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Allometric growth pattern and morphological development of sailfin molly - *Poecilia latipinna* (Cyprinodontiformes, Poeciliidae) during early development

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Abstract. This study was conducted to survey the allometric growth pattern and morphological development of sailfin molly *Poecilia latipinna* during early development under rearing conditions. For this purpose, the fries were sampled after birth up to 30 day after birth (DAB), their left sides were photographed and morphometric parameters, including total length, head length, tail length, trunk length, eye diameter, snout length, and body depth were measured. The newly hatched fries were 9.83 ± 0.83 and 15.74 ± 0.34 mm in TL on 1 and 30 DAB, respectively. The results revealed growth priorities of this species during the early developmental stages. Based on the results, black molly born with developed jaws and eye that capable them to take the food immediately after birth and increasing the size of the mouth afterward to take larger food item. The morphological changes during the ontogeny of this species are associated to snout length, trunk length and body depth that may be related to change in feeding habit and adaptation to their environmental conditions.

Key Words: livebearer, molly fish, aquarium, ontogeny.

Introduction. Study of early developmental stages of fishes is an important tool to understand differences in reproductive strategies among populations under different environmental conditions (Reznick & Endler 1982; Reznick & Miles 1989; Reznick et al 1990, 1997; Johnson & Belk 2001). In addition, a successful aquaculture depends on understanding this process in candidate fish species (Pyka et al 2001). Differential relative growth pattern of various body parts is defined as allometry (Fuiman 1983; Dettlaff et al 1993). Allometry is a common feature during early larval development, ensuring to develop functional organs with their priority for survival (Osse & Van den Boogart 1995). In viviparity, which nourishment is supplied by maternal structures, the larval has evolved (e.g., Poeciliids) and the fish is born as juveniles (Wourms 1981).

The family Poeciliidae contains about 200 species in 22-29 genera and is widely distributed in America and Africa (Lucinda 2003). The sailfin molly (*Poecilia latipinna*) is a member of the family Poeciliidae and one of the popular ornamental fishes that can serve as biological control (Robins et al 1986). This species is native to the coastal waters of the Gulf of Mexico and the Atlantic Ocean, from southeast North Carolina to the Yucatan, including estuaries and freshwater tributaries (Burgess 1980; Meffe & Snelson 1989; Robins et al 1986). Both sexes of this species have rows of dark spots along each scale row, but are otherwise dimorphic. The dorsal fin in males is long and sail-like, with an orange edge, a series of black bars toward the outer half, and dark lines and spots near the base. Females lack bright coloration, most markings, and the elongated dorsal fin (Robins et al 1986).

Early developmental information of *P. latipinna* is sparse (Trexler 1985), probably due to complication of study of viviparous species during early developmental stage, e.g. the unavailability of developing embryos for examination and presence of the sexual dimorphism (Martyn et al 2006). Therefore, the present study performed to study the allometric growth pattern and morphological development of *P. latipinna* in a controlled aquarium condition before appearance of sexual dimorphism.

Material and Method. A total of twenty *P. latipinna* with swollen abdomen, were obtained from a commercial ornamental fish shop in August 2014 and reared in a glass aquarium at the laboratory of University of Tehran (Karaj, Iran). After giving birth, the newly born were collected. During the rearing period, temperature, hardness and pH were 24 ± 0.3ºC, 100 mg L^{-1} and ≥7, respectively. During the rearing period, fries were fed using *Artemia* nauplii and micro-worms (*Panagrellus redivivus*, nematode) and along with their growth with a mixture of the *Artemia* nauplii and commercial food pellet (Biomar, Denmark; 58% protein, 15% lipid).

For study the allometric growth pattern, a total number of 120 specimens from 1 to 30 DAB (day after birth), were sampled as following; 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 DAB, followed every other days till 30 DAB. Six specimens were randomly sampled for different stages by a plastic pipette and scoop net, and anaesthetized using 1% clove oil and their left sides were photographed by a stereomicroscope equipped with a digital Cannon camera with a 5 MP resolution. Then, the fries were preserved in 5% buffered formalin and stored in 70% ethanol after 24 hours for further examination. The visceral content of the specimens were examined under stereomicroscope to determine their sex that was not detectable up to 30 DAB; therefore the measured morphometric data of two sexes were pooled and analyzed.

Seven morphometric characters, including total length (TL), head length (HL), tail length (TaL), trunk length (TrL), eye diameter (ED), snout length (SnL) and body depth (BD) were measured. All measurements were taken along lines parallel or perpendicular to the horizontal axis of the body from obtained images using ImageJ software (version 1.240) (Figure 1).

The allometric growth patterns were calculated as a power function of total length using non-transformed data: $Y = aX^b$, where Y is the independent variable; X, the dependent variable; a, the intercept and b, the growth coefficient. Isometric, positive and negative allometric growth patterns are indicated by b = 1, b > 1, b < 1, respectively (Van Snik et al 1997). Robustness of the regression was measured by calculating R^2 and its significance level.

The inflexion points of growth curves were determined according to Fuiman (1983) and Van Snik et al (1997). Drawing plates and data analysis were performed in MS-Excel 2013 (Microsoft Corporation). Data analysis was performed Past 2.17 for Windows.

For study of the morphological changes during early development, the specimens were examined for observations on general morphology, pigmentation and fin development by a stereomicroscope (Leica M5).

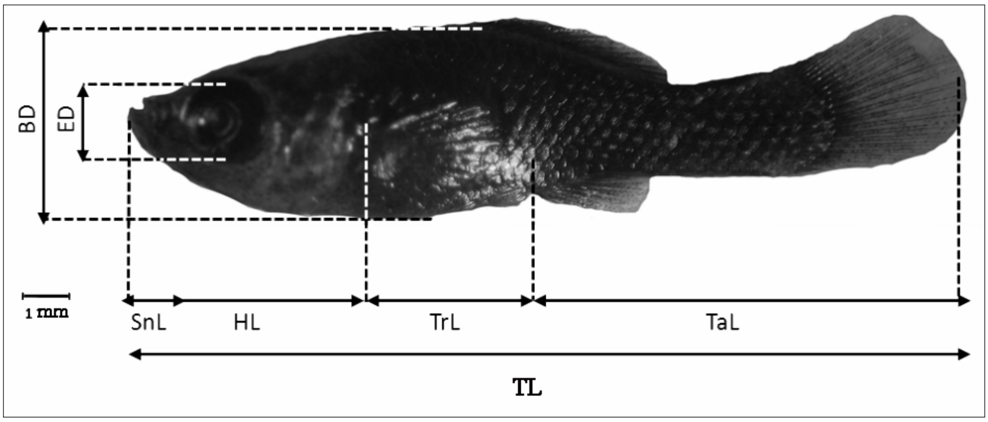

Figure 1. Measured morphometric characters in *P. latipinna* from 1 till 30 day after birth.

Results. The newly hatched fries were 9.83 ± 0.83 and 15.74 ± 0.34 mm in TL 1 and 30 DAB, respectively. HL was 25% of TL day-1 after birth; this proportion subsequently increased with the growth of the fries, reaching 29% and 27% of TL 9 and 30 DAB. SnL was 5% of TL day-1, increasing to 8% and 6% of TL 16 and 30 DAB, respectively. ED was initially 8% of TL, reaching 10% of TL 28 DAB, reaching 8% in 30 DAB. TrL initially was 21% of TL, reaching 23% and 21% on 20 and 30-day old fries. BD initially was 16% of TL at the birth, reaching 25% of TL day-26 and then decreased with their growth day-30.

The results showed that growth pattern of all body segments can be divided into two phases (Figure 2). Allometric growth of the HL (b = 1.02) and ED (b = 0.99) showed an isometric pattern prior to their inflection points, at 13.1-13.73 mm of TL, respectively (at 9 and 28 DAB, respectively), and after inflection points, their patterns were negative. In addition, SnL showed a positive growth pattern up to 16 DAB (14 mm TL), then changed to a strongly negative allometric pattern. The allometric growth patterns of TrL (b = 1.45) and BD (b = 1.57) were positive prior to their inflection points, 14.56, 13.83 mm of TL, respectively (20 and 26 DAB, respectively). During post inflection point, allometric growth pattern of TrL was isometric, whereas that of BD (b = 0.38) was strongly negative. The growth pattern of TaL was relatively isometric (b = 0.85) before its inflection point and after this point in 14.12 mm of TL (24 DAB), it was changed to a positive pattern.

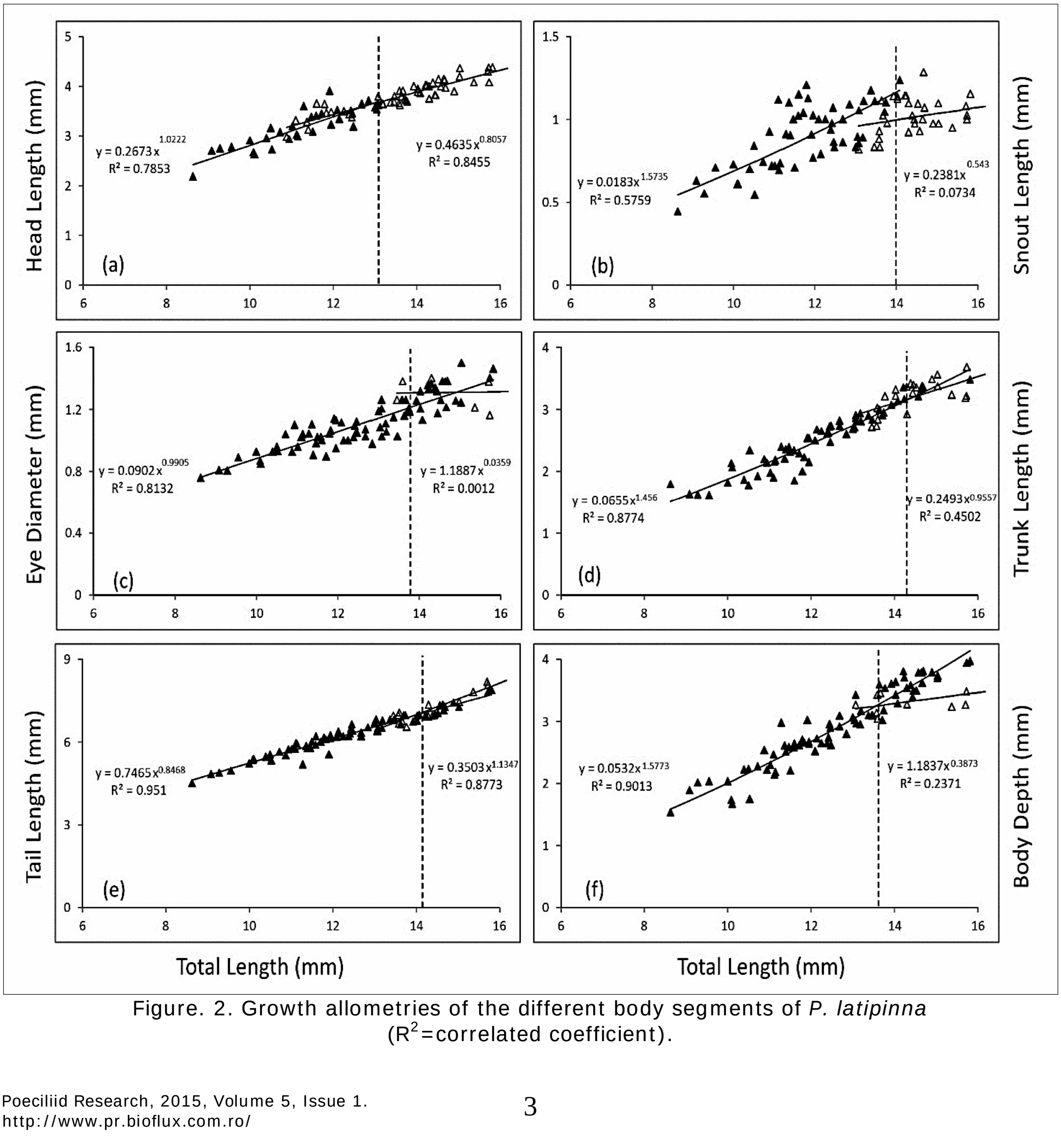

Figure. 2. Growth allometries of the different body segments of *P. latipinna* (R^2=correlated coefficient).

Figure 3 shows the external morphological changes of *P. latipinna* from 1 to 30 DAB. The results revealed there is no sexual dimorphism during this period. Based on our observation, the newly hatched fries possess relatively depleted yolk sac and many functional structures such as developed jaws, pigmented eye and relatively developed fins after their birth. Although, different degrees of the yolk sac were found in some fries, especially in the first days after birth. Complete developments of the fins were occurred along with their growing 16 DAB. Pigmentation was presented on the body with different patterns during early developmental stage. The newly hatched fries were transparent grayish with some punctuated scattered melanophores, particularly on the caudal peduncle region and dorsal face of the head till five DAB. From 5 to 30 DAB, the fries became dark brownish and the concentration of the melanophores was on fins and head. Therefore, many melanophores were appeared on the fins, particularly on the pectoral, dorsal and caudal and increased in the number with their growth.

Figure 3. Morphometric development of *P. latipinna*: (a) TL = 9.6 mm at 2 DAB, (b) TL = 12.28 mm at 5 DAB, (c) TL = 14 mm at 16 DAB, (d) TL = 15.74 mm at 30 DAB (scale bar = 1 mm).

Discussion. Allometric growth pattern is a common phenomenon during early development of fishes, containing important information on ecological and biological demands and functional performance of fishes (Gisbert et al 1998; Osse & Van den Boogaart 1995; Huysentruyt et al 2009; Peña & Dumas 2009; Çoban et al 2012). Based on the results, early developmental study of *P. latipinna* as a livebearers species showed that many of its biological systems are functional at the moment of birth. These features may be related to ecological and biological demands of this species comparing to those of oviparous species (Peña & Dumas 2009). Presence of different degree of the yolk sac in some newly hatched fries in this study may depend on nutrient availability for the broods (Trexler 1985). If females have access to enough nutrient sources, they considered “truly viviparous” (Amoroso 1960; Scrimshaw 1945).

A positive allometric growth pattern of the snout length during early development of *P. latipinna* may be related to changing its feeding habit, e.g. to obtain larger food items. The size of mouth has an important effect on prey catching (Hjelm et al 2003). As larvae hatches, head and snout lengths grow and increasing in food particle size occurs simultaneously (Osse et al 1997). Hence, feeding shifts and morphological changes in this species is concomitant. In fact, fries can take the food by developed jaws on the mouth, similar to the guppy (Mousavi-Sabet et al 2014; Shahjahan et al 2013). Therefore, the developed jaws in newly hatched fries of *P. latipinna* along with rapid growth of the snout length during early development can assist this species to take larger algae and detritus as food items (Zedler 2001).

In addition, the isometric growth pattern of head and eye diameter in newly hatched fries were observed during early development. The head and eye are associated with the nervous and sensory systems for prey detection and enabling fish to follow points of reference moving across their field of vision (Fuiman 1983; Koumoudours et al 1999; Arnold 1974). The growth pattern of the head and eye in *P. latipinna* i.e. developed at the hatching, showing importance of head and eye to survive immediately after birth.

The positive allometric growth patterns of the trunk length and body depth during early development can be related to development of the abdominal visceral organs such as alimentary tract. According to Osse & Van den Boogaart (2004), an extensive shift in ontogenetic development occurs to increase the possibility of survival. In addition, this species lives in shallow marsh areas (Williams et al 1998). Therefore, a positive allometric growth pattern of the body depth probably related to its life style suggesting that growth functionally optimizes the survival (Osse et al 1997) and adaptation to the environmental conditions (Dettlaff et al 1993). A positive allometric body depth reflects obtaining a deeper body shape. Such a body form is related to rapid turning and maneuvering in tight quarters, such as area with aquatic plants as seen in marshes (Ontario 2015).

Conclusions. The results of this study provided valuable information on changes in functional demands throughout ontogeny of *P. latipinna* showing a natural transition in growth priorities since primary functions have been fulfilled during the early developmental stages. In addition, the information on morphology during the early life stages is essential, particularly for investigating mechanisms of survival. The results also revealed that *P. latipinna* born with developed jaws and eye that capable them to take the food immediately after birth and increasing the size of the mouth afterward to take larger food items. In addition, the allometric growth pattern of this species showed that the inflection points of the most of body segments occur during 16-28 DAB. These morphological changes are associated to snout length, trunk length and body depth that may be related to changing in feeding habit and adaptation to their environmental conditions.

References

Amoroso E. C., 1960 Viviparity in fishes. In: Hormones in fish. Jones I. C. (ed), Symposium of the Zoological Society of London, pp. 153-181.

Arnold G. P., 1974 Rheotropism in fishes. Biological Reviews 49:515-576.

Burgess G. H., 1980 *Poecilia latipinna* (Lesueur). In: Atlas of North American freshwater fishes. Lee D. S., Gilbert C. R., Hocutt C. H., Jenkins R. E., McAllister D. E., Stauffer J. R. (eds), Pub. 1980-12, North Carolina Biological Survey, North Carolina State Museum of Natural History. Raleigh, NC. USA, 549 pp.

Çoban D., Suzer C., Yıldırım Ş., Saka Ş., Firat K., 2012 Morphological development and allometric growth of sharpsnout seabream (*Diplodus puntazzo*) larvae. Turkish Journal of Fisheries and Aquatic Sciences 12:883-891.

Dettlaff T. A., Ginsburg A. S., Schmalhausen O. I., 1993 Sturgeon fishes. Developmental biology and aquaculture. Berlin, Springer-Verlag, 300 pp.

Fuiman L. A., 1983 Growth gradients in fish larvae. Journal of Fish Biology 23:117-123.

Gisbert E., Rodriguez A., Castello-Orvay F., Williot P., 1998 A histological study of the development of the digestive tract of Siberian sturgeon (*Acipenser baeri*) during early ontogeny. Aquaculture 167:195-209.

Hjelm J., van de Weerd G. H., Sibbing F. A., 2003 Functional link between foraging performance, functional morphology, and diet shift in roach (*Rutilus rutilus*). Canadian Journal of Fisheries and Aquatic Sciences 60:700-709.

Huysentruyt F., Moerkerke B., Devaere S., Adriaens, D., 2009 Early development and allometric growth in the armoured catfish *Corydoras aeneus* (Gill, 1858). Hydrobiologia 627:45-54.

Johnson J. B., Belk M. C., 2001 Predation environment predicts divergent life history phenotypes among populations of the livebearing fish *Brachyrhaphis rhabdophora*. Oecologia 126:142-149.

Koumoudouros G., Divanach P., Kentouri M., 1999 Ontogeny and allometric plasticity of *Dentex dentex* (Osteichthyes: Sparidae) in rearing conditions. Marine Biology 135(3):561-572.

Lucinda P. H. F., 2003 Family Poeciliidae. In: Fishes of south and Central America; check list of the freshwater. Reis R. E., Kullander S. O., Ferraris C. J. (eds), EDIPUCRS, Porto Alegre, Brazil, pp. 555–581.

Martyn U., Weigel D., Dreyer C., 2006 In vitro culture of embryos of the guppy, *Poecilia reticulata*. Developmental Dynamics 235:617-622.

Meffe G. K., Snelson Jr. F. F., 1989 An ecological overview of Poeciliid fishes. In: Ecology and evolution of livebearing fishes (Poeciliidae). Meffe G. K., Snelson Jr. F. F. (eds), New Jersey, Prentice Hall, Englewood Cliffs, pp. 13–31.

Mousavi-Sabet H., Azimi H., Eagderi S., Bozorgi S., Mahallatipour A., 2014 Growth and morphological development of guppy *Poecilia reticulata* (Cyprinodontiformes, Poeciliidae) larvae. Poeciliid Research 4(1):24-30.

Ontario B., 2015 Fish morphology. Retrieved from: http://www.eoearth.org/view/article/152776.

Osse J. W. M., Van den Boogart J. G. M. 1995 Fish larvae, development, allometric growth, and the aquatic environment. ICES Marine Science Symposia 201:21-34.

Osse J. W. M., Van den Boogaart J. G. M., 2004 Allometric growth in fish larvae: timing and function. In: The development of form and function in fishes and the question of larval adaptation. Govoni J. (ed), American Fisheries Society Syposium, Bethesda, MD, USA, pp. 167-194.

Osse J. W. M., van den Boogart J. G. M., Van Snik G. M. J., Van der Sluys L., 1997 Priorities during early growth of fish larvae. Aquaculture 155:249-258.

Peña R., Dumas S., 2009 Development and allometric growth patterns during early larval stages of the spotted sand bass *Paralabrax maculatofasciatus* (Percoidei: Serranidae). Scientia Marina 73:183-189.

Pyka J., Bartel R., Szczerbowski J. A., Epler P., 2001 Reproduction of gattan (*Barbus xanthopterus*), shabbout (*Barbus grypus*) and Bunni (*Barbus sharpeyi*) and rearing stocking material of these species. Archives of Polish Fisheries 9:235-246.

Reznick D. N., Endler J. A., 1982 The impact of predation on life history evolution in Trinidadian guppies (*Poecilia reticulata*). Evolution 36:160–177.

Reznick D. N., Miles D. B., 1989 A review of life history patterns in poeciliid fishes. In: Ecology and evolution of livebearing fishes (Poeciliidae). Meffe G. K., Snelson F. F. (eds), New Jersey, Prentice Hall, pp. 125-148.

Reznick D. N., Bryga H., Endler J. A., 1990 Experimentally induced life-history evolution in a natural population. Nature 346:357-359.

Reznick D. N., Shaw F. H., Rodd F. H., Shaw R. G., 1997 Evaluation of the rate of evolution in natural populations of guppies (*Poecilia reticulata*). Science 275:1934-1937.

Robins C. R., Ray G. C., Douglas J., 1986 A field guide to Atlantic coast fishes of North America. Houghton Mifflin Co. New York, USA, 354 pp.

Scrimshaw N. S., 1945 Embryonic development in Poeciliid fishes. Biological Bulletin 88:233-246.

Shahjahan R. M., Jubayer Ahmed M., Ara Begum R., Abdur Rashid M., 2013 Breeding biology of guppy fish, *Poecilia reticulata* (Peters, 1859) in the laboratory. Journal of the Asiatic Society of Bangladesh Science 39(2):259-267.

Trexler J. C., 1985 Variation in the degree of viviparity in the sailfin molly, *Poecilia latipinna*. Copeia 1985:999-1004.
Van Snik G. M. J., Van Den Boogaart J. G. M., Osse J. W. M., 1997 Larval growth patterns in *Cyprinus carpio* and *Clarias gariepinus* with attention to the finfold. Journal of Fish Biology 50:1339-1352.
Williams G. D., Desmond J. S., Zedler J. B., 1998 Extension of two nonindigenous fishes, *Acanthogobius flavimanus* and *Poecilia latipinna*, into San Diego Bay marsh habitats. California Fish and Game 84:1-17.
Wourms J. P., 1981 Viviparity: the maternal-fetal relationship in fishes. American Zoologist 21(2):473-515.
Zedler J. B., 2001 Handbook for restoring tidal wetlands. CRC Press, Boca Raton, FL, 439 pp.

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