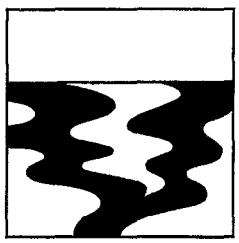

Early development of an endangered African barb, Barbus trevelyani *(Pisces: Cyprinidae)*

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SUMMARY

The Border barb (Barbus trevelyani GUNTHER, *1877*) *is an endangered African freshwater fish species.* B. trevelyani *were artificially induced to breed using a human chorionic gonadotrophin. Eggs were fertilized and their development was followed through embryonic, larval and juvenile stages. Their developmental rate and morphology are described. Fertilized eggs, 1,5 mm (1,4-1,7 mm) in diameter, were demersal and adhesive. Larvae hatched after 2,8 days at temperatures of 17-19 °C. Larval size at hatching was 3,7 mm (3,5-4,0 mm), at yolk absorption 7,1 mm and at pelvic bud formation 10,6 mm. Pigment patterns are described. Larval behaviour of this minnow was similar to that of the more widespread barb,* B. anoplus. *The need to study the early development of more African cyprinids is discussed.*

KEY WORDS: Cyprinidae — *Barbus trevelyani* — Behaviour — Development — Endangered — Larval fish.

RÉSUMÉ

PREMIERS STADES DU DÉVELOPPEMENT D'UNE ESPÈCE MENACÉE DE BARBUS AFRICAINS, *Barbus trevelyani* (PISCES : CYPRINIDAE)

Barbus trevelyani GUNTHER, *1877, est une espèce de poisson d'eau douce africain menacée de disparition. La ponte d'individus collectés dans le milieu naturel a été artificiellement provoquée en utilisant une gonadotropine humaine.*

Les œufs ont été fertilisés et leur développement a été suivi du stade embryonnaire au stade juvénile. La vitesse du développement et la morphologie des différents stades ont été décrites. Les œufs fertilisés de 1,5 mm (1,4 à 1,7 mm) de diamètre sont démersaux et adhésifs. Ils éclosent après 2,8 jours à une température de 17-19 °C. La larve à l'éclosion a une taille de 3,7 mm (3,5 à 4,0 mm). Cette taille est de 7,1 mm à la résorption de la vésicule vitelline et de 10,6 mm lors de la formation du bourgeon pelvien. La pigmentation a été décrite. Le comportement larvaire de ce Barbus *est similaire à celui de* B. anoplus *qui a une vaste répartition. La nécessité d'étudier les premiers stades de développement des Cyprinidae africains est discutée.*

MOTS-CLÉS : *Barbus trevelyani* — Cyprinidae — Comportement — Developpement — Espèce menacée — Larves.

1. INTRODUCTION

Barbus trevelyani GÜNTHER, 1877, is one of the endangered minnows listed in the South African Red Data Book-Fishes (SKELTON, 1977). GAIGHER *et al.* (1980) note that if present land use trends continue there is very little hope of this species surviving in its natural range. The Border barb only occurs in the upper reaches of the Keiskamma and Buffalo River systems in the Eastern Cape, South Africa. It inhabits clear perennial streams with a stony substratum. The largest *B. trevelyani*

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collected by GAIGHER (1975) was a female with a fork length of 103 mm. GAIGHER's (1975) ecological study and the field studies of BOK & HEARD (1982) revealed that the species is threatened through habitat deterioration caused by siltation, dam construction, water extraction and predation by exotic fish species. BOK & HEARD (1982) were able to induce spawning of this barb by injecting *Labeo umbratus* pituitary extract and a human chorionic gonadotrophin (Pregnyl).

Using their method, *B. trevelyani* were collected just prior to the breeding season, injected with Pregnyl, stripped and the developmental rate followed. This work was performed initially at the Pirie Trout Hatchery, King Williams Town from where they were transported to the Douglas Hey Limnological Research Station. Two continuous morphological series of this species were preserved. This study was undertaken to further our knowledge of the early life history stages of *B. trevelyani*, which provides valuable information for the future conservation of the species. The behaviour of the embryos and larvae are now understood and the early larval stages can be recognised. The distinctive adult pigment pattern of a bow-stripe only begins to occur at a length of 25 mm TL.

GAIGHER (1975) outlined the need for proclaimed conservation areas to protect the habitat in which *B. trevelyani* occur. Although methods now exist to artificially propagate this species, a sanctuary within its natural distribution range is still required.

2. METHODS

On 22 November 1982 fish were collected from the clear, rocky Mgqakwebe stream (32° 47′ S; 27° 16′ E), a tributary of the Buffalo river in the Eastern Province, and transported 15 km to the Pirie Trout Hatchery. Males and females in ripe, running condition were stripped, and their fertilized eggs formed the first developmental series. The remainder of the fish were artificially induced to breed using the method of BOK & HEARD (1982). A human gonadotrophin (Pregnyl) was injected (0,05 ml; 125 iu) into 13 ripe females at 18 h 00. [redacted] temperatures of 20° to 21 °C. The ripe and running males were placed in a holding cage in an outside circular pond for the night, with a temperature range of 18° to 20 °C. The following day at 09 h 30, 10 of the 13 females could be stripped, and translucent eggs were easily shed when light pressure was applied to the abdomen. The stripping and fertilization procedures followed the method of BOK & HEARD (1982), except that the natural stickiness of the eggs was left intact so that any behavioural advantage of this adhesiveness could be followed. Fertilized eggs were spread uniformly into hatching trays placed in hatching troughs with a continuous flow of water (9,75 l min^{-1}) at 17 °C. Eggs were treated with a solution of Malachite Green to prevent fungal infections. On 29 November 1982 larval fish of both series were transported to the Douglas Hey Limnological Station (about 500 km) where they were kept in aerated aquaria.

Series 1 commenced on 22 November 1982 and was terminated on 5 April 1983. In all 88 collections were made from the fertilized egg stage to juvenile fish during this 135 day period. Collection intervals were: every 30 min. for 4,5 h; every 2 h for 16 h; every 4 h for 56 h; every 12 h for 3,5 days; every 24 h for 8 days; every 2 days for 84 days and from every 3 to 11 days for 33 days. Series 2 commenced on 23 November 1982 and ended on 12 July 1983. During this 232 day period, 84 collections were made at the following intervals: every 30 to 60 min. for 7 h; every 4 h for 56 h; every 6 h for 24 h; every 12 h for 2,5 days; every 24 h for 7 days; every 2 days for 66 days; every 3 to 4 days for 18 days and then every 3 to 21 days for 131 days. All developmental stages were initially preserved in 10 % formalin and later transferred to 5 % buffered formalin. Aquarium care and feeding were similar to the methods described by CAMBRAY (1983).

Specimens were illustrated with the use of a camera lucida and a binocular dissecting microscope. Eight morphometric and seven meristic characters were measured or counted. Eggs and larvae were measured with an ocular micrometer and dissecting microscope. Larger specimens were measured with dial calipers to the nearest 0,05 mm. All measurements were made at least four months after preservation. Measurements are as outlined by CAMBRAY (1985).

Meristic characters included counts of preanal and postanal myomeres and caudal (principal), dorsal, pectoral and pelvic fin rays. Myomeres were counted as outlined by CAMBRAY (1985). Vertebral counts, including one urostylar and four Weberian elements, were made on a radiograph of 27 *B. trevelyani* ($x = 48,8$ mm SL $\pm$ 4,4 mm S.D., range [redacted] have been catalogued in the ichthyological collection of the Albany Museum, Grahamstown. A photographic record of many of the stages was also made.

3. RESULTS

Eggs

Ripe, unshed eggs were pale yellow, granular and had a modal diameter of 1,3 mm (1,2 - 1,4;

S.D. = 0,1; n = 29), when collected. The fertilized water-hardened eggs had a modal diameter of 1,5 mm (1,4 - 1,7; S.D. = 0,1; n = 47) when collected. The swelling of the vitelline membrane is therefore minimal, and accounts for only 13 % of the diameter of the shed, fertilized egg. The chorionic membrane was spherical, colourless and adhesive. Eggs adhered to each other and debris passing through the hatching trough adhered to the membrane. The yolk was pale yellow, with no oil globules, and the eggs were demersal.

Larvae (1)

Newly hatched (Fig. 1A), length 3,7 mm (3,5 - 4,0 mm; S.D. = 0,2; n = 34); 31 - 34 myomeres; yolk sac bulbous anteriorly, tubular posteriorly; yolk slightly grainy, lacking oil globules; head deflected ventrally over anterior margin of yolk sac until ca. 5,2 - 5,4 mm (6,5 days); posterior gas bladder chamber inflated ca. 6,7 mm (10,5 days); yolk absorbed ca. 7,1 mm (11,5 days); functional mouth parts formed at ca. 7,2 mm (14,5 days); anterior gas bladder chamber forming ca. 11,7 mm (34 days); caudal finfold paddle-shaped (6,7 mm) and starting to fork at ca. 8,8 mm (23 days); first caudal fin rays (7,7 - 7,8 mm, ca. 16 days); notochord flexion commenced (7,7 mm); first dorsal rays formed (10,6 mm ca. 34 days); incipient dorsal fin margin partially differentiated (8,0 - 8,4 mm, ca. 20 days) and completely differentiated (11,2 - 11,9 mm, ca. 36 days); dorsal fin origin over myomeres 12 - 14; incipient anal fin margin partially differentiated at ca. 9,4 mm and completely differentiated at 13,8 - 14,6 mm (ca. 42 days); anal and dorsal fin rays commenced branching at 18 - 19 mm; pelvic buds formed anterior to dorsal fin origin 10,6 mm (ca. 36 days); first pelvic rays at ca. 11,8 - 13,8 mm (40 days); gut commences S-shaping at 10,8 mm; entire finfold absorbed at 18,0 - 18,9 mm (ca. 52 days); smallest individual with some scales 22 mm (75 days); posterior maxillary barbs were forming at ca. 20,2 mm (72 days); anterior maxillary barbs were forming at ca. 32,3 - 34,4 mm (132 days).

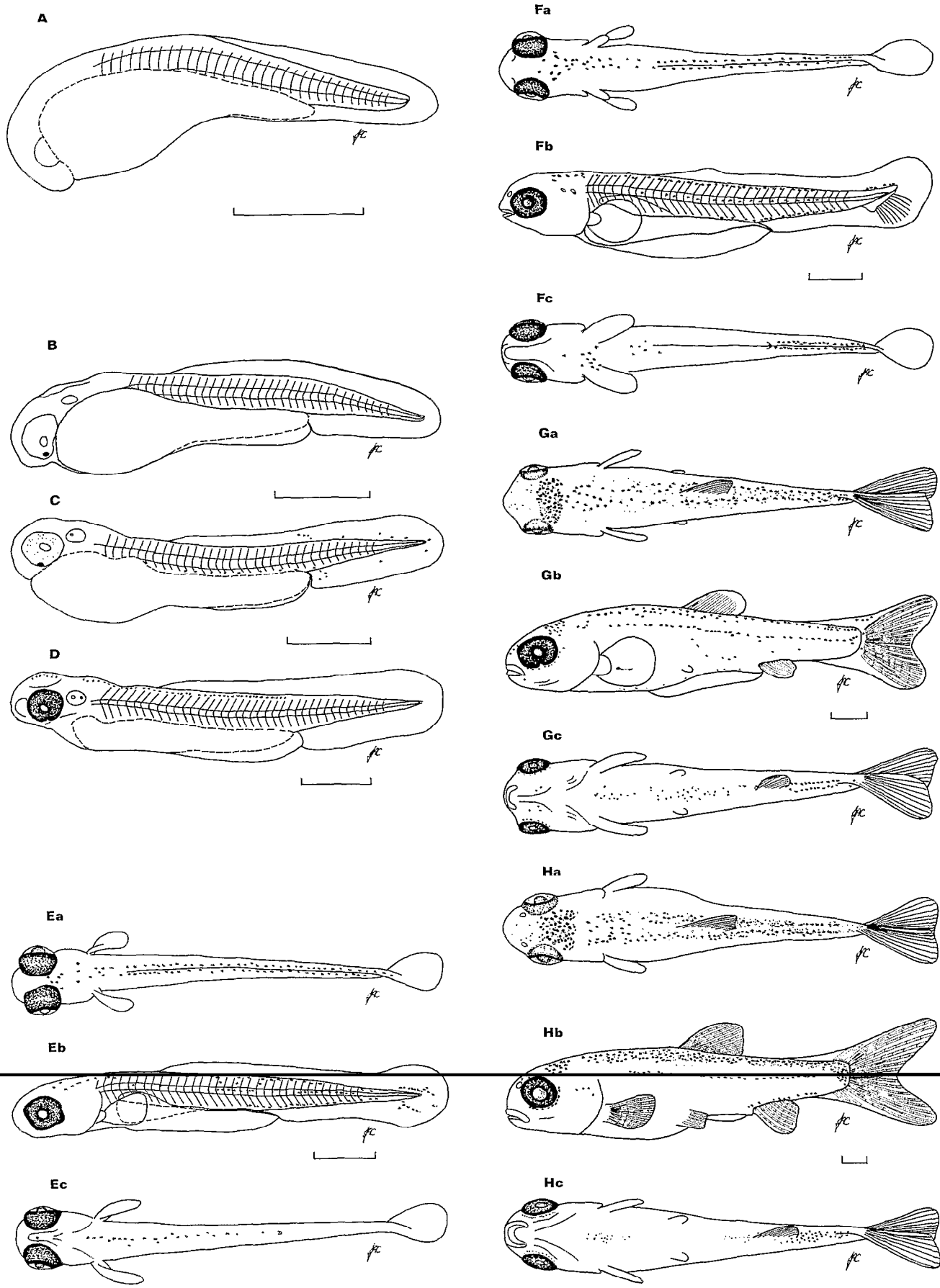
Pigmentation

Length 3,5 - 4,0 mm, newly hatched (Fig. 1A); no pigment on larval fish. Length 4,6 mm (4,5 days: Fig. 1B), first pigment occurred in retina of eye ventral to lens. Length 5,2 mm (6,2 days; Fig. 1C); entire eye lightly pigmented. Length 6,3 mm (7,7 days Fig. 1D), eye well pigmented, melanophores on dorsum of head and scattered along dorsal surface under finfold, start of subdermal pigment on anterior — dorsal surface of yolk sac. Length 7,0 mm (11,5 days; Fig. 1E): Dorsal — no pigment on snout, more on posterior dorsum of head and two rows of pigment along dorsal surface to caudal area. Lateral — mid-lateral row of scattered pigment, subdermal pigmentation below auditory capsule, over swim-bladder and along dorsal surface of intestinal tract. Ventral — a few large melanophores on anterior abdominal region. Length 8,5 mm (20,5 days; Fig. 1F); dorsal and lateral similar to above. Ventral — few more pigments between pectoral fins and two distinct rows from anus to caudal area. Length 12,4 mm (34 days; Fig. 1G). Dorsal — pigment on snout, more on posterior region of head and scattered along dorsal surface. Lateral — pigment behind eye. Ventral — similar to last stage. Length 17,3 mm (44 days; Fig. 1H). Dorsal — heart-shaped pigment pattern on dorsum of head and two distinct rows of pigment along dorsal surface. Lateral — more pigment behind eye, and scattered along upper 25 % of lateral surface, with caudal spot forming. Length 20,3 mm (69 days; Fig. 1I). Dorsal — more pigment on snout, heart-shaped pattern on head faintly visible. Lateral — mid-lateral stripe more dominant and more scattered pigment on dorsal, caudal and anal fins. Length 25,2 mm (77 days; Fig. 1J). Dorsal pigment more 'peppery', smaller scattered along entire dorsal surface except for anterior tip of snout. Lateral — caudal spot, and more pigment on anal, caudal and dorsal fins. Some pigment from mid-lateral row ventrally and this is the start of the characteritic bow-stripe of the adult. Length 35,2 mm (132 days; Fig. 1K). Dorsal — now triangular pigment patch on dorsum of head. Lateral — fine pigment extends from botton of bows-tripe to dorsal surface, caudal spot dark, and dorsal, caudal, anal, pectoral and pelvic fins lightly pigmented. Ventral — no change, row from anus to caudal area. The pigmentation is now similar to adult (see JUBB, 1967).

Meristics and morphometry

Myomere number remained relatively unchanged after a total length of 6 mm was obtained (Table I), after which means and standard deviations for 154 specimens were 25,8 $\pm$ 0,5 (preanal), 10,1 $\pm$ 0,6 (postanal) and 35,9 $\pm$ 0,7 (total). Total vertebrae for 27 *B. trevelyani* were 36,4 $\pm$ 0,6 S.D. Order of

(1) Ranges given in parenthesis indicate the total length of the smallest individual with, and the largest individual without the named structure.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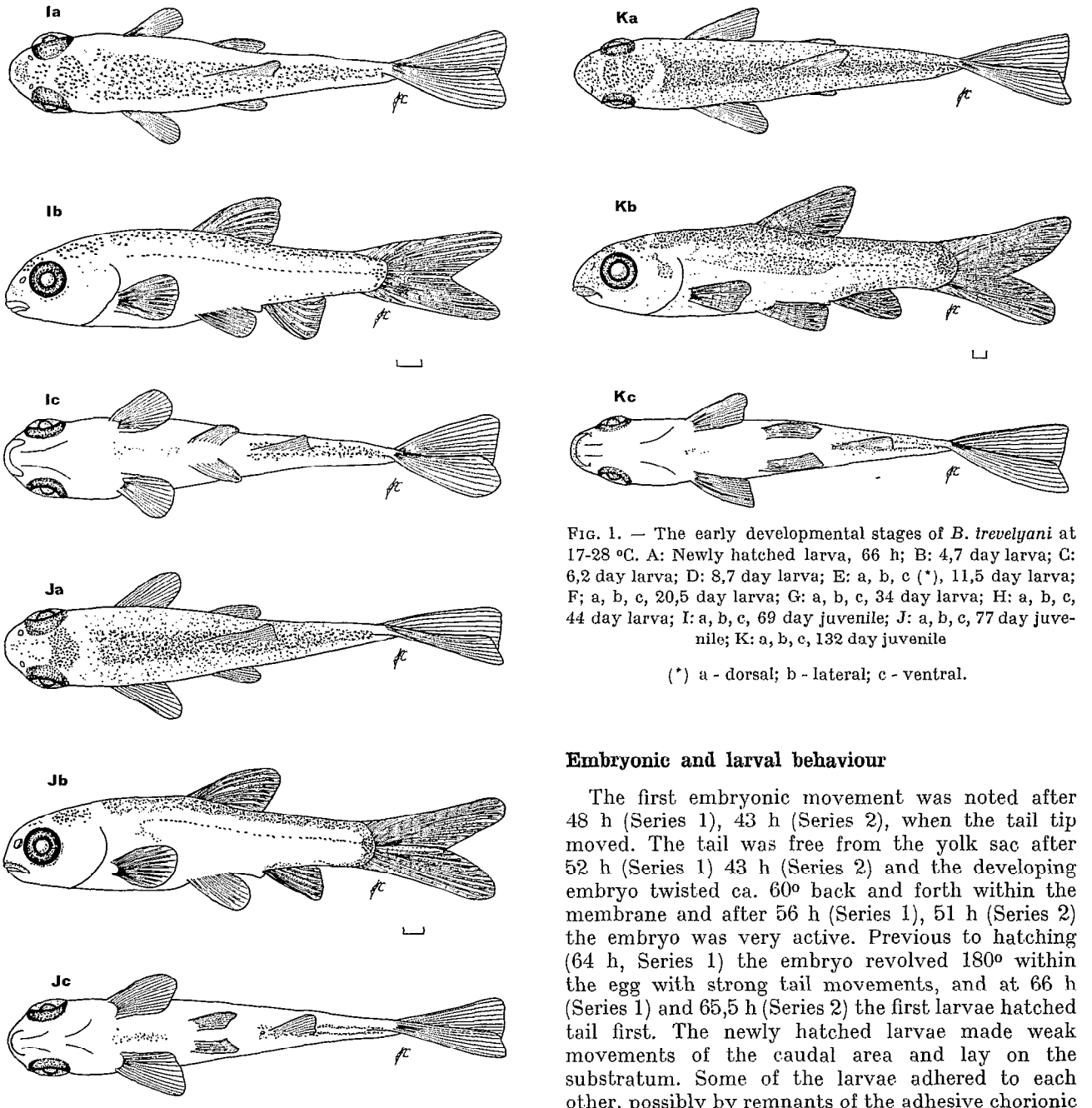

FIG. 1. — The early developmental stages of *B. trevelyani* at 17-28 °C. A: Newly hatched larva, 66 h; B: 4,7 day larva; C: 6,2 day larva; D: 8,7 day larva; E: a, b, c (*), 11,5 day larva; F; a, b, c, 20,5 day larva; G: a, b, c, 34 day larva; H: a, b, c, 44 day larva; I: a, b, c, 69 day juvenile; J: a, b, c, 77 day juvenile; K: a, b, c, 132 day juvenile

(*) a - dorsal; b - lateral; c - ventral.

fin-ray formation was caudal, dorsal and anal with rays in the paired fins developing last (Table I). The dorsal fin formula is III + 7, occasionally III + 6 or III + 8 and the anal fin formula is III + 5, occasionally III + 4 or III + 6.

The changes in body proportions for 244 specimens are shown in Tables II and III.

Embryonic and larval behaviour

The first embryonic movement was noted after 48 h (Series 1), 43 h (Series 2), when the tail tip moved. The tail was free from the yolk sac after 52 h (Series 1) 43 h (Series 2) and the developing embryo twisted ca. 60° back and forth within the membrane and after 56 h (Series 1), 51 h (Series 2) the embryo was very active. Previous to hatching (64 h, Series 1) the embryo revolved 180° within the egg with strong tail movements, and at 66 h (Series 1) and 65,5 h (Series 2) the first larvae hatched tail first. The newly hatched larvae made weak movements of the caudal area and lay on the substratum. Some of the larvae adhered to each other, possibly by remnants of the adhesive chorionic membrane. Within 76 h (Series 1) approximately 40 % of the larvae had hatched, whereas 50 % of Series 2 hatched after 83 h. After 3,6 days (Series 1) 90 % had hatched and the larvae occurred in clusters on the substratum, and periodically underwent rapid tail movements which moved them haphazardly on the substratum. After 5,5 days (Series 1) larvae were either clustered together on the substratum, with their heads adhering to each

TABLE I

Meristic characteristics of *Barbus trevelyani* larvae and early juveniles grouped by 1 mm intervals of total length (n = sample size)

Length		Myomeres			Fin rays				
Intervals	n	Preanal	Postanal	Total	Caudal	Dorsal	Anal	Pelvic	Pectoral
3	10	23-26	5-9	31-34	-	-	-	-	-
4	10	24-26	7-11	32-37	-	-	-	-	-
5	9	26-27	9-10	34-37	-	-	-	-	-
6	12	25-27	9-12	35-38	-	-	-	-	-
7	10	25-26	10-12	35-37	0- 6	-	-	-	-
8	7	25-26	10-11	35-37	6-19	-	-	-	-
9	10	25-26	9-11	35-36	18-19	-	-	-	-
10	6	25-26	9-11	35-37	18-19	0- 9	0- 7	-	-
11	10	25-26	9-10	34-36	18-19	8- 9	4- 7	0- 5	0- 3
12	12	25-26	9-11	35-37	19	7- 9	6- 7	0- 5	0- 6
13	12	25-27	9-11	35-37	18-19	9	7	0- 7	0- 8
14	12	25-26	9-10	35-36	18-19	9	6- 8	5- 9	7-10
15	10	25-26	10-11	35-37	18-19	9-10	7- 8	6- 9	9-12
16	10	25-27	9-11	35-36	17-19	9	7- 8	6- 8	10-12
17	10	25-27	10-11	35-37	17-19	9-10	7- 8	5- 8	10-13
18	11	26	9-10	35-36	17-19	9-10	7- 8	7- 9	10-12
19	10	25-27	9-11	35-37	18-20	9-10	7- 8	7- 9	12-13
20	10	25-27	10-11	35-37	18-19	iii, 6- 7	iii, 5	7- 9	12-13
21	5	26	10-11	36-37	19	iii, 6- 7	iii, 4- 5	8	12-13
22	5	26	10-11	36-37	18-19	iii, 7	iii, 5- 6	8	12-13
23	6	-	-	-	17-19	iii, 7	iii, 4- 5	8	12-13
24	5	-	-	-	19-20	iii, 6- 7	iii, 4- 5	7- 8	12-13
25	6	-	-	-	17-19	iii, 6- 7	iii, 4- 5	6- 8	12-13
26	3	-	-	-	19	iii, 7	iii, 5	8	12-13
27	3	-	-	-	17-19	iii, 7	iii, 5	8	12-13
28	5	-	-	-	19-20	iii, 7	iii, 4- 5	8- 9	12-13
29	6	-	-	-	18-19	iii, 6- 8	iii, 3- 5	7- 8	10-13
30	4	-	-	-	18-19	iii, 7	iii, 5	8	12-13

other or singularly adhering to the sides of the aquarium. The larvae appear to have a cement gland on the anterior section of their heads, and adhered to other larvae, dead eggs or the edges of the aquarium glue. When the larvae were separated from a cluster, they moved rapidly around on the substratum until they again adhered to a cluster of larvae. A few larvae 'floated' after 6,5 days (Series 1), and hung perpendicularly from the surface of the water. Some larvae were very active and swam to the surface and then passively sank. After 10,5 days (Series 1) the larvae were all actively swimming and food was first noted in the intestinal tract after 11,5 days.

4. DISCUSSION

GAIGHER (1975) and BOK & HEARD (1982) have completed important studies on the endangered Border barb. The former study on the ecology of this species stressed that it is in danger of extinction due to habitat deterioration including the presence of introduced exotic species. The latter study provided a method by which *B. trevelyani* could be induced to spawn so that a large-scale propagation and stocking programme could be initiated in selected areas. The present study on the ontogeny of this endangered species provides additional information on larval behaviour, identification and

TABLE II

Morphometry of *Barbus travelyani* larvae and early juveniles grouped by 1 mm intervals of total length (n = sample size)

	Lengths (mm)						Body depth (mm)	
	Total	Standard	Preanal	Head	Snout	Eye	Widest	At anus
10	3,6(3,5-3,7)	3,4(3,3-3,5)	2,5(2,4-2,6)	-	-	-	1,1(1,0-1,3)	0,4(0,3-0,5)
10	4,5(4,1-4,9)	4,3(3,8-4,8)	3,1(2,7-3,5)	-	-	0,4(0,3-0,4)	1,1(1,0-1,2)	0,5(0,4-0,6)
9	5,1(5,0-5,4)	4,9(4,8-5,1)	3,6(3,5-3,8)	-	-	0,5(0,4-0,5)	1,1(1,1-1,3)	0,6(0,5-0,7)
12	6,5(6,0-6,9)	6,2(5,7-6,5)	4,2(4,0-4,5)	1,4(1,2-1,4)	0,3(0,2-0,3)	0,5(0,4-0,6)	1,0(0,8-1,1)	0,7(0,6-0,7)
9	7,4(7,1-7,8)	6,9(6,6-7,4)	4,7(4,4-5,1)	1,5(1,4-1,6)	0,2(0,2-0,3)	0,6(0,5-0,6)	1,0(1,0-1,1)	0,6(0,6-0,7)
7	8,4(8,0-8,8)	7,8(7,5-8,0)	5,3(5,1-5,7)	1,8(1,7-2,0)	0,3(0,2-0,3)	0,6(0,6-0,7)	1,3(1,2-1,5)	0,8(0,7-0,9)
10	9,6(9,1-9,9)	8,6(8,3-9,0)	6,0(5,7-6,1)	2,1(2,0-2,3)	0,4(0,3-0,5)	0,7(0,7-0,8)	1,7(1,5-1,8)	0,9(0,9-1,1)
6	10,4(10,0-10,9)	9,1(8,8-9,5)	6,6(6,2-6,9)	2,5(2,3-2,6)	0,5(0,4-0,6)	0,9(0,8-0,9)	2,0(1,6-2,2)	1,2(1,0-1,3)
10	11,4(11,0-11,8)	9,6(9,2-10,1)	6,9(6,6-7,4)	2,6(2,4-2,7)	0,5(0,4-0,6)	0,9(0,7-1,0)	2,2(2,0-2,4)	1,3(1,2-1,5)
12	12,5(12,0-12,9)	10,2(9,8-10,5)	7,5(6,9-7,7)	2,9(2,8-3,1)	0,6(0,5-0,7)	1,0(0,9-1,1)	2,4(2,2-2,6)	1,6(1,4-1,8)
12	13,5(13,1-13,9)	10,9(10,4-11,3)	8,2(7,9-8,5)	3,2(3,0-3,3)	0,6(0,5-0,8)	1,1(1,0-1,2)	2,8(2,4-3,1)	1,7(1,6-1,9)
12	14,4(14,1-14,7)	11,4(11,0-12,0)	8,4(8,1-9,0)	3,4(3,2-3,6)	0,7(0,6-0,8)	1,2(1,0-1,3)	2,9(2,6-3,2)	1,8(1,5-2,1)
10	15,4(15,0-15,8)	12,2(12,0-12,5)	8,9(8,6-9,1)	3,6(3,5-3,8)	0,8(0,6-0,9)	1,3(1,2-1,4)	3,1(2,9-3,3)	2,0(1,8-2,2)
10	16,3(16,0-16,6)	12,7(12,4-13,3)	9,3(8,9-9,6)	3,8(3,7-4,0)	0,8(0,8-1,0)	1,3(1,2-1,4)	3,3(3,2-3,6)	2,2(2,0-2,3)
10	17,4(17,0-17,9)	13,5(13,0-14,0)	9,7(8,8-10,1)	4,1(3,7-4,5)	0,9(0,8-1,1)	1,4(1,3-1,5)	3,5(3,3-3,8)	2,3(2,1-2,5)
11	18,4(18,0-18,9)	14,4(13,9-14,7)	10,1(9,6-10,7)	4,4(4,0-4,8)	1,0(0,8-1,2)	1,5(1,4-1,5)	3,7(3,5-4,1)	2,5(2,3-2,7)
10	19,6(19,0-19,9)	15,1(14,4-15,4)	10,6(10,2-10,9)	4,7(4,3-5,1)	1,1(0,9-1,3)	1,5(1,4-1,6)	3,7(3,5-3,9)	2,5(2,3-2,6)
10	20,5(20,1-20,9)	15,8(15,3-16,2)	11,0(10,4-11,5)	4,9(4,6-5,1)	1,1(1,0-1,3)	1,6(1,5-1,7)	3,9(3,6-4,3)	2,6(2,3-2,9)
5	21,5(21,2-21,9)	16,8(16,3-17,1)	11,6(11,5-11,8)	5,4(5,2-5,6)	1,1(1,0-1,3)	1,7(1,7-1,8)	4,0(3,8-4,1)	2,8(2,5-2,9)
5	22,5(22,1-22,8)	17,5(17,1-17,8)	12,2(11,6-12,5)	5,4(5,0-5,7)	1,2(1,0-1,4)	1,8(1,7-1,8)	4,2(3,9-4,3)	2,8(2,6-2,9)
6	23,3(23,0-23,7)	17,8(17,1-18,5)	12,2(11,7-12,9)	5,6(5,2-6,3)	1,2(1,0-1,3)	1,8(1,7-1,8)	4,3(4,2-4,6)	3,0(2,9-3,2)
5	24,5(24,1-24,9)	18,8(18,7-19,1)	13,2(12,4-13,5)	6,0(5,9-6,2)	1,2(1,1-1,3)	1,8(1,8-1,9)	4,8(4,5-5,1)	3,3(3,1-3,5)
6	25,4(25,0-25,7)	19,5(18,9-20,1)	13,5(13,0-13,9)	5,9(5,4-6,4)	1,3(1,2-1,4)	1,9(1,9-2,0)	5,0(4,7-5,3)	3,5(3,4-3,6)
4	26,4(26,1-26,9)	20,6(20,0-21,0)	14,2(13,8-14,3)	6,5(6,1-6,7)	1,3(1,1-1,5)	2,1(2,0-2,1)	5,0(4,8-5,3)	3,6(3,4-3,6)
2	27,4(27,0-27,8)	21,5(21,4-21,5)	14,7(14,5-14,9)	6,4(6,1-6,6)	1,5(1,4-1,5)	2,0	5,6	3,8(3,7-3,9)
5	28,2(28,0-28,9)	21,9(21,2-22,5)	15,0(14,6-15,6)	6,9(6,7-7,1)	1,6(1,4-1,7)	2,1(2,0-2,3)	5,7(5,4-6,0)	3,8(3,6-4,1)
5	29,5(29,1-29,8)	22,6(21,7-23,5)	15,1(14,4-15,8)	6,9(6,6-7,3)	1,6(1,5-1,9)	2,3(2,2-2,4)	5,7(5,1-6,2)	4,0(3,7-4,2)
4	30,5(30,1-30,7)	23,3(23,1-23,9)	16,2(15,3-17,0)	7,4(7,0-8,0)	1,7(1,6-1,9)	2,3(2,2-2,4)	5,8(5,6-6,0)	4,1(3,9-4,2)
4	31,4(31,1-31,8)	24,2(24,1-24,4)	16,9(16,5-17,2)	7,5(7,1-7,9)	1,7(1,6-1,7)	2,4(2,3-2,4)	6,0(5,7-6,4)	4,3(4,1-4,6)
5	32,5(32,2-32,9)	25,3(24,5-26,0)	17,6(17,2-18,2)	8,0(7,8-8,2)	1,8(1,5-2,0)	2,4(2,3-2,6)	6,3(6,0-6,7)	4,5(4,4-4,6)
1	33,8	25,6	18,1	7,4	2,0	2,4	7,1	4,8
3	34,5(34,3-34,8)	26,6(26,5-26,7)	18,0(17,7-18,2)	8,1(8,0-8,2)	1,9(1,7-2,1)	2,5(2,4-2,6)	6,8(6,6-7,0)	5,0(5,0-5,1)
2	35,4(35,2-35,6)	27,7(27,2-28,1)	18,7(18,1-19,2)	8,4	2,0	2,7(2,6-2,7)	6,9(6,6-7,2)	5,0(4,7-5,3)
1	36,9	28,7	20,0	8,5	2,2	2,6	6,8	5,1
1	38,3	30,1	20,7	8,7	2,6	2,7	6,8	5,2

TABLE III

Proportional measurements relative to total length (TL, mm) or head length (HL, mm) for some *Barbus trevelyani* larvae and juveniles. Values are means + SD, with ranges in parenthesis

n	TL	SL : TL	Preanal :TL	HL : TL	Eye diameter : TL	Snout length : TL	Body depth at anus: TL	Eye diameter : HL	Snout length : HL	Body depth at anus: HL
20	4,03±0,52 (3,5-4,9)	0,96±0,02 (0,93-0,98)	0,7±0,02 (0,62-0,74)	-	-	-	0,12±0,02 (0,08-0,14)	-	-	-
21	5,91±0,74 (5,0-6,9)	0,95±0,01 (0,93-0,98)	0,68±0,03 (0,63-0,74)	-	0,09±0,01 (0,07-0,1)	-	0,11±0,01 (0,09-0,14)	-	-	-
16	7,81±0,6 (7,1-8,8)	0,93±0,01 (0,9-0,95)	0,64±0,01 (0,61-0,66)	0,21±0,01 (0,18-0,23)	0,08±0,0 (0,07-0,08)	0,03±0,01 (0,01-0,04)	0,09±0,01 (0,08-0,11)	0,38±0,04 (0,32-0,46)	0,14±0,03 (0,08-0,19)	0,44±0,04 (0,38-0,5)
16	9,91±0,51 (9,1-10,9)	0,88±0,02 (0,83-0,91)	0,63±0,01 (0,6-0,65)	0,23±0,01 (0,21-0,24)	0,08±0,0 (0,07-0,08)	0,04±0,01 (0,03-0,06)	0,1±0,01 (0,08-0,12)	0,34±0,01 (0,08-0,12)	0,19±0,02 (0,14-0,23)	0,45±0,04 (0,35-0,5)
22	11,96±0,63 (11,0-12,9)	0,83±0,02 (0,8-0,88)	0,6±0,01 (0,58-0,63)	0,23±0,01 (0,21-0,24)	0,08±0,01 (0,06-0,09)	0,05±0,01 (0,04-0,06)	0,12±0,01 (0,11-0,15)	0,34±0,02 (0,29-0,38)	0,2±0,02 (0,15-0,25)	0,52±0,05 (0,46-0,64)
24	13,99±0,52 (13,1-14,7)	0,8±0,01 (0,78-0,82)	0,59±0,02 (0,57-0,62)	0,23±0,01 (0,22-0,24)	0,08±0,01 (0,07-0,09)	0,05±0,01 (0,04-0,06)	0,13±0,01 (0,1-0,14)	0,35±0.02 (0,3-0,38)	0,21±0,02 (0,16-0,24)	0,54±0,04 (0,47-0,62)
20	15,83±0,53 (15,0-16,6)	0,79±0,01 (0,77-0,81)	0,57±0,01 (0,55-0,59)	0,24±0,01 (0,22-0,25)	0,08±0,01 (0,08-0,09)	0,05±0,01 (0,04-0,06)	0,13±0,01 (0,12-0,15)	0,35±0,03 (0,32-0,4)	0,22±0,02 (0,17-0,25)	0,56±0,03 (0,51-0,63)
21	17,93±0,63 (17,0-18,9)	0,78±0,01 (0,76-0,81)	0,55±0,02 (0,51-0,59)	0,24±0,01 (0,22-0,26)	0,08±0,0 (0,07-0,09)	0,05±0,01 (0,04-0,06)	0,13±0,01 (0,12-0,15)	0,34±0,02 (0,31-0,39)	0,23±0,02 (0,2-0,27)	0,57±0,02 (0,52-0,61)
20	20,03±0,52 (19,0-20,7)	0,77±0,01 (0,74-0,79)	0,54±0,02 (0,5-0,56)	0,24±0,01 (0,22-0,26)	0,08±0,0 (0,07-0,08)	0,05±0,01 (0,05-0,07)	0,13±0,01 (0,12-0,14)	0,33±0,02 (0,3-0,36)	0,22±0,02 (0,2-0,27)	0,53±0,04 (0,49-0,61)
10	22,03±0,61 (23,0-24,9)	0,78±0,01 (0,74-0,78)	0,54±0,01 (0,51-0,56)	0,25±0,01 (0,22-0,27)	0,08±0,0 (0,07-0,08)	0,05±0,01 (0,04-0,06)	0,13±0,01 (0,13-0,19)	0,32±0,02 (0,29-0,35)	0,21±0,02 (0,19-0,23)	0,52±0,03 (0,48-0,62)
10	25,81±0,62 (25,0-26,9)	0,77±0,01 (0,75-0,78)	0,53±0,01 (0,51-0,55)	0,24±0,01 (0,22-0,26)	0,08±0,0 (0,07-0,08)	0,05±0,0 (0,04-0,06)	0,14±0,0 (0,13-0,14)	0,33±0,02 (0,3-0,34)	0,21±0,02 (0,2-0,24)	0,57±0,04 (0,52-0,63)
7	28,0±0,56 (27,0-28,9)	0,78±0,01 (0,76-0,8)	0,53±0,01 (0,52-0,54)	0,24±0,01 (0,23-0,25)	0,07±0,0 (0,07-0,08)	0,05±0,0 (0,05-0,06)	0,14±0,01 (0,13-0,15)	0,31±0,01 (0,3-0,33)	0,23±0,01 (0,2-0,24)	0,57±0,03 (0,52-0,61)
9	29,94±0,56 (29,1-30,7)	0,76±0,02 (0,75-0,79)	0,52±0,02 (0,49-0,55)	0,24±0,01 (0,22-0,26)	0,08±0,0 (0,07-0,08)	0,05±0,01 (0,05-0,06)	0,13±0,01 (0,13-0,14)	0,31±0,01 (0,3-0,32)	0,23±0,02 (0,2-0,26)	0,56±0,03 (0,53-0,64)
9	31,99±0,63 (31,1-32,9)	0,77±0,02 (0,75-0,78)	0,54±0,01 (0,53-0,56)	0,24±0,01 (0,23-0,25)	0,07±0,0 (0,07-0,08)	0,05±0,0 (0,05-0,06)	0,14±0,0 (0,13-0,15)	0,31±0,01 (0,29-0,33)	0,23±0,02 (0,19-0,25)	0,57±0,04 (0,53-0,65)
4	34,33±0,41 (33,8-34,8)	0,77±0,01 (0,76-0,77)	0,52±0,01 (0,52-0,54)	0,23±0,01 (0,22-0,24)	0,07±0,0 -	0,06±0,0 (0,05-0,06)	0,14±0,0 (0,14-0,15)	0,31±0,01 (0,14-0,15)	0,25±0,03 (0,21-0,27)	0,63±0,02 (0,61-0,65)
4	36,5±1,4 (35,2-38,3)	0,78±0,01 (0,77-0,79)	0,53±0,01 (0,51-0,54)	0,23±0,01 (0,23-0,24)	0,07±0,0 (0,07-0,08)	0,06±0,0 (0,06-0,07)	0,17±0,01 (0,13-0,15)	0,31±0,01 (0,31-0,32)	0,26±0,03 (0,24-0,3)	0,6±0,03 (0,56-0,63)

TABLE IV

Comparison of several developmental traits of *B. anoplus* and *B. trevelyani*

Trait	B. anoplus	B. trevelyani
Eggs, demersal and adhesive	Yes	Yes
Fertilised egg diameter (mm)	1,1	1,5
Hatching time	53h at 19-21°C	67h at 17-19°C
(a) hatching	3,1	3,7
(b) yolk absorption	4,5	7,1
(c) pelvic bud formation	8,4-9,5	10,6
Larval behaviour		
(a) active upwards, passive sinking	Yes	Yes
(b) adhere to objects	Yes	Yes
(c) pelagic larvae	Some	Few
(d) cluster together on substratum	No	Yes

developmental rates. The only other African study on small *Barbus* ontogeny is the one by Cambray (1983) on *B. anoplus*. Table IV compares a few developmental traits of the two species.

B. trevelyani prefer clear, perennial streams with a clean stony substratum and are probably midstream spawners (GAIGHER, 1975). The parents for the present study were collected in a clear-flowing, rocky stream, with no aquatic macrophytes. Since some of the fish were in a ripe-running condition we can only assume that this is their breeding habitat. The demersal, adhesive eggs would have to adhere to the rocks, thus they could be suffocated from excessive silt. Therefore for the survival of this species it is important that the catchment area be conserved and managed to prevent excessive siltation and that the streams remain perennial as *B. trevelyani* are dependant on running water (GAIGHER, 1975). The larval stages adhere to objects and therefore they would also be prone to suffocation until they obtain a more mobile stage of active upward swimming and passive sinking. CAMBRAY (1983) suggested that some of the developmental traits of *B. anoplus* partially enabled it to become a widespread freshwater fish species in southern Africa. *B. trevelyani* has a much more limited distribution (GAIGHER, 1975; SKELTON, 1977) although this species has many of the larval behavioural traits of *B. anoplus* (Table IV). The ability of some larvae to float appears to be highly variable within a cohort and deserves further attention. Very few *B. trevelyani* floated and the individuals that did possibly used a remnant of the chorionic membrane to increase the area in contact with the surface of the water. The majority of *B. trevelyani* larvae clustered together on the substratum head to head. If one larval fish was artificially removed from a cluster the released larva would immediately force its way back into the group again. This behaviour was not noted for *B. anoplus* larvae. However, pelagic larval *B. anoplus* sometimes clustered together and formed a small 'raft'. Like *B. anoplus* (CAMBRAY, 1983), many of the *B. trevelyani* larvae undertook active upward swimming and passive sinking which is characteristic of many fish species (SHELTON & STEPHENS, 1980). Possibly the upwardly mobile fish could adhere to flotsam and this would aid them in their distribution.

At present life history work relies on egg counts of a species to give an indication of its possible reproductive success. However larval descriptions and therefore field and laboratory recognition of larvae will allow for a more thorough analysis of a species reproductive success and early life history

requirements which require urgent attention for threatened species such as *B. trevelyani*. In Africa there are only complete ontogenetic studies for six cyprinid species (see CAMBRAY, 1985). To enable a better understanding of the diversity of African cyprinid larvae further work is urgently needed. A state of the art paper on the identification of cyprinid fish larvae of the Atlantic coast drainages of North America states that four major characters are useful in segregating all cyprinid larvae into distinct, though unrelated groups (FUIMAN *et al.*, 1983). These characters include relative preanal length, eye shape, preanal myomere number and ventral pigmentation. When more is known about African cyprinid larvae we will be able to test these four characters as well as others to ascertain which will be the most useful for identification purposes.

Another very important aspect of completing developmental series is their usefulness to infer phylogenetic relationships by studying developmental osteology. DUNN (1983 : 1) has noted that "Osteological studies of fish larvae and rigorous documentation and analyses of such studies ... have the potential to notably increase our understanding of teleost phylogeny." When there have been more developmental series completed on the African cyprinids then it will be worthwhile to have a close look at their developmental osteology. At this stage in our understanding there is a need to make studies of the early development of African freshwater fish easily comparable. Attention to behavioural as well as morphological characteristics should be made.

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