BIOLOGY OF LANDLOCKED *NEOSALANX PSEUDOTAIHUENSIS* IN THA XUJIAHE RESERVOIR, CHINA

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Abstract The morphological and reproductive traits, growth and diet of *Neosalanx pseudotaihuensis* are described based on the samples collected between May 1992 and August 1996 in Xujiahe Reservoir, Hubei province, China. The fish fed predominantly on cladocerans and copepods. Its reproductive periods were between March and June with spawning activity peaking in the middle of April. Data on length-frequency and gonadal development demonstrate that the fish typically died with a few weeks after spawning. Therefore, its life span was one year with only one spawning population (the spring spawning population) in Xujiahe Reservoir. By the age of 12 months, the had reached 61.4 mm in body length and 0.98 g in body weight in average. The relationship between body weight and body length could be expressed as $W = 2.014 \times 10^{-6} L^{3.170} (r = 0.999)$. The respective von Bertalanffy growth equations were $L_t = 65.07[1 - e^{-0.2394(t+0.5066)}]$ for body length and $W_t = 1.128[1 - e^{-0.2394(t+0.5066)}]^{3.170}$ for body weight.

Key words Biology, *Neosalanx pseudotaihuensis*, Xujiahe Reservoir

Neosalanx pseudotaihuensis Zhang is a short-lived icefish inhabiting freshwater waters in the midstream and downstream of the Yangtze River, and its tributaries and attached waters[10, 8, 4]. This species contributes a major proportion of icefish production in Hubei province, China[7]. Unfortunately, there were only limited data on its biology[4]. Detailed descriptions of morphology, reproductive biology, growth and feeding have not been well documented.

The purpose of this paper is to ascertain the reproductive traits, growth and diet of the in Xujiahe Reservoir in order to provide some scientific information for the production and resource management.

1 Materials and Methods

1.1 Study Site and Sampling This work was carried out in Xujiahe Reservoir situated on

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the national highway 316, Guangshui City, Hubei province, China.

Seine net, which was comprised of two 40 m long wings with a 25 mm mesh and a 100 m long packet with a 2 mm mesh and each of which had a depth of 10 m, was used to catch *N. pseudotaihuensis* in Xujiahe Reservoir. About 21 different sites were surveyed and 8 of them were visited regularly at depths ranging from 3 - 20m. Samples were collected on Seventh, Eighth and Ninth of each month between May 1992 and April 1996. Specimens were classified and fixed in 10% formalin for later analysis.

1.2 Measurement of Biological Parameters The fresh specimens were brought back to the laboratory, measured (standard length) and weighed to the nearest 1mm and 0.01g, respectively. The sex of each fish was determined by secondary sexual characteristics by examining its gonads under a dissecting microscope. Each identifiable gonad was removed, weighed to the nearest 0.01g and staged according to the criteria of Bagenal[1].

The stomach contents of 30 specimens from each month analyzed using the frequency of occurrence and point methods. The former gives the percentage of stomachs in which each taxon occurs, whereas the latter provides an estimate of the overall relative volume of each taxon in stomachs.

2 Results

2.1 Reproductive Biology of Icefish

2.1.1 Gonads A female of *N. pseudotaihuensis* has a pair of ovaries located asymmetrically in the sides of the intestine. The right ovary lies posterior to the intestine is well developed. The left ovary lies anterior to the intestine is poorly developed. This allocation of the ovaries allows the relatively small somatic cavity of icefish to contain a number of eggs. The male possesses only one testis which lies on the right side anterior to the intestine.

2.1.2 Fecundity Fecundity increased with female length. There was highly significant relationship between fecundity and female length indicated as below:

$$E = 64.33L - 2808.3 \quad (p < 0.001,\ r^2 = 0.42)$$

$$\log E = 3.74 \log L - 3.64 \quad (p = 0.002,\ r^2 = 0.38)$$

where E = number of eggs per fish, L = standard length (mm).

The absolute fecundity was correlated significantly with weight of female, and the relationship betweem them was described by the following equations:

$$E = 1295.1W - 330.4 \quad (p = 0.009,\ r^2 = 0.62)$$

$$\log E = 2.98 + 1.40 \log W \quad (p < 0.001,\ r^2 = 0.56)$$

where E = number of eggs per fish, W = total weight (g).

The number of matured eggs in the ovaries of 60 matured females ranged from 418 to 1370, with a mean of 950, and its 95% confidence interval was ± 63. Relative fecundity varied from 440 to 1223 eggs/g of total weight, with a mean of 953 ± 43 (95% confidence limits) eggs·g^{-1}.

2.1.3 Gonad Maturity Stages Female gonad weight increased slowly from a minimum, GSI 0.64%, in September to 2.17% in December, then rapidly to the GSI maximum 18.4% in April.

The ovaries of all female fish collected from May to August were so minute that they were virtually undetectable, even under dissecting microscope. By September, the ovaries were at stage II. This stage remained unchangeable until December. Stages III or IV ovaries were recorded between January and February. White oval ripening eggs containing post-ovulatory follicles were found in the gonads of the female fish with ovarian stages V and VI in March and April and in all ovaries at these stages in May.

2.2 Age and growth

The length of *N. pseudotaihuensis* caught in January 1995 ranged from 46.5 to 61.1 mm (Fig.1). It remained virtually unchanged during the next month and the vast majority of the fish exceeded 60 mm in length in March 1995. A discrete group of smaller fish appeared for the first time in April and length-frequency histograms show two discrete size groups, the smaller fish ranged from 20.6 to 29.4 mm, produced a sharply defined modal length class at 22-30 mm and the larger fish from 47.3 to 73.8 mm. Subsequent monthly modes of the smaller fish defined very sharply and followed a highly consistent pattern, increasing from 20.6 mm in April to 50.7 mm in December. The number of the cohort of the larger fish collected in March decreased greatly and disappeared after June, it is assumed that the members of this cohort almost invariably die soon after they have finished spawning.

An ANOVA analysis for the slopes and elevations did not reveal any significant differences in months, hence, the data were combined and followed L : W relationship calculated:

$$W = 2.014 \times 10^{-6} L^{3.170} \quad (r = 0.999,\ n = 960)$$

The von Bertalanffy growth curve was fitted to the mean body length and body weight. The use of the non-linear growth curve fitting technique employing the means in the curves yielded growth curve parameters: $L_\infty = 65.07$ mm, $k = 0.2934$, $T_0 = -0.5066$, $b = 3.170$, $W_\infty = 1.128$ g. Therefore, the von Bertalanffy growth equations of *N. pseudotaihuensis* in Xujiahe Reservoir are as follows:

$$L_t = 65.07[1 - e^{-0.2394(t+0.5066)}]$$

$$W_t = 1.128[1 - e^{-0.2394(t+0.5066)}]^{3.170}$$

The length of 54.6 mm and the weight of 0.66 g at 7 months predicted respectively for *N. pseudotaihuensis* from the von Bertalanffy growth equations were very close to the respective mean length of 54.3 mm and mean weight of 0.64 g at the this age. Similarly, the growth equations yield respective length of 61.8 mm and weight of 0.96 g at 12 months, which are close to the means of 61.4 mm and 0.96 g recorded for the fish of this age. The results show that the von Bertalanffy growth curves provided good descriptions of the pattern of *N. pseudotaihuensis*.

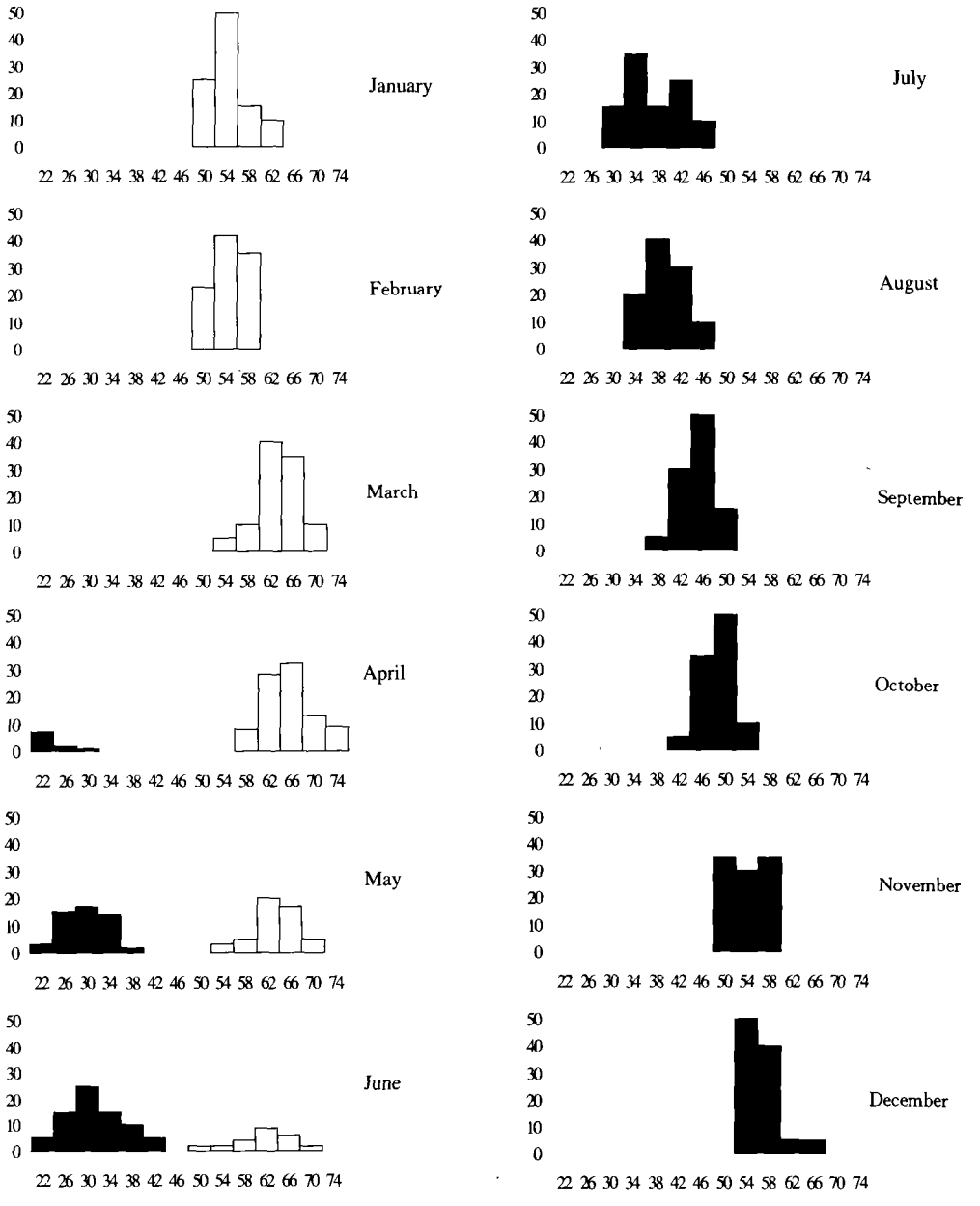

Fig. 1 Length-frequency histograms for the 1993, and 1994, year generations of *N. pseudotaihuensis* sampled between March and July 1994.

2.3 Diet

The food of age groups of *N. pseudotaihuensis* consisted mainly of wide range of protozoa, crustaceans and algae (Tab. 1). The small prey, such as protozoa, rotifers and crustacean larvae, frequently occurred in the stomachs of the fish at the age of 1 - 3 months. However, zooplankton, such as cladocerans and copepods, made a major contribution to the diets in the whole life of the fish from the age 1 to 12 months. Algae were occasionally in-

gested and it is assumed that algae were taken into the stomachs when the fish fed on zooplankton. Cladocerans and copepods contributed 57.1% at the age of 1 - 3 months, 81.7% at the age of 4 - 6 months and more than 90% at the age of 7 - 12 months to the diet (Fig. 2). In zooplankton, copepods contributed little bit more than cladocerans did. The fish do not stop feeding during the period of spawning at the age of 11 and 12 months.

Tab.1 Predominant dietary items found in the stomach contents of *N. pseudotaihuensis*

Algae:	Cladocera:
Diatoms	*Diaphnosoma sp.*
Bluealgae	*Diaphnia sp.*
Protozoa:	*Bosmina sp.*
Diffugia sp.	*Moina sp.*
Cucurbitella sp.	Copepoda:
Rotifera:	*Mesocyclops sp.*
Brachious sp.	*Thermocyclops sp.*
Keratella sp.	*Cyclops sp.*
Asplanchna sp.	*Sinocalanus sp.*
Polyarthra sp.	*Neutodiaptomus sp.*
Filinia sp.	

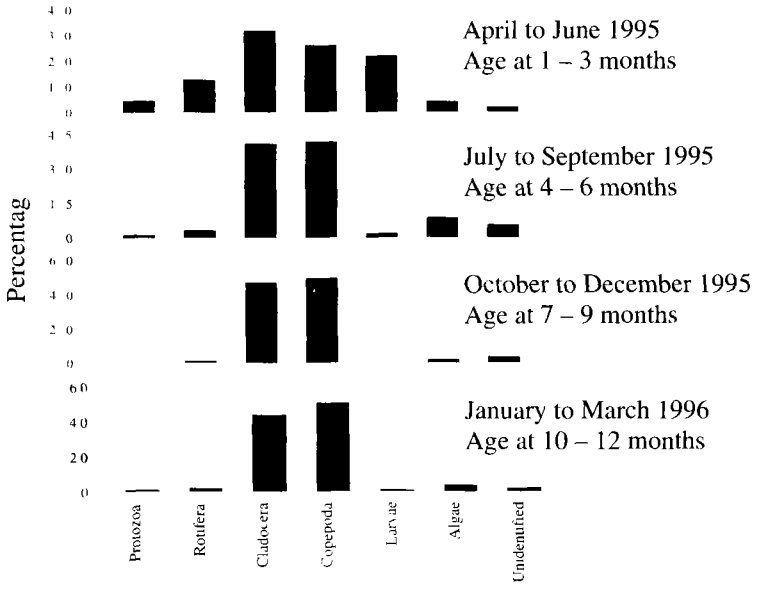

Fig.2 Percentage occurrence of the main dietary items in the stomach contents of a range of sizes of *N. pseudotaihuensis* in each of the three months

3 Discussion

3.1 Spawning period

The data on the recruitment of 0^+ fish and the trends shown by the reproductive indices are used to determine the spawning period of *N. pseudotaihuensis*. Since some of the 0^+

fish had already reached 18 - 22 mm in body length by mid-April, when these new recruits first appeared in samples, spawning is assumed to have commenced in March. Such a conclusion is consistent with the fact that, by the end of March, the GSI of females had risen to their peak, several ovaries were matured and, for the first time, some of these contained post-ovulatory follicles. Since larvae, which were less than 20 mm in length, were present in samples collected in April, May and June, whereas the minimum length in July and the immediately ensuing months exceeded 30 mm, spawning probably did not extend beyond June. This view is consistent with disappearing of the cohort of the larger fish. Although spawning apparently extended from March to June, the combination in the time and size at which 0^+ age class is recruited, and in the monthly trends exhibited by the GSIs, gonadal stages, oocyte diameters and the incidence of post-ovulatory follicles, provided strong evidence that *N. pseudotaihuensis* spawns between March and June, with spawning activity peaking in mid-April and mid-May. Comparable data for *N. taihuensis* indicate that this species breeds from March to May, with peak spawning occurring in April[2].

3.2 Age structure of spawing stock and life span

Length-frequency histograms for *N. pseudotaihuensis* in June 1996 showed two discrete size groups, and July 1996 had single group (Fig. 1). Since the small fish were not present in samples prior to April, and as spawning occurs from March to May, these fish are assumed to represent new 0^+ recruits. Therefore, the spawning age structure of *N. pseudotaihuensis* is simple, and only one-year-old fish (supplementary population) and no remainder population attend reproduction. This is different from *N. taihuensis*. Chen and Zhang reported that there were two spawning stocks for *N. taihuensis*, spring spawning population (from the mid-February to the mid-may) and autumn spawning population (from the beginning of September to the mid-November), in Poyang Lake[2]. Even it was separated into two or three spawning stocks when it was introduced to Dianchi Lake, Yunnan province[3]. The study also demonstrates that the life span of the fish has a 1 year life cycle and they die quickly after last spawning. Miller cited that Cole designated as "semelparous" those life-histories involving only a single reproductive event, followed by death, and as "iteroparous" those in which reproduction occurs on more than one occasion during lifespan[7]. *N. pseudotaihuensis* is "annual fish", with a single breeding season of life. The ovary of *N. pseudotaihuensis* returned to stage IV after spawning, the fish continued developing quickly to mature and spawning again in the same reproductive season.

3.3 Growth

By age 12 months, *N. pseudotaihuensis* had reached 61.4 mm in body length and 0.98 g in body weight in average, which is smaller than *N. taihuensis*[5]. Therefore, the growth of *N. pseudotaihuensis* in Xujiahe Reservoir is slower than that of *N. taihuensis* in Taihu Lake. The fact is that Xujiahe Reservoir is oligotrophic waters with poor natural food resource, in contrast Taihu Lake is eutrophic lake with an abundant natural food resource, is

assumed to result in growth gap in between the two species. This may be the same reason why the growth of *N. taihuensis* in Taihu Lake is slower than in Dianchi Lake located in highland of Yunnan province.

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徐家河水库陆封近太湖新银鱼生物学研究

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摘要 1992年5月至1996年8月对徐家河水库近太湖新银鱼的形态学, 繁殖特性, 生长以及食性进行了研究. 结果表明, 徐家河水库近太湖新银鱼主要以枝角类和桡足类为食, 繁殖季节为3—6月, 其中4月中旬为繁殖高峰期, 与太湖新银鱼不同只有春季产卵群体, 生命周期为一年. 体重与体长关系为: $W = 2.014 \times 10^{-6} L^{3.170}$ ($r = 0.999$). 其 von Bertalanffy 生长方程为 $L_t = 65.07[1 - e^{-0.2394(t+0.5066)}]$ for body length and $W_t = 1.128[1 - e^{-0.2394(t+0.5066)}]^{3.170}$.

关键词 生物学, 近太湖新银鱼, 徐家河水库