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AGE COMPOSITION AND REPRODUCTIVE PERIOD OF THE SHAD, *Konosirus punctatus*, IN CHEONSU BAY

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淺水灣 전어(*Konosirus punctatus*)의 年齡組成과 繁殖期

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Abstract: Age composition and reproductive period of the shad, *Konosirus punctatus*, in Cheonsu Bay were determined through analysis of size, age and maturity of fish. Samples were collected with trap in the bay mouth from May, 1981 to December, 1982.

Shads start entering the bay for feeding and spawning in spring when water temperature exceeds 8°C. They stay in inner part of the bay in summer and move out to sea in autumn before water temperature decreases to 8°C. Fish grows very rapidly during first summer after birth. Mean lengthes of 1-4 year old fishes were 12.2cm, 15.8cm, 17.6cm and 20.9cm, respectively. The largest and oldest fish observed was 22.0cm long with age 4. Shads of Cheonsu Bay reach maturity at 2 years old at the size greater than 14cm. Data on size and age at first maturity indicate that maturity of shad depends on size and not on age. Spawning occurs from late April to late May when water temperature is between 8°C and 15°C.

要約：淺水灣에 棲息하는 전어의 體長, 年齡 및 成熟度를 분석하여, 年齡組成과 繁殖期에 대하여 고찰하였다. 資料는 1981年 5月부터 1982年 12月 사이 灣入口에서 小型定置網으로 蒐集하였다.

전어는 봄에 수온이 8°C 정도로 상승하였을 때 灣으로 들어온다. 여름 동안 이곳에서 자란 후, 가을에 水溫이 8°C 이하가 되기 전에 灣을 빠져 나간다. 전어는 태어난 첫해에 가장 빨리 자라며, 1~4歲群의 平均體長은 各各 12.2, 15.8, 17.6 및 20.9cm이었다. 관찰된 가장 큰 個體는 22.0cm였고 나이는 4歲이었다. 淺水灣 전어는 태어난지 2년이 지나면 成熟되며, 이때 體長은 14cm에 이른다. 成熟年齡과 體長을 분석한 결과 전어의 成熟은 年齡에 의하여 決定되지 않고 體長에 左右됨이 밝혀졌다. 전어는 水溫이 8~15°C인 4月末에서 5月末 사이 產卵한다.

INTRODUCTION

Cheonsu Bay is located in the middle part of west coast of Korean Peninsula (Fig. 1). It covers 380 km^2 with 5.5 km wide bay mouth. The current velocity measured in the bay mouth during tidal exchange amounts 4-6 km/hr. Fishing by means of traps which is operated by strong tidal currents is concentrated on the bay mouth. Shad (*Konosirus punctatus*), scaled sardine (*Harengula zunasi*) and anchovy (*Engraulis japonica*) comprise a substantial proportion of catches with traps.

The shad is widely distributed in coastal waters of central and east Asia (Chung, 1977). This wide distribution of fish would lead to vary life history characteristics after the water conditions. Information on the biology and ecology of the shad in various waters of Japan are available (Takita, 1978a, b). Data on this species in Korean waters have not, in general, been

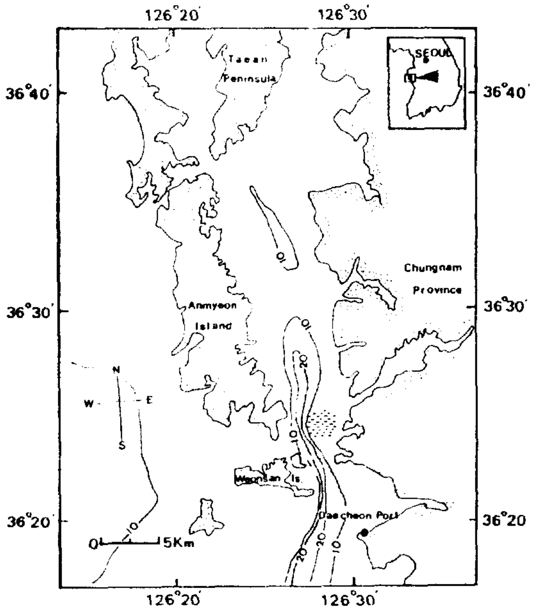

Fig. 1. Map of Cheonsu Bay showing bottom topography. Shaded area represents sampling site.

based on investigation involving frequent and consistent sampling programs (Huh *et al.*, 1979, 1981).

The purpose of this note is to provide information on age composition, growth and reproductive period of the shad in Cheonsu Bay, through analysis of size, age and maturity of fishes collected with traps in the bay mouth.

MATERIALS AND METHODS

The trap used for the collection of sample is called "Jumokmang" in the west coast of Korea. The net is 50 m long and its mouth measures 20m wide and 20m high. The gear is tapering from the mouth to the cod end. The mesh size decreases from 33cm in the mouth to 1mm in the last 12m of the cod end. Strong tidal currents make fishes enter the nets. Since content of net is emptied during high tides, catch per unit effort was expressed as catch in one trap during a tidal cycle.

Samples are collected from March 1981 to December 1982 in bay mouth. Interval of sampling was principally one month with frequent sampling during the reproductive period. Catches for sampling were carried out during the spring tides when maximum catch could be expected (Seok, 1982).

One-two kg of fishes were randomly taken from the catch. The weight and fork length of the fishes were recorded to the nearest 100mg and 1mm respectively. Only the length was measured for samples collected in 1981. Scales were taken from the subsamples to provide data on age. Gonads were fixed with modified Gilson's fluid (Simpson, 1951: in Bagenal and Braum, 1978) for measurement of oocytes. The diameter of oocytes lager than 0.1mm were measured under a microscope with a micrometer.

Sex was determined by examination of the gonads. The observed value of sex ratio were compared to the theoretical value of 1 to 1 with a level of significance 5%. To describe the growth in length, observed lengths were adjusted to von Bertalanffy's equation by Gulland's method (Gulland, 1964).

RESULTS AND DISCUSSIONS

SEASONAL VARIATION OF CATCH

The figure 2 shows the monthly variations of water temperature and catch per unit effort of the shad in the bay mouth. Catch per unit effort was expressed as catch in a trap during a tidal cycle. Since trap is fixed facing seawards and cod end was emptied during the high tide, the gear is effectively operated only during the flood tides.

Catch per unit effort shows a marked and consistent seasonal pattern. In every year the catch reaches a peak in early May and only a few or no individuals were caught in winter and summer. One observes slight increase of catch in autumn. These data clearly imply that there is a marked movement of fishes between the sea and the bay. The results depicted in the figure 2 can be interpreted as migratory behavior of the shad. In spring when warm water condition of the bay becomes favorable for fishes, shads moves toward the bay and large catch could be observed in the bay mouth. In summer, only a few or no fishes were caught with traps. There are studies which indicate that shads stay in the coast or in the inner part of the bay in summer. Shad occupied more than half of catch with gill net in the coastal lagoons of east coast of Korea in summer (Huh *et al.*, 1979). Shads in Ariake Sound were caught principally in the inner part of the bay in summer, while large catch was observed near the bay mouth in winter(Takita, 1978a). Catch increased in autumn when fishes regain the sea. However, the values do not reach maximum value observed in spring. It seems that the movement toward the sea is not concentrated as it was in spring.

Examination of the Figure 2 reveals that movement of the fish between the bay and the sea is related to water temperature. Huh *et al.* (1979) reported that low temperature of 4-6°C in early winter inhibited swimming of shads which were prisoned in the brackish lagoons. It seems that temperature below 8°C is not favorable for the life of shad. It is obvious that fishes start entering

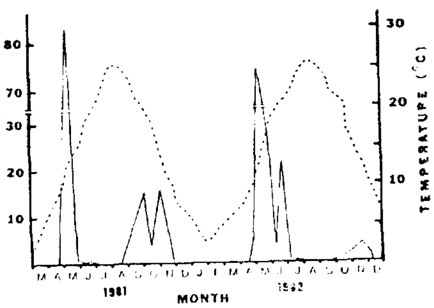

Fig. 2. Variation of water temerature (broken line) and catch per unit effort (solid line) of shad caught with trap in themouth of Cheonsu Bay from March 1981 to December 1982.

Cheonsu Bay in spring when water temperature exceeds 8°C and regain the sea before water temperature decreases 8°C.

SIZE AND AGE COMPOSITION

Size frequency analysis of the shad from May 1981 to December 1982 suggests that the population exhibits more than 2 years life span(Fig. 3). Although sampling was carried out more

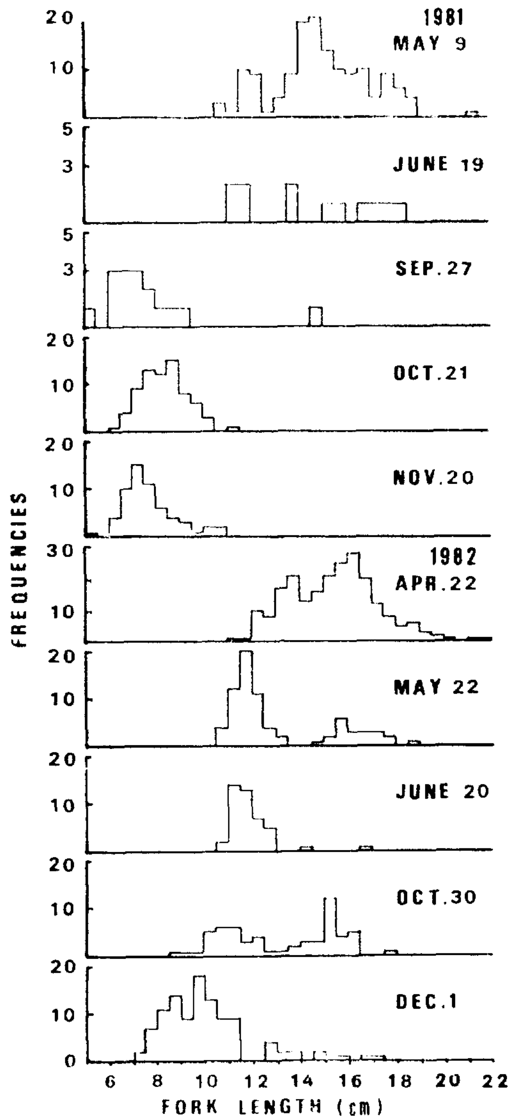

Fig. 3. Size frequency distribution of shad collected in the mouth of Cheonsu Bay from May 1981 to December 1982.

frequently in spring and in autumn, only a size composition per month is depicted in the Figure 3 for simplicity and clarity of representation. There is no representation of size distribution in summer and in winter when a few or no shads were caught. Life history patterns between corresponding dates of the two years studied were similar.

Annual marks are relatively well defined on the scales of shads. Examination of scales proves that annual mark appears in June. In this study, winter is regared as the time on which the age designation changes. The age of a fish which was collected between April and May was obtained by adding one to the number of annual marks.

From the end of September, small shads ranging from 5 to 12 cm in length commenced to be caught. They show no apparent growth stops on the scales. It explains that they were released in spring and have grown during summer. Absence of the fishes smaller than 5cm in 1981

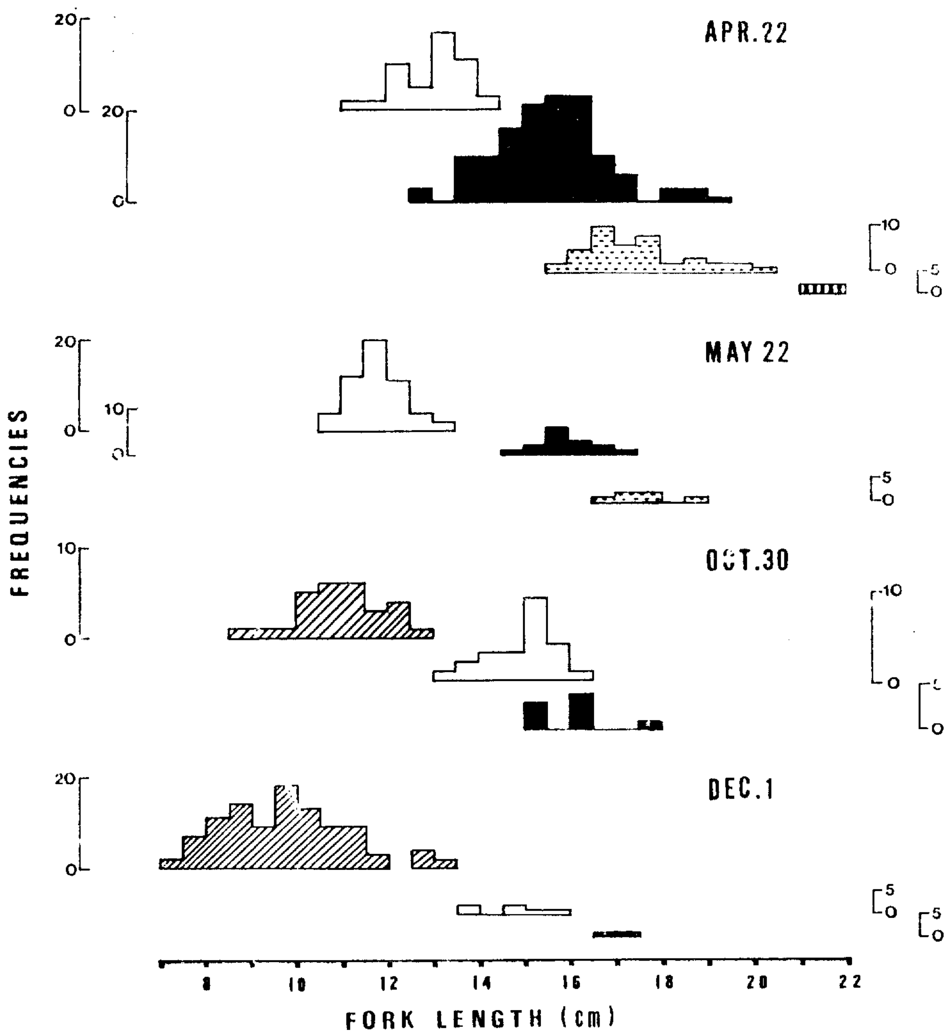

Fig. 4. Size frequency distribution against age of shad collected in spring and in autumn 1982. Age groups 0~4 are represented by diagonally hatched, open, solid, dotted, and vertically hatched histograms, respectively.

and 7 cm in 1982 may be interpreted as a behavioral character of shad. Considering that small organisms such as larvae of sand eel and mysiids, were caught in the traps, there is no reason that young shads smaller than 5cm could not be caught due to selectivity of the sampling gear. It proves that young shads as well as adults feed and grow in shallow inner part of the bay in summer.

One observed two apparent modes in size frequency distribution obtained in April and in May. Their modal lengthes are approximately 12cm and 16cm. Examination of scales reveals that the smaller group consists of one year old fishes, and the larger group consists of 2-4 year old fishes (Fig. 4). The proportion of an age group decreases with increase of age. Four year old fishes are few in number. It is noteworthy that the relative proportion of large fishes decreases with month and they are nearly absent in catch of June.

Size and age distributions vary during a season when fishes enter the bay or move out to sea (Fig. 3, 4). This variation is not due to growth of cohorts but probably resulted from the fact that individuals belonging to a population move between the sea and the bay at different time. This comment is substantiated by the fact that average length of 1 age group in spring 1982 or that of 0 age group in autumn 1982 decreases with time.

SEX AND MATURITY

Sex ratio was caculated from fishes more than the 2 year old which are collected in April and in May 1982, because the sex is readily determined by gross inspection of gonads in matured fishes and because their size compositions do not vary significantly during the succesive years studied. Sex ratio estimated in April was 59:41 in favor of female and 48:52 in May. These values were not statistically different from the theoretical value of 50 to 50 with a level of significance 95%.

Maturity stages of shad collected in Cheonsu Bay was relatively well classified. Fishes of age group 1 which were generally smaller than 14 cm were immature, whereas fishes of age group 2~4 whose lengthes were larger than 14cm were gravid according to classification of Lagler (1978). Gonad weight varies nearly independently with size for the individuals smaller than 14cm (Fig. 5). Gonad weight of fishes larger than 14cm tends to increase with increase of body length. Although there is very great variability in gonad weight of the same length, increase in weight of ovary and testis do not show a different tendency with increase of body length.

Most fishes of age group 1 collected in April and May 1982 contain the oocytes which do not

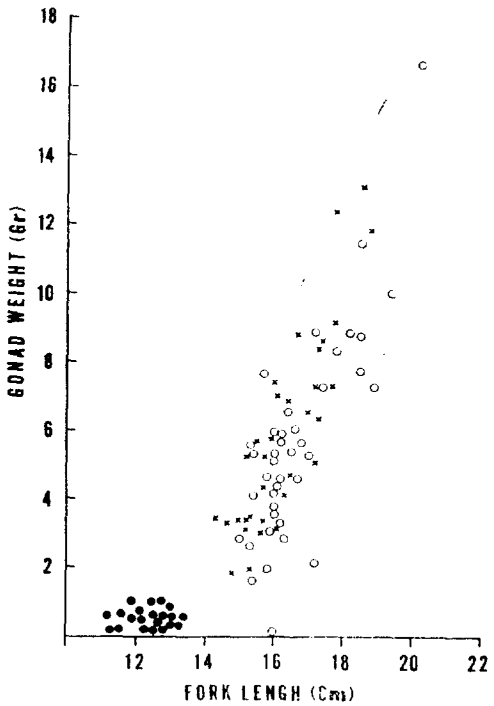

Fig. 5. Relationship between gonad weight and body length of shad in Cheonsu Bay. Solid circle, open circle and cross indicate immature fish, mature female and mature male, respectively.

exceed 0. 1 mm in diameter. Egg diameter distribution shown in the Figure 6a is obtained from an individual which contains the largest eggs among fishes belonging to age group 1. Frequency distribution of oocyte diameter in the ovaries of matured fishes represents 1～4 modes (Fig. 6b,c). This result is similar to the obsevations on the eggs before hydration of matured shads in Ariake Sound(Takita, 1978b). Although 1～4 modes in egg diameter distribution would indicate typically 1～4 spawning in a season, it is difficult to determine the number of spawning produced annually by an individual (Blaxter and Hunter, 1982).

Fishes of age group 2～3 caught in June, though few in number, were in the stage of spent. It explains that shads spawn between late April and late May. At that time, water temperature is between 8～15°C. In Garolim Bay located in the north side of Taean Peninsula, eggs of shad were collected with egg net only in May and their density increased as approaching to inner part of the bay(Huh, *et al.*, 1981). Since the shad produces demersal eggs, it seems that strong tidal current in the bay permitted collection of some eggs with egg net. This observation proves that the shad spawns principally in the inner part of the bay.

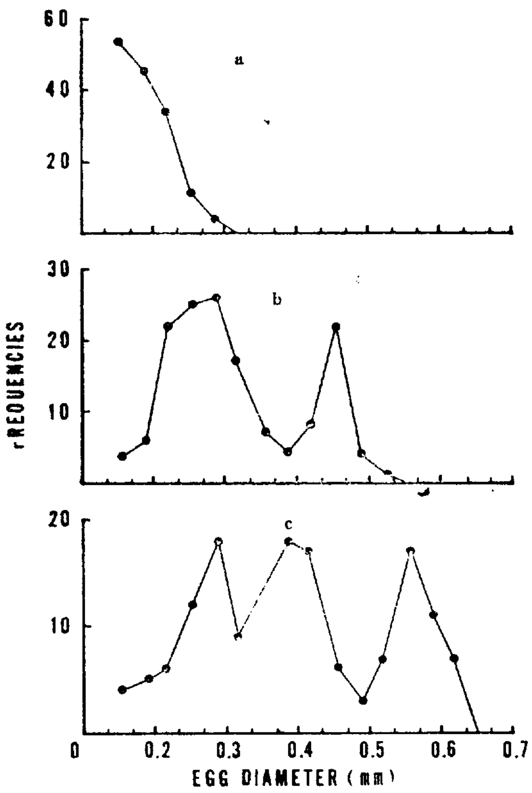

Fig. 6. Frequency distribution of oocyte diameter in the ovaries of shad collected in May 1981. The distributions are obtained from an individual which contain the largest oocytes among fishes belonging to age group I (a) and from matured fishes (b and c).

The shads of Cheonsu Bay reach maturity at 2 year old at a fork length of 14cm. The same species spawns at age 1 in Ariake Sound(Takita, 1978a). However, the size at first maturity were similar in the two waters. Standard length at first maturity was 13cm in Ariake Bay. Beverton (1963) showed length of clupeid at first reproduction was proportional to their maximum fish length(L^{∞}, from the von Bertalanffy equation). It is obvious that maturity of *Konosirus punctatus* depends on size and not on age.

Growth

Since size and age composition during a migrating season vary due to differential movment of the individuals belonging to a population, average length and average weight were estimated considering the fishes caught between April and June as catch in May, and those caught between October and December as catch in November. Average length and weight were plotted against age (Fig.7, 8). Age of fish caught in November is designated by adding 0. 5 to age evaluated by scales.

Examination of growth ratio in length reveals that fish grows very rapidly during first summer after birth (Fig. 7). From the data for spring 1982, the mean lengthes of fishes of age 1～4 were 12. 2, 15. 8, 17. 6, and 20. 9 cm, respecti-

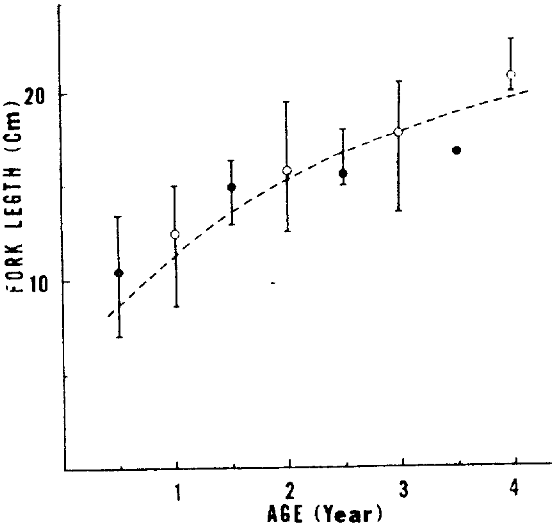

Fig. 7. Growth in length of shad fitted to von Bertalanffy's curve (dotted line). Open and solid circle indicate average lengths obtained in April-June and in October-December 1982, respectively. Vertical bars represent ranges of observed lengths.

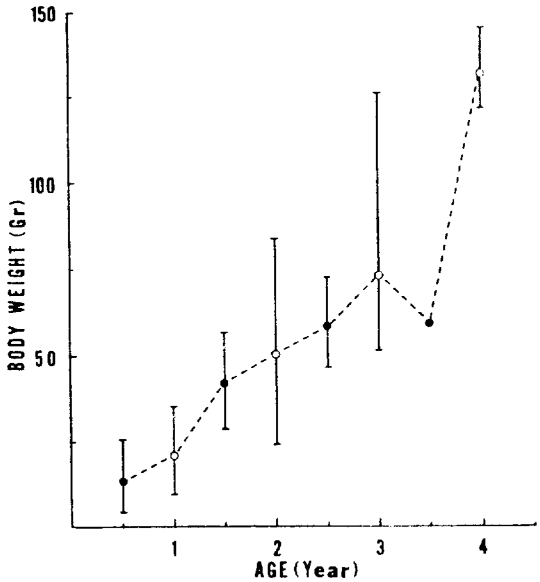

Fig. 8. Growth in weight of shad. Vertical bar, open and solid circles represent range of observed weight, average weights obtained in April-June and in October-December 1982, respectively.

vely. It reveals that a change in growth rate occurs during the first year of fish life. This growth "stanzas" is substantiated by the length for age 1 estimated from individuals belonging to age group 2 or 3 by back calculation. Calculated lengths for age 1 were significantly different from observed value.

From adjusted von Bertalanffy's equation, length at age t as a function of t expressed as:

$$l_t = 23.5\{1 - \exp[-0.39(t+0.70)]\}$$

This equation is represented by dotted curve in the figure 7. Low value of t_0 is obviously related to growth "stanzas" during the first year of fish life. Therefore, the growth curve is valuable for t larger than 0.5 to describe growth in length.

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