fig. 3 shows the breakdown by arm length of the principal species of sea stars. The arm length of individual A. amurensis observed varied between 20 mm and 200 mm, and individuals with an arm length in the vicinity of 50 mm to 70 mm constituted a fairly high

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percentage. The breakdown by arm length of L. yesoensis shows a single mode centring around 60 to 70 mm. Two groups of D. nippon were observed, centring around 50 mm and 70 mm arm lengths. In the case of A. pectinifera, the percentage of individuals with an arm length of 40 mm was high.

2. Stomach Contents of Sea Stars

The stomach contents of sea stars observed this time are shown in Table 2. The number of individuals observed and the percentage of those accounted for by individuals with an empty stomach was 142 and 86.6% in the case of A. amurensis, 27 and 70.3% in the case of D. nippon, 463 and 14.8% in the case of L. yesoensis, and 23 and 73.9% in the case of A. pectinifera. In the case of L. yesoensis, the percentage of individuals in which food was found in the stomach was high. In the other species of sea stars, individuals with an empty stomach accounted for a high percentage - over 70%. In the case of A. amurensis, D. nippon and A. pectinifera, the number of shiomushi* that had been eaten was fairly large, and more than 0.6 shiomushi had been eaten per sea star. The L. yesoensis had eaten large numbers of bivalves; 9.6 bivalves had been eaten per individual L. yesoensis. In particular, the number of individual P. sybillae and M. chinensis that had been eaten was very large, 4.7 individuals [per sea star] in each case.

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*Translator's note: Transliteration of Japanese name. Search for Latin name unsuccessful.

Fig. 4 shows the percentage of individuals of the L. yesoensis population that had eaten P. sybillae and M. chinensis at the various survey points. P. sybillae had been eaten by 50 to 75% of L. yesoensis in the Notsuke Peninsula fishing ground and by over 80% of that species on the western side of the Ryūjin Bank fishing ground. In the case of M. chinensis, the percentage was low on the western side of the Notsuke Peninsula fishing ground and on the eastern side of the Ryūjin Bank fishing ground, but they had been eaten by 5 to 35% of L. yesoensis on the eastern side of the Notsuke Peninsula fishing ground and by over 80% of that species on the western side of the Ryūjin Bank fishing ground.

Fig. 5 shows the average number of individual P. sybillae and M. chinensis that had been eaten by L. yesoensis at each point. The number of individual P. sybillae eaten per individual L. yesoensis was small off the Notsuke Peninsula fishing ground, but between the Notsuke Peninsula fishing ground and the Ryūjin Bank fishing ground the number was 2.0 to 5.0, and on the western side of the Ryūjin Bank fishing ground the number was greater than 5. The number of individual M. chinensis eaten was less than 0.5 in the Notsuke Peninsula fishing ground, but in the Ryūjin Bank fishing ground the number was greater than 5.

3. Distribution of Juvenile P. sybillae and Juvenile M. chinensis

The distribution of juvenile P. sybillae and juvenile M. chinensis in this sea area was as shown in Fig. 6. With regard to juvenile P. sybillae, an average density of 52 individuals/$m^2$ was observed in the Notsuke Peninsula fishing ground, but in the area along

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the shore the density tended to be high. In the Ryūjin Bank fishing ground there were 26.6 individuals/$m^2$ on the western side, there were 90 individuals/$m^2$ in the central part, and none was observed on the eastern side. The distribution of juvenile M. chinensis was centred in the southwestern part of the Ryūjin Bank, and low-density distribution was observed off the Notsuke Peninsula fishing ground and on the eastern side of the Ryūjin Bank.

Fig. 7 shows the breakdown by shell length of P. sybillae and M. chinensis eaten by L. yesoensis and the breakdown by shell length of the juveniles of these two species in their natural habitat. The breakdown by shell length of P. sybillae observed in the stomach of L. yesoensis resembled the breakdown of the species in its natural habitat. Individuals with a shell length of 2 mm constituted a high percentage, and a small mode was observed also at 7 to 8 mm. In the case of M. chinensis as well, the breakdown by shell length of individuals found in the stomach of L. yesoensis resembled the breakdown for the natural population, and in both cases individuals with a shell length of 2 mm constituted a high percentage.

## Discussion

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In the benthic animal communities in areas with sandy bottoms such as fishing grounds for P. sybillae, sea stars are situated at the apex of the food web, and not only are they directly predatory on benthic animals, they are also competitive with animals such as flatfish, which use benthic animals for food [2)10)]. The percentage of individuals with an empty stomach was high - over 70% - in the case of

A. amurensis, D. nippon and A. pectinifera among the four species of sea stars whose stomach contents were observed this time, but individuals in whose stomach food was found had principally eaten shiomushi, and small crustaceans and bivalves were found only in small quantities. When these species eat large animals, however, they project their stomach outside their body to cover the prey, which they digest and absorb. Because they do not take the prey into the body, it was impossible, by the observation this time of only the stomach contents, to account for all of the animals that had been eaten. In particular, it is known that A. amurensis, which appeared in the highest concentrations, dig up and eat bivalves buried in the sand[5)6)], and in order to estimate the quantities of P. sybillae and M. chinensis eaten in this sea area, further study based on the observation of phenomena such as this type of feeding behaviour will be necessary. p. 136

On the other hand, because L. yesoensis ingest their food whole, the percentage of individuals with an empty stomach was low, 14.8%, and large quantities of food were observed in the stomach. Very large numbers of the food animals were juvenile P. sybillae and M. chinensis, and in addition to these two species, animals such as other bivalves, spiral-shelled molluscs, small crustaceans and polychaeta were observed in very small numbers. It is known that the animals eaten as food by the Luidea genus are principally echinoderms such as serpent's starfish[2)]. L. ciliaris is predatory on the sea stars Asterias rubens and A. glacialis[11)], L. clathrata is predatory on foraminifers and gastropods[12)], L. foliolata is predatory on serpent's starfish and scaphopods[2)], and on the sea cucumber Cucumaria lubrica

and the bivalve Protothaca staminea[13], and L. sarsi is predatory on the serpent's starfish Ophiura albida[14]. It is known that among species native to Japan, L. quinaria is predatory on serpent's starfish and polychaeta[15], but it is reported that L. yesoensis is predatory on shellfish[1)4)].

Of the stomach contents of L. yesoensis observed this time as well, bivalves constituted a high percentage, and with regard to echinoderms, only a small number of Scaphechinus griseus (Mortensen) were observed. The stomach contents were different from those found in other members of the genus Luidea.

It is clear that in the sea area surveyed this time the predatory behaviour of L. yesoensis is a factor in the decrease of P. sybillae and M. chinensis populations. Because the time required for the L. yesoensis to digest the bivalves is unclear, however, it is difficult to estimate the quantity of bivalves eaten by this species. It will be necessary to estimate the quantity of bivalves eaten on the basis of rearing experiments.

As described above, sea stars are predators of benthic animal populations in areas with sandy bottoms, and decreasing the quantity of this predation should also be a means of promoting the proliferation of useful benthic animals. For this purpose, not only capture by means of dredge nets but also the sprinkling of slaked lime[9)16)] and capture by means of traps[8)] are being contemplated. In addition, because seasonal p. 137 changes are observed in the feeding behaviour of sea stars, a method whereby bivalves would be released during periods when the feeding activity of sea stars is decreasing[17)] has been proposed. Because the

P. sybillae and M. chinensis eaten by the L. yesoensis observed this time were limited to small individuals, it is believed that the quantities of P. sybillae and M. chinensis eaten change as the animals grow. In order to study measures to prevent predation by sea stars, it is believed that these aspects of feeding behaviour and the quantities of bivalves eaten must be observed seasonally.

## Summary

Observations were made of the actual distribution of sea stars and of their predation of bivalves along the shore of Notsuke Peninsula at Bekkai-chō and on the Ryūjin Bank.

1. The density of sea stars was 0.397 individuals/$m^2$ in the Notsuke Peninsula fishing ground, and 0.168 individuals/$m^2$ in the Ryūjin Bank fishing ground.

2. Seven species of sea stars inhabit this sea area. It was found that the two species Asterias amurensis and Luidea yesoensis constitute over 90% of the total number, and that Distolasterias nippon, Asterina pectinifera, Solaster borealis, Lysatrosoma anthostictha and Certonardoa semiregularis combined constitute less than 6%.

3. When the stomach contents of the sea stars were observed, it was found that large numbers of shiomushi had been eaten by A. amurensis, D. nippon and A. pectinifera, and that 0.6 shiomushi had been eaten per sea star. In the case of L. yesoensis, the quantities of juvenile P. sybillae and juvenile M. chinensis eaten were large, in each case 4.7 individuals per sea star.

4. In the Notsuke Peninsula fishing ground, 50 to 75% of the L. yesoensis population had eaten juvenile P. sybillae, and 5 to 35% had eaten juvenile M. chinensis. On the western side of the Ryūjin Bank fishing ground, over 80% had eaten juvenile P. sybillae and juvenile M. chinensis.

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*Translator's note: The spellings of Japanese personal names given here indicate the probable readings of the names.

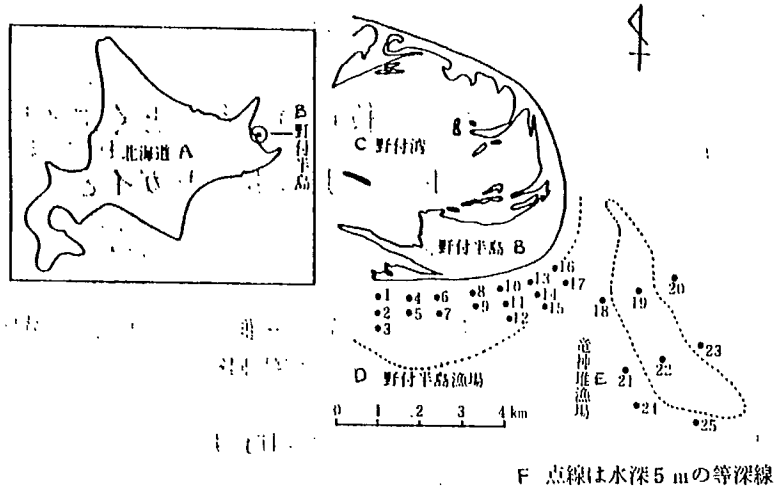
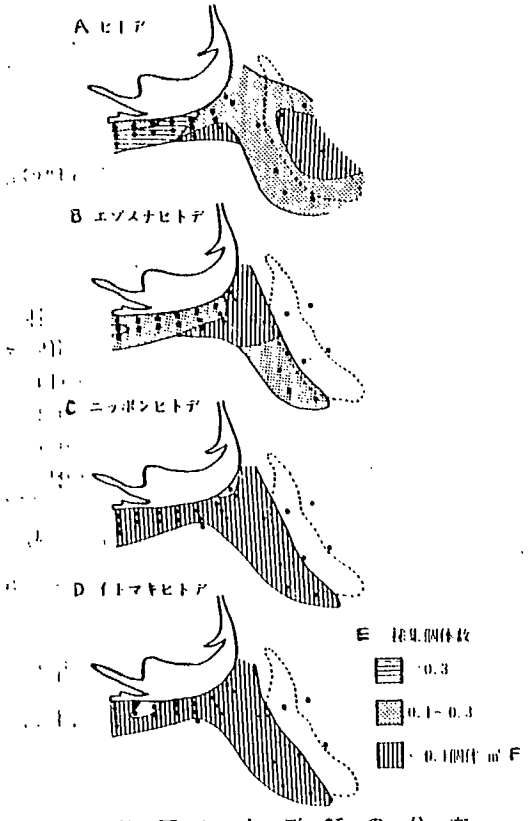



Fig. 1. Survey points 第1図 調 査 地 点

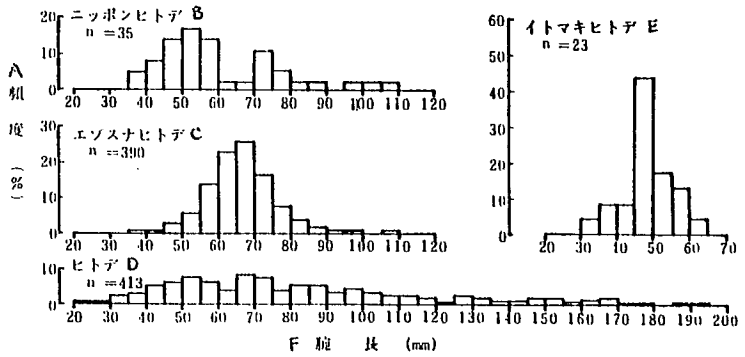
Key: A. Hokkaidō, B. Notsuke Peninsula, C. Notsuke Bay, D. Notsuke Peninsula fishing ground, E. Ryūjin Bank fishing ground, F. Dotted line is a contour line indicating a depth of 5 m.




第2図 ヒ ト デ 類 の 分 布

Fig. 2. Distribution of Sea Stars

Key: A. Asterias amurensis, B. Luidea yesoensis, C. Distolasterias nippon, D. Asterina pectinifera, E. Number of individuals collected, F. $<0.1$ individual/$m^2$.

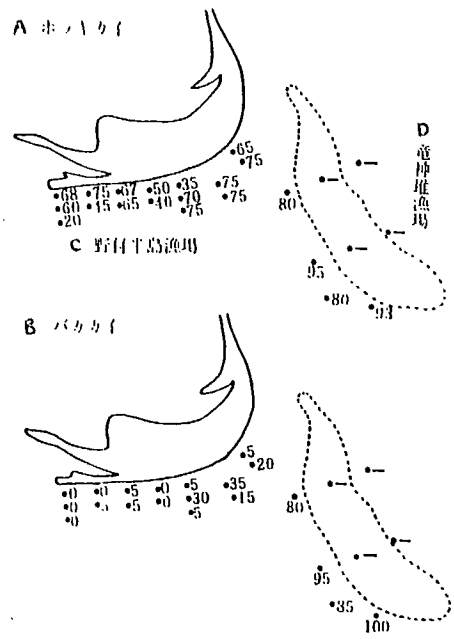



第3図 ヒトデ類の腕長組成

n＝測定個体数

Fig. 3: Breakdown by Arm Length of Sea Stars

Key: A. Frequency (%), B. Distolasterias nippon, C. Luidea yesoensis, D. Asterias amurensis, E. Asterina pectinifera, F. Arm length (mm), n. Number of individuals measured.

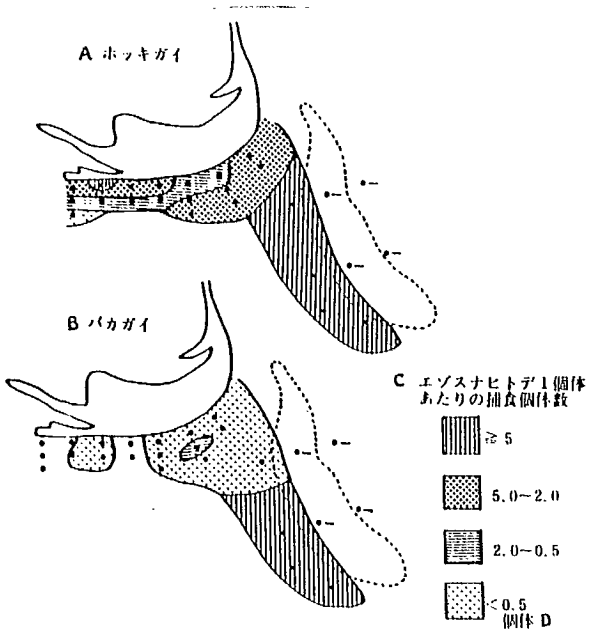



—はエゾスナヒトデが生息していない調査点

第4図 エゾスナヒトデ個体群中に占めるホッキガイとバカガイを捕食しているエゾスナヒトデの比率（%）

Fig. 4: Percentage of Total Luidea yesoensis Population That Had Eaten Pseudocardium sybillae and Mactra chinensis

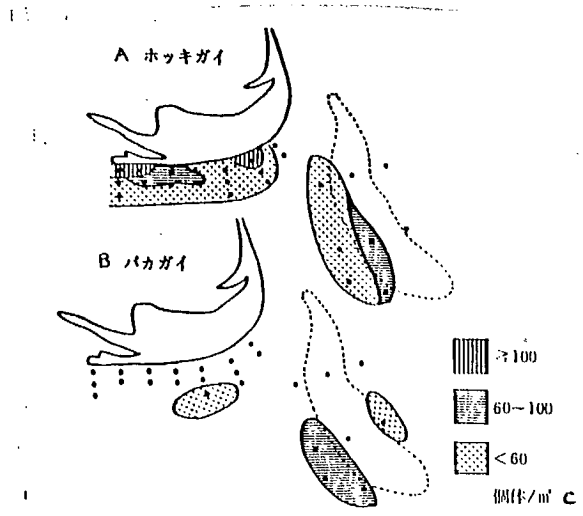
Key: A. Pseudocardium sybillae, B. Mactra chinensis, C. Notsuke Peninsula fishing ground, D. Ryūjin Bank fishing ground, – indicates a survey point at which Luidea yesoensis were not found.




第5図 エゾスナヒトデに捕食されているホッキガイとバカガイの個体数

Fig. 5: Numbers of Pseudocardium sybillae and Mactra chinensis Eaten by Luidea yesoensis

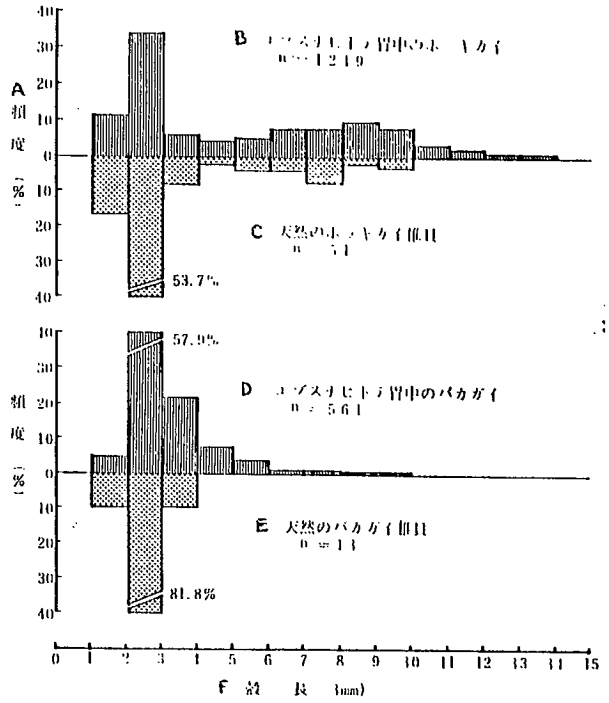
Key: A. Pseudocardium sybillae, B. Mactra chinensis, C. Number of individuals eaten per individual Luidea yesoensis, D. Individuals, - indicates a survey point at which Luidea yesoensis were not found.




第6図 ホッキガイ稚貝とバカガイ稚貝の分布

Fig. 6: Distribution of Juvenile Pseudocardium sybillae and Juvenile Mactra chinensis

Key: A. Pseudocardium sybillae, B. Mactra chinensis, C. Individuals/$m^2$.




nは測定個体数

第7図 エゾスナヒトデに捕食されたものと天然のホッキガイ稚貝とバカガイ稚貝の殻長組成

Fig. 7: Breakdown by Shell Length of Juvenile Pseudocardium sybillae and Juvenile Mactra chinensis Eaten by Luidea yesoensis and of Those Found in Their Natural Habitat

Key:

A. Frequency (%), B. Pseudocardium sybillae in the stomach of Luidea yesoensis, C. Juvenile Pseudocardium sybillae found in their natural habitat, D. Mactra chinensis in the stomach of Luidea yesoensis, E. Juvenile Mactra chinensis found in their natural habitat, F. Shell length (mm), n. Number of individuals measured.

Table 1: Density and Percentage Breakdown of Sea Stars

第1表 ヒトデ類の密度と編組比率

| A ヒトデの種類 | F 野付半島漁場 H 密度(個体/m²) | I 編組比率(%) | G 竜神堆漁場 H 密度(個体/m²) | I 編組比率(%) |
|---|---|---|---|---|
| B ヒトデ | 0.238 | 59.9 | 0.110 | 65.4 |
| C エゾスナヒトデ | 0.136 | 34.3 | 0.052 | 31.0 |
| D ニッポンヒトデ | 0.012 | 3.0 | 0.003 | 1.8 |
| E イトマキヒトデ | 0.011 | 2.8 | 0.003 | 1.8 |

Key:

A. Species of sea stars, B. Asterias amurensis, C. Luidea yesoensis, D. Distolasterias nippon, E. Asterina pectinifera, F. Notsuke Peninsula fishing ground, G. Ryūjin Bank fishing ground, H. Density (individuals/$m^2$), I. Percentage breakdown.

Table 2: Stomach Contents of Sea Stars

第2表 ヒトデ類の胃内容物

| A 胃内に出現する動物 | B 捕食個体数* | | | |
|---|---|---|---|---|
| | C ヒトデ | D ニッポンヒトデ | E エゾスナヒトデ | F イトマキヒトデ |
| G ホッキガイ | 0.315 | | 4.760 | |
| H バカガイ | 0.105 | 0.125 | 4.714 | |
| I オオミゾガイ | | | 0.403 | |
| J フリソデガイ | | | 0.015 | |
| K オオキヌラガイ | | 0.125 | | |
| L ビノスガイ | | | + | |
| M オオノガイ | | | + | |
| N ケショウシラトリガイ | | | + | |
| O エゾイソシジミ | | | + | |
| P ノミハマグリ | | | + | |
| Q 他の二枚貝類 | | | 0.037 | |
| R チシマタマガイ | | | + | |
| S タマツメタガイ | | | + | |
| T ハデクチキレ | | 0.125 | + | |
| U 他の巻貝類 | | 0.125 | 0.020 | |
| V シオムシ | 0.789 | 0.625 | 0.128 | 0.666 |
| W ヨコエビ類 | | | 0.017 | |
| X ワレカラ類 | | | + | |
| Y クマ類 | 0.052 | | + | |
| Z エビジャコ | 0.105 | | | |
| AA長尾類 | 0.105 | | + | 0.166 |
| BB クリガニ | | | + | |
| CC 短尾類 | | | 0.027 | |
| DD ハイイロハスノハカシパン | | | + | |
| EE ホヤ類 | | | + | |
| FF 多毛類 | | | 0.012 | |
| GG ヒモ形類 | | | + | |

*ヒトデ類の捕食個体数は、胃内容物を観察したヒトデ類のうち空胃個体を除くヒトデ類1個体あたりの平均捕食個体数。0.001未満は切り捨て、＋は0.001未満の頻度で出現したことを示す。

*The number of individuals eaten by sea stars is the average number of individuals eaten per sea star among the sea stars whose stomach contents were observed, excluding individuals with an empty stomach. Cases in which the figure was less than 0.001 were omitted, and + indicates cases in which the animal was found at a frequency less than 0.001.

Key:
A. Animals found in stomach, B. Number of individuals eaten*, C. Asterias amurensis, D. Distolasterias nippon, E. Luidea yesoensis, F. Asterina pectinifera, G. Pseudocardium sybillae, H. Mactra chinensis, L. Siliqua alta (Broderip et Sowerby), J. Yoldia (Cnesterium) notabilis Yokoyama, K. Acila divaricata (Hinds), L. Mercenaria stimpsoni (Gould), M. Mya (Arenomya) arenaria (?) oonogai Makiyama, N. Keshōshiratorigai**, O. Ezoisoshijimi**, P. Nomihamaguri**, Q. Other bivalves, R. Chishimatamagai**, S. Tamatsumetagai**,

**Transliteration of Japanese name. Search for Latin name unsuccessful.

T. Hadekuchikire **, U. Other spiral-shelled molluscs, V. Shiomushi**, W. Yokoebi**-like animals, X. Skeleton shrimp, Y. Kuma**-like animals, Z. Ebijako**, AA. Marcura, BB. Kurigani**, CC. Brachyura, DD. Scaphechinus mirabilis (A. Agassiz), EE. Ascidians, FF. Polychaeta, GG. Nemertea.

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**Transliteration of Japanese name. Search for Latin name unsuccessful.

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# ヒトデ類による二枚貝の捕食—とくにエゾスナヒトデによるホッキガイとバカガイの捕食

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ヒトデ類は一般に肉食性で、とくに二枚貝を捕食することが知られており[1)~6)]、有用二枚貝漁場に大きな被害をもたらしたり[7)]、アカガイやホタテガイでは種苗放流直後の減耗を大きくする要因となっている[8)9)]。このため、二枚貝の個体群動態を解明するには、ヒトデ類による被食量を明らかにする必要がある。また、有用二枚貝の漁場造成や種苗放流を行う場合には、当該海域におけるヒトデ類の分布や捕食行動について把握しておくべきであろう。

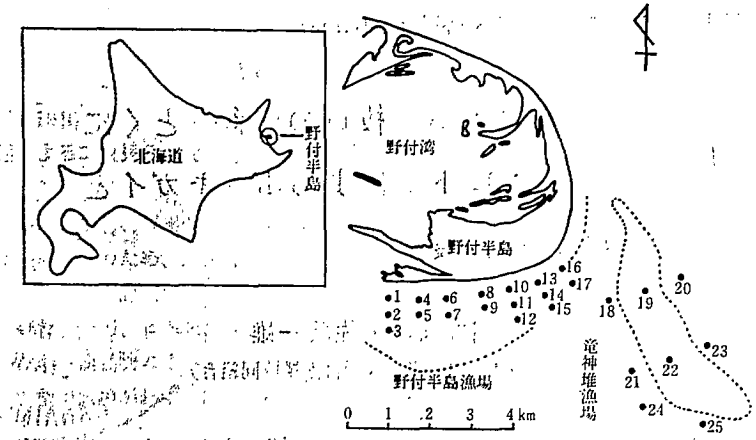
今回は、ホッキガイとバカガイの漁場となっている別海町の野付半島沿岸と竜神堆において、ヒトデ類の分布と胃の内容物を観察し、とくにエゾスナヒトデによるホッキガイとバカガイの被食の実態を明らかにした。

本文に入るに先立ち、この調査にご協力いただいた野付漁業協同組合、根室北部水産技術普及指導所、別海町水産課の関係諸氏に謝意を表する。

## 調査方法

調査海域は、根室海峡の中央部に存在する野付半島沿岸域とその南東に位置する水深2～5mの竜神堆周囲である（第1図）。この海域は、底質が細砂で水深5m以浅がホッキガイとバカガイの漁場となっている。

ヒトデ類は、1981年11月10日にホタテガイけた網を改良したヒトデ駆除用のけた網（けた幅2m、目合6cm）を用い、野付半島漁場（st. 1～17）では沿岸線と平行に、竜神堆漁場（st. 18～25）では東西方向に250mえい網して採集し




点線は水深5mの等深線

**第1図　調　査　地　点**

た。採集したヒトデ類は、種ごとに計数し、一部を腕長、湿重量、および胃内容物の観察に供した。とくに、エゾスナヒトデについては各地点20個体を10%フォルマリン固定して研究室に持ち帰り、胃内容物を観察した。この胃内容物は種ごとに計数し、ホッキガイとバカガイについてはスライディングキャリパーにより殻長を測定した。

また、この調査時のホッキガイ稚貝とバカガイ稚貝の分布を知るために、スミス・マッキンタイヤー採泥器（採集面積0.05㎡）を用いて採泥し、1㎜目合のふるいによりホッキガイとバカガイを底質から分離した。採集された。ホッキガイとバカガイは殻長を上記と同様の方法で測定した。

## 結　　果

### 1. ヒトデ類の分布

今回の調査で採集されたヒトデ類は、次の7種である。

ヒトデ　*Asterias amurensis*
ニッポンヒトデ　*Distolasterias nippon*
ユルヒトデ　*Lysatrosoma anthostictha*



エゾスナヒトデ　*Luidea yesoensis*
アカヒトデ　*Certonardoa semiregularis*
イトマキヒトデ　*Asterina pectinifera*
アカニチリンヒトデ　*Solaster borealis*

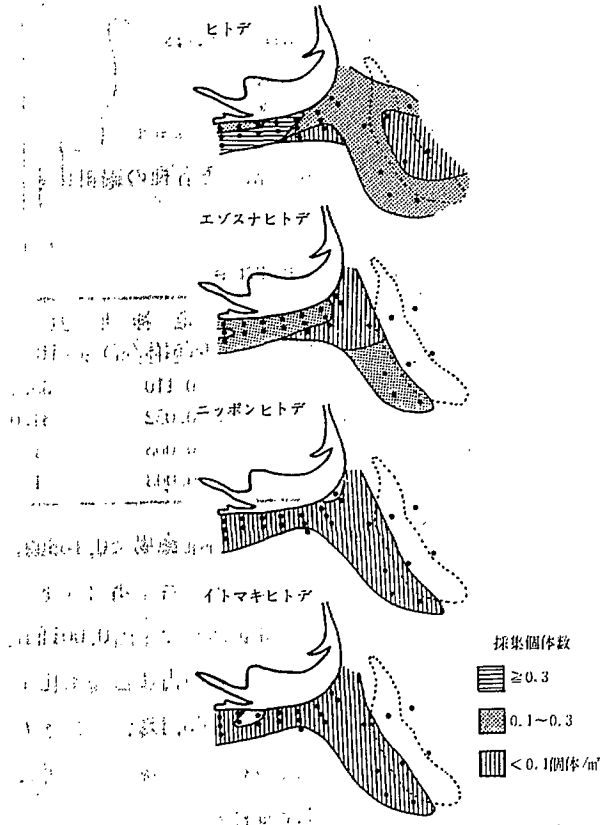
野付半島漁場と竜神堆漁場におけるヒトデ類の密度と各種の編組比率を第1表に示す。

**第1表　ヒトデ類の密度と編組比率**

| ヒトデの種類 | 野付半島漁場 | | 竜神堆漁場 | |
|---|---|---|---|---|
| | 密度(個体/㎡) | 編組比率(%) | 密度(個体/㎡) | 編組比率(%) |
| ヒトデ | 0.238 | 59.9 | 0.110 | 65.4 |
| エゾスナヒトデ | 0.136 | 34.3 | 0.052 | 31.0 |
| ニッポンヒトデ | 0.012 | 3.0 | 0.003 | 1.8 |
| イトマキヒトデ | 0.011 | 2.8 | 0.003 | 1.8 |

ヒトデ類の密度は、野付半島漁場で0.397個体/㎡、竜神堆漁場で0.168個体/㎡である。両漁場ともヒトデとエゾスナヒトデが高密度で、ニッポンヒトデとイトマキヒトデが低密度である。他のヒトデ類は、3種あわせても0.001個体/㎡未満なのでこの表から除外した。ヒトデ類のなかで各種の占める編組比率は、野付半島および竜神堆漁場でそれぞれヒトデが59.9%、65.4%、エゾスナヒトデが34.3%、31.0%で、この2種が90%以上を占める。ニッポンヒトデとイトマキヒトデはそれぞれ3.0%、1.8%と2.8%、1.8%である。

第2図にヒトデ類の分布の様相を示す。ヒトデは調査海域の全域に出現し、多くの調査地点で0.1～0.3個体/㎡であるが、野付半島漁場東側の沖合に0.3個体/㎡以上の高密度域があり、竜神堆中央部は0.1個体/㎡未満である。エゾスナヒトデは野付半島漁場の西側と竜神堆漁場の南西側で0.1～0.3個体/㎡、両漁場の中間域で0.1個体/㎡未満、竜神堆漁場の東側からは採集されなかった。ニッポンヒトデとイトマキヒトデは0.1個体/㎡未満の低密度ではあるが、竜神堆東側を除く調査海域に広く分布している。他のヒトデ類は採集個体が少ないので図示していないが、アカニチリンヒトデが st. 10と st. 13 で、ユルヒトデとアカヒトデは st. 10でそれぞれ1個体採集されたのみである。



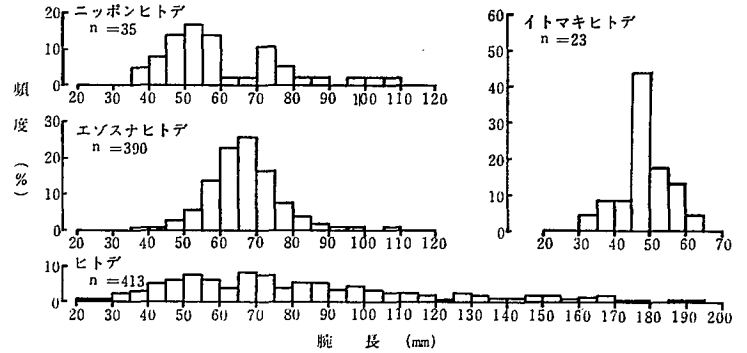

第2図 ヒトデ類の分布

第3図に主なヒトデ類の腕長組成を示す。ヒトデは腕長20㎜から 200㎜までの個体がみられ、腕長50㎜、70㎜付近の個体がやや高率である。エゾスナヒトデは60~70㎜を中心した単一モードの腕長組成を示している。ニッポンヒトデは腕長50㎜と70㎜を中心とした2群が認められる。イトマキヒトデは腕長40㎜台の比率が高い。

2. ヒトデ類の胃内容物

今回観察したヒトデ類の胃内容物を第2表に示す。観察した個体数およびその中に占める空胃個体の比率は、それぞれヒトデが142個体と 86.6%、ニッポ






第3図 ヒトデ類の腕長組成

n＝測定個体数

ンヒトデが27個体と70.3%、エゾスナヒトデが 463個体と14.8%、イトマキヒトデが23個体と73.9%である。エゾスナヒトデは餌が胃中に存在していた個体の比率が高い。他のヒトデ類は空胃個体の比率が70%以上と高率を占める。ヒトデ、ニッポンヒトデおよびイトマキヒトデはシオムシの捕食個体数がやや多く、1個体あたり 0.6個体以上のシオムシを捕食している。エゾスナヒトデは二枚貝を多く食べており、1個体あたり 9.6個体捕食している。とくにホッキガイとエゾバカガイ捕食個体数が非常に多く、両者ともとそれぞれ 4.7個体捕食している。

第4図に各調査地点のエゾスナヒトデ個体群中に占めるホッキガイとバカガイを捕食している個体の比率を示す。ホッキガイは野付半島漁場で50~75%、竜神堆漁場の西側で80%以上のエゾスナヒトデにより捕食されている。バカガイは、野付半島漁場西側と竜神堆漁場東側では低率であるが、野付半島漁場の東側では5~35%、竜神堆漁場の西側では80%以上のエゾスナヒトデにより捕食されている。

第5図に、エゾスナヒトデによって捕食されたホッキガイとバカガイの平均個体数を地点ごとに示した。エゾスナヒトデ1個体に捕食されているホッキガイの被食個体数は、野付半島漁場の沖合で少ないが、野付半島漁場と竜神堆漁場の中間で2.0~5.0個体、竜神堆漁場西側で5個体を上回っている。バカガイ

第2表 ヒトデ類の胃内容物

| 胃内に出現する動物 | 捕食個体数* | | | |
|---|---|---|---|---|
| | ヒトデ | ニッポンヒトデ | エゾスナヒトデ | イトマキヒトデ |
| ホッキガイ | 0.315 | | 4.760 | |
| バカガイ | 0.105 | 0.125 | 4.714 | |
| オオミゾガイ | | | 0.103 | |
| フリソデガイ | | | 0.015 | |
| オオキララガイ | | 0.125 | | |
| ビノスガイ | | | + | |
| オオノガイ | | | + | |
| ケショウシラトリガイ | | | + | |
| エゾイソシジミ | | | + | |
| ノミハマグリ | | | + | |
| 他の二枚貝類 | | | 0.037 | |
| チシマタマガイ | | | + | |
| タマツメタガイ | | | + | |
| ハデクチキレ | | 0.125 | + | |
| 他の巻貝類 | | 0.125 | 0.020 | |
| ツオムシ | 0.789 | 0.625 | 0.128 | 0.666 |
| ヨコエビ類 | | | 0.017 | |
| ワレカラ類 | | | + | |
| クマ類 | 0.052 | | + | |
| エビジャコ | 0.105 | | | |
| 長尾類 | 0.105 | | + | 0.166 |
| クリガニ | | | + | |
| 短尾類 | | | 0.027 | |
| ハイイロハスノハカシパン | | | + | |
| ホヤ類 | | | + | |
| 多毛類 | | | 0.012 | |
| ヒモ形類 | | | + | |

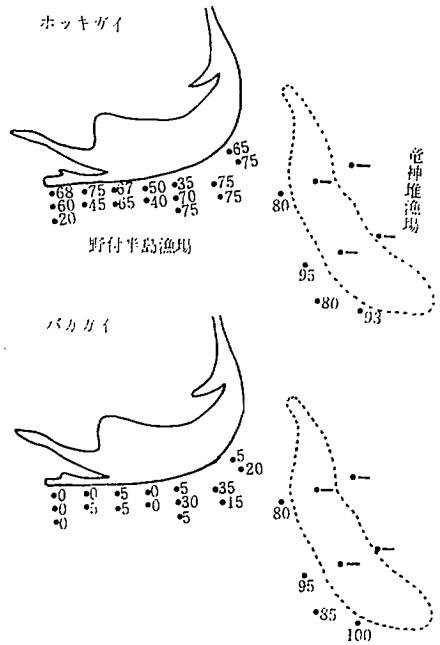
*ヒトデ類の捕食個体数は、胃内容物を観察したヒトデ類のうち空胃個体を除くヒトデ類1個体あたりの平均捕食個体数。0.001未満は切り捨て、+は0.001未満の頻度で出現したことを示す。

の被食個体数は野付半島漁場で 0.5個体未満であるが、竜神堆漁場では5個体以上である。

3) ホッキガイ稚貝とバカガイ稚貝の分布

この海域のホッキガイ稚貝とバカガイ稚貝の分布は、第6図に示すとおりで



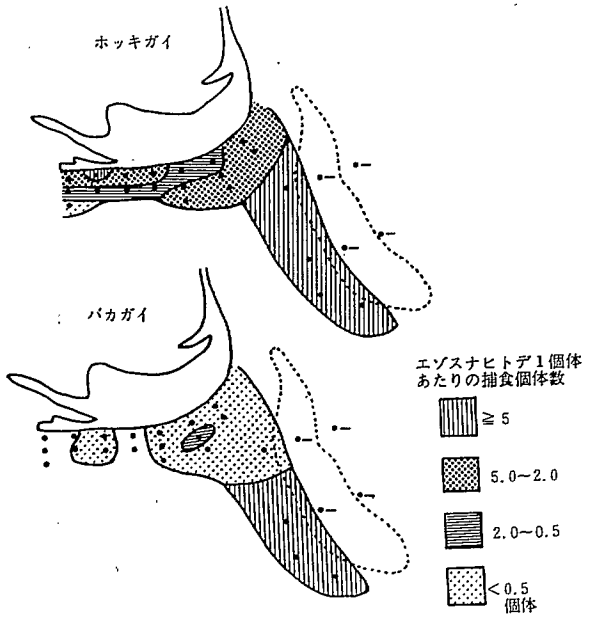



—はエゾスナヒトデが生息していない調査点

第4図 エゾスナヒトデ個体群中に占めるホッキガイとバカガイを捕食しているエゾスナヒトデの比率（%）

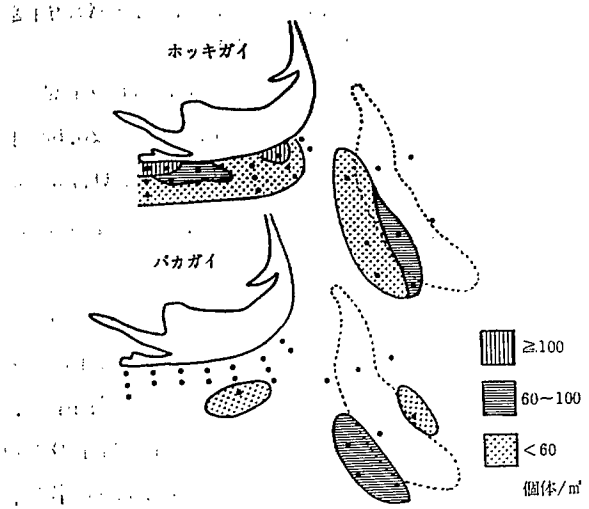
ある。ホッキガイ稚貝は野付半島漁場では平均52個体/m² の生息がみられるが沿岸域で密度が高い傾向がある。竜神堆漁場では、西側で 26.6個体/m²、中央部で90個体/m²、東側では生息がみられない。バカガイ稚貝は竜神堆南西部に分布の中心があり、野付半島漁場沖合と竜神堆東側に低密度の分布がみられる。

第7図に、エゾスナヒトデに捕食されたホッキガイおよびバカガイの殻長組成と両種の天然稚貝の殻長組成を示した。エゾスナヒトデ胃中にみられたホッキガイの殻長組成は、天然のものと類似し、2㎜台の個体が高率で、7～8㎜にも小さなモードがみられる。バカガイもエゾスナヒトデ胃中のものと天然の個体群の殻長組成は類似しており、両者とも2㎜台の個体が高率を占めている。



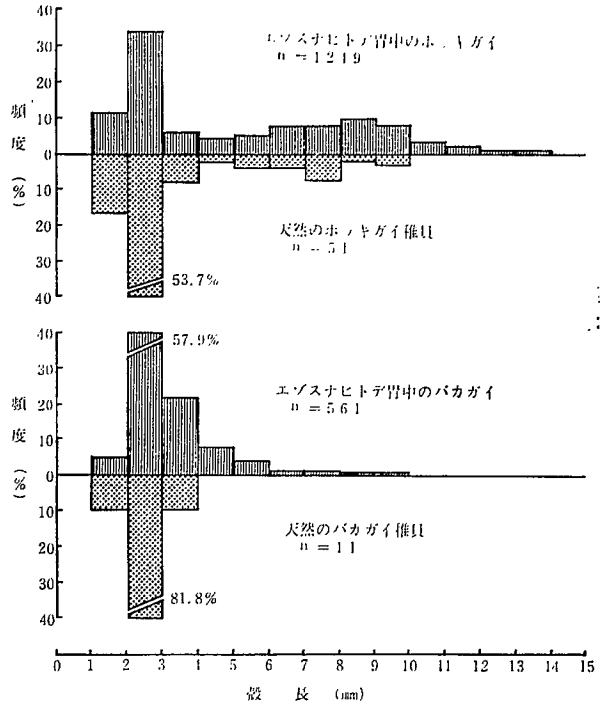

—はエゾスナヒトデが生息していない調査点

**第5図　エゾスナヒトデに捕食されているホッキガイとバカガイの個体数**




**第6図　ホッキガイ稚貝とバカガイ稚貝の分布**






nは測定個体数

**第7図　エゾスナヒトデに捕食されたものと天然のホッキガイ稚貝とバカガイ稚貝の殻長組成**

## 考　　察

ホッキガイ漁場のような砂底域の底生動物群集のなかで、ヒトデ類は食物網の頂点に位置する動物で、底生動物を直接捕食するばかりでなく、底生動物を餌とするカレイ類などの競合種ともなっている[2)10)]。今回胃内容物を観察した4種のヒトデ類のうち、ヒトデ、ニッポンヒトデ、イトマキヒトデは空胃個体の比率が70%以上と高く、胃内に餌料がみられる個体はシオムシを主に捕食し小型甲殻類と二枚貝類がわずかにみられる程度である。しかし、これらの種は大型の餌を捕食する際には胃を体外に出してこれを覆うようにして消化吸収し、

体内にとり込まないので今回の胃内容物だけの観察では餌料動物のすべてを明らかにすることはできない。とくに、最も高密度に出現したヒトデは潜砂状態の二枚貝を掘り出して捕食することが知られており[5)6)]、この海域におけるホッキガイとバカガイの被食量の推定のためには、この種の摂餌行動の観察などからさらに検討する必要があろう。

一方、エゾスナヒトデは餌をまるごとのみ込むため、空胃個体の比率が14.8％と低く、捕食した餌が胃内に多数みられる。餌動物はホッキガイとバカガイの稚貝が非常に多く、この2種以外では他の二枚貝、巻貝、小型甲殻類、多毛類などがわずかにみられた。*Luidea* 属の餌動物は主としてクモヒトデ類などの棘皮動物であることが知られている[2)]。*Luidea ciliaris* は、ヒトデ類の *Asterias rubens* と *A. glacialis* を[11)]、*L. clathrata* は有孔虫と腹足類を[12)]、*L. foliolata* はクモヒトデ類と掘足類や[2)]、ナマコ類の *Cucumaria lubrica* と二枚貝の *Protothaca staminea* を[13)]、*L. sarsi* はクモヒトデ類の *Ophiura albida* を[14)]捕食している。日本産のものでは、スナヒトデ *L. quinaria* はクモヒトデ類と多毛類を捕食することが知られているが[15)]、エゾスナヒトデは貝類を捕食することが報告されている[1)4)]。

今回観察したエゾスナヒトデの胃内容物も二枚貝が高率を占め、棘皮動物はハイイロハスノハカシパンがわずかにみられたにすぎず、他の *Luidea* 属のものとは胃内容物が異なっていた。

今回の調査海域においては、エゾスナヒトデの捕食行動はホッキガイとバカガイ個体群の減耗要因となることは明らかである。しかし、エゾスナヒトデが捕食した二枚貝の消化に要する時間が明らかでないのでこの種による二枚貝被食量の推定は困難である。今後、飼育実験により二枚貝捕食の量的な推定をする必要があろう。

これまで述べてきたように、ヒトデ類は砂底域における底生動物個体群の捕食者となっており、この捕食量を少なくすることが有用な底生動物の増殖を図るための手段ともなろう。このためには、けた網による採捕ばかりではなく、消石灰の散布[9)16)]、トラップ採捕[8)]が考えられているほか、ヒトデ類の摂餌行動に季節変化がみられることから、二枚貝をヒトデ類の摂餌活動が低下する時期に放流する方法[17)]が提案されている。今回観察したエゾスナヒトデが捕食しているホッキガイとバカガイの大きさが小型のものに限定されているので、ホッキガイやバカガイの被食量は成長にともない変化するとも考えられる。ヒトデ類の食害防止策を検討するためにはこれらの摂餌行動や二枚貝の捕食量を季節的に観察することが必要と考える。



## 要　　約

別海町の野付半島沿岸と竜神堆においてヒトデ類の分布と二枚貝捕食の実態について観察した。

1. ヒトデ類の密度は野付半島漁場で 0.397個体/m²、竜神堆漁場で0.168個体/m²であった。

2. この海域には7種のヒトデ類が生息し、その編組比率はヒトデとエゾスナヒトデの2種で90％以上を占め、ニッポンヒトデ、イトマキヒトデ、アカニチリンヒトデ、ユルヒトデ、アカヒトデはあわせて6％未満であった。

3. ヒトデ類の胃内容物を観察した結果、ヒトデ、ニッポンヒトデ、イトマキヒトデはシオムシの捕食個体数が多く、1個体あたり 0.6個体のシオムシを捕食していた。エゾスナヒトデはホッキガイ稚貝とバカガイ稚貝の捕食量が多く、それぞれ 4.7個体捕食していた。

4. 野付半島漁場ではエゾスナヒトデ個体群の50～75％がホッキガイ稚貝を、5～35％がバカガイ稚貝を捕食し、竜神堆漁場西側では、80％以上がホッキガイ稚貝とバカガイ稚貝を捕食していた。

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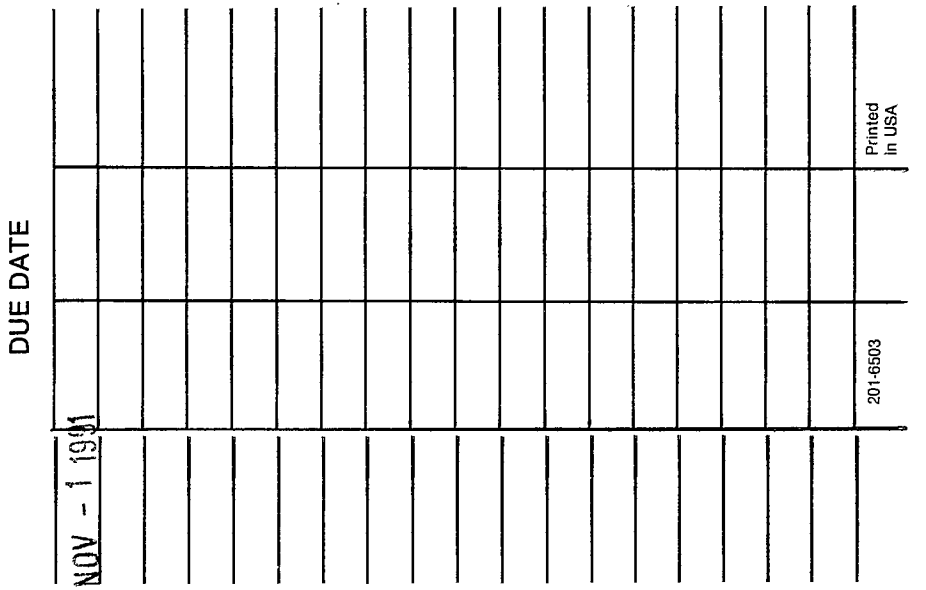


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# Predation of Bivalves by Sea Stars, with Special Reference to the Predation of Pseudocardium sybillae and Mactra chinensis by Luidea yesoensis

by Noriyoshi TAKAMARU (Kushiro Fisheries Experimental Station)
and Ichio SATO (Notsuke Fishermen's Cooperative Association)

Sea stars are generally carnivorous, and are known to be predators of bivalves in particular[1) ~ 6)], they cause considerable damage to fishing grounds for useful bivalves[7)], and are a factor causing large decreases in the numbers of seed Anadara broughtonii and Patinopecten yesoensis immediately after their release[8)9)]. Therefore, in order to shed light on the movement of bivalve populations, it is necessary to determine the quantities eaten by sea stars. In addition, when creating fishing grounds for useful bivalves or releasing seeds, one should first have an understanding of the distribution and predatory behaviour of sea stars in the sea area concerned.

This time, the distribution and the stomach contents of sea stars were observed along the shore of Notsuke Peninsula at Bekkai-chō and on the Ryūjin Bank, which are fishing grounds for Pseudocardium sybillae and Mactra chinensis, and greater understanding of the predation of P. sybillae and M. chinensis by Luidea yesoensis in particular was obtained.

Before proceeding with this report, the authors would like to express their gratitude to persons connected with the Notsuke Fishermen's Cooperative Association, the Nemuro North Guidance Centre for the Dissemination of Fisheries Technology, and the Bekkai-chō Fisheries Section who cooperated in this survey.

## Survey Methods

The sea areas surveyed were the area along the shore of Notsuke Peninsula in the central part of the Nemuro Strait and the vicinity of the Ryūjin Bank, 2 to 5 m deep, situated to the southeast of it (Fig. 1). This sea area is a fishing ground for P. sybillae and M. chinensis with a depth of 5 m and a substrate of fine sand.

The sea stars were collected on November 10, 1981 by means of a dredge net (width of beam 2 m, mesh 6 cm) for the extermination of sea stars - modified from a P. yesoensis dredge net - which was towed 250 m parallel to the shoreline in the Notsuke Peninsula fishing ground (st. 1 to 17) and in an east-west direction in the Ryūjin Bank fishing ground (st. 18 to 25). The sea stars collected were sorted by species and counted, and for some of the specimens the length of the arms, the wet weight and the contents of the stomach were determined. In the case of L. yesoensis in particular, 20 individuals collected at each

point were fixed in 10% Formalin and brought to the laboratory, where the stomach contents were observed. The stomach contents were sorted by species and counted, and for P. sybillae and M. chinensis the shell length was measured by means of a sliding caliper.

In addition, in order to determine the distribution of juvenile P. sybillae and juvenile M. chinensis at the time of this survey, samples of the substrate were obtained by means of a Smith-McIntyre bottom sampler (collection area: 0.05 $m^2$), and the P. sybillae and M. chinensis were separated from the substrate by means of a 1 mm mesh sieve. These were collected, and the shell length of the P. sybillae and the M. chinensis was measured by the above-mentioned method.

## Results

### 1. Distribution of Sea Stars

The sea stars collected during this survey belonged to the following seven species: Asterias amurensis, Distolasterias nippon, Lysatrosoma anthostictha, Luidea yesoensis, Certonardoa semiregularis, Asterina pectinifera and Solaster borealis. p. 129

The densities and the percentages accounted for by the various species of sea stars in the Notsuke Peninsula fishing ground and the Ryūjin Bank fishing ground are shown in Table 1. The density of the sea stars was 0.397 individuals/$m^2$ in the Notsuke Peninsula fishing ground and 0.168 individuals/$m^2$ in the Ryūjin Bank fishing ground. In both fishing grounds the density of A. amurensis and L. yesoensis was high, and that of D. nippon and A. pectinifera was low. The other three species of sea stars were excluded from this table because their combined density was less than 0.001 individual/$m^2$. With regard to

the percentages accounted for by the various species of sea stars in the Notsuke Peninsula and Ryūjin Bank fishing grounds, A. amurensis constituted 59.9% and 65.4% respectively, and L. yesoensis 34.3% and 31.0%. These two species accounted for more than 90% of the total. D. nippon constituted 3.0% and 1.8% respectively, and A. pectinifera 2.8% and 1.8%.

Fig. 2 shows the distribution of sea stars. Sea stars were found over the entire sea area surveyed, and at many of the survey points there were 0.1 to 0.3 individuals/$m^2$, but there was a high-density area with more than 0.3 individuals/$m^2$ to the east of the Notsuke Peninsula fishing ground. At the centre of the Ryūjin Bank the density was less than 0.1 individual/$m^2$. The density of L. yesoensis was 0.1 to 0.3 individuals/$m^2$ on the western side of the Notsuke Peninsula fishing ground and on the southwestern side of the Ryūjin Bank fishing ground, in the area between the two fishing grounds it was less than 0.1 individual/$m^2$, and on the eastern side of the Ryūjin Bank fishing ground, no individuals were collected. The density of D. nippon and A. pectinifera was low - less than 0.1 individual/$m^2$ - but these species were widely distributed over the sea area surveyed, with the exception of the eastern side of the Ryūjin Bank. Because the numbers of individuals collected of the other species of sea stars were small, they are not shown in the table, and only one individual S. borealis each at st. 10 and st. 13 and one individual each of L. anthostictha and C. semiregularis at st. 10 were collected.

Fig. 3 shows the breakdown by arm length of the principal species of sea stars. The arm length of individual A. amurensis observed varied between 20 mm and 200 mm, and individuals with an arm length in the vicinity of 50 mm to 70 mm constituted a fairly high

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percentage. The breakdown by arm length of L. yesoensis shows a single mode centring around 60 to 70 mm. Two groups of D. nippon were observed, centring around 50 mm and 70 mm arm lengths. In the case of A. pectinifera, the percentage of individuals with an arm length of 40 mm was high.

2. Stomach Contents of Sea Stars

The stomach contents of sea stars observed this time are shown in Table 2. The number of individuals observed and the percentage of those accounted for by individuals with an empty stomach was 142 and 86.6% in the case of A. amurensis, 27 and 70.3% in the case of D. nippon, 463 and 14.8% in the case of L. yesoensis, and 23 and 73.9% in the case of A. pectinifera. In the case of L. yesoensis, the percentage of individuals in which food was found in the stomach was high. In the other species of sea stars, individuals with an empty stomach accounted for a high percentage - over 70%. In the case of A. amurensis, D. nippon and A. pectinifera, the number of shiomushi* that had been eaten was fairly large, and more than 0.6 shiomushi had been eaten per sea star. The L. yesoensis had eaten large numbers of bivalves; 9.6 bivalves had been eaten per individual L. yesoensis. In particular, the number of individual P. sybillae and M. chinensis that had been eaten was very large, 4.7 individuals [per sea star] in each case.

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*Translator's note: Transliteration of Japanese name. Search for Latin name unsuccessful.

Fig. 4 shows the percentage of individuals of the L. yesoensis population that had eaten P. sybillae and M. chinensis at the various survey points. P. sybillae had been eaten by 50 to 75% of L. yesoensis in the Notsuke Peninsula fishing ground and by over 80% of that species on the western side of the Ryūjin Bank fishing ground. In the case of M. chinensis, the percentage was low on the western side of the Notsuke Peninsula fishing ground and on the eastern side of the Ryūjin Bank fishing ground, but they had been eaten by 5 to 35% of L. yesoensis on the eastern side of the Notsuke Peninsula fishing ground and by over 80% of that species on the western side of the Ryūjin Bank fishing ground.

Fig. 5 shows the average number of individual P. sybillae and M. chinensis that had been eaten by L. yesoensis at each point. The number of individual P. sybillae eaten per individual L. yesoensis was small off the Notsuke Peninsula fishing ground, but between the Notsuke Peninsula fishing ground and the Ryūjin Bank fishing ground the number was 2.0 to 5.0, and on the western side of the Ryūjin Bank fishing ground the number was greater than 5. The number of individual M. chinensis eaten was less than 0.5 in the Notsuke Peninsula fishing ground, but in the Ryūjin Bank fishing ground the number was greater than 5.

3. Distribution of Juvenile P. sybillae and Juvenile M. chinensis

The distribution of juvenile P. sybillae and juvenile M. chinensis in this sea area was as shown in Fig. 6. With regard to juvenile P. sybillae, an average density of 52 individuals/$m^2$ was observed in the Notsuke Peninsula fishing ground, but in the area along

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the shore the density tended to be high. In the Ryūjin Bank fishing ground there were 26.6 individuals/$m^2$ on the western side, there were 90 individuals/$m^2$ in the central part, and none was observed on the eastern side. The distribution of juvenile M. chinensis was centred in the southwestern part of the Ryūjin Bank, and low-density distribution was observed off the Notsuke Peninsula fishing ground and on the eastern side of the Ryūjin Bank.

Fig. 7 shows the breakdown by shell length of P. sybillae and M. chinensis eaten by L. yesoensis and the breakdown by shell length of the juveniles of these two species in their natural habitat. The breakdown by shell length of P. sybillae observed in the stomach of L. yesoensis resembled the breakdown of the species in its natural habitat. Individuals with a shell length of 2 mm constituted a high percentage, and a small mode was observed also at 7 to 8 mm. In the case of M. chinensis as well, the breakdown by shell length of individuals found in the stomach of L. yesoensis resembled the breakdown for the natural population, and in both cases individuals with a shell length of 2 mm constituted a high percentage.

## Discussion

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In the benthic animal communities in areas with sandy bottoms such as fishing grounds for P. sybillae, sea stars are situated at the apex of the food web, and not only are they directly predatory on benthic animals, they are also competitive with animals such as flatfish, which use benthic animals for food [2)10)]. The percentage of individuals with an empty stomach was high - over 70% - in the case of

A. amurensis, D. nippon and A. pectinifera among the four species of sea stars whose stomach contents were observed this time, but individuals in whose stomach food was found had principally eaten shiomushi, and small crustaceans and bivalves were found only in small quantities. When these species eat large animals, however, they project their stomach outside their body to cover the prey, which they digest and absorb. Because they do not take the prey into the body, it was impossible, by the observation this time of only the stomach contents, to account for all of the animals that had been eaten. In particular, it is known that A. amurensis, which appeared in the highest concentrations, dig up and eat bivalves buried in the sand[5)6)], and in order to estimate the quantities of P. sybillae and M. chinensis eaten in this sea area, further study based on the observation of phenomena such as this type of feeding behaviour will be necessary. p. 136

On the other hand, because L. yesoensis ingest their food whole, the percentage of individuals with an empty stomach was low, 14.8%, and large quantities of food were observed in the stomach. Very large numbers of the food animals were juvenile P. sybillae and M. chinensis, and in addition to these two species, animals such as other bivalves, spiral-shelled molluscs, small crustaceans and polychaeta were observed in very small numbers. It is known that the animals eaten as food by the Luidea genus are principally echinoderms such as serpent's starfish[2)]. L. ciliaris is predatory on the sea stars Asterias rubens and A. glacialis[11)], L. clathrata is predatory on foraminifers and gastropods[12)], L. foliolata is predatory on serpent's starfish and scaphopods[2)], and on the sea cucumber Cucumaria lubrica

and the bivalve Protothaca staminea[13], and L. sarsi is predatory on the serpent's starfish Ophiura albida[14]. It is known that among species native to Japan, L. quinaria is predatory on serpent's starfish and polychaeta[15], but it is reported that L. yesoensis is predatory on shellfish[1)4)].

Of the stomach contents of L. yesoensis observed this time as well, bivalves constituted a high percentage, and with regard to echinoderms, only a small number of Scaphechinus griseus (Mortensen) were observed. The stomach contents were different from those found in other members of the genus Luidea.

It is clear that in the sea area surveyed this time the predatory behaviour of L. yesoensis is a factor in the decrease of P. sybillae and M. chinensis populations. Because the time required for the L. yesoensis to digest the bivalves is unclear, however, it is difficult to estimate the quantity of bivalves eaten by this species. It will be necessary to estimate the quantity of bivalves eaten on the basis of rearing experiments.

As described above, sea stars are predators of benthic animal populations in areas with sandy bottoms, and decreasing the quantity of this predation should also be a means of promoting the proliferation of useful benthic animals. For this purpose, not only capture by means of dredge nets but also the sprinkling of slaked lime[9)16)] and capture by means of traps[8)] are being contemplated. In addition, because seasonal changes are observed in the feeding behaviour of sea stars, a method whereby bivalves would be released during periods when the feeding activity of sea stars is decreasing[17)] has been proposed. Because the

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P. sybillae and M. chinensis eaten by the L. yesoensis observed this time were limited to small individuals, it is believed that the quantities of P. sybillae and M. chinensis eaten change as the animals grow. In order to study measures to prevent predation by sea stars, it is believed that these aspects of feeding behaviour and the quantities of bivalves eaten must be observed seasonally.

## Summary

Observations were made of the actual distribution of sea stars and of their predation of bivalves along the shore of Notsuke Peninsula at Bekkai-chō and on the Ryūjin Bank.

1. The density of sea stars was 0.397 individuals/$m^2$ in the Notsuke Peninsula fishing ground, and 0.168 individuals/$m^2$ in the Ryūjin Bank fishing ground.

2. Seven species of sea stars inhabit this sea area. It was found that the two species Asterias amurensis and Luidea yesoensis constitute over 90% of the total number, and that Distolasterias nippon, Asterina pectinifera, Solaster borealis, Lysatrosoma anthostictha and Certonardoa semiregularis combined constitute less than 6%.

3. When the stomach contents of the sea stars were observed, it was found that large numbers of shiomushi had been eaten by A. amurensis, D. nippon and A. pectinifera, and that 0.6 shiomushi had been eaten per sea star. In the case of L. yesoensis, the quantities of juvenile P. sybillae and juvenile M. chinensis eaten were large, in each case 4.7 individuals per sea star.

4. In the Notsuke Peninsula fishing ground, 50 to 75% of the L. yesoensis population had eaten juvenile P. sybillae, and 5 to 35% had eaten juvenile M. chinensis. On the western side of the Ryūjin Bank fishing ground, over 80% had eaten juvenile P. sybillae and juvenile M. chinensis.

## Literature


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*Translator's note: The spellings of Japanese personal names given here indicate the probable readings of the names.

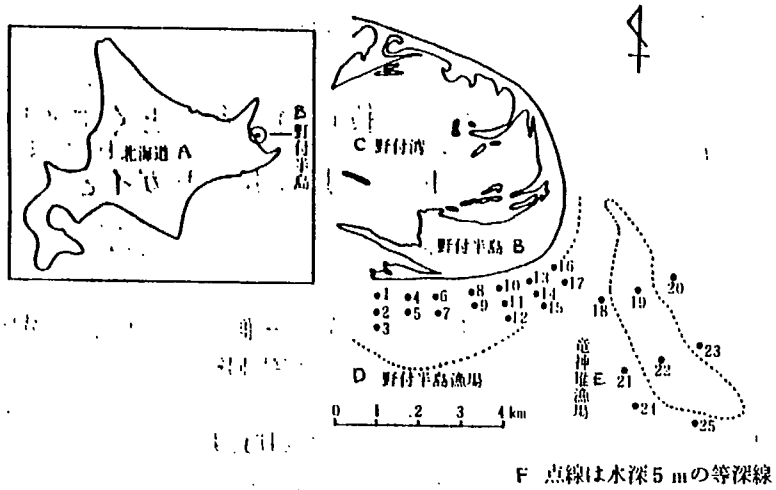


Fig. 1. Survey points 第1図 調 査 地 点

Key: A. Hokkaidō, B. Notsuke Peninsula, C. Notsuke Bay, D. Notsuke Peninsula fishing ground, E. Ryūjin Bank fishing ground, F. Dotted line is a contour line indicating a depth of 5 m.

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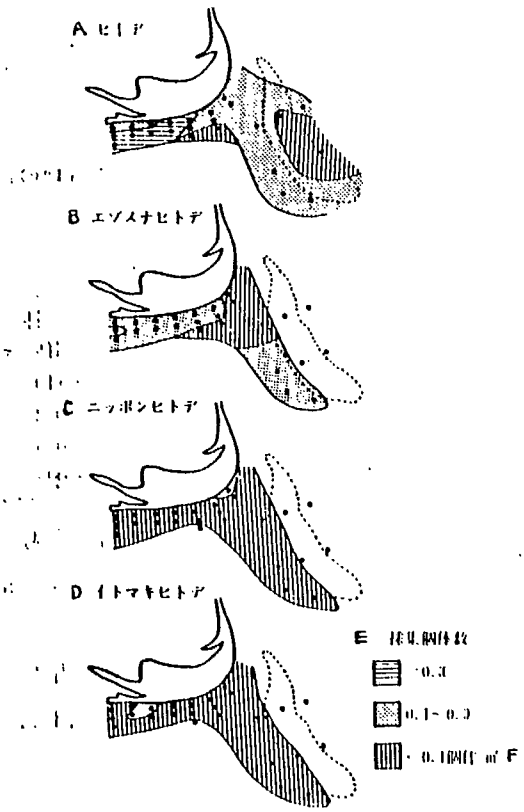
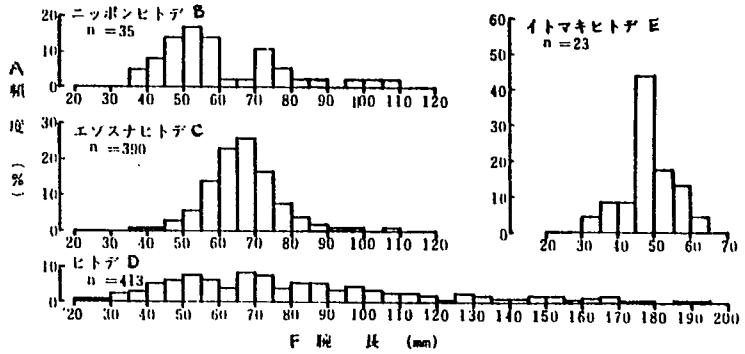



第2図 ヒ ト デ 類 の 分 布

Fig. 2. Distribution of Sea Stars

Key: A. Asterias amurensis, B. Luidea yesoensis, C. Distolasterias nippon, D. Asterina pectinifera, E. Number of individuals collected, F. $<0.1$ individual/$m^2$.




第3図 ヒトデ類の腕長組成

n＝測定個体数

Fig. 3: Breakdown by Arm Length of Sea Stars

Key: A. Frequency (%), B. Distolasterias nippon, C. Luidea yesoensis, D. Asterias amurensis, E. Asterina pectinifera, F. Arm length (mm), n. Number of individuals measured.

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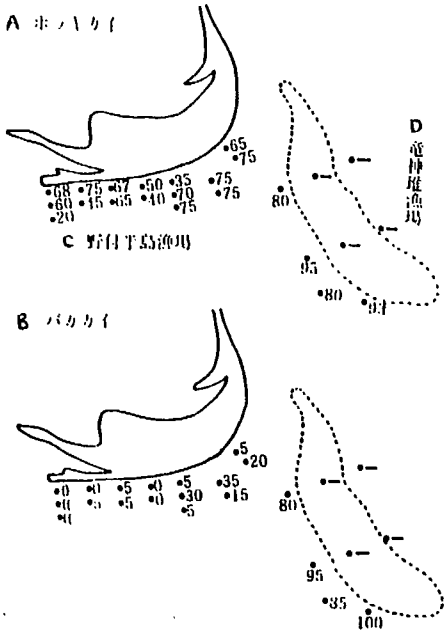
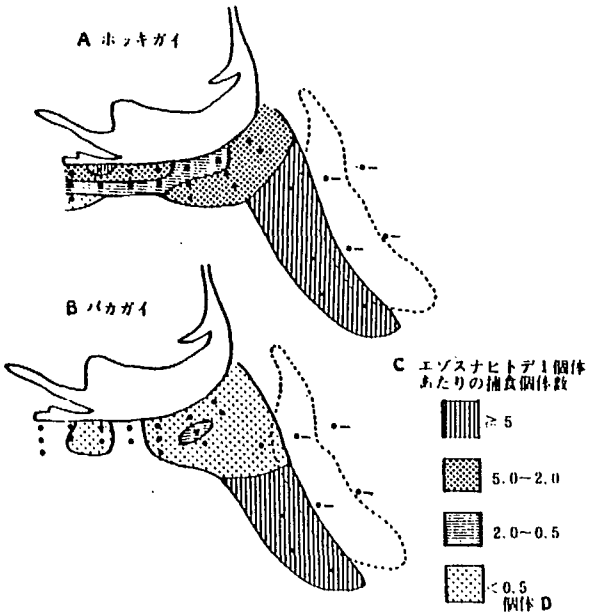



—はエゾスナヒトデが生息していない調査点

第4図 エゾスナヒトデ個体群中に占めるホッキガイとバカガイを捕食しているエゾスナヒトデの比率（%）

Fig. 4: Percentage of Total Luidea yesoensis Population That Had Eaten Pseudocardium sybillae and Mactra chinensis

Key: A. Pseudocardium sybillae, B. Mactra chinensis, C. Notsuke Peninsula fishing ground, D. Ryūjin Bank fishing ground, – indicates a survey point at which Luidea yesoensis were not found.




第5図 エゾスナヒトデに捕食されているホッキガイとバカガイの個体数

Fig. 5: Numbers of Pseudocardium sybillae and Mactra chinensis Eaten by Luidea yesoensis

Key: A. Pseudocardium sybillae, B. Mactra chinensis, C. Number of individuals eaten per individual Luidea yesoensis, D. Individuals, — indicates a survey point at which Luidea yesoensis were not found.

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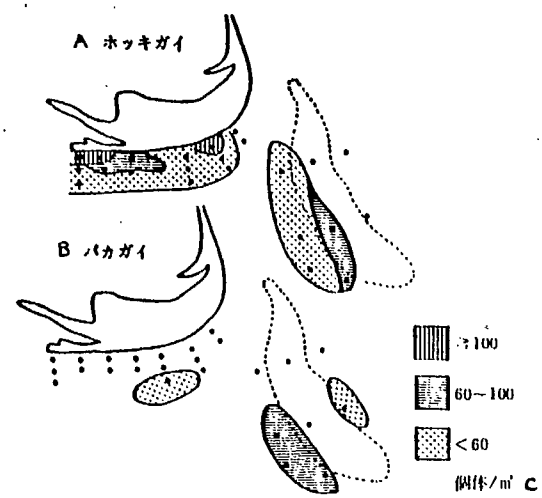
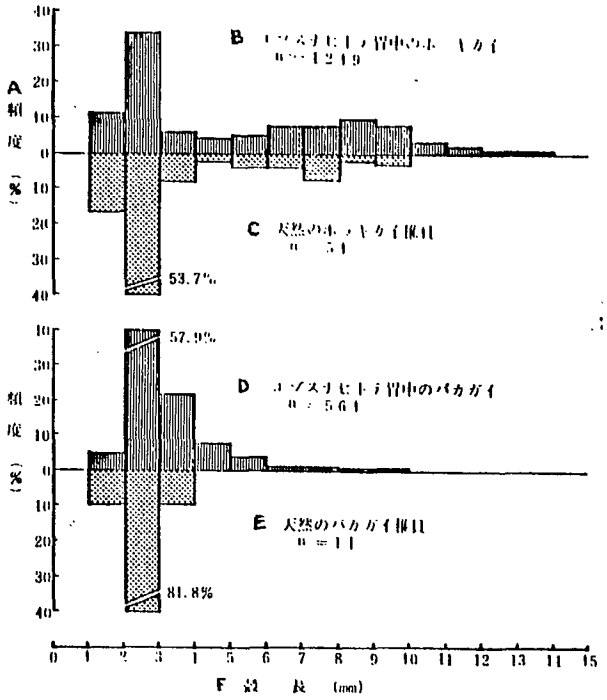



第6図 ホッキガイ稚貝とバカガイ稚貝の分布

Fig. 6: Distribution of Juvenile Pseudocardium sybillae and Juvenile Mactra chinensis

Key: A. Pseudocardium sybillae, B. Mactra chinensis, C. Individuals/$m^2$.




nは測定個体数

第7図 エゾスナヒトデに捕食されたものと天然のホッキガイ稚貝とバカガイ稚貝の殻長組成

Fig. 7: Breakdown by Shell Length of Juvenile Pseudocardium sybillae and Juvenile Mactra chinensis Eaten by Luidea yesoensis and of Those Found in Their Natural Habitat

Key:

A. Frequency (%), B. Pseudocardium sybillae in the stomach of Luidea yesoensis, C. Juvenile Pseudocardium sybillae found in their natural habitat, D. Mactra chinensis in the stomach of Luidea yesoensis, E. Juvenile Mactra chinensis found in their natural habitat, F. Shell length (mm), n. Number of individuals measured.

Table 1: Density and Percentage Breakdown of Sea Stars

第1表 ヒトデ類の密度と構組比率

| A ヒトデの種類 | F 野付半島漁場 H 密度(個体/m²) | I 構組比率(%) | G 竜神堆漁場 H 密度(個体/m²) | I 構組比率(%) |
|---|---|---|---|---|
| B ヒトデ | 0.238 | 59.9 | 0.110 | 65.4 |
| C エゾスナヒトデ | 0.136 | 34.3 | 0.052 | 31.0 |
| D ニッポンヒトデ | 0.012 | 3.0 | 0.003 | 1.8 |
| E イトマキヒトデ | 0.011 | 2.8 | 0.003 | 1.8 |

Key:

A. Species of sea stars, B. Asterias amurensis, C. Luidea yesoensis, D. Distolasterias nippon, E. Asterina pectinifera, F. Notsuke Peninsula fishing ground, G. Ryūjin Bank fishing ground, H. Density (individuals/$m^2$), I. Percentage breakdown.

Table 2: Stomach Contents of Sea Stars

第2表 ヒトデ類の胃内容物

| A 胃内に出現する動物 | B 捕食個体数* | | | |
|---|---|---|---|---|
| | C ヒトデ | D ニッポンヒトデ | E エゾスナヒトデ | F イトマキヒトデ |
| G ホッキガイ | 0.315 | | 4.760 | |
| H バカガイ | 0.105 | 0.125 | 4.714 | |
| I オオミゾガイ | | | 0.103 | |
| J フリソデガイ | | | 0.015 | |
| K オオキララガイ | | 0.125 | | |
| L ビノスガイ | | | + | |
| M オオノガイ | | | + | |
| N ケショウシラトリガイ | | | + | |
| O エゾイソシジミ | | | + | |
| P ノミハマグリ | | | + | |
| Q 他の二枚貝類 | | | 0.037 | |
| R チシマタマガイ | | | + | |
| S タマツメタガイ | | | + | |
| T ハデクチキレ | | 0.125 | + | |
| U 他の巻貝類 | | 0.125 | 0.020 | |
| V シオムシ | 0.789 | 0.625 | 0.128 | 0.666 |
| W ヨコエビ類 | | | 0.017 | |
| X ワレカラ類 | | | + | |
| Y クマ類 | 0.052 | | + | |
| Z エビジャコ | 0.105 | | | |
| AA 長尾類 | 0.105 | | + | 0.166 |
| BB クリガニ | | | + | |
| CC 短尾類 | | | 0.027 | |
| DD ハイイロハスノハカシパン | | | + | |
| EE ホヤ類 | | | + | |
| FF 多毛類 | | | 0.012 | |
| GG ヒモ形類 | | | + | |

*ヒトデ類の捕食個体数は、胃内容物を観察したヒトデ類のうち空胃個体を除くヒトデ類1個体あたりの平均捕食個体数。0.001未満は切り捨て、＋は0.001未満の頻度で出現したことを示す。

*The number of individuals eaten by sea stars is the average number of individuals eaten per sea star among the sea stars whose stomach contents were observed, excluding individuals with an empty stomach. Cases in which the figure was less than 0.001 were omitted, and + indicates cases in which the animal was found at a frequency less than 0.001.

Key:
A. Animals found in stomach, B. Number of individuals eaten*, C. Asterias amurensis, D. Distolasterias nippon, E. Luidea yesoensis, F. Asterina pectinifera, G. Pseudocardium sybillae, H. Mactra chinensis, L. Siliqua alta (Broderip et Sowerby), J. Yoldia (Cnesterium) notabilis Yokoyama, K. Acila divaricata (Hinds), L. Mercenaria stimpsoni (Gould), M. Mya (Arenomya) arenaria (?) oonogai Makiyama, N. Keshōshiratorigai**, O. Ezoisoshijimi**, P. Nomihamaguri**, Q. Other bivalves, R. Chishimatamagai**, S. Tamatsumetagai**,

**Transliteration of Japanese name. Search for Latin name unsuccessful.

T. Hadekuchikire **, U. Other spiral-shelled molluscs, V. Shiomushi**, W. Yokoebi**-like animals, X. Skeleton shrimp, Y. Kuma**-like animals, Z. Ebijako**, AA. Marcura, BB. Kurigani**, CC. Brachyura, DD. Scaphechinus mirabilis (A. Agassiz), EE. Ascidians, FF. Polychaeta, GG. Nemertea.

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**Transliteration of Japanese name. Search for Latin name unsuccessful.