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Larval Development of the Cyprinid Fish *Barbus sharpeyi* (Gunther, 1874)

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ABSTRACT

The early development of the cyprinid fish *Barbus sharpeyi*, from fertilization to juvenile, was recorded using living material. Three embryonic steps, one free embryo and four larval steps were identified. Hatching occurred between 70-79 h (post-activation); the free embryo period was extremely short in duration (5-13 h). The transition from larva to juvenile occurred in 50 days when the fish were fully scaled and the lateral line organ was clearly visible. Indication of different degrees of complexity of physiological and morphological developments within each step were clear through both embryo and larva periods of development as steps increased in duration.

Key words: *Barbus sharpeyi*, free embryo, larva, riverine-cyprinid, tigris-euphrates rivers

INTRODUCTION

Bunni, *Barbus sharpeyi* (Gunther, 1874), is one of the most widely distributed riverine-cyprinid species in the southern and mid parts (marshes) of Tigris-Euphrates basin (Banister, 1980). This specie is scarce in Northern of Baghdad on Tigris and Ramadi on Euphrates. Recently there is a semi-isolated population in north bays of Tharthar reservoir (Personal observations; Ali *et al.*, 1988).

Due to recent reduction of water level of many parts of Tigris and Euphrates and exposition of traditional spawning grounds to dryness (Anonymous, 1982; Ali and Tomas, 2009), the natural reproduction becomes insufficient and the need to culture this specie became evident in recent years. Thus, we undoubtedly think, that this species (Bunni) can prosperously cultured in common carp ponds, basins or/and even cages. Because *B. sharpeyi* considered most important among other local cyprinid species for its high economical and consumption values, it has specific eco-biological characteristics that make it a promising for aquaculture.

Larval development in cyprinid fishes is well documented (Sado and Kimura, 2002, 2005, 2006; Al-Hazzaa and Hussein, 2007) but little has been reported about Iraqi fishes and in particular *B. sharpeyi*, except for Al-Nasih (1992).

The aim of the present study was to clarify early life stages morphology and biology of the species using results of induces spawning and reared specimens.

MATERIALS AND METHODS

Bunni mature eggs and semens obtained from broodstocks collected from the Euphrates River at Thiqr Governorate, 400 km south of Baghdad City. Males and females were in their 6-7th year of age, ranged from 430-470 mm and 2500-3000 g in standard length and body weight, respectively. Female fecundity ranged between 230-250 and 93-97 thousand eggs for absolute and actual counts, respectively. Eggs were maintained at the state artificial spawning laboratory, Suwera, Kut Governorate, south of Baghdad. Fertilization carries out by dry method. Incubation and development take place in 10 L jars (Veisa jars). Water temperature was maintained, between 22-24°C, as in the natural environment. For description and drawing the embryonic and larval development stages, the dissecting binocular (X 10 MBC (microscope by celestron), VNIRO modification) were used, it supplemented with measuring lens and lucida apparatus. About 20-30 eggs and larvae were sampled periodically every 10 min interval in the beginning, then every 2-3 h.

Samples were examined, described and drawn directly from alive specimens. Egg diameter, total length of larvae and all body proportions were measured to the nearest 0.1 mm under a binocular microscope fitted with an ocular micrometer. All phases and stages counted in relative to fertilizing moment; tell complete organogenesis following (Balon, 1975; Cerny, 1977).

RESULTS

Eggs: Unfertilized eggs with yellowish dusky colour, not bright, spherical in shape, 1.3-1.5 mm in diameter. Fertilized eggs are adhesive. Embryonic development is shown in Table 1 and in Plate 1. Hatching occurred 70-79 h after fertilization at 22-24°C.

Larvae and Juveniles

General morphology: Body length of larvae and juveniles at each developmental stage are shown in Table 2 and Plate 2. Newly hatched larvae measured 4.7-5.5 mm, yolk sac pear-shaped,

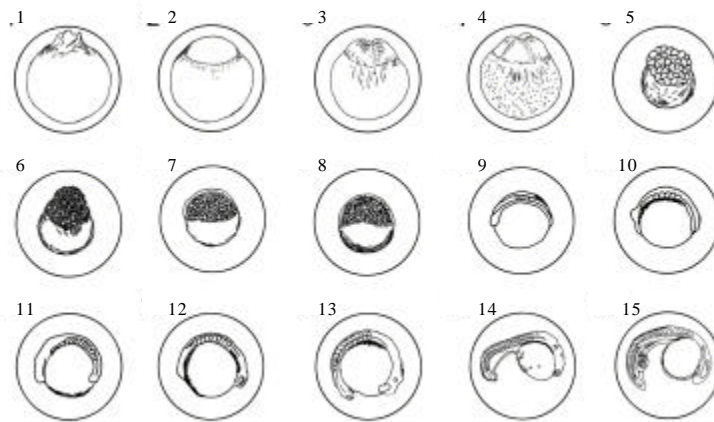


Plate 1(1-15): Stages in the embryonic development of *Barbus sharpeyi*; (1) previtelline phase.15-25 min, (2) blastodisc phase 45 min, (3) first cleavage 1 h 15 min, (4) 1 h 40 min during blastomere stage, (5) 2 h 20 min during one-layer stage, (6) 4 h during gastrulation, (7) 7 h, (8) 11 h during morula stage, (9) 22 h completed gastrulation stage, (10) 23 h during somites stage, (11) 26 h during head and tail differentiation stage, (12) 27 h during 10-12 somites stage, (13) 29 h during 17-18 somites stage, (14) 35 h during eye-lens appearing stage, (15) 41 h during defined brain stage

Table 1: Embryonic development of *Barbus sharpeyi* at 22-24°C

Time elapsed after fertilization	Development stages observed
1st Embryonic Period	
0 h 15 min-1 h 15 min	The egg diameter slightly increased to attain 1.6-1.7 mm, cytoplasm becomes a thread form, yolk surface becomes smooth and flattened then became condensed and granulated at the end of this period. Disappearance of micropile area, space between cytoplasm and chorion enlarged and swollen, filled with liquid. Formation of blastodisc and start of 1 st cleavage followed by bicleavage of cytoplasm. Formation of spindle. Egg with no oil globule.
2nd Embryonic Period	
1 h 40 min-7 h 0 min	Four blastomere formation through 2nd line of cleavage then radial cleavage ended producing more than 64 cells. Their number increased dramatically extending around the yolk sac. Morula and then blastula stages are formed. Cells became irregular and asymmetrical with blastodisc shape remains unchanged.
11 h 0 min-26 h 0 min	Blastodisc flattened with formation of three germ layers that encircle yolk sac. Gastrulation completed. Formation of premordium head. Mesodermal tissue sectioned into equal segments. Somite number increased from 5 to 12. Formation of forebrain, neural cord extends backward, head and tail clearly differentiated.
3rd Embryonic period	
26 h 30 min-30 h 30 min	Formation and enlargement of optic vesicle; somites increased from 10 and exceeding 21 reaching tail region; formation of Kupffer's vesicle; egg mean diameter reaches 2.1 mm with yolk sac and embryo take elliptical shape; start of muscle contraction in the somite region; appearance of auditory vesicle as narrow circle
32 h 0 min-35 h 0 min	Continuous movement at the posterior end of the yolk sac and the caudal region of the embryo; formation of heart as pouch; number of somites reaches 28; Kupffer's vesicle disappeared; formation of eye lens; formation of tail region; no melanophores; yolk sac diameter 1.0 mm; embryo total length 2.2 mm
38 h 0 min-48 h 0 min	Three brain vesicle well defined; expansion of neural cord; somites reaches 40 (28 trunk, 12 tail); embryo increased in length reaches 4.2 mm in total length, active with pointed straight tail, free from yolk sac; increased heart pulsing, circulation starts with movement of colourless blood cells and appearance of dorsal aorta; otic vesicle moved toward optic cup area with the appearance of otoliths
50 h 0 min-63 h 0 min	Formation of blood circulatory system with increased blood flow especially around optic vesicle and brain lobes, extension of dorsal aorta to tail region forming dorsal artery and caudal vein; yolk absorbed; completion of tail configuration; appearance of anus as a notch beneath 28-29 th somite; formation of alimentary tract; embryo reaches 4.3 mm in total length; head elongated over yolk sac; pectoral fin bud becomes visible
75 h 0 min	Hatching with emergence of free embryo

Table 2: Body length of each developmental stage of *B. sharpeyi* at 22-24°C

Stage	Range (mm)	Mean	n
Yolk sac larva (free embryo)	4.7-5.5	5.0	25
Preflexion larva	5.5-6.0	5.7	25
Flexion larva	9.0-9.4	9.2	25
Postflexion	11.0-13.0	12.75	25
Juvenile	>30.0	-	25

thin (0.3 mm) about 2.85 mm in length, becoming smaller with growth; yolk completely absorbed ≥ 5.5 mm body length. Fin-fold of newly hatched larvae relatively flat, caudal peduncle notch present at hatching. In juvenile at 14.8 mm, the dorsal fin is completely developed, separating from the fin fold at the anterior side of the caudal fin, the eight actinotrichia of the

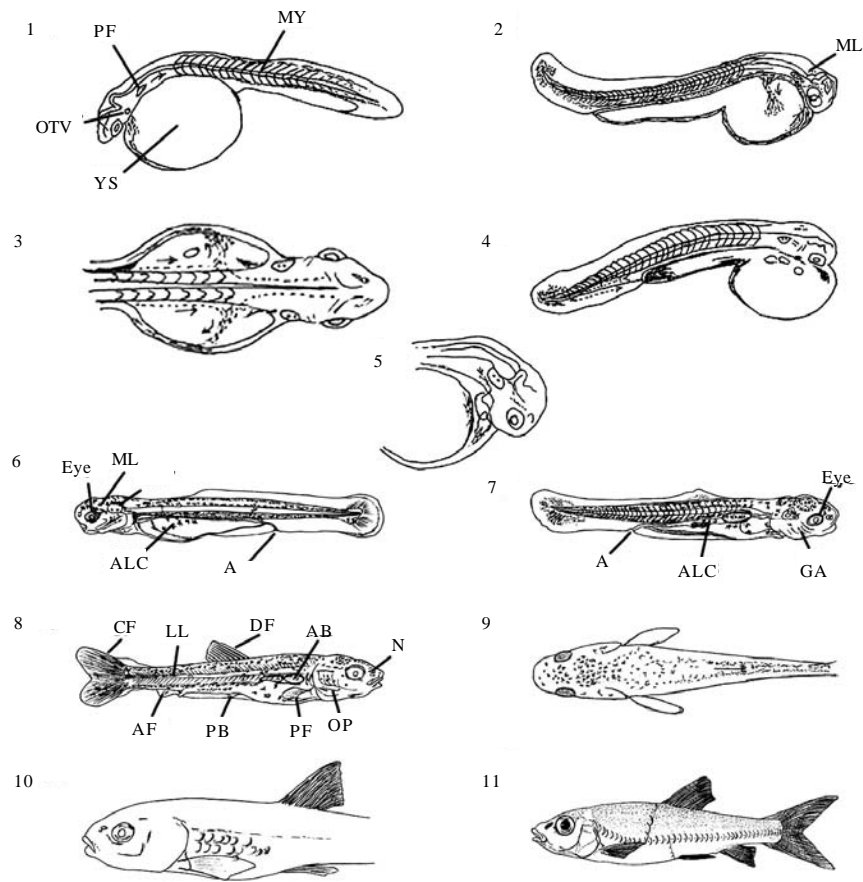


Plate 2(1-11): Successive stages of free embryo and larval development of *Barbus sharpeyi*: (1) free embryo (4 mm L_T), (2) larva (4.3 mm L_T), (3) dorsal view of the anterior part of larva head (4.3 mm L_T), (4) larva (4.4 mm L_T), (5) head of larva (4.4 mm L_T), (6) larva (6 mm L_T), (7) larva (9 mm L_T), (8) early juvenile (11.8 mm L_T), (9) juvenile pigmentation (11.8 mm L_T), (10) early scale formation (31.3 mm L_T), (11) juvenile (70 mm L_T). A: anus; Ab: Air-bladder; Af: anal fin; ALC: Alimentary canal; CF: Caudal fin; DF: Dorsal fin; GA: Gill arches; LL: Lateral line; YS: Yolk sac; ML: Melanophores; MY: Myotomes; N: Nostril; OP: Operculum; PB: Pelvic buds; PF: Pectoral fin

dorsal fin visible with one hard serrated spine at the anterior edge; the anal fin still with mesenchymal tissue; the caudal fin becomes slightly fork-shaped with increasing actinotrichia; the pectoral fin relatively long but without actinotrichia and attaining about 20% of body length.

The rate of growth of the embryo-prelarva interval relatively fast, under relatively constant water temperature of incubation. However, after hatching (dichoriation) it distinctly gets down (Fig. 1).

Mouth, gill openings forming in the yolk sac larvae 4.7-5.5 mm body length. Five gill arches become clearly defined with blood circulation; rudiments of gill filaments appear along the posterior side of gill arches and at ≥ 9.0 mm length, cover all gill arches. Lower jaw completely formed and become movable as mandible in larvae ≥ 5.0 mm body length. Somites distributed as 25 trunk and

17 caudal in yolk sac larva 4.7-5.5 mm body length. Neuromast capulae well defined, spread along lateral line in larvae ≥ 9.0 mm body length, notochord flexion initiated and completed at 4.7-5.5 mm body length. Swim bladder visible at the anterior end of alimentary canal in yolk sac larvae 4.7-5.5 mm body length and attains two-parts shape at ≥ 12.9 mm body length. Scales appearing on body just under the anterior end of lateral line in larvae ≥ 31.0 mm body length; squamation completed in juveniles at 33.9 mm body length.

Proportions: Head short, 0.85 mm in yolk sac larva (4.7-5.5 mm body length), proportion increasing with growth, reaching to 9.0 mm in scaled juvenile >30.0 mm body length. Body depth 0.8 mm initially; decreasing to 0.70 mm in resting larval stage, subsequently increasing in juvenile and scaled juvenile, reaching to 0.98 mm in juvenile (11.0-13.0 mm) and 1.99 mm in scaled juvenile (>30.0 mm). Eye small, 0.20 mm in yolk sac larva (4.7-5.5 mm), rapidly increase with growth to 1.99 mm in scaled juvenile.

Fin development: Dorsal fin development starts at 9.35 mm body length, the actinotrichia are well defined with heavy concentration of mesenchyme, attaining full complement at 12.9 mm body length; the 8 actinotrichia visible with one hard serrated spin at the anterior edge. Anal fin anlage appearing at 12.9 mm body length, fin ray formation at 13.0 mm body length, attaining full complement at 14.8 mm body length; ray segmentation initiated at 12.9 mm body length, branching completed at 14.9 mm body length. Caudal fin anlage appearing at 6.0 mm body length, fin ray formation at 9.35 mm body length, attaining full complement at 33.9 mm body length, ray segmentation initiated at 12.9 mm body length. Caudal fin forked in juvenile phase I with increased number of actinotrichia. Pectoral fin buds appeared in the newly hatched larvae, taking blade-shape at 5.0 mm body length, becoming long, but without actinotrichia at juvenile larvae stage I, attaining full complement in juvenile larvae stage II. Pelvic fin buds appearing at 9.35 mm body length, attaining full complement at juvenile larvae stage II, ray segmentation initiated at 12.9 mm body length.

Pigmentation: Melanophore deposition on eyes initiated in the yolk sac larvae and completed early in the resting interval stage (5.5 and 5.7 mm body length, respectively); few stellate melanophores appearing at the pectoral fin fold area in yolk sac larvae (4.7-5.5 mm body length). Melanophores subsequently appearing on the side of body and at median dorsal line (5.5 mm body length); increasing in number on the anterior and posterior parts of the yolk sac (5.7 mm body length). Spread melanophores appearing at vertex of head and at dorsal and ventral sides of notochord (6.1 mm body length), increasing in number spread widely on surface of body become embedded, dark pigments near base of fins, above head and between eyes.

Ecological notes: Yolk sac larvae <4.7 mm body length usually remained with little movement on the bottom of the aquarium, with sudden movement. Yolk sac larvae >4.7 mm body length began to move passively with the help of water movement at lower layer of the aquarium feeding on some diatoms. Larvae >6 mm body length swim actively in the water column. Larvae at 9.35 mm body length observed feeding on rotifers. Larvae >9.35 mm body length responding to light and hiding in shaded areas. Active larvae >9.35 mm body length change their food to zooplankton to include mainly *Daphnia* nauplii and other cladocerans such as *Keratella* sp., *Lecana* and *Polyarthra* sp., but phytoplankton items remain dominant ($>70\%$ of the total food items). Larvae at juvenile phase I show a decrease rate in the growth accompanied with zooplankton reduction

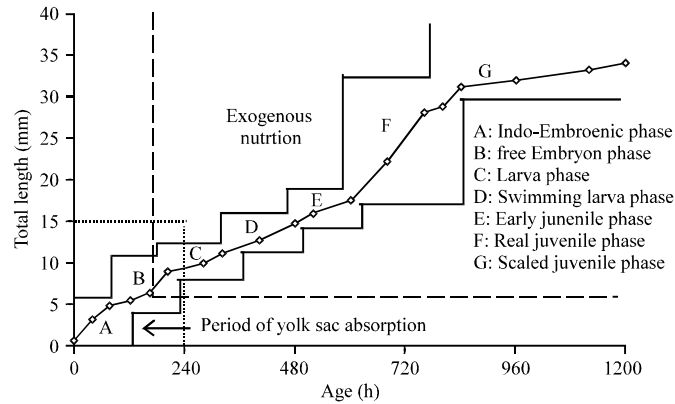


Fig. 1: *B. sharpeyi* embryo and larvae growth

Table 3: Natural food structure of early developmental larvae and fries of Bunni

Parameters	Age after fertilization (days)							
	9	18	28	40	56	133	175	267
Total body length (cm)	1.1	1.2	1.7	3.2	5.5	8	10.5	15.9
Total body mass (gm)	0.01	0.03	0.15	0.30	1.08	2.05	11.00	42.00
Food composition (%):								
Phytoplankton	10	82	40	87.5	62	48	77	72
- Diatomaceae	10	70	20	26	35	30	60	42
- Chlorophyceae	-	7	20	8.5	3	-	7	2
- Cyanophyceae	-	5	-	53	24	18	10	28
Zooplanktons	90	12	50	1	35	35	9	5
- Rotatoria	70	10	20	1	10	20	5	5
- Copepoda	-	2	25	-	18	15	4	-
- Cladocera	20	-	5	-	7	-	-	-
Benthos	-	2	5	2.5	1	-	-	1
Insects	-	-	1	8	2	-	-	-
Higher water plants	-	-	-	-	-	10	12	10

and phytoplankton increase. Larvae at juvenile phase II show fast growth rate with zooplankton dominance in the food item (Table 3, Fig. 1).

DISCUSSION

Very little is known about the embryology of Iraqi cyprinids. Al-Nasih (1992) and Pyka *et al.* (2001) gave a brief account about the embryological development of the cyprinid fish *Barbus sharpeyi*. Their work lacks detailed description of the morphology of the larvae, juvenile and decent illustration of the developmental stages. The present study is the first detailed description of *B. sharpeyi* from this region. The results presented in this work allowing comparison of this species with the other cyprinid species living together in the same environment. A negative correlation between fecundity and egg size at the interspecific level is depending on the female body temperature (Kamler, 1992). In cyprinids, egg incubation period is short, thus many small eggs will be produced if the species lives in warm water. Egg size may vary amongst species of the same family as a function of different ecological niches (Calta, 1998). The egg diameter obtained for *B. sharpeyi* in the present study is similar to the diameter of other *Barbus* species (Cambray, 1983, 1985).

Comparing the egg size with members of cyprinid genera other than *Barbus*, it is clear that *Leuciscus cephalus* and *Cyprinus carpio* (Economou *et al.*, 1991; Hoda and Tsukahara, 1971) and *Chondrostoma nasus* (Keckeis *et al.*, 2001), have eggs larger than those of *B. sharpeyi*. On the other hand, *Abramis brama* (Penaz and Gajdusek, 1979), shows slightly smaller eggs than *B. sharpeyi*. Such differences can be based on the differences in parental size and ecology of those species (Kamler, 1992). On the basis of egg diameter, eggs of *B. sharpeyi* can easily separated from those of other cyprinid species living in the same environment such as *L. cephalus* and *C. carpio*.

The range of egg diameter and size of the newly hatched larvae recorded in the present work are 1.3-1.5 and 4.5-5.5 mm, respectively. Al-Nasih (1992) and Pyka *et al.* (2001) have already reported that the egg diameter and length of newly-hatched larvae of this species is ranging between 1.37-1.70 and 5.0-5.2 mm, respectively. Variation in water temperature and salinity might have a direct change on the diameter of the eggs and size of newly-hatched larvae (Almatar *et al.*, 2000). Thus, both egg diameter and larvae size did not show great changes over 15 years the massive changes in water physical and chemical parameters over the period (TEFS, 1972; Anonymous, 1982; Ali *et al.*, 1988). On the other hand, egg diameter and size of newly-hatched larvae in *B. sharpeyi* are much greater than in *B. luteus* (Al-Hazzaa and Hussein, 2003) that occupies the same ecological niches. Such differences will enable ecologists to separate the eggs and larvae of those two species in the field.

Since, the demersal and adhesive eggs of *B. sharpeyi* are adhered to submerged plants or rocks, they are prone to suffocation through silting. Therefore, for the survival of this species it is important that catchment area be conserved and managed to prevent excessive silting.

The last few decades have seen the rise of various problems regarding lack of standardization of nomenclature applied to early development in fishes (Balinisky, 1948; Balon, 1971; Snyder, 1981; Kendall *et al.*, 1984; Pinder and Sutcliffe, 2001; Urho, 2002). The embryogenesis of *B. sharpeyi* closely follows the pattern reported for barbel *Barbus barbus* (L.) (Krupka, 1988), sofie *Chondrostoma toxostoma* (Vallot) (Gozlan *et al.*, 1999a), tench *Tinca tinca* (L.) (Penaz *et al.*, 1981) and bream *Abramis brama* (L.) (Penaz and Gajdusek, 1979). The prehatching period increased in duration to >50% of the entire embryonic period. This increase in duration may be due to the increasing complexity of development that occurs within each ontogenetic stage. Pinder and Gozlan (2004) reached a similar conclusion with respect to the cyprinid species *Leucaspine delineatus*. The range in incubation temperatures during embryonic development within the present study, although high (22.0-24.0°C), are not higher than *B. sharpeyi* eggs may be subjected to the wild. Embryonic development, however, did progress rapidly with the first free embryo hatching from 70 h. In the previous studies of *B. sharpeyi* development, Al-Nasih (1992) reported hatching at the end of the third day at 18.5-23.5°C and Pyka *et al.* (2001) reported hatching at the mid of the fourth day at 20-22°C, but that hatching can commence earlier, if incubation temperatures are raised to 22-24°C. Hatching often occurs over a period of hours or days and commencing over a range of states of morphological development (Balon, 1990; Penaz, 2001). During the present study, hatching occurred over 11h with the earliest embryos to hatch showing poor swimming capabilities. Similar delay in hatching process was also noticed in the development of sunbleak, *L. delineatus* (Pinder and Gozlan, 2004).

The yolk-sac embryo phase of development in *B. sharpeyi* was observed to be extremely short in duration (11 h), when compared with other barbel, *Barbus barbus* (7 days at 19.2-20.2°C) (Krupka, 1988) and sofie (*Chondrostoma toxostoma*) (4 days at 16-18°C) (Gozlan *et al.*, 1999a) but it is similar to that of sunbleak, *L. delineatus* (Pinder and Gozlan, 2004).

The onset of feeding in the preflexion larvae of *B. sharpeyi* happened 70 h after hatching. This result differs from those of Alikunhi (1958), Swee and McCrimmon (1966) and Hoda and Tsukahara (1971) on *C. carpio*. The latter authors reported preflexion larvae feeding in a short time after hatching. Environmental factors may play a vital role in the developmental rate which has a direct effect on the development of mouth (Hoda and Tsukahara, 1971). Another variable that might be affected by the environment is the development of scales. In *B. sharpeyi*, scale development completed in the juvenile stage at length 33.9 mm, the larvae are slightly larger in size than those of *C. carpio* (Hoda and Tsukahara, 1971).

The transition from the pre-flexion to flexion larval stage was important by the onset of purely exogenous feeding and the flexion of the urostyle. Gozlan (1998) found that the flexion of the urostyle in *Chondrostoma toxosomat* corresponded with a significant increase in swimming capability. Gisbert (1999) also showed, how the increase in depth of the caudal peduncle, i.e. flexion of the urostyle during the early development of Siberian silurion, *Acipenser baeri* Brandt, was associated with the improvement of swimming ability, resulting in enhanced predator avoidance and prey capture skills and thus, increasing survival opportunities. In *B. sharpeyi*, this transition was observed to correspond with a dramatic change in feeding habit, with larvae switching to their first food the rotifer, *Keratella* sp. and subsequent start of mechanical and chemical digestion. The onset of flexion larva also coincides with an increase in the density of melanophores on the dorsal surface and head. The development of dorsal pigmentation in *B. sharpeyi*, at this time, may be an important device, affording increased camouflage against the newly utilized substratum from predators.

The complete absorption of the yolk sac in *B. sharpeyi* took place five days after hatching. This is slightly faster than the duration taken by other cyprinid species, *Barbus luteus* (Al-Hazzaa and Hussein, 2007) but it is still slower than other cyprinid species studied by Penaz (2001). The slowness in the process of yolk absorption may be due to the *adlibitum* availability of good quality food. Such availability of food might limit the role of the yolk sac contents in nourishing-yolk-feeding larvae. A similar case is observed in another cyprinid species, *Leuciscus cehalus* by Calta (2000). Consequential development in the respiratory system, buoyancy ability and swimming activity may coincide with the process of yolk sac depletion.

The results on the course of the larval periods of development under natural conditions presented in this study are same as those given by Pyka *et al.* (2001) and Al-Nasih (1992) under experimental conditions and in an artificial culture. In the natural conditions, the dark colouration of the eye, the complete absorption of yolk sac and mouth movement occurred earlier in the development than in the artificial conditions (Pyka *et al.*, 2001).

The pattern of melanophore distribution does not vary much between individuals, but is difficult to consider such pattern a species-specific as data on the embryology of other freshwater species living in the same area of *B. sharpeyi* is lacking. Uniformity in distribution of melanophores is also observed in other cyprinid species, *Leuciscus cephalus* (Economou *et al.*, 1991). The larvae of *B. sharpeyi* are bottom dwellers during the period before inflation of the swim bladder. The almost complete absence of pigmentation during the period 0-70 hours after hatching may be an adaptation against predation. Similar results were obtained by Economou *et al.* (1991) on chub, *L. cephalus*. In Iraq, the latter species inhabits the same river's area that of *B. sharpeyi*. Thus, the lack of pigmentation will make it difficult to separate the two species according to this criterion.

As in most cyprinids, eye pigmentation in *B. sharpeyi* takes place in the early larval period (Hoda and Tsukahara, 1971; Penaz, 2001; Al-Hazzaa and Hussein, 2007). During metamorphosis

of the larva, the pattern of pigmentation shows inconsistency, but develops during larval ontology and disappears after metamorphosis (Urho, 2002; Parichy and Turner, 2003). The melanophore patch at the base of the caudal fin and over the head remains up to the juvenile stage and changes completely to adulthood pigmentation pattern latter on. This change in pattern may have an ecological role conferring protection against predators (Fuiman and Magurran, 1994). Such changes in pigmentation pattern from the larval stage through the juvenile stage and to the adulthood might be governed by the following factors: (1) metabolism, (2) effect of specific hormones, (3) growth factors that accelerate metamorphosis (Christensen and Korsgaard, 1999; Solbakken *et al.*, 1999; Bolker and Hill, 2000), (4) mutation and food items (Bolker and Hill, 2000; Diler and Dilek, 2002), (5) genes and genetic environmentally sensitive factors (Toyoda *et al.*, 2000; Parichy and Turner, 2003) and (6) habitat (Urho, 2002).

As in many fish larvae, access to air at the water surface is necessary for swimbladder inflation (Chapman *et al.*, 1988). Larvae of the species in question show no failure to activate their swimbladder which seem to be common among laboratory-reared larvae of many species (Barrows *et al.*, 1988; Battaglione and Talbot, 1990). The extraordinary jerky movements of *B. sharpeyi* larvae before the activation of the swimbladder have been interpreted as response to continuous sedimentation in the river habitat (Soin, 1968). Alternatively, these movements may serve a respiratory function, as suggested by Weihs (1981) for the newly hatched anchovy, *Engralis mordax* (Girard), larvae. The latter explanation seems more likely to apply to *B. sharpeyi* larvae for two reasons: first, because after hatching, the cyprinid larvae respire almost exclusively through the body surface (El-Fiky *et al.*, 1987). Second, because this pattern is present in the newly hatched larvae of other cyprinid species such as *B. luteus* (Al-Hazzaa and Hussein, 2007) which normally deposit their eggs in aquatic vegetation.

A significant improvement in swimming performance of *B. sharpeyi* larvae has been observed during the developmental process. Such correlation may be due to the increase mechanical power produce by muscles as in case of the common carp, *Cyprinus carpio* (Wakeling *et al.*, 1999) and in himri, *B. luteus* (Al-Hazzaa and Hussein, 2007) and increased functioning of swimming organs. In larval period, swimming activity and performance resulted from the morphological changes that occur in larvae and level-off towards adulthood (Fuiman and Webb, 1988).

The more advanced the development of the eggs is, the more the appearance of new organs enable the embryo to adapt to environmental conditions (Gozlan *et al.*, 1999b). Among such adaptations is the early appearance and rapid development of the circulatory system. A few hours after hatching, the blood of *B. sharpeyi* becomes clear pink, as seen in the atrium. Toward the end of the yolk-sac larval step, blood circulation branches appear in the trunk region. This event takes place at the same time as an increase in heart rate, probably in order to satisfy the needs of a new feeding mode, which starts with the subsequent larval step.

A clear acceleration in growth was observed in post flexion larval stage of *B. sharpeyi*. This may be due to the development of fins and forward position of the mouth (Osse, 1990; Adrians *et al.*, 2001) during larval periods, flexion-postflexion, which would suggest enhanced swimming capabilities and prey capture efficiencies. The looping of the previously straight gut that occurs during the flexion larval period has been reported to increase digestion time and absorptive processes in fishes (Hofer, 1991; Mann *et al.*, 1997). Bioenergetics, growth and survival might be enhanced through catching more diverse and larger prey items by using the combination of the swimming capabilities and the developing jaw and mouth structures (Keckeis *et al.*, 2001).

The transition of *B. sharpeyi* larvae to juvenile is slow, where it takes over two weeks. Such a delay might be influenced by a variety of factors, including environmental conditions, the availability of suitable food and genetic heterogeneity, as recorded in many other species (Copp and Kovac, 1996; Fuiman *et al.*, 1998; Gozlan *et al.*, 1999b; Vilizzi and Walker, 1999; Ara *et al.*, 2009).

The fifth stage in the development of *B. sharpeyi* is the transition between larva and juvenile stages. It is during this period that changes in morphology occur, resulting in the stabilization of relative growth and the acquisition of the adult morphology (Pinder and Gozlan, 2004). During this step the scales become fully formed, the digestive tract completes its twisting shape, accommodating the new role in feeding and the onset of the pharyngeal tooth formation, which will be used in the wider food spectrum that includes in addition to planktonic food items, specifically benthic organisms such as chironomid larvae and oligochaetes. This is the phase when the shift from bottom habitats used by *B. sharpeyi* larvae to the mid water column of the pond. The boundaries that were defined as the end of the larval period, results in *B. sharpeyi* having a short juvenile period.

Fuiman *et al.* (1983) stated a number of characters that can be used to separate cyprinid larvae. These are relative preanal length, eye shape, preanal myomere number and ventral pigmentation. It is presently impossible to test these four characters as well as others to ascertain which will be the most useful for identification purposes due to lack of detailed information on the ontogeny of Iraqi cyprinid larvae.

B. sharpeyi grows fast during the first year, but is exceeded by the growth of carp, *C. carpio* (Hoda and Tsukahara, 1971). It reaches about 160 mm in total length at the end of the first year. The large initial size of *B. sharpeyi* larva may be responsible for this rapid growth (Kennedy, 1969).

Due to absence of definite agreement in literature about separating of the development stages and phases of early life of fishes and difficulty of definition the borders and intervals between these phases (Russell, 1976; Cerny, 1977; Balon, 1984; Krupka, 1988) we, based in our stating of the development description and integration of early stages, on the facts contrives from the genetic and environmental, particularity of Iraqi freshwater fishes (Banister, 1980; Hanel *et al.*, 1993). Therefore, it is possible, at least for first time, to determine only eight general developmental periods describing the early development and organogenesis of *Barbus sharpeyi* in Iraqi waters. These periods and stages differ in its longevity and growth rate (Fig. 1).

Larval description and therefore, field and laboratory recognition of larvae will facilitate a thorough analysis of the reproductive success of particular species and early life history requirements which need urgent attention with respect to the large cyprinid species such as *B. sharpeyi*.

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