Folia Zool. – 49 (Suppl. 1): 187–192 (2000)

On the ecology of spined loach in Lake Müggelsee

David RITTERBUSCH[1] and Jörg BOHLEN[2]

Institute of Freshwater Ecology and Inland Fisheries, Department of Biology and Ecology of Fish, P.O. Box 850 119, 12561 Berlin, Germany; e-mail: d.ritter@web.de

Received 3 June 1999; Accepted 8 February 2000

Abstract. The growth, density and diet of a lacustrine diploid- polyploid- complex of spined loach was investigated. The recruitment of juveniles was irregular due to the dependence of reproduction on filamentous algae. If compared to literature data, the growth was rather fast but varied between the years; possibly the lack of young age classes led to differences in density dependent factors influencing the growth. After appearance in spring the fish behaved stationary with only single mobile individuals. During this period, the distribution at the shore was very irregular. In autumn the animals disappeared from the shallow shore area. The fish fed exclusively upon benthic organisms and showed a special size spectrum of ingested items. No differences between the genetic forms concerning the investigated aspects were found. This indicates a high niche overlap between the levels of ploidy, which should lead to strong competative interactions. The fragile structure of the population- complex can be described as a sexual parasite- host interaction.

Key words: *Cobitis*, growth, density, diet, diploid-polyploid-complex, competition

Introduction

Genetic complexes of spined loaches with different levels of ploidy have been described from several localities in eastern Europe and Asia (Sezaki et al. 1985, Vasil'ev et al. 1989, Boroń 1992, Ráb & Slavík 1996). Until now, few data on population biology and demography of such complexes has been reported. Vasil'ev et al. (1989) described different frequencies of ploidy forms from different localities in the Moscow River, indicating the possibility of ecological differences between the diploid species and the polyploid hybrids. No information on differences in ecological parameters like growth or diet have been published.

In the present study we report data on growth, age, movements and nutrition of a diploid-polyploid complex of spined loach in Lake Müggelsee, east Germany. In this lake, the polyploids outnumber the diploids by far, leading to a strongly female-biased sex-ratio (Bohlen & Ritterbusch 2000).

We tried to determine whether or not the genetic heterogeneity was reflected in the investigated factors. Such different patterns may indicate ecological differences between the genetic forms.

Material and Methods

Spined loach were caught between April 1996 and October 1998 in Lake Müggelsee near Berlin using a dip net. After determination of total length and sex the fish were released. The sex was fixed upon the presence of a lamina circularis in fish larger than 50 mm TL. This character is expressed in sexual mature fish only. To avoid underestimation of the amount of

Present address: [1] Institute of Inland Fisheries e. V., Jägerhof am Sacrower See, 14476 Groß Glienicke, Germany; e-mail: d.ritter@web.de, [2] Institute of Animal Physiology and Genetics, Academy of Sciences of the Czech Republic, 277 21 Liběchov, Czech Republic, e-mail: bohlen@iapg.cas.cz

males within the 0+ cohort, the size limit of juvenile fish was chosen to be higher than the minimum male size reported by R o b o t h a m (1981). In the beginning of July 1997, a release-recatch experiment was carried out to estimate the density of spined loach at one locality. The fish were marked by the injection of 1 mm pieces of metal wire (NMT Comp.) in their dorsal muscles. To detect horizontal movements, we sampled at different locations along the shoreline.

We measured the total length and weight of the 423 tagged fish to calculate the length-weight relation and the Fulton index of condition.

In 1997, a total of 81 spined loaches was collected for investigations of age, nutrition and genetic features. Age was identified by counting the annuli in scales and vertebrae (cleaned in 2,5% KOH and ethanol). Of these fish, 48 specimens were caught at sunrise, killed immediatly and fixed in buffered formaldehyde. In the laboratory, the guts were removed and their contents were counted completely in 1ml Sedgwick-Rafter-cells. The sizes of the 20 largest and the 20 smallest items of each food category were measured.

In most of the collected loaches we distinguished diploid and polyploid individuals by differences in erythrocyte cell sizes. Blood from the heart was smeared on slides, fixed with methanol and stained with Giemsa soluted in Sörrensen's buffer, according to F l a j š h a n s (1997). The major axes of 50 erythrocyte cells and nuclei for each fish were measured with a micrometer at 1000- fold magnification.

Results

A g e a n d g r o w t h

The biggest female we caught was four years old and reached 115 mm, the biggest male was three years old and measured 76 mm. Due to the low percentage of males caught in the period of investigation (1996: 3%, 1997: 4%, 1998: 10.5%), we restrict the following data and equations to female individuals. We found apparent differences in the cohort composition between 1996 and 1997 (Fig. 1). Four age classes were detectable in 1996. In 1997, only two individuals of the 1+ age class were found. The growth of the spined loaches followed the von Bertalanffy growth equation $TL_t = 154 \cdot (1 - e^{-0,3 \cdot (t + 0,41)})$. This equation describes the total length (TL) in relation to age in years (t).

The growth of the age classes within 1997 is shown in Fig. 2 (the one year old fish lacking, as mentioned above). In November, the average lengths of the 2+ and the 3+ age classes exceeded the lengths of the following class (3+ and 4+ respectively) in April. Therefore, the fish grew faster in 1997 than in 1996.

Total length (TL) and weight (W) followed the correlation $W = 2.7 \cdot 10^{-6} \cdot L^{3,13}$, the condition factor was 0.49 ± 0.04 g/cm^{-3}.

P o p u l a t i o n d e n s i t y a n d m o v e m e n t s

In 1997, the first spined loach was caught at the beginning of March. The population density in shallow waters, measured as catch per unit of effort, increased to maximum in July. Later, the number of fish decreased until November 11, when the last fish was caught at the shore.

On June 25 and 26, we collected 258 spined loaches at one locality, tagged and released them. One week later, July 2 and 3, we caught 221 individuals at the same locality, 56 of them were marked (25%). If 221 specimens equal 25% of the whole population, a total number of approximatly 1000 ± 100 individuals in the investigated area of 220 m² or a density of 4.5 ind./m² can be supposed. The unmarked fish of the second sampling were tagged before

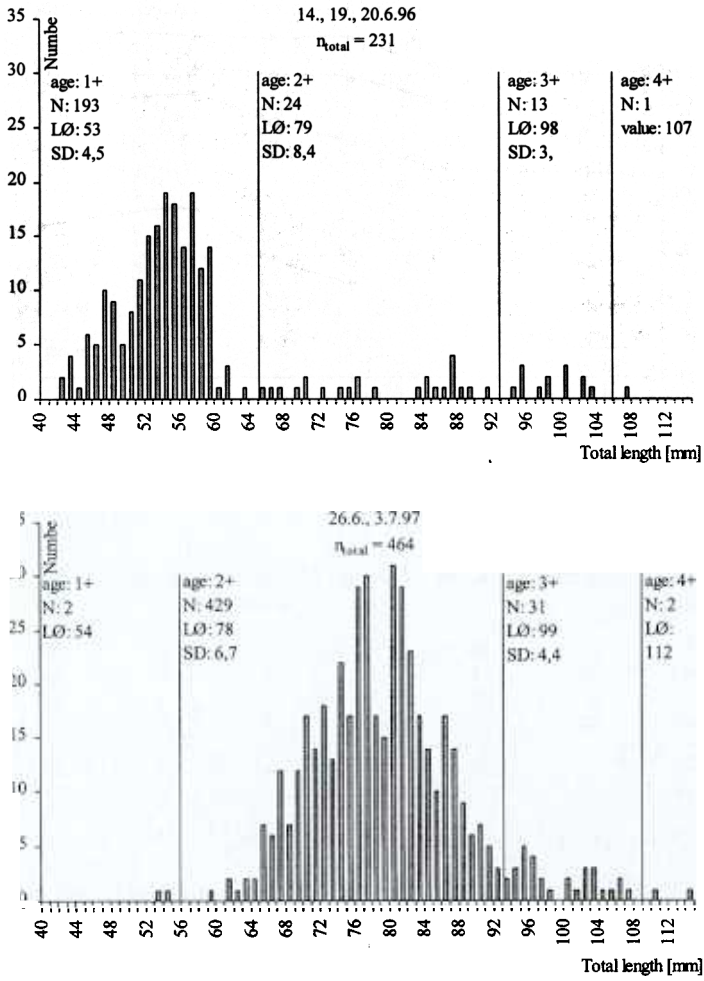

Fig. 1. Length-frequency distributions of female spined loach in Lake Müggelsee in summer. The age classes with number of individuals (n), mean lengths (LØ) and standard deviation (SD) are added.

being released, leading to a total number of 423 tagged specimen. The percentage of tagged fish at the investigated locality decreased with a rate of 0.2% per day until November 1997 (R^2 = 0.96). In the catches along the shoreline to detect horizontal movements we found two marked individuals. The first was caught 135 m eastwards from the area of release on July 25, the other 70m westwards on July 29.

Diet

The main food items throughout the season were small crustaceans (Table 1). They made up at least 90% of the number of food organisms in every fish. The dominant crustacean taxon was season dependent. The size of food organisms ranged from less than 10 µm (single algae cells and detritus) to more than 1 cm (chironomid larvae). The size spectrum of ingested organisms depended on the size of the feeding fish (Fig. 3).

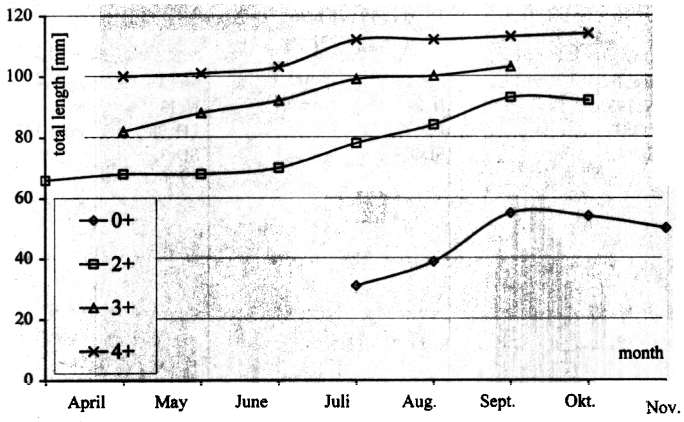

Fig.2. Mean lengths of cohorts of female spined loach in 1997. The 1+ cohort was missing.

Table 1. Percentage composition by number of food items in spined loach from Lake Müggelsee. N indicates the number of investigated fish.

Date	Harpacti-coidea	Cladocera	Ostracoda	Nauplia	Chironomid larvae	Others	n	Empty guts
07.05.	31	24	30	8	7	0	9	4
11.06.	14	66	14	3	2	1	10	0
13.08.	0	16	78	1	4	1	22	1
23.10.	8	66	21	4	1	0	7	4
Total	13	43	36	4	4	1	48	9

Differences of diploid and polyploid forms

No differences between diploid and polyploid females regarding age, length, weight, condition factor and nutrition were found. Within the age classes, no two groups of fish with different growth were detectable (Fig.1).

Discussion

The loaches of Lake Müggelsee showed a rather fast growth and high length-weight relationship compared to populations from Great Britain (Robotham 1981) and the Czech Republic (Slavík & Ráb 1995). However, they do not reach the age of five years found in other populations (Slavík & Ráb 1996, Robotham 1981). Recruitment in the observed population varied considerably between the years. The number of juveniles seemed to correspond to the development of filamentous *Cladophora* algae. In 1995, algae as well as spined loaches grew well, while in 1996 the lack of juveniles was accompanied by an exceptional early breakdown of algae population. In 1997, both development of algae and number of young spined loaches were intermediate. Therefore, in Lake Müggelsee the development of filamentous algae determines the strengths of the year class in spined loach.

The growth of the age classes differed between the years. At the end of 1997, the young-of- the- year nearly reached the size of the two year old fish in the beginning and therefore replaced the lacking 1+ cohort. The older age classes showed an enhanced growth in this

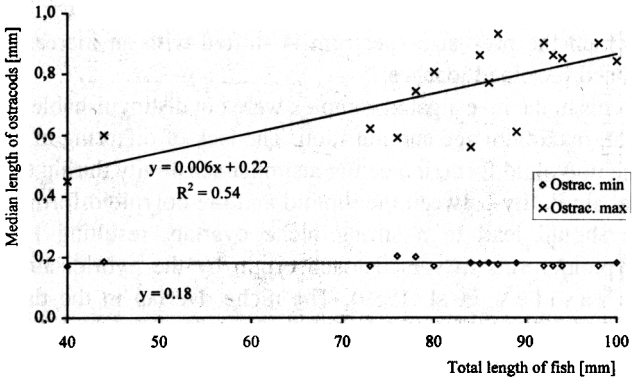

Fig. 3. Size spectrum of ostracods in the guts of spined loach (13 August '97). The median length of the 20 biggest and the 20 smallest ingested Ostracods is shown.

year, too. The most likely explanation for the enhanced growth is a decreased level of intraspecific competition because of the dropout of the 1+ cohort and the low number of 0+ fish. This would imply a growth limitation by density-dependent factors.

We observed a density of 4.5 ind/m² in the area of our release-recatch experiment. The distribution of loaches was very heterogeneous, and the catch per hour of effort was strikingly the highest in this area. Additionally, the catch per hour of effort in shallow waters varied seasonally. Therefore, it is not possible to estimate the standing stock of spined loach in Lake Müggelsee with the observed density.

The exchange of fish in the area of tagging with non-tagged spined loaches was 0.2% per day. We consider this exchange rate to be small, indicating a stationary behavior of the population. Nevertheless, we have recaught single marked individuals in areas nearby, an evidence of a small component of the population performing movements. A similar composition of a stationary population with a mobile component was found in gudgeon (Stott 1967), stone loach (Brunken 1988) and bullhead (Waterstraat 1992), it seems to be a frequent behaviour in small, bottom dwelling fish. Besides the single horizontal movements, the whole stock of spined loaches in Lake Müggelsee undertook annual vertical migrations. The first individual entered the shallow water along the shore in March, the last one left this habitat in November. Proximate reasons for this behaviour may be found in the freezing of the shallow waters in winter and the occurrence of anoxia in deeper waters in summer. However, a prevention of these events does not explain the behaviour of the loaches sufficently. In 1997, the anoxic layer reached up to 3.5 m and lasted two weeks (Gervais, pers. comm.), while the loaches were found in water depths up to 40 cm for nine months. They disappeared from the shore long before the lake was covered with ice. The ultimate reasons for the vertical migrations have to be found in other factors like water temperature (Bohlen & Ritterbuch 2000).

The spined loaches fed exclusively upon benthic organisms with crustacean taxa as dominant food organisms. Similar observations were found by Robotham (1977) and Boroń & Boroń (1994). Spined loaches are known to be non- selective filter feeders with a specialized mechanism of food intake (Robotham 1982). In this ecological guild, no selection of the biggest possible organisms is observed like it is predicted for particle-feeding species by the theory of optimal foraging. The filter apparatus with zones of adhesive mucus in the pharyngeal cavity explains the observed size spectrum of food particles. The

upper limit of food size increases but even in large specimen, no lower limit exists. Unlike other fishes, in which the prey size spectrum is shifted with an increased body size, this spectrum is enhanced in spined loaches.

The genetic forms in the investigated complex were not distinguishable concerning growth in length or weight, maximum age and nutrition. The lack of offspring in 1997 affected both the diploid and the polyploid form, indicating a similar sensitivity during early development.

The ecological similarity between the diploid and the polyploid form of spined loach in Lake Müggelsee should lead to a strong niche overlap, resulting in a high level of competition. Polyploid forms in spined loach origin by the hybridisation of at least two parental species (V a s i l e v et al. 1989). The niche overlap in the different forms may explain the recent lack of a second diploid species in most of the described complexes. One of the parental species seems to be outcompeted by the polyploid strain, according to Gause's principle of competitive exclusion. On the other hand, the outcompetition of the remaining diploid species by the polyploid strain is prevented by a strong sexual parasite-host interaction. In gynogenetic fish, the reproduction of the polyploid strain depends on the presence of males, which in general are diploid.

LITERATURE

BOHLEN, J. & RITTERBUCH, D., 2000: Which factors affect sex ratio of spined loach (genus *Cobitis*) in Lake Müggelsee? *Environ. Biol. Fish., 59: 347–352.*

BOROŃ, A., 1992: Karyotype study of diploid and triploid *Cobitis taenia* (Pisces, Cobitididae) from Vistula river basin. *Cytobios, 72: 201–206.*

BOROŃ, A. & BOROŃ, S., 1994: Diet of spined loach, *Cobitis taenia* (L.) from Zegrzyński Dam reservoir. *Acta Icht. Pisc., 24(2): 111–124.*

BRUNKEN, H., 1988: Ausbreitungsdynamik von *Noemacheilus barbatulus* (Linnaeus, 1758). *PhD thesis at the Technische Universität Braunschweig, 220 pp (in German).*

FLAJŠHANS, M., 1997: A model approach to distinguish diploid and triploid fish by means of computer-assisted image analysis. *Acta vet. Brno, 66: 101–110.*

RÁB, P. & SLAVÍK, O., 1996: Diploid-triploid-tetraploid complex of the spined loach, genus *Cobitis* in Pšovka Creek: the first evidence of the new species of *Cobitis* in the ichthyofauna of the Czech Republic. *Acta Univ. Carol. – Biologica, 39(1995), 3–4: 201–214.*

ROBOTHAM, P.W.J., 1977: Feeding habits and diet in two populations of spined loach, *Cobitis taenia. Freshw. Biol., 7 : 469–477.*

ROBOTHAM, P.W.J., 1981: Age, growth and reproduction of a population of spined loach, *Cobitis taenia* (L.). *Hydrobiologia, 85: 129–136.*

ROBOTHAM, P. W. J., 1982: An analysis of a specialised feeding mechanism of the spined loach, *Cobitis taenia* (L.), and a description of the related structures. *J.Fish Biol., 20: 173–181.*

SEZAKI, K., KOBAYASI, H., WATABE, S. & HASHIMOTO, K., 1985: Erythrocyte size and polyploidy of Cobitid fishes in Japan. *Bull. Jap. Soc. Sc. Fish., 51: 777–781.*

SLAVÍK, O. & RÁB, P., 1995: Effect of microhabitat on the age and growth of two stream-dwelling populations of spined loach, *Cobitis taenia. Folia Zool., 44: 167–174.*

SLAVÍK, O. & RÁB, P., 1996: Life history of spined loach, *Cobitis taenia*, in an isolated site (Pšovka creek, Bohemia). *Folia Zool., 45: 247–252.*

STOTT, ST., 1967: The movements and population densities of roach (*Rutilus rutilus* (L.)) and gudgeon (*Gobio gobio* (L.)) in the River Mole. *J. Anim. Ecol., 36: 407–423*

VASIĽEV, V. P., VASIĽEVA, E. D. & OSINOV, A. G., 1989: Evolution of a diploid-triploid-tetraploid complex in fishes of the genus *Cobitis* (Pisces, Cobitidae). In: Dawley, R.M. & Bogart J.P. (eds.), Evolution and ecology of unisexual Vertebrates. *New York State Museum, Albany Bulletin, 466: 153–169.*

WATERSTRAAT, A., 1992: Populationsökologische Untersuchungen an *Cottus gobio* L. und anderen Fischarten aus zwei Flachlandbächen Nordeutschlands. *Limnologica, 22: 137–149 (in German).*