Early ontogeny of *Labeo capensis* (Pisces: Cyprinidae)

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The early ontogeny of *Labeo capensis* (A. Smith 1841) is described from wild-spawned, laboratory-reared specimens which were monitored for five months. Fertile eggs were non-adhesive, demersal and 2,9 mm (2,7 – 3,4 mm) in diameter. Total length at hatching was 5,4 mm (5,3 – 5,7 mm); at yolk absorption 7,9 mm and at pelvic bud formation 11,1 mm. Pigment patterns during larval development are described. Pigmentation began on the head and covered most of the body by the juvenile period. Myomere number remained constant after hatching and fin rays appeared in the order of caudal, dorsal, anal, pelvic and pectoral. Larvae periodically swam upwards and then passively sank, as has been reported for other *Labeo* species. Egg buoyancy and larval behaviour are discussed with relevance to spawning habitat.

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Die vroeë ontwikkeling van *Labeo capensis* (A. Smith 1841) vanaf die natuurlike bevrugting van die eiers tot die latere versorging van die spesie onder laboratoriumtoestande en wat oor 'n tydperk van 5 maande waargeneem is, word beskryf. Bevrugte eiers was nie-klewerig, waterlewend en met 'n deursnit van 2,9 mm (2,7 – 3,4 mm). Totale lengte na uitbroeiing was 5,4 mm (5,3 – 5,7 mm); by die stadium van dooierabsorpsie 7,9 mm en met buikholtevorming was die lengte 11,1 mm. Pigmentvorming gedurende die larvale stadium word beskryf. Pigmentasie begin op die kopgedeelte en bedek later die hele liggaam. Die getal myomere het konstant gebly na uitbroeiing en die vinstrale het in die volgorde stert-, dorsaal, anaal, buik- en pektoraal verskyn. Die larwes het periodiek opwaarts geswem en dan passief gesink soos ook beskryf is vir ander *Labeo* spesies. Dryfvermoë van eiers en larvale gewoontes word bespreek met betrekking tot die uitbroeihabitat.

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Details of the ontogeny of most African cyprinids is a conspicuously neglected area of research (Cambray 1983). Barnard (1943) described several larval stages for a number of South African cyprinids. However nearly complete descriptions of larval development are only available for *L. victorianus* from Lake Victoria (Fryer & Whitehead 1959), *L.mesops* from Lake Malawi (Anon 1965), *Barbus aeneus* from the Vaal River (Groenewald 1961) and *B.anoplus* from the Orange River (Cambray 1983, in press). Less complete descriptions are available for *B.natalensis* of Natal (Wright & Coke 1975) and *L.umbratus* of the eastern Cape (Gaigher, Ntloko & Visser 1975). In contrast, there are many published works describing the early development of Indian *Labeo* species (e.g. Khan 1925; Ahmad 1944; Mookerjee, Mazumdar & Dasgupta 1944; Mookerjee 1945; Jones 1946; Mookerjee & Mazumdar 1946; Alikunhi & Rao 1948; Alikunhi, Ganapati & Rao 1949; Mookerjee & Ganguly 1949; Alikunhi 1956; Chondar 1971).

Proper identification of fish larvae is essential for research on reproduction, population dynamics, and age and growth, as these studies should include larval components. In addition, characteristics present in larvae can indicate possible phylogenetic relationships that might be more obscure in adult forms (Fuiman 1979). Illustrations should accompany larval descriptions as they can aid embryologists, morphologists as well as fishery biologists (Faber & Gadd 1983).

Methods

Fertilized *L.capensis* eggs were collected from the Orange River at Blouputs (28°31′00″S/20°12′30″E) during September 1982 (Cambray 1985). The eggs were collected in the rapids by moving boulders and holding a dip net, with a mesh size of 0,4 mm, downstream. All eggs were held in a 200 ℓ plastic drum half-filled with river water, and transported 600 km to the Douglas Hey Limnological Research Station at Vanderkloof. En route, hourly samples of eggs and larvae were taken from the drum and preserved in 10% formalin. At the laboratory the eggs, larvae and river water were placed in aerated aquaria (62 × 32 × 32 cm). Samples were taken hourly for the first 16 h, two-hourly for the next 12 h, daily at 08h00 for 20 days, every second day for the next 10 days, and once a week for 14 weeks. All developmental stages were initially preserved in 10% formalin and later transferred to 5% buffered formalin.

At first-feeding, larvae were offered cooked egg yolk mixed with a finely ground commercial warmwater fish food (Lopis, 46% protein) at 08h00 and *Artemia* sp. nauplii at 15h00 daily. Solid wastes and dead eggs or larvae were removed from the containers daily. Total water changes were made with aged

tap water every 5 to 10 days. Extreme water temperatures were measured with max. – min. thermometers.

Specimens were illustrated with the use of a camera lucida and a binocular dissecting microscope. Seven morphometric and seven meristic characters were measured or counted. Selected eggs and larvae were measured with an ocular micrometer and dissecting microscope. Larger specimens were measured with dial calipers. All measurements were made at least four months after preservation. The measurements that were made are given below.

Total length (TL): Distance from most anterior point of head to posterior margin of caudal finfold or fin.

Standard length (SL): Distance from most anterior point of snout to posterior tip of notochord, in small larvae (i.e. before notochord flexure). After notochord flexure the measurement was made to the posterior margin of the hypural plates.

Preanal length: Distance from most anterior point of head to origin of anal fin; in small larvae before development of the anal fin, anterior end of head to posterior end of anus.

Body depth: (i) Greatest vertical distance. (ii) Vertical distance measured from immediately posterior to anus to the dorsal surface of the body (exclusive of the finfold).

Eye diameter: Maximum width of eye measured on horizontal axis.

Head length: Horizontal distance from tip of snout to the cleithrum.

Lengths of specimens are reported as mm total length in text unless otherwise stated.

Meristic characters included counts of preanal and postanal myomeres and caudal (principal), dorsal, anal, pectoral and pelvic fin rays. Myomeres were counted with the aid of polarizing filters (Fuiman 1982). Preanal myomeres included all segments whose bordering myosepta were at least partly anterior to the anus, including one segment anterior to the first myoseptum. Postanal myomeres included all segments posterior to the preanal myomeres including a urostylar segment (Fuiman 1982). Myomeres of large opaque specimens were not counted because of lack of clarity. Vertebral counts, including one urostylar and four Weberian elements, were made on radiographs of 29 *L.capensis* juveniles ($\bar{x}$ = 35,4 mm ± 6,03 mm *S.D.*; range 23,9 – 46,9 mm) of the developmental series. All specimens have been catalogued in the ichthyological collection of the Albany Museum, Grahamstown.

Results

Egg

Ripe, unshed *L. capensis* eggs from a 41,1 cm FL specimen with a mass of 1290 g and a gonado-somatic index of 14, collected at Echo corner (28°32′44″S/20°17′15″E) below Augrabies Falls on 11 November 1982, were light yellow and had a modal diameter of 1,5 mm (1,3 – 1,7 mm; *S.D.* = 0,09; *n* = 100). The fertilized water-hardened eggs collected at Blouputs on 23 September 1982 had a modal diameter of 2,9 mm (2,7 – 3,4 mm; *S.D.* = 0,17 mm; *n* = 50). Therefore the swelling of the vitelline membrane accounts for 48% of the diameter of the shed, fertilized egg. The chorionic membrane was spherical, colourless and non-adhesive at time of collection. The yolk was pale yellow, with no oil globules, and the eggs were demersal. Several developmental stages of the embryo are shown in Figure 1A – F.

Larvae

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

Newly hatched (Figure 1G), length 5,4 mm (5,3 to 5,7 mm; *S.D.* = 0,16 mm; *n* = 10) 38 to 41 myomeres; small pectoral buds present; yolk sac bulbous anteriorly, tubular posteriorly; yolk slightly grainy, lacking oil globules; head deflected ventrally over anterior margin of yolk sac until *ca.* 6,2 mm; yolk absorbed (7,9 – 8,1 mm, *ca.* 6 days); functional mouth parts formed (*ca.* 6,7 mm); posterior gas bladder chamber inflated (*ca.* 7,0 mm); anterior chamber forming (10,2 – 11,2 mm); caudal finfold paddle-shaped (*ca.* 6,1 mm); first caudal fin rays (8,0 – 8,4 mm); notochord flexion commenced (8,0 – 8,1 mm); first dorsal rays formed 9,2 – 9,6 mm); incipient dorsal fin margin partially differentiated (8,0 – 8,1 mm), completely differentiated (13,5 – 15,7 mm); dorsal fin origin over myomeres 11 – 13 (*ca.* 11 – 12,2 mm); incipient anal fin margin partially differentiated (*ca.* 10,2 mm), completely differentiated (13,5 – 14,9 mm); pelvic buds formed posterior to dorsal fin origin (11,1 – 11,6 mm); first pelvic rays (*ca.* 12,9 mm); gut commences S-shaping (12,6 – 13,5 mm); entire finfold absorbed (17,9 – 20,5 mm); smallest individual with some scales 20,9 mm; posterior maxillary barbs were forming at *ca.* 14,9 mm; anterior maxillary barbs were forming at *ca.* 15,5 mm.

Pigmentation

Length 5,3 – 5,7 mm, (Figure 1G). Newly hatched, pigment in some larvae not all, occurred in retina of eye ventral to lens as a small dot.

Length 6,7 mm (Figure 1H). Eyes well pigmented, several stellate melanophores on occipital region, start of subdermal pigment on dorsum of yolk sac.

Length 8,1 mm (Figure 1I). Dorsal: several large stellate melanophores in interorbital region. Lateral: eye black, subdermal pigment extended to edge of operculum and posteriorly over gut to anus. Ventral: subdermal pericardial melanophores, faint row from anus to caudal area.

Length 9,1 mm (Figure 1J). Dorsal: few scattered melanophores on snout, interorbital area, dorsum of head and along dorsal line posterior to head. Lateral: few stellate pigments on hypaxial region. Ventral: few on lower jaw.

Length 12,3 mm (Figure 1K). Dorsal: heart-shaped pigment pattern on dorsum of head. Lateral: accumulation of pigments on caudal peduncle, caudal fin-rays well pigmented. Subdermal pigment on brain, auditory capsule, over dorsum of swimbladder chambers and gut, over entire length of developing vertebrae.

Length 15,4 mm (Figure 1 L, M & N). Dorsal: row of pigment on head to caudal with scattered pigment each side of row. Lateral: more heavily pigmented at dorsal, caudal and anal fin bases, scattered pigment on dorsal and caudal fin-rays along entire length of ray. Ventral: row of pigment caudal area to anus then splits to pelvic fin area, few on lower jaw.

Length 20,2 mm (Figure 1 O, P & Q). Dorsal: snout and dorsum of head heavily pigmented. Lateral: more scattered pigment especially upper two-thirds of body. Ventral: only throat and area anterior to pelvic fins clear of pigment.

Length 26,9 mm (Figure 1R, S & T). Dorsal: most of dorsal surface was now heavily pigmented, heart-shaped pattern still

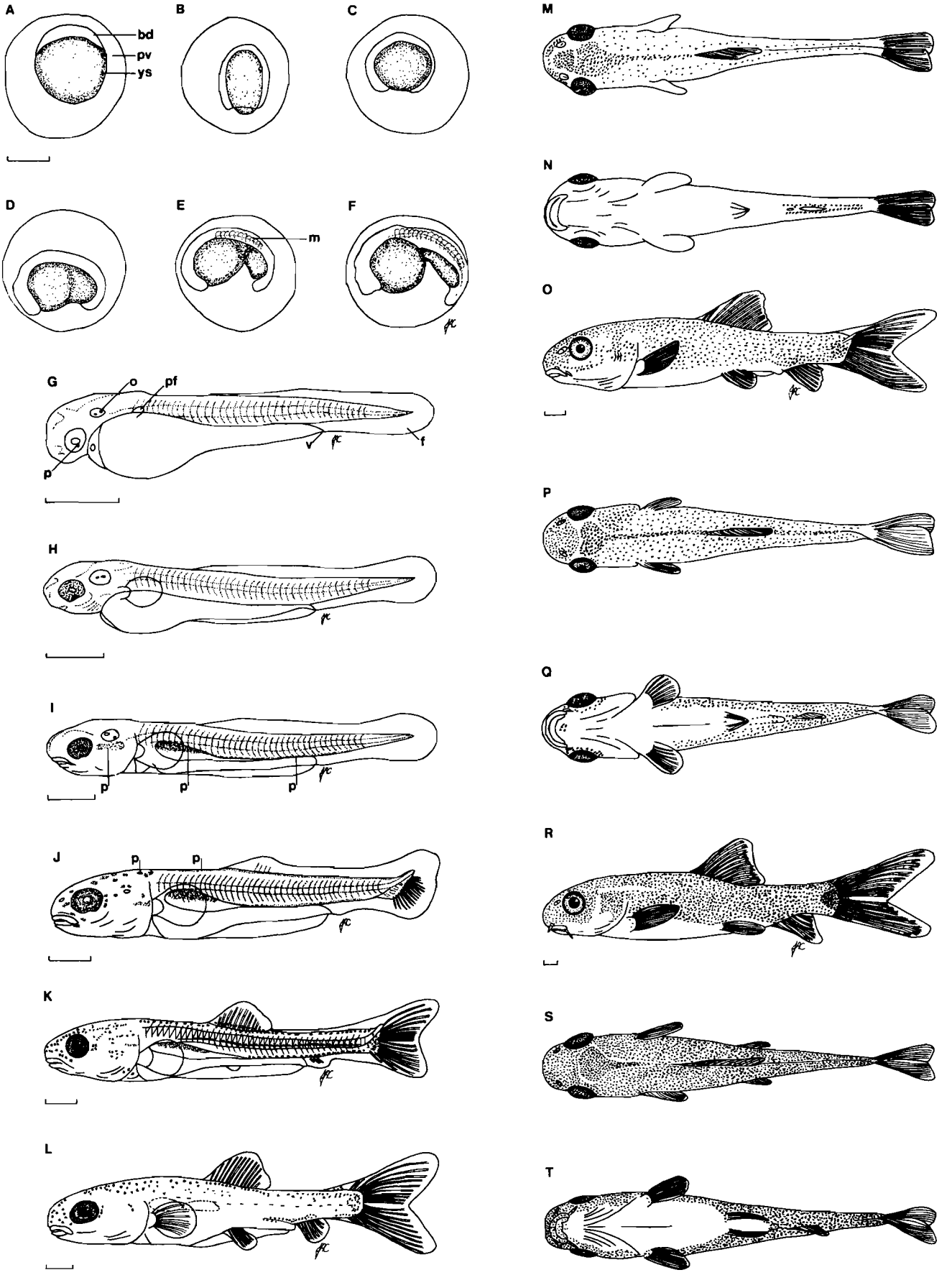

Figure 1 The early developmental stages of *L. capensis*. All times given are approximate, because the series was from several wild spawnings, possibly occurring within 2 days of each other (Cambray 1985). A. Blastoderm (0 h, first collection). B. Yolk-plug stage (4 h). C. Embryo (7 h). D. Embryo, yolk shape changing (8 h). E. 12 myomere stage (9 h). F. Late embryo stage (11 h). G. Newly hatched larva (73 h). H. Larva (4 h after wild collection). I. Larva (4 days). J. Larva (10 days). K. Larva (51 days). L. Larva, lateral view (51 days). M. Larva, dorsal view (51 days). N. Larva, ventral view (51 days). O. Larva, lateral view (51 days). P. Larva, dorsal view (51 days). Q. Larva, ventral view (51 days). R. Juvenile, lateral view (117 days). S. Juvenile, dorsal view (117 days). T. Juvenile, ventral view (117 days). Scale bar = 1 mm, bd: blastoderm, m: myomere, o: otolith, p: pigment, pf: pectoral fin bud, pv: perivitelline space, ys: yolk sac.

visible on dorsum of head. Lateral: caudal peduncle more heavily pigmented than rest of lateral surface and pigmented along rays of all fins. Ventral: no distinct row of pigment from caudal fin to anus, belly and throat still clear of pigment. Subdermal pigment covered the intestinal tract between pelvic and pectoral fins.

Meristics and morphometry

Myomere number remained almost unchanged after hatching (Table 1). Means and standard deviations for 122 specimens were 32,0 ± 0,8 (preanal), 9,5 ± 0,7 (postanal) and 41,4 ± 1,0 (total). Total vertebrae, for 29 juvenile *L. capensis* were 42,1 ± 0,7 *S.D.* Order of fin-ray formation was caudal, dorsal, anal, with rays in the paired fins developing last, (Table 1). The dorsal and anal fin formulae are III 10–11 and III 5 respectively.

The changes in body proportions for 217 specimens are shown in Table 2. The least allometry occurs in SL:TL and preanal: TL. Positive allometry occurs in head length, eye diameter and body depth relative to total length. Eye diameter and body depth relative to head length showed an almost isometric relationship (Table 3).

Larval behaviour

In the laboratory 250 eggs of approximately the same developmental stage were separated from the others. Fifty per cent of the larvae hatched 73 h after collection time and the last larvae hatched after 90 h (temperatures: river 21,5 °C; maximum during transport 31,5 °C; in laboratory until hatching 20,8 °C to 21,5 °C). The larvae hatched tail first after repeated lashings of the tail against the membrane. The newly hatched larvae lay quietly on the bottom of the container in clusters, periodically undergoing short flourishes of movement along the substratum. Within two days the larvae were very active, swimming to the surface and passively sinking head first. Within five days the larvae were swimming actively and food was first seen in the digestive tract. They fed both off the bottom and in mid-water. At this stage they would dart quickly away from the collecting pipette. After 16 days the larvae were very active within centimetres of the substratum.

Discussion

Since there are few complete studies of early development of African *Labeo* species, few comparisons can be made. The chorionic membrane of *L. capensis* was not adhesive when collected as in *L. victorianus* (Fryer & Whitehead 1959). Anon (1965) noted that the membrane of *L. mesops* eggs was without any characteristic features and that slight currents were sufficient to move it along or even off the substratum, suggesting non-adhesive properties. *L. umbratus* was reported to have slightly adhesive eggs by Jackson & Coetzee (1982), possibly due to surface tension (Tómasson, Cambray & Jackson 1984) and also to have non-adhesive eggs (Mitchell

Table 1 Meristic characteristics of *Labeo capensis* larvae and early juveniles grouped by 1-mm intervals of total length (*n* = sample size)

Length interval	*n*	Myomeres			Fin rays				
		Preanal	Postanal	Total	Caudal	Dorsal	Anal	Pelvic	Pectoral
5	10	30–32	7–10	38–41	–	–	–	–	
6	10	30–32	9–10	39–41	–	–	–	–	
7	11	31–33	9–10	40–42	–	–	–	–	
8	10	31–33	9–10	40–43	2–10				
9	10	32	9–11	41–43	11–18	0–4			
10	10	31–33	9–11	41–43	20–22	8–11			
11	11	32–33	9–11	41–44	20–21	7–11	0–5		
12	9	32–33	9–10	41–43	19–21	11–12	0–6	0–4	0–4
13	10	31–33	9–10	40–43	19	10–14	6–7	3–8	5–8
14	8	32–33	9–10	41–43	19	12–14	7	4–7	4–10
15	8	31–33	8–10	41–42	19	13–14	7–8	6–9	7–12
16	3	32	9	41	19–21	13–14	7–8	7	8–12
17	7	32–33	9–10	41–42	19	13–14	8	7–8	12–13
18	7	32	9–10	41–42	19–20	13–14	8–9	7–8	12–13
19	5	31–33	8–10	40–42	19	13–14	8	7–9	12–14
20	4				19	14	8	8–9	11–14
21	8				18–20	13–14	8	8–9	12–15
22	2				19	14	8	8	13–14
23	8				19–21	13–14	8	9–10	15–16
24	4				19	14–15	8	8–10	15
25	3				19	13–15	8	8–10	15–17
26	5				19–20	14–15	8	9	14–15
27	2				19	13–14	8	9	15
28	6				19–20	13–15	8	9–11	13–16
29	6				19–20	13–14	8–9	8–10	14–17
30	6				18–20	13–14	8–9	8–10	15–17
31	4				19–20	14	8	9–10	15–16
32	4				19	11–14	8	9	16–17
33	3				19–20	13–14	8	9	16
34	3				19–20	13–14	8	8–9	16–17
35	3				19	13–14	8–9	9–10	16–17
36	4				19–20	13–14	8	9	17
37	4				19	13–14	8	8–9	15–18
38	4				19–20	13	8	9–10	16–18
39	1				18	13	8	9	17
40	3				19	14	8	9	15–16

Table 2 Morphometry of *Labeo capensis* larvae and early juveniles grouped by 1-mm intervals of total length (*n* = sample size)

	Lengths (mm)					Body depth (mm)	
n	Total	Standard	Preanal	Head	Eye	Widest	At anus
10	5,5 (5,3 – 5,7)	5,2 (5,0 – 5,5)	4,0 (3,8 – 4,1)		0,3(0,2 – 0,3)	1,3(1,2 – 1,3)	0,5(0,4 – 0,5)
10	6,4 (6,1 – 6,8)	6,1 (5,8 – 6,5)	4,6 (4,2 – 4,6)	0,9(0,8 – 1,0)	0,3	1,2(1,0 – 1,3)	0,6(0,5 – 0,6)
11	7,4 (7,0 – 7,9)	7,0 (6,5 – 7,5)	5,1 (4,8 – 5,5)	1,5(1,2 – 1,7)	0,4(0,3 – 0,4)	1,1(1,0 – 1,2)	0,6(0,5 – 0,7)
10	8,4 (8,0 – 8,8)	7,9 (7,4 – 8,3)	5,9 (5,6 – 6,1)	1,8(1,7 – 2,0)	0,5(0,4 – 0,5)	1,3(1,1 – 1,4)	0,7(0,6 – 0,8)
10	9,4 (9,1 – 9,9)	8,7 (8,4 – 9,0)	6,6 (6,3 – 6,9)	2,1(2,0 – 2,2)	0,5(0,5 – 0,6)	1,4(1,3 – 1,5)	0,7(0,7 – 0,8)
10	10,6(10,2 – 10,9)	9,3 (8,9 – 9,6)	7,2 (7,0 – 7,4)	2,5(2,3 – 2,6)	0,7(0,6 – 0,7)	1,7(1,5 – 1,8)	0,9(0,8 – 1,0)
11	11,4(11,1 – 11,6)	9,9 (9,6 – 10,2)	7,7 (7,5 – 7,9)	2,6(2,4 – 2,8)	0,7(0,6 – 0,7)	1,9(1,7 – 2,1)	1,0(0,9 – 1,1)
9	12,4(12,1 – 12,9)	10,4(10,1 – 10,8)	8,2 (8,0 – 8,7)	2,9(2,6 – 3,1)	0,8(0,7 – 0,9)	2,1(1,9 – 2,3)	1,1(0,9 – 1,2)
10	13,5(13,0 – 13,9)	11,0(10,7 – 11,5)	8,7 (8,2 – 8,9)	3,2(3,1 – 3,4)	0,9(0,8 – 1,0)	2,3(1,9 – 2,4)	1,2(1,1 – 1,4)
8	14,6(14,3 – 14,9)	11,8(11,1 – 12,2)	9,2 (8,7 – 9,4)	3,5(3,3 – 3,7)	0,9(0,8 – 1,0)	2,5(2,3 – 2,7)	1,4(1,2 – 1,5)
8	15,4(15,0 – 15,8)	12,1(11,6 – 12,6)	9,3(9,0 – 10,0)	3,6(3,4 – 3,8)	1,0(0,9 – 1,1)	2,5(2,3 – 2,8)	1,4(1,3 – 1,5)
3	16,5(16,2 – 16,8)	13,0(12,5 – 13,7)	10,0 (9,5 – 10,7)	3,9(3,7 – 4,2)	1,2(1,1 – 1,2)	2,8(2,6 – 3,2)	1,5(1,4 – 1,7)
7	17,3(17,0 – 17,9)	13,6(13,1 – 14,1)	10,4(10,1 – 11,0)	4,2(4,0 – 4,4)	1,2(1,1 – 1,3)	3,2(2,9 – 3,6)	1,7(1,5 – 1,8)
7	18,4(18,1 – 18,9)	14,4(14,0 – 14,9)	10,7(10,0 – 11,0)	4,4(4,2 – 4,5)	1,2(1,1 – 1,2)	3,2(2,8 – 3,5)	1,8(1,6 – 1,8)
5	19,5(19,1 – 19,8)	15,1(14,3 – 15,6)	11,6(11,0 – 12,1)	4,6(4,5 – 4,7)	1,2(1,2 – 1,3)	3,6(3,4 – 3,9)	2,0(1,8 – 2,1)
4	20,4(20,0 – 20,9)	15,6(15,1 – 15,9)	11,9(11,5 – 12,5)	5,0(4,8 – 5,2)	1,4(1,2 – 1,6)	3,7(3,5 – 3,9)	2,2(2,0 – 2,3)
8	21,4(21,0 – 21,9)	16,3(15,6 – 17,1)	12,4(12,0 – 12,9)	5,1(4,8 – 5,3)	1,4(1,3 – 1,5)	3,8(3,7 – 4,2)	2,2(1,9 – 2,4)
2	22,6(22,2 – 22,9)	17,4(17,2 – 17,5)	13,2(13,1 – 13,2)	5,4(5,3 – 5,4)	1,5	4,4	2,6(2,5 – 2,6)
8	23,6(23,4 – 23,9)	17,9(17,6 – 18,6)	13,6(13,5 – 13,9)	5,7(5,4 – 5,9)	1,5(1,4 – 1,6)	4,5(4,3 – 4,8)	2,5(2,4 – 2,6)
4	24,4(24,1 – 24,6)	18,2(17,9 – 18,5)	13,8(13,6 – 14,0)	5,9(5,5 – 6,2)	1,5(1,4 – 1,7)	4,5(4,2 – 4,7)	2,5(2,2 – 2,7)
3	25,4(25,1 – 25,8)	19,8(19,2 – 20,8)	15,0(14,7 – 15,5)	6,0(5,9 – 6,2)	1,8(1,7 – 1,9)	4,5(4,4 – 4,7)	2,7(2,5 – 3,0)
5	26,7(26,4 – 26,9)	20,3(19,6 – 20,4)	15,2(14,7 – 15,7)	6,3(6,1 – 6,6)	1,7(1,6 – 1,9)	5,0(4,6 – 5,5)	2,9(2,7 – 3,1)
2	27,4(27,1 – 27,6)	22,4(20,6 – 24,2)	16,9(15,5 – 18,2)	7,0(6,5 – 7,5)	1,9(1,8 – 2,0)	5,3(4,5 – 6,0)	3,3(2,8 – 3,8)
6	28,6(28,0 – 28,9)	21,7(21,2 – 22,2)	16,4(15,8 – 16,9)	6,7(6,3 – 7,1)	1,7(1,5 – 1,9)	5,3(4,8 – 5,7)	3,2(2,9 – 3,3)
6	29,4(29,0 – 29,6)	22,1(21,7 – 22,3)	16,9(16,5 – 17,4)	7,0(6,6 – 7,4)	1,8(1,7 – 1,9)	5,6(5,3 – 6,1)	3,3(3,1 – 3,4)
6	30,6(30,3 – 30,9)	23,0(22,7 – 23,6)	17,4(17,2 – 17,9)	7,3(7,0 – 7,7)	1,9(1,7 – 2,1)	5,7(5,1 – 6,1)	3,4(3,2 – 3,5)
4	31,4(31,1 – 31,7)	23,8(23,1 – 24,5)	18,0(17,6 – 18,3)	7,4(7,3 – 7,5)	1,9(1,8 – 2,0)	5,8(5,5 – 6,1)	3,5(3,3 – 3,7)
4	32,3(32,0 – 32,8)	24,2(23,7 – 25,1)	18,4(18,2 – 18,7)	7,5(7,2 – 7,6)	2,1(1,9 – 2,2)	6,1(5,3 – 7,1)	3,6(3,5 – 3,9)
4	33,4(33,1 – 33,7)	25,1(24,7 – 25,5)	19,2(18,9 – 19,6)	7,8(7,7 – 8,1)	2,0(2,0 – 2,1)	6,0(5,5 – 6,8)	3,7(3,5 – 3,8)
3	34,4(34,0 – 34,8)	26,3(26,1 – 26,4)	19,9(19,4 – 20,3)	7,8(7,3 – 8,2)	2,2(2,1 – 2,3)	6,5(6,2 – 6,7)	3,8(3,6 – 4,0)
3	35,5(35,2 – 35,8)	26,7(26,1 – 27,0)	20,4(20,0 – 20,8)	8,2(8,1 – 8,3)	2,1(2,0 – 2,2)	6,4(5,8 – 6,8)	4,2(3,8 – 4,8)
4	36,8(36,7 – 36,8)	27,8(27,4 – 28,4)	21,3(20,8 – 21,5)	8,5(8,3 – 8,7)	2,3(2,2 – 2,3)	7,1(6,9 – 7,3)	4,2(4,1 – 4,2)
4	37,4(37,2 – 37,5)	26,9(23,2 – 28,5)	21,9(21,1 – 22,4)	8,7(8,2 – 9,0)	2,3(2,2 – 2,3)	6,4(6,0 – 6,7)	4,3(4,0 – 4,5)
4	38,5(38,2 – 38,9)	29,1(28,5 – 29,5)	22,5(22,2 – 22,7)	8,9(8,7 – 9,1)	2,3(2,0 – 2,5)	6,6(6,5 – 6,8)	4,2(4,1 – 4,3)
1	39,4	29,2	22,8	9,3	2,4	6,5	4,2
3	40,4(40,0 – 40,7)	30,6(30,3 – 30,9)	23,7(23,4 – 24,2)	9,4(9,1 – 9,6)	2,3(2,2 – 2,5)	7,3(7,2 – 7,4)	4,5(4,4 – 4,6)

Table 3 Regression statistics for logarithmic plots of several morphometric parameters of *Labeo capensis* larvae and early juveniles (*n* = sample size)

Parameters	Slope[a]	Y-intercept	*n*
Standard *vs.* total length	0,85	1,24	217
Preanal *vs.* total length	0,86	0,92	217
Head *vs.* total length	1,12	0,16	207
Eye diameter *vs.* total length	1,13	0,04	217
Body depth *vs.* total length	1,18	0,06	217
Eye diameter *vs.* head length	0,97	0,28	207
Body depth *vs.* head length	0,98	0,43	207

[a]Slope indicates the degree of allometry. Relatively slower growth of a body part shown by values less than 1,00 (negative allometry) whereas relatively faster growth indicated by values greater than 1,00 (positive allometry). Values near 1,00 indicate isometric growth.

1984).

Water-hardened eggs of *L. victorianus* (Fryer & Whitehead 1959), *L. mesops* (Anon 1965) and *L. capensis* (this study) were only a little denser than water and slight currents were sufficient to move the eggs off the bottom. The swelling of the membrane increased the buoyancy of the eggs, and Fryer & Whitehead (1959) suggested that this is an adaptation to ephemeral flood conditions which enables eggs to enter the main river as the water recedes. The large size of the perivitelline space would also offer protection to the embryo against buffeting in turbulent waters.

Fifty per cent of the *L. capensis* larvae hatched after 73 h, while some did not hatch until 90 h after collection (temperature range 21,5 – 31,5 °C). Fryer & Whitehead (1959) also noted a large variability in hatching times for *L. victorianus*. They suggested that during the delay in hatching, the enlarged perivitelline space affords protection to the developing embryo and probably assures optimal larval survival. This variability in hatching times might also be an important adaptation for dispersion of the species. Tómasson *et al.* (1984) have noted that *L. capensis* juveniles do not disperse readily. This lack of movement might be somewhat compensated for by dispersal of developing embryos in the main river channel. Hora (1930) suggested that the large size of the perivitelline space in certain Indian cyprinids was an advantage in their swift-water habitats, and allowed an active, relatively well-developed larva to hatch out. Yolk and water-hardened egg sizes for several African and Indian *Labeo* species are given in Table 4. The vitelline membrane of the Indian species (*L. rohita*) swells to a greater extent than any of the African species.

Table 4 Yolk, water-hardened egg and newly hatched larvae sizes for some African and Indian *Labeo* species

Species	Yolk size (mm)	Water-hardened egg size (mm)	Newly hatched larvae (mm)	Reference
Labeo capensis	–	–	4,0	Mulder 1971
Labeo capensis	1,3 – 1,7	2,7 – 3,4	5,3 – 5,7	This study
Labeo mesops	*ca.* 1,0	3,5	*ca.* 4,3	Anon 1965: egg size from their Figure 1; larval size from their Figure 8.
Labeo umbratus	–	–	5,0	Gaigher *et al.* 1975
Labeo umbratus	–	–	3,28	Mitchell pers. comm.
Labeo victorianus	1,0 – 1,5	3,5 – 4,0	*ca.* 5,0	Fryer & Whitehead 1959: larval size from their Figure 16
Labeo rohita	1,1	5,0	3,5 – 4,5	Mookerjee 1945; Mazumbar 1957; Khan 1972
Labeo rohita	–	4,5 – 4,8	4,4 – 4,5	Chaudhuri 1960
Labeo rohita	–	4,1 – 4,8	3,62 – 3,83	Chakrabarty & Murty 1972

The behavioural trait noted in *L. capensis* larvae (Mulder 1973; this study), *L. mesops* (Anon 1965) and *L. victorianus* (Fryer & Whitehead 1959) of intermittently swimming to the surface is probably an aid to dispersal (Fryer & Whitehead 1959; Cambray 1983).

Larval size at hatching is given in Table 4 for several African and Indian *Labeo* species. The lengths of newly hatched larvae of both African and Indian *Labeo* species are variable. Fryer & Whitehead (1959) noted that the posterior extension of the yolk sac in *L. victorianus* larvae and certain Asiatic cyprinids including *L. gonius* (Ahmad 1944) may prove to be of taxonomic importance. *L. mesops* (Anon 1965), *L. umbratus* (Gaigher *et al.* 1975), *L. capensis* (this study), *L. rohita* (Charkrabarty & Murty 1972), *B. aeneus* (Groenewald 1961), *B. anoplus* (Cambray 1983) and *B. trevelyani* (Cambray in press) all have a posterior extension of the yolk sac. Fryer & Whitehead (1959) suggested that this extension permits flexing movements, which has been supported by Anon (1965), Cambray (1983, in press) and this study.

There are few stable meristic characters in cyprinid larvae of which myomere counts are one of the most useful taxonomically (Fuiman, Conner, Lathrop, Buynak, Snyder & Loos 1983). Total myomere number can usually be predicted from vertebral number in the adult (including four Weberian vertebrae) minus one (Fuiman 1982). The total myomere count for *L. capensis* was 41,4 ± 1,0 *S.D.* ($n = 122$); total vertebral count was 42,1 ± 0,7 *S.D.* ($n = 29$). No other work on African *Labeo* myomere counts was available for comparison.

Chromatophores in larval fish form basic patterns of pigmentation that are important taxonomic characters (Faber & Gadd 1983). Balinsky (1948) used the interior pigmentation patterns, supplemented with other characters, to subdivide the larvae of European cyprinid fishes. Fuiman *et al.* (1983) found that the ventral melanophore pattern, rather than their number, size or intensity, was helpful in grouping North American cyprinid larvae. However ontogenetic changes in these patterns can limit the duration of their usefulness. Barnard (1943) noted that *L. capensis* of 21 – 25 mm can be readily distinguished from young *Barbus aeneus* by a heavier pigmentation. Further studies of African cyprinid development should pay close attention to the pigment patterns on larval fish. These patterns may aid in identifying species or different groups of fishes in their early developmental stages.

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