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Laboratory studies on the reproduction of the European mudminnow, *Umbra krameri* WALBAUM, 1792

(Pisces: Umbridae)

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Abstract

The European mudminnow, *Umbra krameri* WALBAUM, was bred in aquaria during seven spawning seasons. The reproductive behaviour, which can be divided into courtship, spawning act, and parental care, is described. No seasonal cycles of temperature and photoperiod were necessary prior to spawning. High social stress and the absence of the prefered spawning substrate also did not prevent reproduction. Females only spawn once per year, males may spawn with several females. The short spawning season makes *U. krameri* vulnerable against disturbances during this period.

Key words: Umbridae, *Umbra krameri*, reproduction, spawning, laboratory study.

Zusammenfassung

Der Europäische Hundsfisch, *Umbra krameri* WALBAUM, wurde über sieben Laichperioden in Aquarien vermehrt. Das Fortpflanzungsverhalten, das sich in Werbung, Laichakt und Brutpflege einteilen läßt, wird beschrieben. Ein saisonaler Wechsel der Temperatur und der Photoperiode war nicht notwendig. Sozialer Stress und das Fehlen des bevorzugten Laichsubstrates verhinderten die Fortpflanzung nicht. Weibchen laichen nur einmal pro Jahr, während Männchen mehrmals mit verschiedenen Weibchen ablaichen können. Die Kürze der Laichzeit macht *U. krameri* empfindlich gegen Störungen während dieses Zeitraumes.

Introduction

The European mudminnow, *Umbra krameri* WALBAUM, 1792, is an endangered fish species throughout most parts of its distribution area (e.g. BARUS & LIBOSVARSKY 1983, LELEK 1987, WANZENBÖCK 1992), and attempts are started to save this species from further disappearance. An extended knowledge on its autecology is necessary to identify the origins of the threat and to work out effective conservation measures. Since reproduction is one of the most important parts of autecology and population dynamics it has to be investigated with special attention.

Reports on successful breeding of mudminnows in aquaria are scarce. In aquaristic literature, BAHR (1906), DREISER (1924), and BÖHM (1978) mention the breeding of the American mudminnow, *Umbra pygmaea* (DEKAY), but without details. WEBER (1902) and SCHREITMÜLLER (1913) described the spawning and reported a parental care by the female. Experiences of breeding the European mudminnow were published by GEYER (1940) and GRAHL (1968). Especially the former provides a detailed study on the species

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including nest building activity, the development of eggs and larvae and the parental care. POVŽ (1990) found some larvae having kept mudminnows in an aquarium from March until May. None of these authors gives a sufficient description of the spawning act or has done experiments on reproduction.

Material and methods

Beginning in September 1988 the reproduction of *U. krameri* was investigated on an aquarium stock. During seven reproductive seasons a total of about 100 specimens ranging in size between 35 and 125 mm were observed. The fishes were kept in tanks ranging in volume from 80 to 200 litres. In order to simulate "natural conditions" a layer of sand on the bottom, areas of dense vegetation (*Elodea* sp., *Ceratophyllum* sp., and *Valisneria* sp.), and bunches of moss (*Vesicularia* sp.) were placed into the aquaria. The photoperiod was controlled by an electronic timer and followed natural cycle. For illumination two luminescence tubes were used above each tank. A small portion of daylight entered the experimental room from a window. Temperature roughly followed the changes of season and ranged between 4 °C in winter and 26 °C in summer. In order to identify the triggering factors of spawning these "natural conditions" were changed. Regarded here as "warm conditions" is a temperature between 18 and 25 °C throughout the year. The animals used in these experiments had never experienced a temperature lower than 18 °C for their whole life. "Constant photoperiod" is the term used for a proportion of 14 h illumination per day to 10 h of darkness during all seasons. The animals were fed with living zooplankton (*Daphnia* sp., copepods, *Chaoborus* larvae) and earthworms. Frequency and amount of feeding changed with season, but generally was plentyful.

Results

Between 1989 and 1994 about 45 spawning acts occurred in the observed aquaria. Six spawning acts were observed directly.

Time of spawning

Table 1 shows the dates of 33 spawning acts. The remaining occurred during the same period of the year but the exact dates were not known. All spawning acts occurred in early spring, mostly in March and April. Spawning took place in the morning as well as in the afternoon with no preference for a certain time of the day.

Age of spawners

The minimum age of spawners, both male and female, was 10 months. The maximum life span of single individuals was found to be at least 7 years. Some of these animals are still alive (May 1995) and have just gone through their seventh spawning time.

Reproductive behaviour

The reproductive behaviour was very similar at all observed occasions and therefore is generalised here. It can be divided into three main parts: the courtship by the males,

Tab. 1: Dates of spawning of *Umbra krameri* in aquaria.

Year	February	March	April	May
1989			27.	
1990		22., 23., 24., 28.	3., 4., 4., 4., 4., 8., 10.	
1991		22., 23., 25., 26.	1., 3.	19.
1992	16., 19., 20., 20.	2., 3., 3.		
1993		9., 13.		
1994		20., 29.	2.	
1995		1., 11.		
Number of spawning acts	4	17	11	1

the spawning act and the parental care (Tab. 2). During the days before spawning the males follow the gravid females and tip their belly with the snouts. First, the female reacts aggressively but becomes more tolerant as this stimulation proceeds. Neither a nest building activity nor a preference for a certain area within the tank is shown by the female. Time and location of spawning is chosen by the female. At the selected location it dives into the substrate, preferably a bunch of moss. Males that notice this immediately enter the spawning location and try to follow the movements of the female. Again, they tip the females belly with their snouts. In all observed spawning acts three to five males were involved. No aggressive behaviour among the males was observed. The group of spawners penetrates into the moss with the female leading. When the female stops somewhere in the substrate the males enter a position at the females side. A portion of eggs is released and fertilized. The eggs stick to the substrate or fall down to the bottom. Then the group leaves the substrate and after several seconds up to a few minutes the whole process is repeated. Since the number of repetitions and the time of the intervals vary, the duration of the total spawning act can range from 30 to 90 minutes. The spawning act is ended by the female. It stops penetrating the substrate and bites away the approaching males. The female mudminnow has a single mode of reproduction with only one spawning act per year. Males may reproduce several times with different females. Directly after the spawning act the parental care begins. The spawning site, now containing the eggs, is fanned intensely by intervals of strong and frequent paddling of the females pectoral fins. Other mudminnows are expelled from the location when they approach closer than one to two body lengths of the female. This parental care was more likely focused on the location than on the brood itself: no attention was payed on eggs out of the fanned area, no change of behaviour was observed when all eggs were taken away by the investigator and sometimes egg cannibalism occurred. The cannibalistic female takes single eggs with moving embryos inside or moving hatchlings in the same manner as it takes food, indicating that it is not able to identify its own offspring. The parental care exceeds over a period of about two weeks.

Under laboratory conditions the parental care was not essential for the development of the brood. When eggs were removed at any developmental stage and reared in petri dishes, neither the hatching rate nor the development of the fry was different from the control in the breeding tank.

Tab. 2: The reproductive behaviour of *Umbra krameri*.

Behaviour	Activities	Duration
Courtship	– males follow female – tipping females belly with snout – female becomes tolerant	1 - 4 days
Spawning act	– female selects spawning site – female penetrates into substrate – 3 - 5 males follow, tipping belly – female stop, males enter side-by-side position – a portion of eggs is released and fertilised – group of spawners leave substrate – repeating – spawning is ended by female aggression	30 - 90 min
Parental care	– fanning the nesting site – defending the nesting site – canibalism on eggs and hatchlings	1 - 2 weeks

The spawning substrate

Whenever a bunch of moss or any other very dense and soft vegetation was available to the fish, the eggs were deposited into this substrate. This happened even when the moss was located on a piece of wood in the upper part of the tank about 20 cm above the bottom and 10 cm beneath the surface. In tanks without dense vegetation the mudminnows choose a single stone on the bottom or a place between a group of plants to deposite the eggs. Digging of a pit in the sandy bottom substrate was never observed. Sometimes the females fanning removed the sand beneath the spawning substrate. As a result a pit was created "accidentally" after spawning.

Eggs and larvae

The eggs measure usually 1.7 to 1.8 mm in diameter (minimum 1.55 mm, maximum 1.95 mm; n = 370). When the larvae started swimming they had a length of about 7.5 mm. *Umbra krameri* spawned at a water temperature ranging from 7.5 to 19 °C depending on different years and conditions.

Triggering factors for spawning

Under warm conditions, mudminnows spawned during the same time of the year as the control group did (Tab. 3). Animals under constant photoperiod behave similarly. Even when both temperature and photoperiod were constant the reproduction took place during the same time of the year as in the control group under natural conditions. The latter experiment was repeated in the following year with a second group of individuals leading to the same result. The influence of high social stress also did not prevent the reproduction, some mudminnows spawned under very high density (0.8 individuals per liter of water). The last factor examined was the necessity of a suitable spawning substrate. As mentioned above, the fishes accepted various substrates in tanks without dense vegetation. Therefore no distinct structure seems to be essentially necessary to induce spawning. No environmental attribute was found which was able to prevent mudminnows from reproduction.

Tab. 3: Triggering factors for the reproduction of *Umbra krameri* in aquaria.

Factors tested	Treatment	Spawning
none	natural temperature regime natural photoperiod	yes
photoperiod	natural temperature regime constantly long day	yes
photoperiod + temperature regime	constantly warm constantly long day (for whole life of animals)	yes
social stress	density of animals up to 0.8 per liter	yes
absence of prefered spawning substrate	sandy ground, light vegetation, no bunch of dense vegetation	yes

Discussion

In agreement with BALON (1975), the reproduction mode of *Umbra krameri* was found to be that of a phytophilous guarder. No nest building activity as described by GEYER (1940) was observed. GRAHL (1968) also did not mention nest building but spawning in the fine structures of roots. Concerning the creation of a nest there seem to be some variation in the reproductive behaviour of the mudminnow, perhaps dependent on the available substrate. Spawning in groups of one female and several males is regular for *U. krameri*. All males involved in the spawning act have the same chance to fertilize eggs. As a consequence, the risk of unfertilized eggs is reduced and the rate of genetic recombination rises.

"In all known fishes that are parental, outside of the Cichlidae, the male is the parent" (BARLOW 1974, cited from BALON 1975). *Umbra krameri* is an outstanding exception from this rule. Additionally in other small sized fish species a single annual spawning of the females is scarce. The parental care in combination with the big eggs can be considered as high energetic costs for the female and may be responsible for their single annual spawning. The concentration of reproduction events in a short spawning season makes the population of mudminnows vulnerable towards disturbances during this time. Negative influences like oxygen depletion, even if lasting only some days or weeks, may destroy the brood of most females. The reproductive success of the population is strongly effected by this because no second brood can be realised if the first one is lost. With regard to the tested triggering factors for spawning, no clear conclusions can be drawn. None of the examined factors seems to be responsible for the initiation of reproduction. On the other hand the mudminnows spawned under constant conditions during the same period of time as the control animals did. Such a precise timing is unlikely to be based upon a physiological clock for individuals which have never experinced natural conditions during their whole lifetime. Therefore the presence of a triggering factor can be assumed. Maybe the small amount of daylight coming through the window of the room was a sufficient timer. This would presume the ability of the fish to differenciate

between natural and artificial light, because the portion of daylight was much smaller than the artificial illumination, which also last much longer per day. Further investigations on possible triggering factors are necessary. The presented results demonstrate a high plasticity of the reproductive behaviour of *U. krameri*.

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