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**EGG AND EARLY LARVAL CHARACTERISTICS OF *POGONIAS CROMIS*,  
*BAIRDIELLA CHRYSOURA* AND *CYNOSCIION NEBULOSUS* (PISCES:  
SCIAENIDAE), FROM THE INDIAN RIVER LAGOON, FLORIDA**

by

**Sabine Alshuth and R. Grant Gilmore**  
Harbor Branch Oceanographic Institution  
5600 U.S. 1 North  
Fort Pierce, Florida 34946

**ABSTRACT**

Surface ichthyoplankton tows were taken to collect fertilized eggs and larvae of *Pogonias cromis*, *Bairdiella chrysoura* and *Cynoscion nebulosus* (Sciaenidae) at known spawning sites within the Indian River Lagoon, Florida. Sciaenid egg and larval development stages were studied up to 30 days after hatching under controlled laboratory conditions. Live eggs could be identified to species by size and pigmentation intensity. Egg diameters varied inversely with salinity, as smaller diameters were correlated with higher salinities. Pelagic spherical sciaenid eggs are buoyant and usually contain one pigmented oil globule in the late developmental stages. Late egg stage embryos and yolk sac larvae showed a specific body melanophore pattern which was basically stable during the yolk sac stage but changed greatly during their larval development from first-feeding until metamorphosis. Newly hatched *P. cromis* larvae are characterized by three chromatophore bands posterior to the vent. Larvae from 3.13 to 5.9 mm TL revealed variations in pigmentation pattern, ranging from small contracted melanophores to pigment scattered across the body in a dense reticulate pattern. Yolk sac stage *B. chrysoura* (2.2 to 2.53 mm TL) can be separated from early larval *P. cromis* (2.66 to 3.13 mm TL) by chromatophore concentrations posterior to the auditory vesicle and the appearance of no more than two body pigment bands in early yolk sac and first-feeding stages. *Cynoscion nebulosus* larvae may be differentiated from *P. cromis* and *B. chrysoura* at nearly all stages by its broadly reticulate body pigmentation and melanophores on the symphysis of the lower jaw.

## INTRODUCTION

Black drum (*Pogonias cromis*), silver perch (*Bairdiella chrysoura*) and spotted seatrout (*Cynoscion nebulosus*) are abundant multiple spawning estuarine sciaenid fish species distributed throughout the Indian River Lagoon of east-central Florida, U.S.A. These three sciaenid species are known to spawn within the estuary, based on analysis of sounds produced during spawning and egg/larval collections (Mok and Gilmore 1983). *Pogonias cromis* spawn from early fall to late spring, whereas *C. nebulosus* spawn from early spring to late fall and silver perch spawn almost all year round with decreased activity during the summer. The spawning seasons of these three species overlap in spring and fall, thus producing three egg and larval types simultaneously in the ichthyoplankton. Syntopy of all these species at particular spawning sites further demonstrates the need for differentiation of early life history stages in these species.

Pearson (1929) was the first to describe larval red fish and other commercial sciaenids as small as 5 mm. Several descriptions have been concerned with formalin-preserved larvae greater than 5 mm in total length (e.g. Powles 1980). The actual live size was much larger than 5 mm due to shrinkage caused by preservation. Thus, larval developmental stages under 5 - 7 mm TL are undescribed. Most previous sciaenid larval studies have been concerned with morphological structures or natural distributions (e.g. Joseph et al. 1964, Ross et al. 1983, Holt et al. 1988, Peters and McMichael 1990). Unfortunately, an adequate key for egg and larval identification does not exist and many egg and larval stages of similar families and species (e.g. other sciaenids and gerreids) are undescribed. Joseph et al. (1964), Holt et al. (1988) and Ditty (1989) described sciaenid eggs and yolk sac larvae in general, but descriptions of live eggs and early larval development would be more useful for identification of fresh live or newly preserved material.

The purpose of the present paper is to characterize and describe live egg and larval *Pogonias cromis*, *Bairdiella chrysoura* and *Cynoscion nebulosus* with emphasis on early larval stages less than 3 mm length and to summarize their diagnostic characters. Length measurement data and modified drawings of *P. cromis* and *C. nebulosus* are used from our previous ICES publications to document significant identification characters.

## MATERIAL AND METHODS

Eggs of *Pogonias cromis*, *Bairdiella chrysoura* and *Cynoscion nebulosus* were collected during their spawning seasons with a 1 meter diameter ring plankton net (335  $\mu$ m) from surface waters in the Indian River Lagoon, east-central Florida, U.S.A. The mean lagoon depth is 1.5 m, the maximum 12 m (Fig.1). Egg collections were made at the most productive spawning sites, which have been characterized by using hydrophones to record male vocalization within spawning aggregations (Mok and Gilmore 1983).

In the laboratory, living ichthyoplankton samples were immediately sorted under the microscope and fertilized planktonic eggs transferred by pipette to experimental tanks. *Pogonias cromis* eggs were incubated at an ambient winter temperature of 20°C, in 10 liter tanks each containing 50 eggs and filtered sea water of salinity 27‰, whereas *Cynoscion nebulosus* and *Bairdiella chrysoura* eggs were incubated at an ambient summer temperature of 25°C and salinity of 25‰. First feeding larvae were fed cultured algae and cultured rotifers (*Brachionus plicatilis*), older larvae were fed brine shrimp *Artemia* nauplii. All larvae were under a photoperiod regime of 12 hours light and 12 hours darkness. Larvae were raised in a separate screen inside the tanks and indirect aeration was provided to reduce mortality of the youngest larvae. The yolk sac stage is particularly sensitive. During the first week the water was not changed except for the addition of small amounts of water together with the food organisms. During the subsequent weeks, the water was partly changed once a week.

Morphological characteristics of eggs and larvae, reared under controlled conditions, were described, drawn and photographed. Larvae were sampled daily for growth measurements during the first week and later at irregular intervals. On each sampling day the total lengths of six to twelve live larvae were measured. Total length is measured from the snout tip to the end of the tail. Live specimen measurements were made using an ocular micrometer in a dissecting microscope. After examination larvae were preserved in a buffered 5% formalin-seawater-solution.

## RESULTS

### I. EGG IDENTIFICATION

*Pogonias cromis*, *Bairdiella chrysoura* and *Cynoscion nebulosus* spawn just after sunset. Fertilized eggs of these species are buoyant and spherical, with a smooth surface and a clear and unsegmented yolk. Oil globules are clear and colorless in live egg stages, from cleavage to gastrula stage (five to seven hours after fertilization), whereas from the early embryo to late embryo stage (7 hours after fertilization to hatching) the embryo and oil globule are characterized by pigmentation. Planktonic eggs float with the oil globule uppermost and the embryo pole downward. Hatching time of sciaenid larvae is dependent on water temperature. At 20°C hatching occurred 24 hours after fertilization, whereas at 30°C hatching takes place 12 hours after fertilization. The hatch rate of eggs was 95-100% at both temperatures.

#### *Pogonias cromis*

**Morphology.** In general a single oil globule is visible, however in early developmental stages, during cleavage to gastrula stages up to seven hours after fertilization, up to four oil globules can be observed (Fig.2a) in approximately 30% of the eggs. In later developmental stages, when the embryo is visible in the early embryo and tail-bud stage at seven to ten hours after fertilization, up to four oil globules are occasionally present. When there is a well developed and pigmented embryo, there is a single heavily pigmented oil globule covered with small melanophores located near the embryo anus (Figs.2b,e).

**Morphometrics.** Diameters of live eggs spawned at a salinity of 34‰ ranged from 0.89 to 0.94 mm, with most eggs having a diameter of 0.93 mm (Fig.3a). Oil globule diameter ranged from 0.13 to 0.17 mm (n=50). Eggs spawned at a salinity of 25‰ have a larger diameter than those from higher salinities (34‰), ranging from 0.95 to 1.07 mm with oil globule diameters ranging from 0.17 to 0.23 mm (n=50). Egg diameters at a salinity of 15‰ ranged from 1.06 to 1.15 mm with oil globule diameters of 0.20 to 0.27 mm (n=50), (Fig.3a, Tab.1).

**Remarks.** *Pogonias cromis* eggs were briefly described by Joseph et al. (1964), who also observed a difference in egg diameter with salinity. They suggested that a lower salinity could explain the occurrence of larger egg diameters. Live *P. cromis* eggs were also described by Alshuth & Gilmore (1992).

***Bairdiella chrysoura***

**Morphology.** In early developmental stages, during cleavage to gastrula, only a single and very rarely two oil globules are visible in live eggs, whereas in formalin preserved eggs up to three smaller oil globules can be observed. During the embryonic development from the early to late embryo stage, at seven hours after fertilization to hatching, melanophores on the embryo and the oil globule become more numerous. The embryo is lightly pigmented in the late embryo stage, just before hatching (Figs.2c,e,f).

**Morphometrics.** Live eggs collected in the ichthyoplankton at a salinity of 34‰ had a diameter ranging from 0.67 to 0.73 mm, with most eggs having a 0.70 mm diameter (Fig.3b). Oil globule diameter ranged from 0.13 to 0.16 mm (n=50). Eggs spawned at a salinity of 25‰ have larger diameters ranging from 0.73 to 0.79 mm with oil globule diameters ranging from 0.14 to 0.17 mm (n=50). Egg diameters at a salinity of 15‰ ranged from 0.79-0.86 mm with oil globule diameters of 0.15 to 0.19 mm (n=50), (Fig.3b, Tab.1).

**Remarks.** *Bairdiella chrysoura* eggs can be easily differentiated from *Pogonias cromis* eggs by their smaller size. Both species' eggs are characterized by a single pigmented oil globule and a pigmented embryo. However, *B. chrysoura* embryos are more lightly pigmented than *P. cromis* embryos. John et al. (1964) also observed differences in egg diameter which probably could be related to different salinity conditions.

***Cynoscion nebulosus***

**Morphology.** Only a single oil globule is visible in early developed live eggs from cleavage to gastrula stages, whereas in formalin-preserved eggs up to four oil globules can be observed. During embryonic development melanophores become more numerous. In late developmental stages with a visible embryo, at seven hours after fertilization to hatching, the dorsal surface of the embryo is heavily covered with stellate melanophores as well as the single oil globule which is located near the anus (Figs.2d,e,f).

**Morphometrics.** Live eggs spawned at a salinity of 34‰ had diameters ranging from 0.73 to 0.79 mm, with most eggs having 0.75 mm diameter (Fig.3c). Oil globule diameter ranged from 0.17 to 0.19 mm (n=50). Eggs spawned at a salinity of 25‰ have larger diameters ranging from 0.79 to 0.89 mm with oil globule diameters ranging from 0.20 to 0.26 mm (n=50), whereas egg diameters at a salinity of 15‰ ranged from

0.89-0.99 mm with 0.23-0.3 mm oil globule diameters (Fig.4c, Tab.1). These observations were made on 50 eggs.

**Remarks.** Earlier descriptions of *Cynoscion nebulosus* eggs (Fable et al. 1978) do not agree with our observations of late developed eggs which are characterized by the occurrence of a heavy pigmented oil globule. *Cynoscion nebulosus* eggs are easily differentiated from the large *Pogonias cromis* eggs by size, from *Bairdiella chrysoura* eggs in pigmentation and slightly larger size. *B. chrysoura* eggs are lightly pigmented compared to the heavy pigmentation of *C. nebulosus* eggs and are differentiated from *C. nebulosus* by smaller egg diameters.

## II. LARVAL DEVELOPMENT

### *Pogonias cromis*

**Morphology and pigmentation.** Yolk sac larvae hatch with unpigmented eyes and a clear primordial marginal fin which surrounds the body from posterior to the head on the dorsal surface to the mid-ventrally located anus. Pectoral fin buds are visible in the yolk sac stage. The oil globule of the yolk sac larvae is positioned near the posterior margin of the unpigmented yolk sac, near the anus (Fig.4a). Pigmentation is formed by bright golden-yellow chromatophores, but viewed with transmitted light these pigments appear dark brown to black. Eye pigmentation was first observed at age two days and the mouth was breaking through at three days (Fig.4c). The pigmentation pattern of yolk sac larvae does not change till the onset of feeding at a mean length of 3.2 mm TL and age five days (Figs.4b, c). At this stage almost all yolk had been absorbed.

The most abundant yolk-sac larval pigmentation type is characterized by three chromatophore bands or partial bands posterior to the anus and the head pigment above the eyes (Fig.4a).

In the postlarval stage of 3.3 mm TL nearly the whole body is covered by a densely pigmented reticulate pattern (Fig.4d). Pigmentation is reduced in later postlarval stages (Figs.4e, f), with expanded branched pigmentation in the dorso- and ventro-lateral postanal body part (Fig.4e). Notochord flexion starts at 5.9 mm TL and age 11 days. In late postlarval stages, large branched melanophores cover the preanal and postanal body parts (Fig.4f). After 30 days all fin rays have been developed and the vertical black bars which remain to adult size appear (Fig.4g). The dorso-lateral part of the chromatophore bars contains black as well as red pigmentation. At 18.0 mm TL the mandibular barbels are present.

**Morphometrics.** The events described are typical for live larvae reared at 20°C. However, rearing temperature affects growth and the duration of different developmental stages. *Pogonias cromis* yolk sac larvae hatch at a mean length of 2.66 mm TL (Tab.2). Transition from the yolk sac stage to active feeding occurred at day five to six. At yolk-sac absorption larvae were approximately 3.14 mm long. Notochord flexion was observed at a mean length of 5.9 mm. Postlarval metamorphosis to the juvenile stage occurred at day 30 when larvae were approximately 16.5 mm in size (Tab.2). These observations were made on 200 larvae.

**Remarks.** Joseph's et al. (1964) description of *Pogonias cromis* yolk sac larvae, based on live material, does not agree with our description but is generally similar to the description of Holt et al. (1988). Joseph et al. (1964) did not describe the location of melanophores on *P. cromis* larvae and their description does not correspond to our newly hatched larvae which hatched at a mean length of 2.66 mm TL. No yolk sac was observed in *P. cromis* larger than 3.2 mm TL which corresponds to Joseph et al. (1964) and Ditty (1889). However, Pearson (1929) did indicate that the yolk sac was still present in his 4.5 mm TL *P. cromis* larva as well as in 5-6 mm SL larvae studied by Scotton et al. (1973).

The pigmentation pattern in *Pogonias cromis* yolk sac larvae varies distinctly. Although the most abundant pigmentation pattern is characterized by three chromatophore bands posterior to the anus. Another type with small pigment spots which outline the posterior end of the notochord has been observed. The pigment may be also expanded across the body to form a reticulate pattern or may be contracted into little spots (Alshuth and Gilmore 1992).

Information on fin development and occurrence of opercular spines, which is not described in the present study, is given by Pearson (1929) and Joseph et al. (1964).

### ***Bairdiella chrysoura***

**Morphology and pigmentation.** Yolk sac larvae hatch at a mean total length of 1.55 mm. The oil globule is positioned near the posterior margin of the unpigmented yolk sac near the anus. *Bairdiella chrysoura* yolk sac larvae are recognized by their two chromatophore bands. A very distinct melanophore band occurs midway between the anus and the tip of the notochord, while a second less distinct variable one occurs anteriorly between the second band and the anus (Fig.5a). Amber chromatophores aggregate behind the unpigmented eye as well as on the dorsal body surface and outline the dorsal part of the vent. One distinct internal chromatophore aggregation is

located posteriorly to the auditory vesicle. Small pigment spots outline the tip of the notochord and melanophores are visible on the dorsal area of the peritoneum as well as internal pigmentation spots on the dorsal gut (Fig.5b). No changes in pigmentation are visible till the end of the yolk sac stage.

With the onset of feeding at an age of five days and 2.53 mm TL the second distinct chromatophore band extends towards the dorsal and ventral contour, the mediolateral pigmentation almost disappears as well as the less distinct band closer to the anus (Fig.5c). At 4.6 mm TL the pigmentation changes again (Fig.5d). This larval stage is characterized by a line of melanophores along the ventral contour from the anus to the tip of the notochord. Midway between the anus and the tip of the notochord a branched melanophore aggregation is visible, mostly distinct on the ventral contour and less visible on the dorsal contour. Heavy pigmentation occurs posteriorly to the auditory vesicle and on the swimbladder. Internal chromatophores occur posteriorly to the operculum. Small pigmentation spots are visible on the lower jaw angle as well as on the ventral anus (Fig.5e). In later developmental stages dorso-lateral chromatophore aggregation occurs on the postanal body part.

**Morphometrics.** Measurements were made on live larvae which hatch at a mean TL of 1.55 mm with unpigmented eyes and a clear primordial marginal fin which surrounds the body. Transition from the yolk sac stage to the postlarval stage occurs at day five. At this stage of yolk-sac absorption larvae measure 2.52 mm TL. Notochord flexion has been observed at 5.5 mm TL (Tab.2). Postlarval metamorphosis to the juvenile stage occurred at day 16, when larvae were about 11.4 mm in size. At this stage, all fin rays have been developed (Fig.5f). These observations were made on 100 larvae.

**Remarks.** Our *Bairdiella chrysoura* yolk sac larvae which hatch at a mean total length of 1.55 mm generally correspond to Kuntz's (1915) description of newly hatched live larvae with 1.5 to 1.9 mm length. Our lengths agree with the observations of Holt et al. (1988). Length during the yolk sac stage (2.2 - 2.53 mm TL) has to be considered because the pigmentation pattern of *B. chrysoura* larvae looks similar to *Pogonias cromis* larvae, with lengths ranging from 2.66 - 3.3 mm TL, when pigmentation is contracted into little melanophore spots. These two species are easily differentiated in the chromatophore aggregation posterior to the auditory vesicle and the internal gut pigmentation in *B. chrysoura* larvae. Postlarvae can be easily differentiated from most other sciaenids in their shortest preanal length (Ditty 1989). *Bairdiella chrysoura* larvae smaller than 5 mm TL are characterized by a "swath" of pigmentation (Powles



and Stender 1978) in the head region. Information on opercular spines and fin development are given by Powles (1980).

### *Cynoscion nebulosus*

**Morphology and pigmentation.** Yolk sac larvae hatch at a mean length of 1.65 mm TL with unpigmented eyes and a clear primordial marginal fin. The oil globule is positioned near the posterior margin of the unpigmented yolk sac near the anus. Spotted seatrout yolk sac larvae are easily recognized by a heavily pigmented reticulate pattern that covers most of the body (Fig.6a). It consists of two broad chromatophore bands, one at the vent and the other between the vent and the tip of the notochord. Small pigment spots outline the notochord tip. Heavy pigment aggregations outline the anterior point of the head and occur behind the eye, and dorsal above the yolk (Fig.6b). The entire yolk sac stage is characterized by this pigmentation pattern. At the end of the yolk sac stage, five days after hatching and at lengths over 2.6 mm TL, pigmentation changes distinctly (Figs.6c,d). Melanophores occur along the dorsal and postanal ventral contours of the body. Large stellate melanophores are present over the dorsal area of the peritoneum.

In later stages of development, in addition to the contoural pigmentation which extends towards the center line, mediolateral melanophores are situated along the center line in a row. Typical melanophores occur on the lower jaw angle and on the anterior point of the lower jaw (Figs.6c, d). During the postlarval stage first branched melanophores are visible on the postanal body at an age of six days with 3.75 mm TL (Figs.6d, e). They extend towards the caudal fin base till the end of the postlarval stage. At age 18 days and 6.4 mm TL the urostyle bends upward and hypural melanophores occur. At 6.8 mm TL first signs of the dorsal and anal fin formations appear as interspinous areas (Fig.6f).

**Morphometrics.** Yolk sac larvae, hatched at a mean total length of 1.65 mm, transition to first feeding at an age of four days and 2.54 mm TL. At this stage, almost all yolk had been absorbed. Completion of the yolk-sac absorption stage has been observed at a mean length of 2.62 mm TL. Notochord flexion takes place at 5.7 mm TL (Tab.2). Postlarval metamorphosis to the juvenile stage occurred at day 25, when larvae were approximately 16.3 mm TL. At this stage all fin rays are developed (Fig.6g). Observation were made on 200 larvae.

Specific characters described above for larval *Cynoscion nebulosus* identification (see arrows in Fig.6) are also evident in preserved specimens, preserved in a buffered formalin-seawater-solution for at least one year.

**Remarks.** Fable et al. (1978) reported standard lengths of preserved *Cynoscion nebulosus* yolk sac larvae with a length of 1.3 to 1.56 mm, which probably corresponds to our live yolk sac larvae at lengths of 1.65 mm. A well pigmented oil globule was also visible at the posterior part of the yolk sac, which was unpigmented in *C. nebulosus* yolk sac larvae described by Fable et al. (1978). Pigmentation undergoes distinct changes after the yolk sac stage, described by Hildebrand and Cable (1934), Fable et al. (1978) and Ditty (1989). *Cynoscion nebulosus* larvae are easily differentiated from other sciaenids in the occurrence of melanophores on the lower jaw angle and on the anterior point of the lower jaw.

## DISCUSSION

The eggs and larvae of three different sciaenid species *Pogonias cromis*, *Bairdiella chrysoura* and *Cynoscion nebulosus* have been collected from the Indian River Lagoon. These three sciaenid species are known to spawn within the estuary, based on analysis of species specific sound production correlated with spawning activity (Mok and Gilmore 1983). Sounds of *Sciaenops ocellata* and *Cynoscion regalis* have not been recorded in this particular study area. Isolation of spawning sites allowed fresh live eggs and larval specimens to be readily collected.

To differentiate planktonic eggs, detailed information on morphology and pigmentation is described based on live specimen observations. Eggs of *Pogonias cromis*, *Bairdiella chrysoura* and *Cynoscion nebulosus* are spherical and characterized by a smooth surface and a very small perivitelline space. The oil globules are clear and colorless in early-developed live eggs whereas in later-developed stages the embryo and the oil globule are characterized by pigmentation. In general, a single oil globule is visible, however in early developmental stages during cleavage up to four oil globules can be observed in *P. cromis* and *B. chrysoura* eggs, whereas in *C. nebulosus* only up to two oil globules occur (Tab.1). Egg diameters measured at 25‰ salinity do not overlap between these species. *Bairdiella chrysoura* eggs have the smallest diameter, followed by *C. nebulosus*. *Pogonias cromis* eggs have the distinct largest diameter.

In later-developed stages, with a well developed embryo, only one pigmented oil globule with melanophores occurs, which is located near the anus of the embryo. This observation was made for all three species. *Pogonias cromis* and *Cynoscion nebulosus* have a distinct heavily pigmented oil globule, whereas *Bairdiella chrysoura* eggs have

a lightly pigmented oil globule. The same observation was made for the pigmentation of the embryo. Compared to *B. chrysoura* with a lightly pigmented embryo, *C. nebulosus* and *P. cromis* are characterized by heavily pigmentation. More recently, Holt et al. (1988) has developed a procedure for identifying eggs of the most common sciaenids. They found that eggs could be identified by one-day-old yolk sac larvae. Egg sizes in their study overlapped between other sciaenid species (e.g. *Cynoscion regalis*, *Sciaenops ocellata*) and this alone was inadequate to identify eggs to the species level. Therefore, correct identifications were made only by using the egg hatching method. Sciaenid eggs can also be easily confused with eggs of some Haemulidae, Gerreidae, Scombridae, Sparidae and Stromateidae, which have similar characteristics (Joseph et al. 1964).

We have found that the egg diameter of *Pogonias cromis*, *Bairdiella chrysoura* and *Cynoscion nebulosus* varies inversely with salinity. Smaller diameters are correlated with higher salinities. The egg diameter within the same salinity does not overlap within species and can be used as an informative character for defining species (Tab.1). Early attempts to characterize the eggs of *P. cromis* and *B. chrysoura* (Joseph et al. 1964) have shown a distinct size difference in egg diameter. The authors suggested that a lower salinity could explain the occurrence of larger egg diameters in species with typically smaller eggs.

We suggest that water salinity should be considered as a very important factor for identifying sciaenid eggs to the species level (Alshuth and Gilmore 1993). The water temperature and spawning season will also provide useful information on occurrence of sciaenid eggs in the water column. We found, that an increase in the water temperature up to 25°C will initiate spawning activity of *Cynoscion nebulosus*. This species usually spawns from early April to late October. Whereas *Pogonias cromis* is a typical winter spawner, who spawns from early October to late March at 20° to 25°C water temperature, *Bairdiella chrysoura* eggs occur all year round at 20° to 33°C.

The yolk sac stage of *Pogonias cromis*, *Bairdiella chrysoura* and *Cynoscion nebulosus* is characterized by a single pigmented oil globule which is positioned near the posterior margin of the homogeneous yolk sac, near the anus. All three species show a specific pattern of melanophores on their body which is almost unchanged during the yolk sac stage. *Pogonias cromis* larvae are characterized by a specific pigmentation pattern consisting of three distinct chromatophore bands and the head pigment above the eyes. We have found that the pigmentation pattern in black drum yolk sac larvae varies (Alshuth and Gilmore 1992). The pigmentation pattern is characterized by three chromatophore bands from the anus back, which may be also expanded across the body to form a heavily pigmented reticulate pattern or may be

contracted into small compact melanophores. At this stage, the pigmentation pattern of *P. cromis* larvae looks similar to *B. chrysoura* larvae, when pigmentation is contracted into small compact melanophores. *Bairdiella chrysoura* can be easily differentiated from *P. cromis* by the chromatophore aggregation posterior to the auditory vesicle and the internal gut pigmentation. *Pogonias cromis* densely pigmented reticulate pigmentation variation is similar to the heavily pigmented reticulate pigmentation of *C. nebulosus*. These two species can be easily differentiated by the heavy pigment aggregations in *C. nebulosus* larvae which occur on the anterior point of the head, postorbital posterior to the eye, and dorsally above the yolk. *Pogonias cromis* are not easily confused with other sciaenids and can be differentiated from similar larvae of *Sciaenops ocellatus* by their seasonal occurrence (Ditty 1989).

In addition, length measurements have to be considered for differentiation of species. Length at hatching differ significantly with largest lengths in *Pogonias cromis* yolk sac larvae with 2.66 mm TL, followed by *Cynoscion nebulosus* at 1.65 mm TL and smallest lengths observed in *Bairdiella chrysoura* at 1.55 mm TL.

Pigmentation undergoes distinctive changes after the yolk sac stage. In the early postlarval stage of *Pogonias cromis*, nearly the whole body is covered by a heavily pigmented reticulate pattern. In later postlarval stages pigmentation is reduced, with expanded branched pigmentation in the dorso- and ventro-lateral postanal and preanal body part. Large branched melanophores are also observed in postlarval *Bairdiella chrysoura*. This species can be differentiated from *P. cromis* by a line of melanophores along the ventral contour from the anus to the tip of the notochord. A very distinct heavy pigmentation occurs behind the auditory vesicle and on the swimbladder. Internal chromatophores occur posterior to the operculum. Small pigmentation spots are visible on the lower jaw angle as well as on the ventral anus. *Cynoscion nebulosus* can be easily differentiated from *P. cromis* and *B. chrysoura* by the lower jaw pigmentation. Typical melanophores occur on the lower jaw angle and on the anterior point of the lower jaw in postlarval *C. nebulosus*. In addition to the contoural pigmentation which extends towards the center line, mediolateral melanophores are situated along the center line in a row.

Differences between the egg and larval descriptions in our work and those in published literature could possibly result from factors such as pigment fading due to preservation and low specimen number available for examination. The differentiation and identification of preserved eggs and sciaenid larvae is difficult, however descriptions of laboratory-reared live material assists greatly in this process.

## KEY FOR SCIAENID EGG/LARVAL IDENTIFICATION

## I. LATE DEVELOPMENTAL EGG STAGES

- |  |                             |
|--|-----------------------------|
| (1) Single pigmented oil globule.....  | 2                           |
| None or multiple oil droplets .....  | 8                           |
| (2) Egg membrane with smooth surface .....   | 3                           |
| Egg membrane with sculptured surface .....   | 8                           |
| (3) Yolk homogeneous .....   | 4                           |
| Yolk segmented.....  | 8                           |
| (4) Small perivitelline space.....   | 5                           |
| Perivitelline space large or absent.....   | 8                           |
| (5) Embryo lightly or heavily pigmented.....                                       | 6                           |
| Embryo unpigmented.....  | 8                           |
| (6) Egg diameter ranging from 0.90 to 1.07 mm (25-34‰ salinity) .....              | <i>Pogonias cromis</i>      |
| Occurrence in the plankton from late October through late March .....              |                             |
| Egg diameter smaller than 0.9 mm.....  | 7                           |
| (7) Egg diameter ranging from 0.75 to 0.89 mm(25-34‰ salinity).....                | <i>Cynoscion nebulosus</i>  |
| Occurrence in the plankton from late April through early October .....             |                             |
| Egg diameter ranging from 0.67 to 0.73 mm(25-34‰ salinity).....                    | <i>Bairdiella chrysoura</i> |
| Occurrence in the plankton from late April through early October .....             |                             |
| (8) Other than <i>P. cromis</i> , <i>B. chrysoura</i> or <i>C. nebulosus</i> ..... |                             |

## II. YOLKSAC LARVAL STAGES

- |   |                            |
|---|----------------------------|
| (1) Position of anus close to yolk .....            | 2                          |
| Anus midway between yolk sac and notochord tip..... | 9                          |
| (2) Yolk homogeneous.....                           | 3                          |
| Yolk segmented.....                                 | 9                          |
| (3) Single oil droplet visible.....                 | 4                          |
| None or multiple oil droplets visible .....         | 9                          |
| (4) Oil globule in posterior part of yolk.....      | 5                          |
| Oil globule in anterior part of yolk.....           | 9                          |
| (5) Oil globule pigmented.....                      | 6                          |
| Oil globule unpigmented .....                       | 9                          |
| (6) Pre- or postanal pigmentation .....             | 7                          |
| No pre- or postanal pigmentation.....               | 9                          |
| (7) Chromatophore bands posterior to anus .....     | 8                          |
| Web-like pigmentation covers most of the body.....  | <i>Cynoscion nebulosus</i> |

1.65 mm TL at hatching. Similar pattern like the rare reticulate pigment variation of larger *Pogonias cromis* larvae.

- (8) Two chromatophore bands posterior to anus.....*Bairdiella chrysoura*  
1.55 mm TL at hatching.  
Three chromatophore bands posterior to anus.....*Pogonias cromis*  
2.65 mm TL at hatching.
- (9) Other than *C. nebulosus*, *B. chrysoura* or *P. cromis*.

### III. POSTLARVAL STAGES

- (1) Light or heavy preanal pigmentation..... 2  
No preanal pigmentation..... 7
- (2) Dorso, ventral or lateral postanal pigmentation..... 3  
No postanal pigmentation..... 7
- (3) Swimbladder lightly or heavily pigmented..... 4  
No swimbladder pigmentation..... 7
- (4) Anus pigmented.....*Bairdiella chrysoura*  
Anus unpigmented..... 5
- (5) Lower jaw angle pigmented..... 6  
No pigmentation on lower jaw.....*Pogonias cromis*
- (6) Anterior point of snout pigmented..... *Cynoscion nebulosus*  
Snout unpigmented..... 4
- (7) Other than *C. nebulosus*, *B. chrysoura* or *P. cromis*

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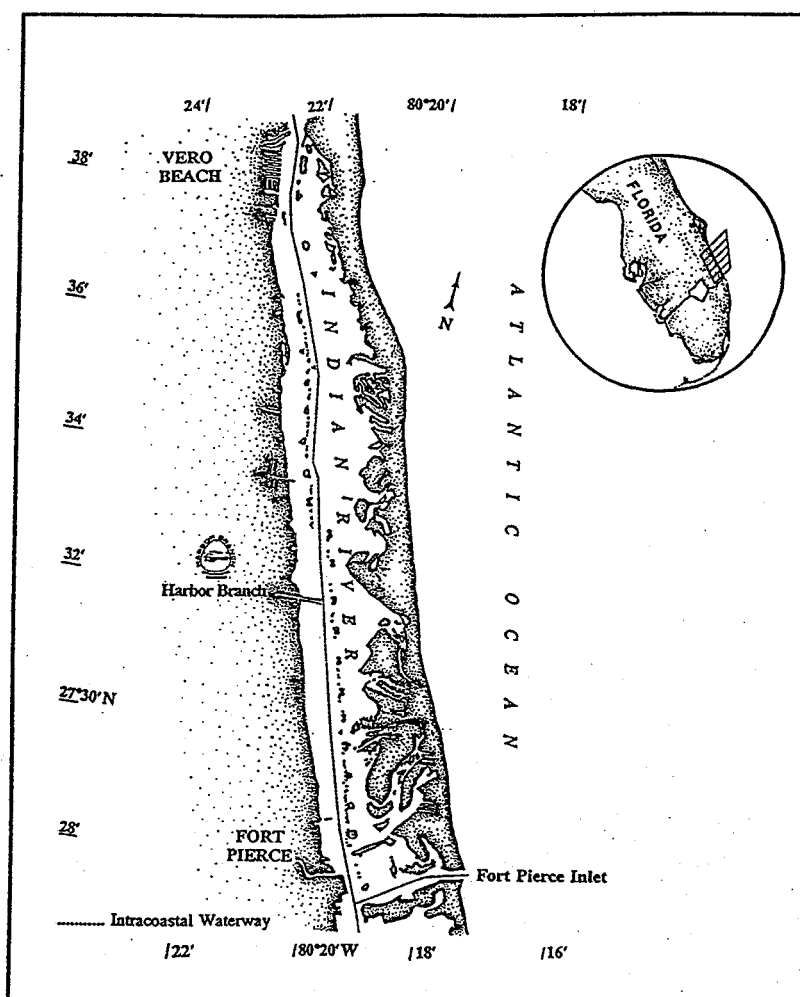


Fig.1: Study area in the Indian River Lagoon, east-central Florida, U.S.A..

Salinity	15‰	25‰	34‰
<i>Pogonias cromis</i>	ED: 1.06-1.15 OD: 0.20-0.27	ED: 0.95-1.07 OD: 0.17-0.23	ED: 0.89-0.94 OD: 0.13-0.19
<i>Bairdiella chrysoura</i>	ED: 0.79-0.86 OD: 0.15-0.19	ED: 0.73-0.79 OD: 0.14-0.17	ED: 0.67-0.73 OD: 0.13-0.16
<i>Cynoscion nebulosus</i>	ED: 0.89-0.99 OD: 0.23-0.30	ED: 0.79-0.89 OD: 0.20-0.26	ED: 0.73-0.79 OD: 0.17-0.19

Tab.1: Live egg diameters (in mm) of *Pogonias cromis*, *Bairdiella chrysoura* and *Cynoscion nebulosus* at different salinities. (ED=egg diameter, OD=oil globule diameter).



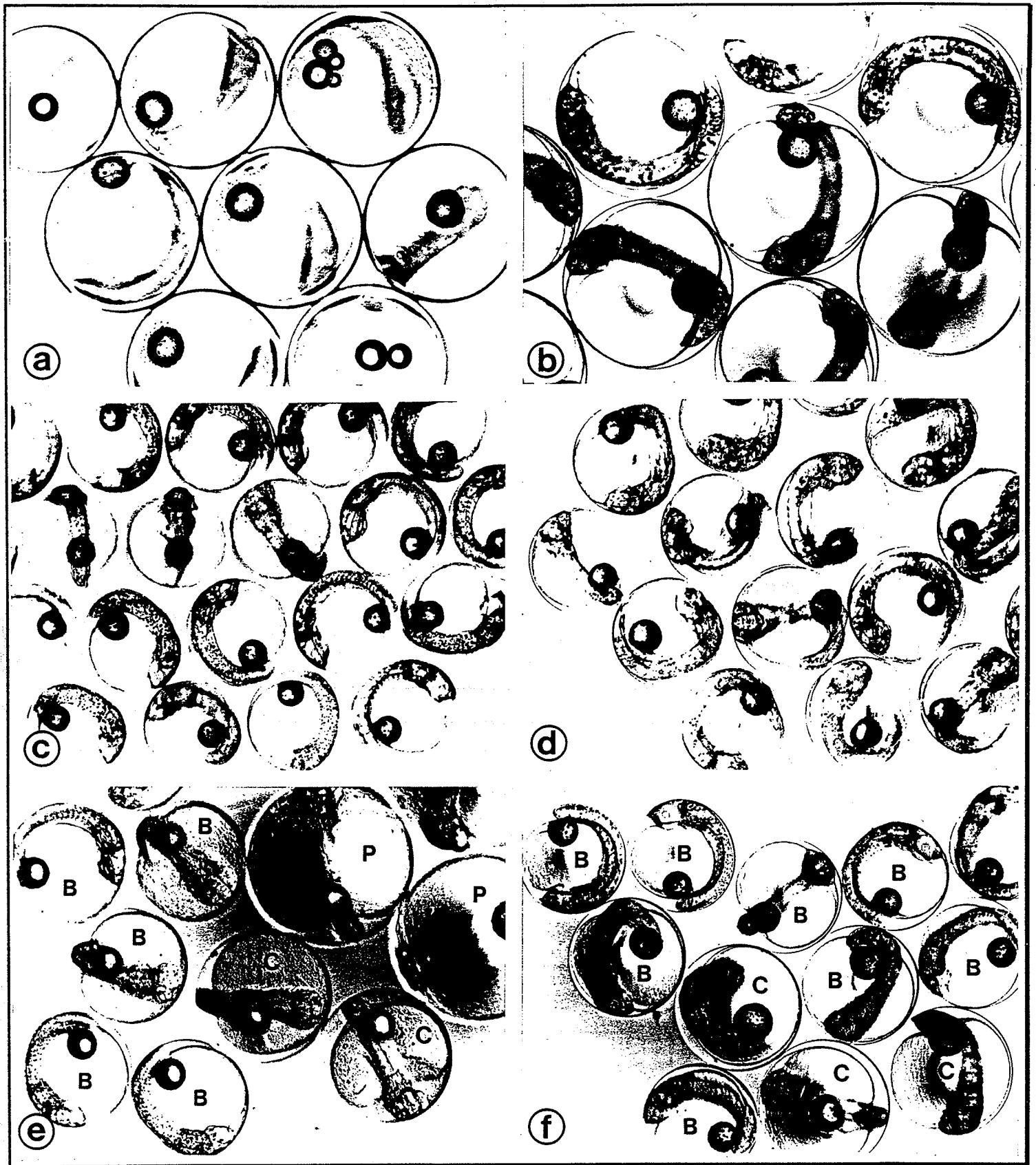


Fig.2: Live sciaenid eggs from the Indian River Lagoon. Pictures taken at the same magnification. (a) *Pogonias cromis* early developmental stage, (b) *P. cromis* late developmental stage, (c) *Bairdiella chrysoura*, late developmental stage, (d) *Cynoscion nebulosus*, late developmental stage, (e) *P. cromis* (P), *B. chrysoura* (B) and *C. nebulosus* (C), (f) *B. chrysoura* (B) and *C. nebulosus* (C).

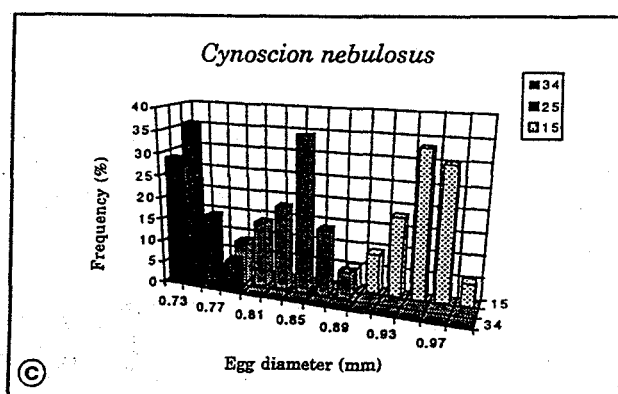
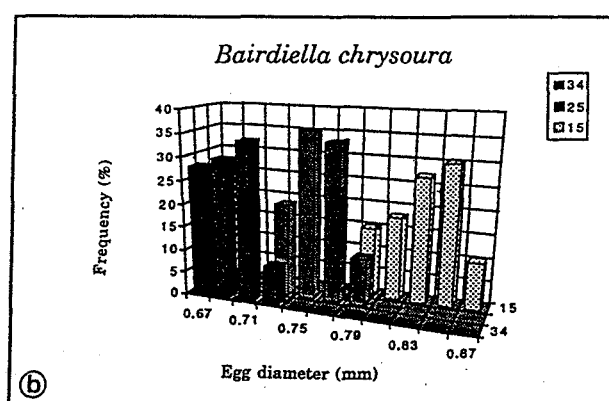
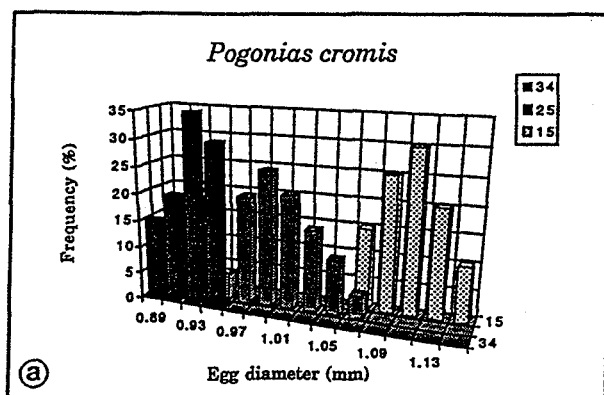
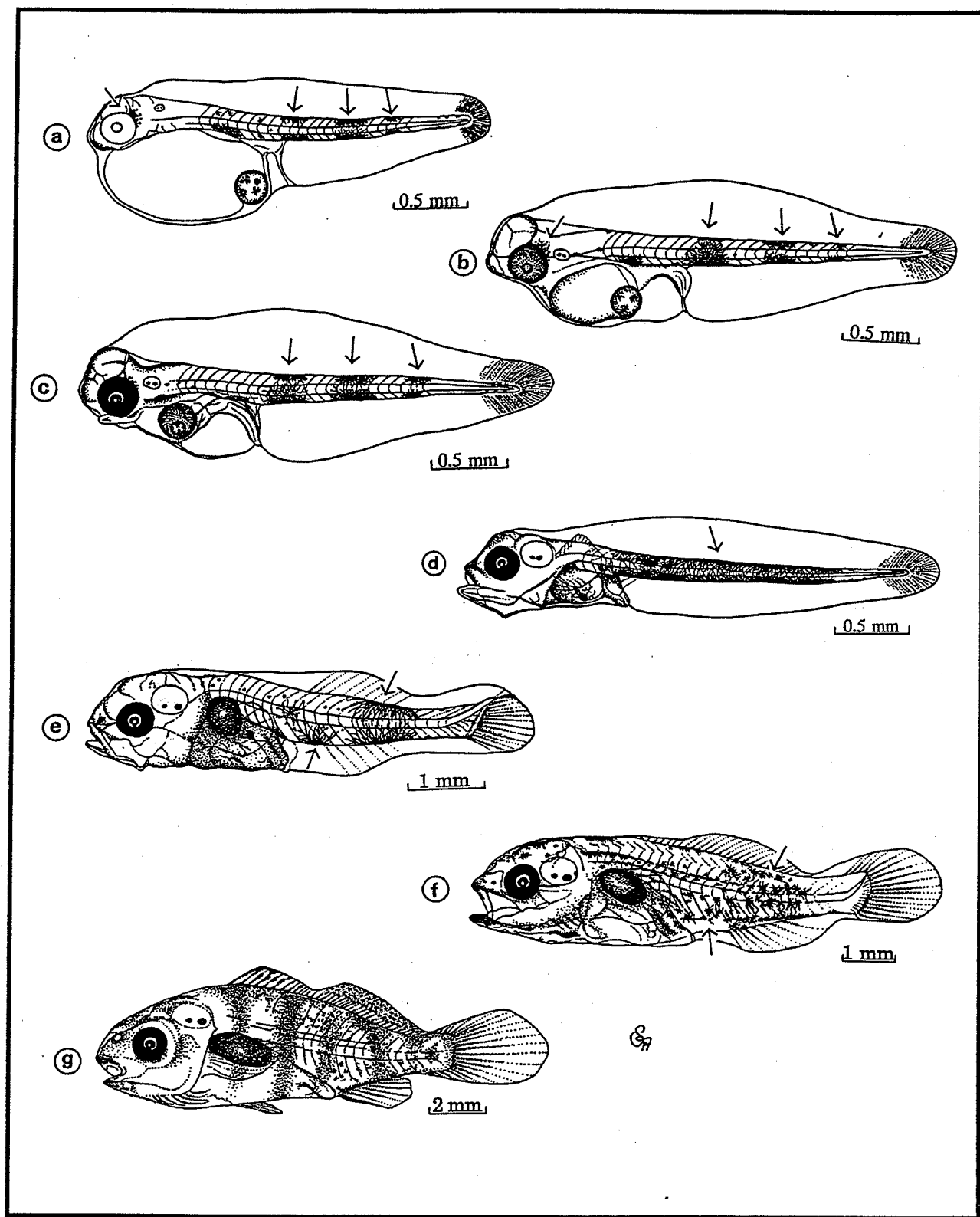


Fig. 3: Frequency distribution of egg diameters at three different salinities ( $S=34\text{‰}$ ,  $S=25\text{‰}$ ,  $S=15\text{‰}$ ). (a) *Pogonias cromis*, (b) *Bairdiella chrysoura*, (c) *Cynoscion nebulosus* (*C. nebulosus* after Alshuth & Gilmore 1993).

Developmental Stage	<i>Pogonias cromis</i>	<i>Bairdiella chrysoura</i>	<i>Cynoscion nebulosus</i>
Hatching	$2.66 \pm 0.04$	$1.55 \pm 0.03$	$1.65 \pm 0.02$
Yolk-sac absorption	$3.14 \pm 0.07$	$2.52 \pm 0.07$	$2.62 \pm 0.06$
Notochord flexion	$5.9 \pm 0.22$	$5.5 \pm 0.21$	$5.7 \pm 0.19$
Metamorphosis	$16.5 \pm 0.98$	$11.4 \pm 1.16$	$16.3 \pm 2.11$

Tab. 2: Mean lengths and standard deviations (in mm) of live specimen for different larval development stages.



**Fig. 4:** *Pogonias cromis* larvae, hatched and raised at 20 °C and 27‰: (a) newly hatched yolk sac larva (2.66 mm TL), (b) 2-day-old larva (3.04 mm TL), (c) 3-day-old larva (3.13 mm TL), (d) 7-day-old larva (3.19 mm TL), (e) 15-day-old larva (5.9 mm TL), (f) 19-day-old larva (9.6 mm TL), (g) 30-day-old juvenile (16.8 mm TL). Arrows indicate specific characteristics (modified after Alshuth & Gilmore 1992).

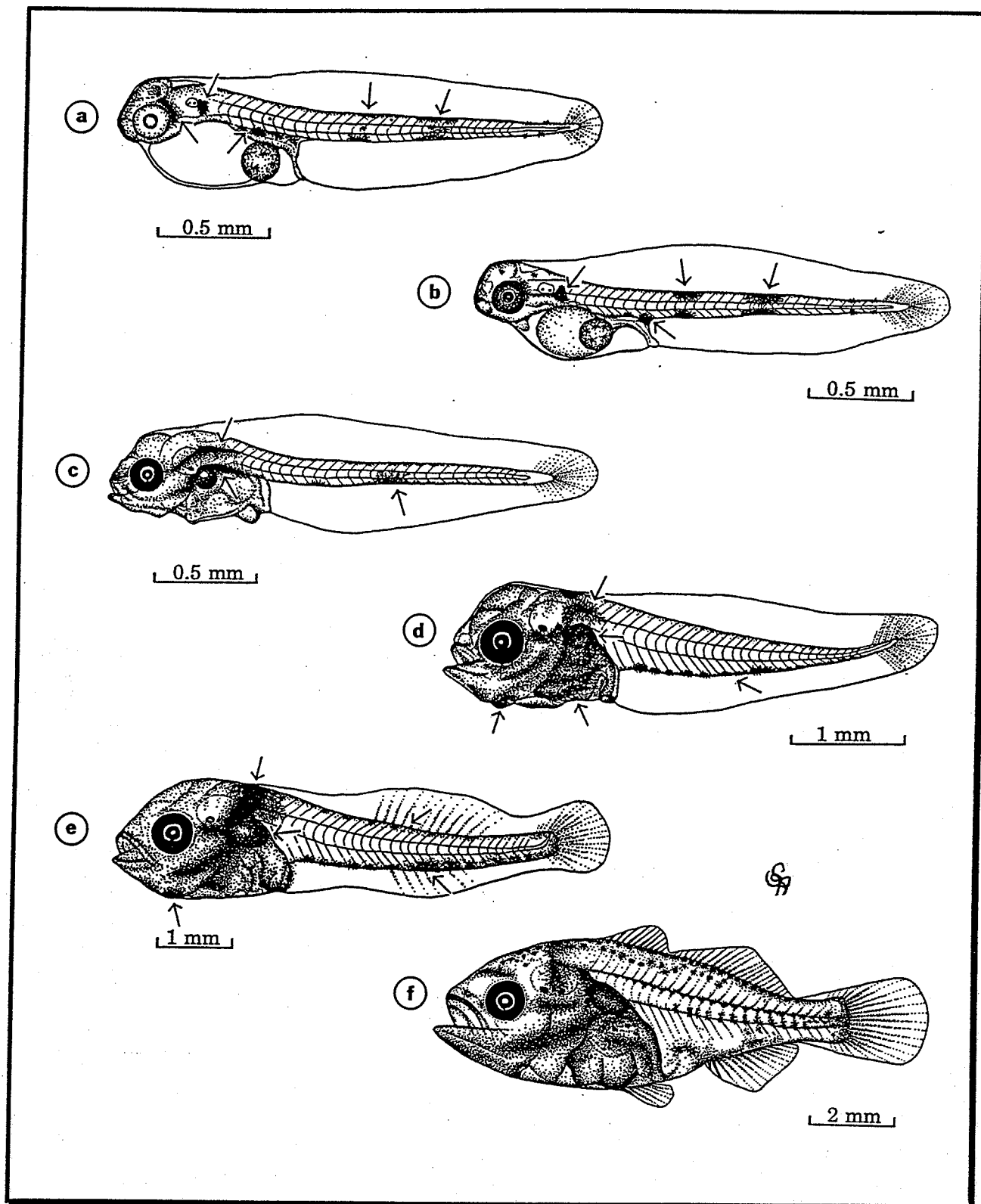
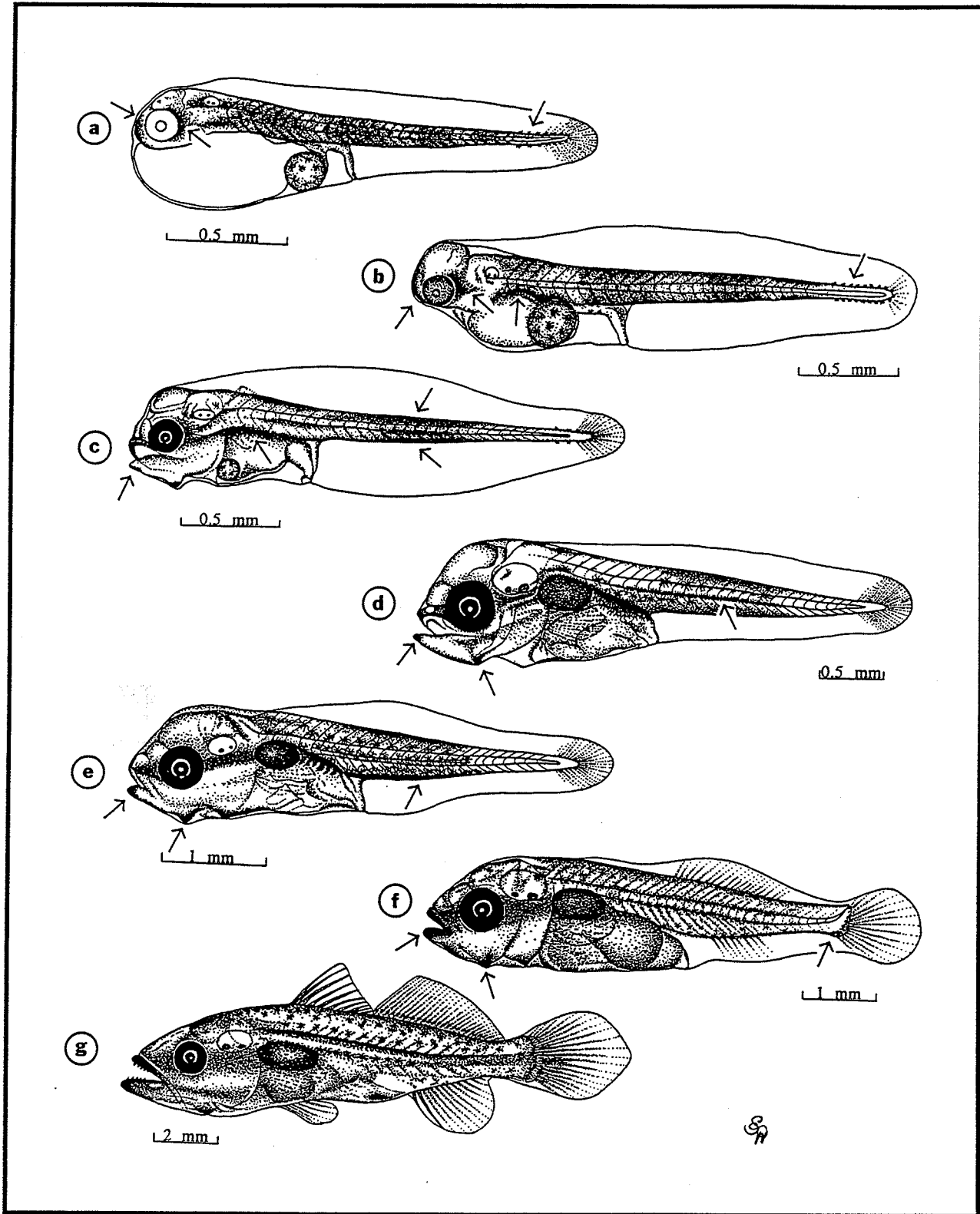


Fig. 5: *Bairdiella chrysoura* larvae, hatched and raised at 25 °C and 25‰: (a) 1-day-old yolk sac larva (2.2 mm TL), (b) 2-day-old larva (2.25 mm TL), (c) 5-day-old larva (2.53 mm TL), (d) 9-day-old larva (4.58 mm TL), (e) 13-day-old larva (7.35 mm TL), (f) 17-day-old juvenile (11.5 mm TL). Arrows indicate specific characteristics.



**Fig. 6:** *Cynoscion nebulosus* larvae, hatched and raised at  $T=25^{\circ}\text{C}$  and  $S=25\text{‰}$ : (a) yolk sac larva (1.95 mm TL), (b) 1-day-old yolk sac larva (2.5 mm TL), (c) 4-day-old larva (2.6 mm TL), (d) 11-day-old larva (3.75 mm TL), (e) 15-day-old larva (4.7 mm TL), (f) 18-day-old larva (6.8 mm TL), (g) 25-day-old juvenile (16.3 mm TL). Arrows indicate specific characteristics (after Alshuth & Gilmore 1993).