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The Development of Brook Trout (*Salvelinus fontinalis* Mitchill, 1814) Embryos During the Yolk Sac Period

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Abstract: The growth rate during yolk absorption, yolk conversion efficiency, dry weight and water contents of brook trout (*Salvelinus fontinalis* Mitchill, 1814) larvae were observed and the relationships between degree-days were evaluated. While the mean wet weight was 72.45 ± 5.58 mg (n = 10) at hatching and reached 98.85 ± 6.22 mg just before the swim-up stage, the mean dry weights of the body and yolk sac were 2.70 ± 0.41 and 23.33 ± 0.59 mg at hatching and 9.49 ± 1.27 and 12.46 ± 1.14 mg at swim-up stages, respectively. The mean body dry matter and water content of the larvae were 36.04% and 63.96% at hatching and 19.22% and 80.78% at swim-up stages, respectively. Considering the relationships between larval development and degree-days, dry yolk and total larval weights and dry matter of the larvae decreased, while dry body weight and water content increased with degree-days. The growth of larva, yolk sac absorption and yolk conversion efficiency were calculated as 0.235 mg/day, 0.477 mg/day and 0.50, respectively. These results can be used for environmental and husbandry manipulations to influence rates of larval development and mortality, and to increase the productivity of hatcheries.

Key Words: Brook trout, *Salvelinus fontinalis*, larval development, yolk conversion efficiency, growth

Kaynak Alabalığı (*Salvelinus fontinalis* Mitchill, 1814) Larvalarının Besin Keseli Periyot Boyunca Gelişimi

Özet: Bu çalışmada kaynak alabalığı (*Salvelinus fontinalis* Mitchill, 1814) larvalarının besin kesesi absorpsiyonu dönemi boyunca, gün-derece ile büyüme oranı, besin kesesi değerlendirme randımanı, su ve kurumadde içeriği arasındaki ilişkiler irdelenmiştir. Yumurtadan çıkışta larvanın 72.45 ± 5.58 mg (n = 10) olan toplam yaş ağırlığı serbest yüzme öncesi 98.85 ± 6.22 mg'a ulaşmış ve bu dönemde kuru vücut ağırlığı 2.70 ± 0.41'dan 9.49 ± 1.27'a yükselmiş, besin kesesi ağırlığı ise 23.33 ± 0.59 mg'dan 12.46 ± 1.14 mg'a düşmüştür. Larvanın kuru madde ve su içeriği, çıkışta sırasıyla %36.04 ve %63.96, serbest yüzme öncesinde ise %19.22 ve %80.78 olarak belirlenmiştir. Gün-derece ile kuru kese, toplam kuru larva ağırlığı ve su içeriği arasında azalan, kuru vücut ağırlığı ve kuru madde oranı arasında ise artan ilişkiler bulunmuştur. Larvanın büyümesi, besin kesesi absorpsiyonu ve besin kesesi değerlendirme randımanı (YCE), sırasıyla 0.235 mg/gün, 0.477 mg/gün ve 0.50 olarak hesaplanmıştır. Bu sonuçlar, larval gelişim ve ölüm oranı üzerine çevre ve işletme yönetiminin geliştirilmesi ve kuluçkahanelerin verimliliğini artırmak amacıyla kullanılabilir.

Anahtar Sözcükler: Kaynak alabalığı, *Salvelinus fontinalis*, larval gelişim, besin kesesi değerlendirme randımanı, büyüme

Introduction

The brook trout, Salvelinus fontinalis, is not a very popular culture species. However, it has been cultured commercially in north America, Europe and in the eastern Black Sea region of Turkey as a secondary species in rainbow trout (*Oncorhynchus mykiss*) farms. A few

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studies were performed on this species under culture conditions (Akbulut et al., 1999; Okumuş et al., 1999a; Okumuş et al., 1999b) in Turkey.

The first external feeding activities of the fish larvae start when the larvae swim up. Observations have demonstrated that the larva has a piece of yolk when swimming up, so in trout hatcheries the first external feeding starts when over 30% of the larvae swim up. As in other finfish species, these development and transition stages of brook trout larvae are also critical due to their susceptibility to diseases and pathogens, environmental fluctuations and starvation. Therefore, it is possible to increase survival and growth rates through proper hatchery management skills during this critical stage(s), and also to produce larvae or fry during times of the year when they are not available under typical conditions. In order to achieve these goals there is a need for qualitative and quantitative species and also site-specific data on issues related to early development. Thus, several studies have been performed on larval development of salmonid species; namely, Atlantic salmon, *Salmo salar* (Hansen and Møller, 1988); rainbow trout (Hodson and Blunt, 1986); and sea trout, *Salmo trutta* (Hansen, 1985). In addition, the larval development of brook trout and Arctic charr, *Salvelinus alpinus*, and their hybrids were also investigated (Dumas et al., 1995).

As can be seen, comparatively little attention has been paid to the early development of newly emerging potential culture species including brook trout. On the other hand, the growth and survival rates of fish larvae are the result of complex interactions among various genetic and environmental factors and salmonids are not exceptions (Ferguson et al., 1995). However, studies performed for a given species under certain environmental variables may not be applicable for other species and environmental conditions. In this study, the growth rate during yolk absorption, yolk conversion efficiency (YCE), and the dry matter and water contents of brook trout larvae were investigated under pilot hatchery conditions in the eastern Black Sea region of Turkey.

Materials and Methods

Eggs from broods were collected from three females and fertilized with milt obtained from two males at a private trout farm in Güneysu, Rize. After hardening, 2000 eggs were transferred to the Faculty of Marine Science, Karadeniz Technical University on the same day. They were placed in an egg tray in a 200 1 tank. The water in the tank was aerated continuously and refreshed 10% daily. Temperature was measured three times a day (at 0830, 1230 and 1600 hours with a mercury thermometer. Dead eggs were removed two times every week.

The sampling was commenced at 3-day intervals from hatching to 790 degree-days post-hatch. The first larvae were sampled at 523 degree-days (50% eggs hatched) and then at 549, 577.5, 607, 636, 661.5, 686.5, 716.5, 751.5 and 790 degree-days (after swim-up stage started), respectively.

Ten larvae were randomly sampled at each sampling period (10 times), i.e. a total of 100 larvae were used during the study. They were preserved in 10% formalin until further analysis. After a minimum interval of 3 weeks, fixed larvae were dissected to separate the yolk from the body. The body and yolk were dried separately at 60 °C for 48 h and weighed (d = ± 0.1 mg) after 48 h (Hansen, 1985).

The significance of all slopes (Ho: b = 0) and regressions was tested at the 0.05 probability level (Hodson and Blunt, 1986).

Results

The incubation water temperature varied between 4.5 and 13.0 °C (9.20 ± 1.92). Hatching started on day 55 (491 degree-days), and 50% hatching occurred on day 58 (523 degree-days) and was completed by day 61 (549 degree-days). The wet weight of larva with yolk increased linearly from 72.45 ± 5.58 mg (n = 10) at hatching to 98.85 ± 6.22 mg just before the swim-up stage (Figure 1). The mean dry weights of body and yolk were 2.70 ± 0.41 and 23.33 ± 0.59 mg at hatching and 9.49 ± 1.27 and 12.46 ± 1.14 mg at the swim-up stage, respectively (Figure 2). The dry matter and water contents of larvae were 36.04% and 63.96% at hatching and 19.22% and 80.78% at the swim-up stage, respectively (Figure 3).

Larval weight exhibited a positive relationship with degree-days; dry yolk and total larval weights and water content decreased, while dry body weight (yolk excluded) and dry matter content (body + yolk) increased with degree-days (Table).

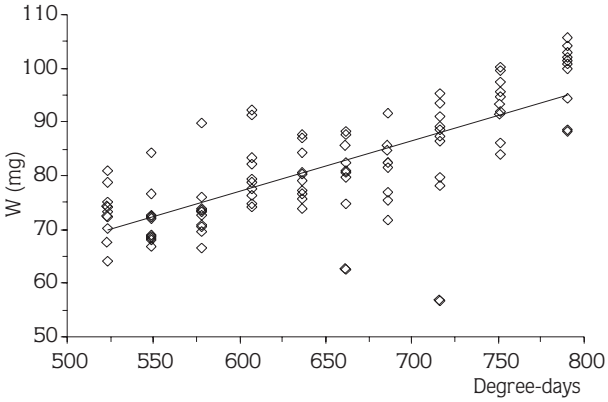

Figure 1. Increments in wet weight of larvae from hatching to swim up (523-790 degree-days).

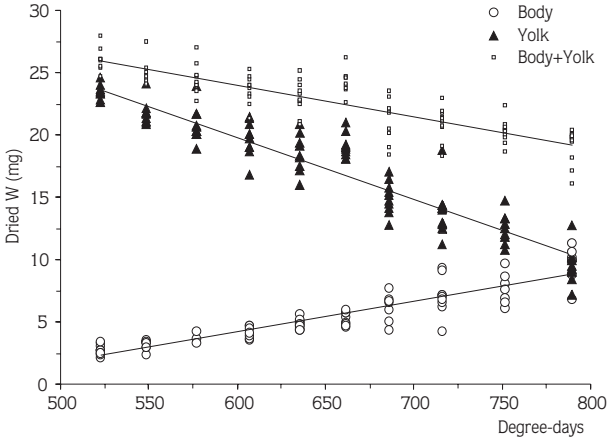

Figure 2. Increase of body weight and decrease of yolk and whole (body + yolk) weights of larvae from hatching to swim up (523-790 degree-days).

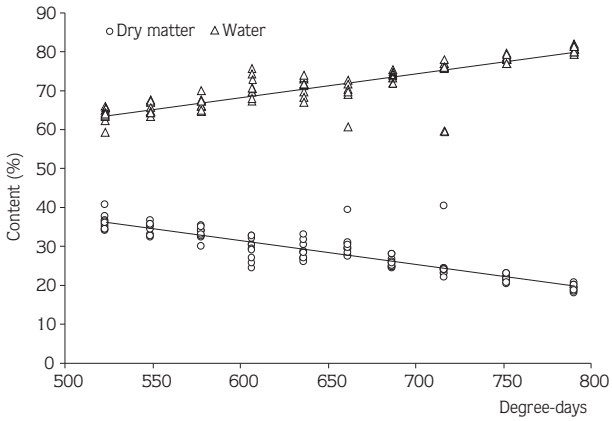

Figure 3. Variations in dry matter and water contents of the larvae from hatching to the swim- up stage (523-790 degree-days).

The growth rate of larva, yolk sac absorption, and YCE values were calculated to be 0.235 mg/day, 0.477 mg/day, and 0.50, respectively.

Discussion

At hatching, the mean wet weight of larvae was 72.45 ± 5.28 mg and reached 98.85 ± 6.22 mg just before the swim-up stage. Although it may vary with egg size (large eggs produce large larva) and incubation period (the shorter the duration, the heavier the larva), this value is quite similar to that reported by Dumas et al. (1995) for post-hatch brook trout larvae, which was 90 ± 2.0 (s.e.) mg.

Table. The linear regression parameters describing the changes in weights, water and dry matter contents of larvae with degree-days.

	Statistics[1]						
Parameters	a	b	r	t_b	*F*	S_y	P value
Total wet weight	20.4485	0.09447	0.755	11.412	130.250	5.4234	< 0.001
Dry yolk weight	49.6304	-0.04969	- 0.940	-27.326	746.720	1.1913	< 0.0001
Dry body weight	-10.5286	0.02450	0.924	23.908	571.600	0.6714	< 0.0001
Dry larva weight	38.9665	- 0.02498	- 0.843	-15.505	240.404	1.0556	< 0.0001
Water content (larva)	31.9173	0.06102	0.885	18.902	357.286	2.1151	< 0.0001
Dry matter (larva)	68.0827	- 0.06102	- 0.886	-18.902	357.286	2.1151	< 0.0001

[1] a: y intercept, b: slope, r: correlation coefficient, t_b: *t* statistics for testing null hypothesis that b = 0, *F: F* statistic for testing the significance of the regression, S_y: standard error of the estimate, P: significance.

The dry yolk weight of brook trout larvae at hatching was calculated to be 23.33 ± 0.59 mg in the present study. This value is much higher than the value of 12.26 mg reported by Dumas et al. (1995), whereas it is much smaller than that presented by Hodson and Blunt (1986) for rainbow trout, which was estimated to be 31 mg from the figures. These within and between species differences in yolk size might arise from egg and larva size, incubation temperature and period, and the nutrition and husbandry of brood fish. There are contrasting views on the relation between the size of larva and amount of yolk at hatching. For example, as cited by Dumas et al. (1995), Rana (1990) observed an inverse relationship between the size of larva and the yolk; in contrast, Dumas et al. (1995) found that hybrids of Arctic charr (female) and brook trout (male) had higher net body weight at hatching than pure Arctic charr larva, but they both had the same amount of yolk. The authors concluded that the amount of yolk at hatching is mainly determined by the maternal species; the larvae of brook trout females had more yolk reserves than the larvae from Arctic charr females.

The dry body weights of brook trout larvae at hatching and before swim up were calculated to be 26.03 ± 087 (36% of total wet weight) and 19.00 ± 1.415 mg (19% of total wet weight), respectively. This decrease in dry matter was also reported by Hansen and Møller (1988) for Atlantic salmon, and Hodson and Blunt (1986) for rainbow trout. There might be two reasons for this. Firstly, salmonids are particularly rich in nutrients and so the dry matter contents of eggs and newly hatched larvae are relatively high. Secondly, the water content of the body increases towards the swim-up stage to ease buoyancy during swimming just before filling the gas or swim bladder.

The observed value of YCE on a dry weight basis approached 0.7, although the theoretical value was 0.82. Blaxter (1969) (cited by Hodson and Blunt (1986)) reviewed estimates of YCE for several species and the range was 0.4-0.8. The values of YCE for *Salmo* species were from 0.41 to 0.70 at 10 °C. Dumas et al. (1995) reported that the YCE value was 0.65 for brook trout at 8-13 °C and Hansen (1985) reported values ranging from 0.46 to 0.68 at 7-8.5 °C for *Salmo trutta*. All these values compare well with our findings.

This preliminary study was undertaken to evaluate the early development (from hatching to free swimming stage) of brook trout larvae and has provided data on the growth rate during yolk absorption, YCE values, and dry weight and water contents. These data can be used for further comparative studies and to assist in developing efficient hatchery management programs.

References

Akbulut, B., Okumuş. İ., Başçınar, N., Kurtoğlu, İ.Z. and Şahin, T. 1999. Egg Production in a Brook Trout (*Salvelinus fontinalis*) Broodstock: Fecundity, Egg Size and Correlation of Body Weight. In: Proceedings of the First International Symposium on Fisheries and Ecology (Eds: M.S. Çelikkale, E. Düzgüneş, İ. Okumuş and C. Mutlu), Karadeniz Tech. Univ. Faculty of Marine Sci., Trabzon, pp. 162-166.

Dumas, S., Blanc, J.M., Audet, C. and de la Noüe, J. 1995. Variation in Yolk Absorption and Early Growth of Brook Charr, *Salvelinus fontinalis* (Mitchill), Arctic charr, *Salvelinus alpinus* (L.), and Their Hybrids. Aquaculture Research, 26: 759-764.

Ferguson, M.M., Liskauskas, A.P. and Danzmann, R.G. 1995. Genetic and Environmental Correlates of Variation in Body Weight of Brook Trout (*Salvelinus fontinalis*). Canadian Journal of Fisheries and Aquatic Sciences, 52: 307-314.

Hansen, T. 1985. Artificial Hatching Substrate: Effect on Yolk Absorption, Mortality and Growth during First Feeding of Sea Trout (*Salmo trutta*). Aquaculture, 46: 275-285.

Hansen, T.J. and Møller, D. 1988. Yolk Absorption, Yolk Sac Constrictions, Mortality, and Growth during First Feeding of Atlantic Salmon (*Salmo salar*) Incubated on Astro-turf. Canadian Journal of Fisheries and Aquatic Sciences. 42: 1073-1078.

Hodson, P.V. and Blunt, B.R. 1986. The Effect of Time from Hatch on the Yolk Conversion Efficiency of Rainbow Trout, *Salmo gairdner*i. Journal of Fish Biology, 29: 37-46.

Okumuş. İ., Başçınar, N., Kurtoğlu, İ.Z. and Yılmaz, K. 1999a. Effects of Stocking Density on Growth Performance, Size Variation, Food Intake and Conversion Rates in Brook Trout, *Salvelinus fontinalis*. In: Proceedings of the First International Symposium on Fisheries and Ecology (Eds: M.S. Çelikkale, E. Düzgüneş, İ. Okumuş and C. Mutlu), Karadeniz Tech. Univ. Faculty of Marine Sci., Trabzon, pp. 224-230.

Okumuş, İ., Çelikkale, M.S., Kurtoğlu, İ.Z. and Başçınar, N. 1999b. Saf ve Karışık Olarak Yetiştirilen Gökkuşağı (*Oncorhynchus mykiss*) ve Kaynak Alabalıklarının (*Salvelinus fontinalis*) Büyüme Performansları, Yem Tüketimi ve Yem Değerlendirme Oranları. Turk J Vet Anim Sci, 23 (Supp. 1): 123-130.