

Features in the Early Development of Bull Trout (*Salvelinus confluentus*)

Abstract

The early development of bull trout through the absorption of the yolk sac was observed. Brain subdivisions, optic cups, auditory vesicles, somites, pectoral fin buds, olfactory pits, liver and opercular openings had appeared by 167 Celsius temperature units (CTU). Melanophores and blood had formed by 206 and 288 CTU, respectively. At 443 CTU newly hatched fish had rays in the median fins. A gular ridge appeared at 724 CTU and the yolk sac was absorbed at 810 CTU. The early development of bull trout largely paralleled those of other species of *Salvelinus* in North America. However, the development of bull trout differed from other members of the genus in the order of appearance of pectoral fin buds and melanophores in relation to other features, the fixed size of oil globules in the yolk sac, the degree of development of the vitelline vein complex during the embryonic stage and the presence of a gular ridge in larvae. The gular ridge is apparently diagnostic for bull trout larvae and provides a means of identifying the larvae of this species, which will permit the identification of spawning areas and evaluations of spawning success from ichthyoplankton samples.

Introduction

Five species of *Salvelinus* occur in North America (Robins *et al.* 1980). The early development of four of these, the lake trout (*Salvelinus namaycush*), Arctic char (*S. alpinus*), brook trout (*S. fontinalis*) (Balon 1980a, b, c) and Dolly Varden (*S. malma*) (Blackett 1968) has been described. This account presents the first report on the appearance of features in the early development of the remaining species, the bull trout (*S. confluentus*), a native of the northwestern United States and Canada (Cavender, 1978).

Methods

Fertilized eggs were obtained by mixing the eggs and sperm from one female and two male bull trout from Whale Creek, a tributary of the North Fork of the Flathead River, Montana, on October 12, 1984. The eggs were then water-hardened, transported to the Bozeman Fish Technology Center, and reared in an incubation tray.

After organogenesis, random samples were taken at 2-9 day intervals with most samples being collected at 7 day periods. Live specimens and material preserved in 10 percent formalin from each sample were examined in transmitted and reflected light under a 7-30X dissecting microscope. Some preserved specimens were also treated with hematoxylin and/or glycerine prior to examination. Specimens taken before hatching

were termed embryos and those after hatching were called larvae (Lagler *et al.* 1977). The total lengths reported are for preserved fish.

Study specimens were held in an incubation tray with a flow-through circulation of spring water chilled in a Living Stream¹ Model BAL 1076 apparatus. Water temperatures in the incubation tray were recorded on a Foxboro Model 12R continuous temperature recorder. Celsius temperature units (CTU) were calculated from hourly temperatures on the thermograph charts following the procedure of Leitritz and Lewis (1976). Dissolved oxygen levels were measured periodically by the Winkler method during the incubation period.

Results

Bull trout embryos and larvae were raised under water temperatures that fluctuated from 4.5 - 8.0°C and dissolved oxygen levels of 7.5 - 8.0 mg/l. The time and order of appearance of features noted under this regime are presented in Table 1.

Sensory organs, muscle formation and brain differentiation appeared early in the developmental process and before melanophore formation. Circulatory and digestive system formation and

¹Reference to trade names does not constitute U.S. Government endorsement of commercial products.

TABLE 1. The time and order of appearance of features in the early development of bull trout.

Day after fertilization	Cumulative Celsius temperature units (CTU)	Number of specimens examined	Average total length (mm)	Appearance of developmental features
5	38	10		Vitelline membrane, yolk sac and blastoderm averaged 5.4, 5.0 and 1.7 mm in diameter, respectively (Fig. 1).
26	167	8	5.7	Forebrain, midbrain and two areas of hindbrain formed (Fig. 2). Optic cups with lenses and auditory vesicle evident. Somites present in head and throughout body. Pectoral fin buds and liver forming. Olfactory pits and opercular openings apparent.
33	206	8	7.2	Eyes with a few melanophores. Pharyngeal arches and anus visible. Vitelline vessels on left side of yolk sac prominent.
40	245	8	8.4	Beating heart apparent. Liver distinct and eyes densely pigmented. Mouth open and vitelline vein formed weak loop on front of yolk sac.
47	288	9	9.8	Melanophores scattered on head but in bands on body (Fig. 3). Jaws forming and bile showing in hind gut. Blood obvious in dorsal aorta, post-cardinal vein, heart and blood islands on yolk sac. Vitelline loops on yolk sac not evident.
55	332	9	10.8	Melanophores on peritoneum. Blood moving through gill arches. Vitelline vein on left side of yolk sac well developed.
61	372	9	12.7	Trunk flexing. Jaws moving sporadically. Melanophores scattered between lateral and dorsal bands of melanophores. Dorsal fin being set off in dorsal finfold. Basal portion of anal fin rays faintly visible.
68	410	8	12.6	Opercular and pectoral fin movements. Opercular openings anterior to three gill arches and pelvic fins forming.
73	443	8	14.7	Some hatching. Caudal fin rays well defined. Basal portions of dorsal and anal fin rays present. Oil globules in yolk sac no larger than 0.25 mm in diameter.
75	456	9	15.3	Opercula cover gill arches. Melanophores present on upper jaw and on caudal fin.
82	503	9	16.6	Hatching nearly complete. Diffuse spot on caudal fin. Pectoral fin rays indistinct and anal fin being set off in finfold.
89	548	10	18.5	Distinct pectoral fin rays. Melanophores scattered along base of dorsal finfold, dorsal area of yolk sac and chin (Fig. 4). Opercula and mouth opening and closing regularly. Swimming observed.
94	586	10	19.7	Concentration of melanophores on body near base of caudal fin.
103	644	10	21.7	Notches in dorsal finfold identified location of future adipose fin. A few melanophores near adipose fin, around heart, on gill arches and fleshy bases of pectoral fins.
110	687	10	22.1	Pelvic fin rays poorly defined. A few melanophores present on pectoral fin membranes.
117	724	10	23.2	A median ridge prominent between the chin and isthmus (Fig. 5). Chromatophores present on anterior edge of dorsal fin.
124	767	9	23.8	Endogenous materials being excreted.
131	810	9	23.9	Finfold absent anterior to dorsal fin but present posteriorly. Ventral finfold persisted anterior and posterior to pelvic fins (Fig. 6). Yolk sac not apparent. First melanophores on belly appeared between pectoral fins. Pelvic and anal fins still without melanophores. Parr marks appearing.



Figure 1. Embryo at 38 CTU with 1.7 mm diameter blastoderm.

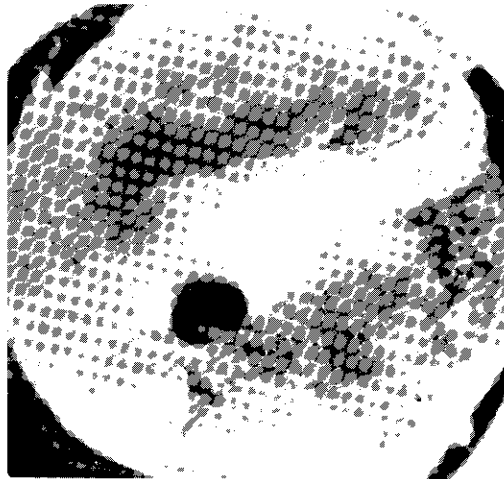


Figure 3. Embryo at 288 CTU with melanophores heavily concentrated in eyes, scattered on head and in bands on the body.

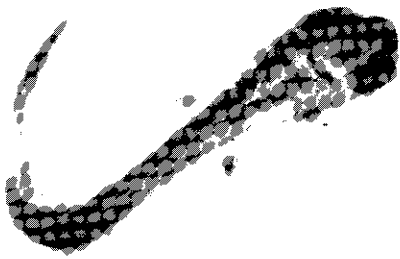


Figure 2. Embryo at 167 CTU showing brain, optic, auditory, pectoral fin bud and somite development.

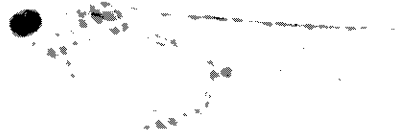


Figure 4. Larva at 548 CTU showing dorsal and anal fin sites, gular ridge and caudal blotch.

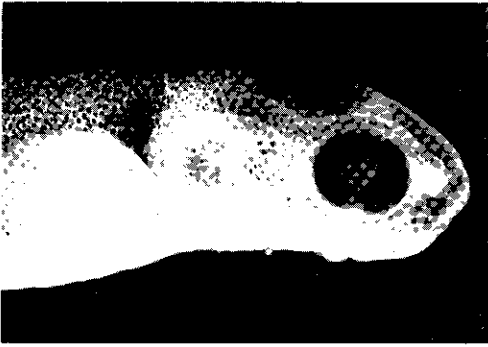


Figure 5. Larva at 724 CTU with close up of gular ridge.



Figure 6. Larva at 810 CTU with only small portions of dorsal and anal fin folds remaining.

finfold differentiation largely occurred following melanophore appearance.

Discussion

The occurrence of specific events in the early development of bull trout and Dolly Varden cannot be readily compared to like events in the development of other North American *Salvelinus* on a temperature unit basis because these species were reared under fluctuating water temperatures. However, the order of appearance of structures in salmonids raised under less than extreme environmental conditions is relatively fixed (Ballard 1973). Therefore, the developmental patterns of salmonids can be compared and Balon (1980d) has done so for lake trout, Arctic char, brook trout and Dolly Varden.

Comparison of the pattern of early development of bull trout to those of other North American *Salvelinus* species indicates many similarities and a few differences. In bull trout, pectoral fin buds formed before melanophores, heart beats, blood and vitelline veins were seen. However, in lake trout the pectoral fin primordia formed after the latter three features had appeared. The oil globule in the yolk sac of bull trout did not increase in size at the end of cleavage as Balon (1980b) reported for Arctic char. The vitelline vein complex in bull trout developed strongly only on the left side of the

yolk sac and not on the right side as reported for Arctic char (Balon 1980b) and brook trout (Balon 1980c). Melanophores appeared on the bodies of bull trout before fin rays developed, whereas, this order of appearance was reversed in Dolly Varden (Blackett 1968). These differences in the early development of bull trout and other named species of *Salvelinus* appear to be of the same magnitude as differences between other species of North American *Salvelinus* (Balon 1980d). However, the gular ridge noted in bull trout larvae apparently is unique and should allow the identification of the larvae of this species from those of other *Salvelinus* in larval fish samples. This will permit biologists to identify the spawning areas and evaluate the spawning success of bull trout.

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