Spawning habitat in the spined loach, *Cobitis taenia* (Cypriniformes: Cobitidae)

Jörg Bohlen

Czech Academy of Sciences, Institute of Animal Physiology and Genetics, 277 21 Liběchov, Czech Republic (e-mail: bohlen@iapg.cas.cz)

Received: December 21, 2001 / Revised: October 2, 2002 / Accepted: November 20, 2002

Ichthyological Research

Ichthyol Res (2003) 50: 98–101

Abstract Spawning habitat of the endangered spined loach *Cobitis taenia* was studied in northwestern Germany. The distribution of eggs of the loach in the field was best correlated with the density of vegetation but had little correlation with current velocity, water depth, or bottom substrate. In the aquarium, the loach chose dense vegetation for an oviposition site, as inferred by the direct observations of spawning and the location of spawned eggs. It is concluded that such habitat specialization is an important element in the autecology of the endangered fish and a critical stage in the habitat requirements of its populations.

Key words *Cobitis taenia* · Spawning substrate · Habitat preference · Reproductive biology

Spawning in many fish species includes behavioral elements that ensure suitable conditions for eggs and young after hatching. A common behavioral element is the selection of a suitable location through preference of certain spawning structures (Balon, 1975). The suitability of the selected location for egg and larval development influences mortality of the offspring, especially in species without parental care.

The spined loach, *Cobitis taenia* Linne, is listed as an endangered species in many European countries (Kotusz, 1996), but the reasons for its decline are uncertain (Lelek, 1987). This fish is highly specialized for life on and in sandy bottoms. During the daytime, the fish burrows in the sand, and during the night it feeds on the sand by a specialized filter-feeding mechanism (Robotham, 1982). Further habitat requirements other than sandy bottom have not been reported in this fish until now (Lelek, 1987; Blohm et al., 1994).

The aim of the present study was to estimate habitat selection for oviposition in the spined loach by identifying its preferred spawning substrate in the field and in aquarium experiments.

Materials and Methods

Study site.—Haaren Creek (Weser River catchment area, northwestern Germany) at the sampling locality 3 km west of Oldenburg is about 3 m wide, and its bottom is about 1.2 m below the level of the surrounding cattle grassland. At the sampling stretch, maximum depth was 0.25 m. Maximum water level during 1995 to 1997 always occurred in February and reached a maximum monthly mean of 90 cm. From spring to autumn, the water level does not reach half the level of the creek channel. The bottom mainly consisted of sand, often with addition of silt but rarely of gravel or peat. Vegetation covered about 30% of the bottom and was dominated by spike rush, *Eleocharis acicularis*, covering contiguous areas of several square meters. *Callitriche palustris* and fusiform algae (*Chladophora*) together formed more or less dense bunches, usually not larger than 300 cm^2. The floating underwater leaves of *Sparganium emersum* covered as much as 1000 cm^2. Sometimes terrestrial grass had fallen into the water, and the roots formed very dense bunches. The vegetation types were distributed in a patchy pattern mainly along the shallow edges. The described conditions can be regarded as typical for the summer situation. Haaren Creek is believed to house a pure population of *Cobitis taenia* (Bohlen et al., 2002).

Lake Müggelsee is located in the drainage of River Elbe at Berlin, eastern Germany. The eutrophic lake has a surface area of 7.3 km^2 and an average depth of 4.9 m (Driescher et al., 1993). Shores are shallow and partly vegetated by *Phragmites* sp. Submerged vegetation is restricted to filamentous algae (*Chladophora*), but a summer bloom of Cyanobacteria occurs regularly. The bottom consists of a varying mixture of mud, sand, and gravel with a layer of fine to coarse detritus along the shore. A complex population including *Cobitis taenia* plus at least three hybrid forms between *C. taenia* and *C. elongatoides* lives in Lake Müggelsee (Bohlen et al., 2002).

Field study.—Eggs were collected on 5 July 1997 in Haaren Creek by placing a plastic tube onto the creek bed, thus isolating an area of 529 cm^2. In a 150-m section of the creek, 85 samples were taken at randomly chosen points. The water in the tube and the top layer of the bottom were thoroughly sieved with a net with 1-mm mesh. For each of the sampling points, the total number of eggs was noted and

the habitat parameters were estimated. The presence of eggs in a sampling point was tested for the effects of habitat parameters by a multiway analysis of variance (ANOVA). In Lake Müggelsee, eggs were collected nonquantitatively by pulling a fine-meshed net along the bottom or by washing vegetation and detritus in a bucket.

Laboratory study.—Spined loaches from Haaren Creek were bred in aquaria during 1998 as described in Bohlen (1999). Each aquarium measured 39 × 39 × 25 (h) cm and was equipped with a layer of fine sand, an air-driven sponge filter, and a plastic box (20 × 20 × 5 cm) covered with metal gauze (mesh size, 5 mm). *Cryptocoryne affinis* and *Sagittaria* sp. were set on the bottom (about 20 plants per tank), *Elodea canadensis* floated at the surface (per tank, 2–5 trunks of 10–15 cm length), and a bunch of moss (*Vesicularia dubyana*) of approximately 150–200 ml was located on the top of the plastic box. Eggs spawned into the moss fell into the plastic box and were removed and counted. To find scattered eggs on the bottom, a fine-meshed net was used. One to five pairs of fish per aquarium were adapted to the experimental conditions for at least 5 months before the first spawning. Spawning behavior was observed on two occasions. At one occasion, the claspings of the female by the males with release of eggs were counted for the substrate selection.

Results

Field study. Eggs were found in 17 of the 85 sampling points (20%). The number of eggs at the 17 points ranged from 1 to 44 with a mean of 7.8 and a total of 133 eggs. Percentage of sampling points containing eggs and the percentage of eggs per category are given in Fig. 1. No significant correlation between the number of eggs per sampling point and any habitat parameter was found. The presence or absence of eggs, however, was explained by the habitat parameter type of vegetation ($F = 2.905$, $P = 0.02$). No significant influence as a source of variation was observed in the parameters current speed ($F = 1.095$, $P = 0.36$), depth ($F = 0.892$, $P = 0.47$), and type of bottom ($F = 0.659$, $P = 0.66$). The type of vegetation preferred by the loach was the dense bunches and the grass.

Sampling of *Cobitis* eggs during the summer of 1996 and 1997 in Lake Müggelsee revealed similar results. On ten sampling dates, 80 eggs were found within the dense masses of fusiforme algae (*Chladophora*), which occurred in water depths of 25–45 cm. No eggs were found outside this structure, and no eggs were found after the algae disappeared in July. No eggs were found in the belt of rough detritus, which indicates a preference of vegetation in water of medium depth rather than detritus in shallow water by the spawning fish.

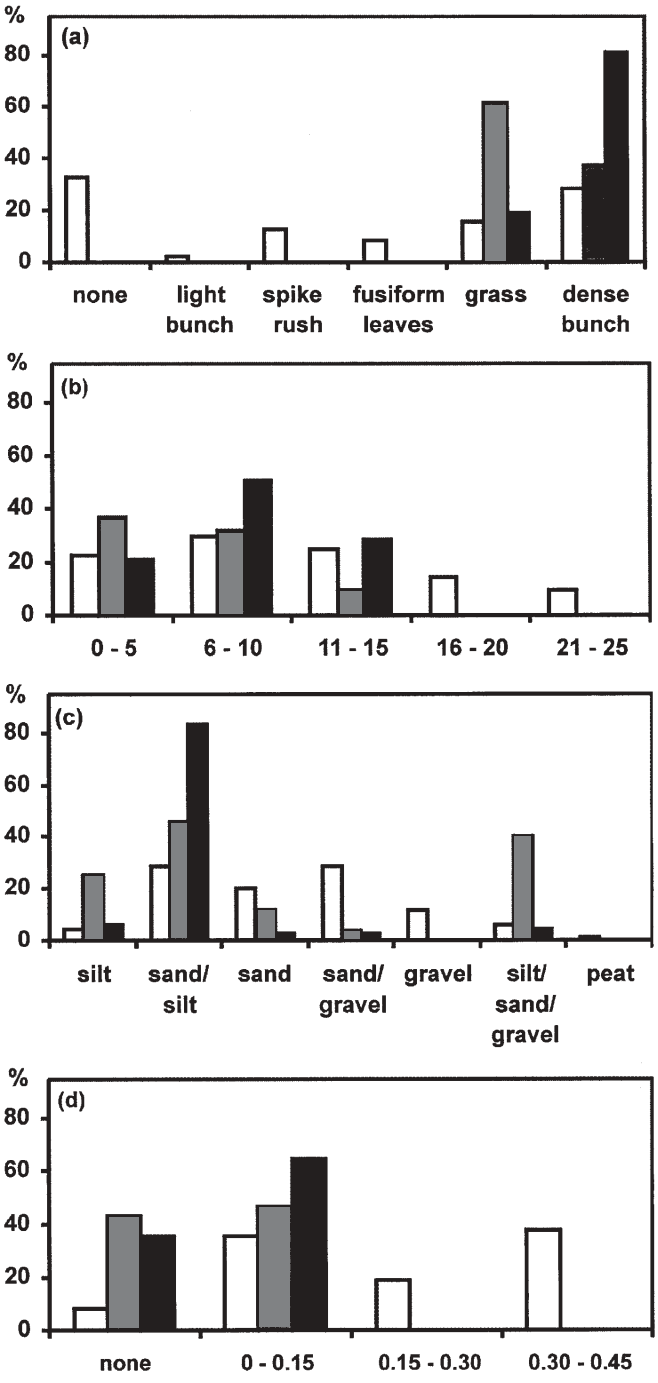

Fig. 1. Frequency (%) of habitat category (*white columns*), of total egg number (*gray columns*), and of sampling points containing eggs (*black columns*) within 85 samples from Haaren Creek, Germany, in relation to type of vegetation (**a**), water depth (cm) (**b**), type of bottom (**c**), and current velocity (in m s^{-1}) (**d**)

Laboratory study. From 74 spawning acts, 33 482 and 1057 eggs were counted inside and outside the box, respectively (Table 1). Altogether, 96.9% (range among spawning acts, 62.4%–100.0%) of the eggs were found within the plastic box. Because the surface area of the box was only 20% of the total surface area available, the high percentage of eggs inside the plastic box indicates a strong selection for the spawning substrate.

During the observed spawning, 36 claspings with release of eggs were counted. Of these, 35 (97.2%) occurred within the bunch of moss and only 1 occurred between strains of *Elodea*. The spawning fish penetrated into the vegetation,

Table 1. Data on the spawning of spined loach in aquaria

Number of females per aquarium	Number of replicates	Total number of spawning acts	Number of eggs per night mean (range)	Percentage of eggs placed into the moss mean (range)
1	6	46	395 (97–875)	96.3 (62.4–100)
2	2	11	436 (220–1091)	97.8 (91.4–100)
5	1	17	681 (38–1557)	95.1 (68.4–100)
Total	9	74	467 (38–1557)	96.3 (62.4–100)

Number of females per aquarium, number of replicates, and the number of spawning acts are given

The total number of counted eggs per night and the percentage of eggs placed into the moss show the selectivity of the spawning fish for the moss as preferred substrate for oviposition

stopped there, and the male embraced the female during egg release. During the second observation, no counts of the claspings were done, but the behavior of the fish was the same as during the first observation.

Discussion

In the field, eggs of spined loach were found nearly exclusively in the densest vegetation available. This exclusive use of dense vegetation was confirmed in the experimental aquaria. The eggs were placed directly into the vegetation, as the observation of spawning animals showed. An alternative interpretation of why the fish in aquaria spawned on the box would be that they prefer to spawn off the bottom. This interpretation is unlikely, because in this case the floating plants also should have acted as spawning substrate. Saitoh (1990) reported that two Japanese species of *Cobitis* spawned in very shallow standing water. From the Haaren data, a tendency toward the more shallow areas with low current velocity also may be seen. This trend is caused by a higher abundance of vegetation along the shallow areas and by the calming effect of vegetation. The rather narrow range of variability of depth and current in Haaren Creek makes it impossible to decide if the fish requires shallow and calm water. In deeper or faster-flowing waters, these parameters may also become limiting. However, in Lake Müggelsee the spined loach clearly did not select shallow areas.

The spined loach showed a strong preference for dense vegetation as spawning substrate, indicating this factor has great importance for its reproductive biology. It was predicted from laboratory data (Bohlen, 2000) that vegetation provides shelter against egg predation and prevents drifting of the eggs. If a suitable spawning habitat is lacking, the eggs will be more exposed to predation or flushing, in general to a higher mortality rate. Because the mortality rate during very early development is understood as critical for recruitment (Kamler, 1992), such absence of suitable spawning habitat may seriously affect population growth. The spawning spined loach accepted grass, filamentous algae, *Callitriche palustris*, or a subtropical moss, indicating that they did not differentiate between species of plants. The fish rather seemed to identify a certain type of structure, which can be characterized as a fine, soft, and dense bunch. This preference represents another habitat requirement in addition to the requirement of sandy bottom as shelter and feeding habitat for adults.

Other cobitid fish prefer different spawning substrates. The females of *Misgurnus anguillicaudatus* scatter their eggs over various substrates (Breder and Rosen, 1966). Species of *Pangio* and *Lepidocephalichthys thermalis* spawn in the open water near the surface (Ott, 1995). Kim and Park (1995) considered the different structures of the adhesive membrane of the oocytes in nine species of Korean cobitid fish to be an adaptation to different spawning substrates. The ecological impact of specialization on a certain spawning habitat was demonstrated by Vasilev et al. (1989) and Saitoh (1990). These authors reported spawning site segregation as an important mechanism for reproductive isolation in sympatric species of *Cobitis*. Altogether, in cobitid fishes spawning substrate seems to vary with species and is an important characteristic of their autecology.

The preferences for a certain spawning habitat should also be considered in the conservation of the endangered spined loach. The spined loach requires dense vegetation as suitable spawning habitats, which occur naturally in shallow, calm areas, e.g., behind curves or along shallow shores. Therefore, conservation measures should focus on the diversity of river morphology and especially shore morphology.

Acknowledgments The author thanks two anonymous reviewers for critical comments on the manuscript. The Niedersächsisches Landesamt für Ökologie gave permission to take specimens from the field and the Department of Ground and Water, Oldenburg, kindly provided daily measurements of water level.

Literature Cited

Balon EK (1975) Reproductive guilds of fishes: a proposal and definition. J Fish Res Board Can 32:821–864

Blohm HP, Gaumert D, Kämmereit M (1994) Leitfaden für die Wieder- und Neuansiedlung von Fischarten (in German). Binnenfischerei Niedersachsen 3:56–58

Bohlen J (1999) Reproduction of spined loach *Cobitis taenia* (Cypriniformes, Cobitidae) under laboratory conditions. J Appl Ichthyol 15:49–53

Bohlen J (2000) Behaviour and microhabitat of early life stages of *Cobitis taenia*. Folia Zool 49(suppl 1):173–178

Bohlen J, Ráb P, Šlechtová V, Rábová M, Ritterbusch D, Freyhof J (2002) Hybridogenous biotypes in spined loaches (genus *Cobitis*) in Germany with implications for the conservation. In: Collares-Pereira MJ, Cowx I, Coelho MM (eds) Freshwater fish conservation—options for the future. Fishing News Books. Blackwell, Oxford, pp 311–321

Breder CM, Rosen DE (1966) Modes of reproduction in fishes. T.F.H. Publications, Neptune City

Driescher E, Behrendt H, Schellenberger G, Stellmacher R (1993) Lake Müggelsee and its environment, natural conditions and anthropogenic impacts. Int Rev Gesamten Hydrobiol 78:327–343

Kamler E (1992) Early life history of fishes: an energetic approach. Chapman & Hall, London

Kim IS, Park JY (1995) Adhesive membrane of oocyte in Korean cobitid species (Pisces, Cobitidae). Korean J Zool 38:212–219

Kotusz J (1996) Species protection of loaches (Cobitoidea, Cypriniformes) in Poland in relation to their distribution and status in other European countries. Zool Pol 41(suppl):147–155

Lelek A (1987) Threatened fishes of Europe. Freshwater fishes of Europe, Bd 9. Aula, Wiesbaden

Ott G (1995) Kenntnisstand der Fortpflanzungsbiologie tropischer Cobitoidea (in German with English summary). In: Greven H, Riehl R (eds) Fortpflanzungsbiologie der Aquarienfische. Schmettkamp, Düsseldorf, pp 129–140

Robotham PWJ (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

Saitoh K (1990) Reproductive and habitat isolation between two populations of the striated spined loach. Environ Biol Fish 28:237–248

Vasilev V, Vasileva ED, Osinov AG (1989) Evolution of a diploid-triploid-tetraploid complex in fishes of the genus *Cobitis* (Pisces, Cobitidae). In: Dawley RM, Bogart JP (eds) Evolution and ecology of unisexual vertebrates. Bulletin 466. New York State Museum, Albany, NY, pp 153–169