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International Council for
the Exploration of the Sea

C.M. 1984/F:30
Mariculture Committee

ARTIFICIAL HATCHING SUBSTRATE IN THE MASS REARING OF LARVAL ATLANTIC SALMON (*Salmo salar*).

by

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ABSTRACT

Eggs from individual Atlantic salmon (*Salmo salar*) were hatched in a Californian hatching system with and without an astro-turf artificial substrate and growth during the first 200 days following hatching was investigated.

The astro-turf promoted yolk absorption rate, yolk conversion efficiency and growth during the hatchery incubation and feeding. However, yolk absorption rate was also dependent on yolk weight at hatching with highest absorption rate in alevins with high yolk weight. Due to an increasing variance, the weight difference between the systems was no longer significant at the termination of the experiment

INTRODUCTION

Controlled hatching of salmonids in artificial substrates like plastic saddles (Leon, 1975), grids (Leon, 1979) and astro-turf (Eriksson and Westlund, 1983; Hansen and Møller, 1984; Hansen, 1984) is well known. Moreover, it is established that compared to traditional flat screened hatching systems these substrates improve growth and increase yolk absorption rate, prevent development of yolk sac constrictions and improve growth and survival during feeding (Leon, 1975; Hansen and Møller, 1984). However, in all the above mentioned experiments growth during feeding has been investigated during a relatively short period (commonly 6 weeks), and consequently little is known about the long term effects.

The purpose of this experiment was to investigate the effects of an astro-turf incubator in a large scale rearing situation. We were especially interested in whether the hatchery incubation had any long term effect on growth.

MATERIALS AND METHODS

Eggs from 36 female Atlantic salmon were stripped, fertilized and incubated at a mean temperature of 6.5 °C in separate hatching trays at Matre Aquaculture Station. The progeny of the different femals were held separately both during hatchery incubation and later during the whole feeding period.

Experimental conditions

At the eyed stage the eggs were shocked, and dead eggs were sorted out by a sorting machine. Twenty of the groups were incubated in standard EWOS hatching trays, the other sixteen were incubated in trays modified according to Hansen and Møller (1984). At commencement of feeding the fry were transferred to separate feeding tanks (1.5x1.5m) and fed an Ewos st 40 startfeed nr 1. After six weeks of feeding the fry were transferred to sircular tank with 1.5m diameter. The feed size was increased as the fry size increased.

The water input in the hatchery was 10 litres per minute per tray and the temperature varied between 5.9 and 6.9 °C. In the startfeeding period the water input was 8 litre per tank per minute and the temperature varied between 9.8 and 11.9 °C with a mean of 11.0.

Sampling and measurements

At hatching, and later at commencement of startfeeding, 25-35 alevins from each hatching tray were transferred to 5% formalin and later dried to constant weight at 60 °C (at least two days). Whole alevins (totalweight) and later yolk and yolk sac constrictions were counted and weighed en masse to the nearest milligram on an electronic microbalance. Mean individual totalweight, yolk weight, bodyweight and weight of yolk sac constrictions were calculated. Yolk conversion efficiency (Blaxter, 1969), yolk absorption rate ((yolk at hatching - yolk at transfer)/ days of incubation) and yolk absorption status ((yolk at hatching - yolk at transfer)/yolk at hatching) was also calculated and included in the statistical testing.

Every week for six weeks after commencement of startfeeding 25-40 fry from each feeding tank were anaesthetized, dried, counted, weighed en masse and the mean individual fry weight calculated. At the end of startfeeding all the groups were reduced to 2000 fry. To get a random sample when reducing the size of the groups the fish were crowded in the feeding tank and then sampled with a dip-net. From this moment and througout the experiment 50-100 fry were collected with a dip-net every month. The fry were counted, the water was drained of and the fry weighed en masse. The mean weight was calculated from the data.

Statistical testing

Statistical testing was carried out by using BMDP statistical software, P2V and P3D, (Dixon, 1981). A critical level of 5% was adopted in all tests.

RESULTS

Dry weight development in the hatchery

At 50% hatching (day 0) no difference neither in body weight nor yolk weight was found between the systems (Table 1).

The astro-turf reared (ATR) alevins had a higher yolk aborption rate (YAR) and a higher yolk conversion efficiency (YCE) than the flat screen reared (FSR) ones, both differences beeing significant. As a consequence the ATR fry had significantly higher body weight and a significantly lower yolk weight than the FSR-fry at commencement of startfeeding (day 33). Moreover, YAR was significantly influenced by yolk weight at hatching ($p=0.013$), with the highest YAR´s in groups with high yolk weights (Fig. 1). However, yolk weight at hatching did not influence the YAS at commencement of startfeeding ($p=0.992$).

Yolk sac constrictions

Yolk sac constrictions (YSC) was found in all the flat screened trays. No such malformations was found in the yolk sacs of the ATR larvae.

Growth during feeding

The weight difference between the ATR and FSR fry was not significant on the days 33 and 43 after hatching (Table 2). However, in the period between day 43 and day 51 the growth rate of the ATR fry was significantly higher than the growth rate of the FSR fry. This resulted in a significant difference in weight between the two systems on day 51.

In the ATR fry a positive growth rate was observed for the first time in the period between day 51 and 58 after hatching. In the FSR fry no weight gain was observed during the startfeeding period, and the difference between the systems increased throughout the startfeeding period.

The ATR fry had a higher wet weight than the FSR fry during the whole experimental period (Table 3), however due to the increasing variance the difference was not significant on day 198. Moreover, also the wet weight growth rate was higher in the ATR fry during the whole experimental period indicating that the difference between the systems increased throughout the experiment. The differences was, however, not significant in the periods following day 108 although very close in the period between day 108 and 138.

DISCUSSION

Dry weight development in the hatchery

The differences in yolk weight at commencement of startfeeding is caused by the significantly higher yolk absorption rate in the ATR alevins during incubation. This difference is accordance with the results of Leon (1975;79), Eriksson and Westlund (1983), Hansen and Møller (1984) and Hansen (1984) and is probably caused by high activity stress in the FSR alevins (Hansen and Møller op.cit.). This higher yolk absorption rate does also increase the growth rate of the ATR alevins (Hansen and Møller op. cit.). However, the main differences in growth rate during incubation is caused by the significantly higher YCE in the ATR alevins.

The difference in YAR between alevins with large and small yolk reserves at hatching will tend to reduce the variance in yolk weight and total weight during alevin growth and development. In this respect the alevins are rather special as the process of growth usually tend to increase the variance. Under natural conditions, however, this difference in YAR may act to concentrate the emergence of the fry and consequently increase their chances of survival.

Yolk sac constrictions

Flat bottomed hatching trays are known to induce yolk sac constrictions in different *Oncorhynchus* species and hybrids (Emadi, 1973) and in Atlantic salmon (Leon, 1975; Gunnes, 1978. D. Poon (pers. comm. in Emadi (1973) attributed this malformation to mechanical injury caused by continual rubbing on the flat surface. Hansen and Møller (1984), however, attributed the constrictions to the high swimming activity. The high swimming activity of the FSR alevins create a backward and lateral force on the yolk sac, causing it to elongate. As the sac gets slimmer and longer, the swimming activity makes the posterior part of the yolk sac move sideways and a constriction is formed.

Weight development during feeding

The higher growth rate of the ATR fry during startfeeding is in accordance with the results of Leon (1975;79) and Hansen and Møller (1984) and is probably a result of a bigger and stronger fry, a more advanced yolk absorption and a more advanced morfological development (Hansen, 1984). It can, however, be argued that the use of a hatching substrate is not nessessary and that in the long run the differences created by the methods will disappear as the difference is no longer significant at day 198. It is however important to notice that the growth rate of the ATR fry are higher than the FSR during the whole experimental period and hence that the difference between the systems increase all the time. The lack of significance on day 198 is consequently not due to a reduction of the difference between the systems, but an increasing variance in the material. However, despite the lack of significance on day 198 the difference could be big enough as to increase the yield of one year old smolts relative to two year old.

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Table 1: Mean, SEM (Standard error of mean), number of observations and the result from a Student t-test on the data on yolk and body weight during the hatchery incubation (all mg dry weight).

PARA-METER	FSR MEAN	FSR SEM	FSR n	ATR MEAN	ATR SEM	ATR n	TEST p-VALUE
body day 0	6.0	0.3	20	6.2	0.4	15	0.673
body day 33	18.7	0.8	19	26.7	0.6	13	0.000+
yolk day 0	48.7	1.1	20	47.9	1.8	15	0.702
yolk day 33	22.0	0.8	19	17.4	1.4	13	0.009+
YAR	0.92	0.04	19	1.09	0.04	12	0.005+
YCE	47.0	1.9	19	67.4	2.5	12	0.000+
YSC	1.9	0.3	19	-	-	13	-

Table 2: MEAN, SEM (Standard error of mean), number of observations and the result from a Student t-test on the data on total weight and growth rate during start feeding (all mg dry weight).

PARA-	FSR			ATR			TEST
METER	MEAN	SEM	n	MEAN	SEM	n	p-VALUE
day 33	40.7	1.0	19	44.1	1.6	13	0.070
day 43	37.3	1.1	20	39.9	1.7	16	0.185
day 51	34.0	1.0	20	39.2	1.2	16	0.002+
day 58	33.3	1.1	20	40.4	1.4	16	0.000+
day 65	31.1	1.6	20	44.5	2.3	16	0.000+
growth 33- 43	- 3.3	0.5	19	- 4.4	0.8	13	0.233
growth 43- 51	- 3.3	0.3	20	- 0.7	1.1	16	0.028+
growth 51- 58	- 0.7	0.3	20	1.3	0.4	16	0.001+
growth 58- 65	- 2.2	0.8	20	4.1	1.2	16	0.000+

Table 3: Mean, SEM (Standard error of mean), number of observations and the result from a Student t-test on the data on total weight and growth rate during 165 days of feeding and (all mg wet weight).

PARA-METER	FSR MEAN	FSR SEM	FSR n	ATR MEAN	ATR SEM	ATR n	TEST p-VALUE
day 33	184	5	18	218	5	14	0.000+
day 79	214	10	18	284	10	14	0.000+
day 108	361	15	17	474	21	13	0.000+
day 138	675	29	18	853	36	14	0.001+
day 158	1355	57	18	1605	91	14	0.021+
day 198	3181	243	18	3671	399	13	0.278
growth 33- 79	30	5	18	66	8	14	0.001+
growth 79-108	146	11	17	189	19	13	0.050+
growth 108-138	322	24	17	393	28	13	0.069
growth 138-158	679	42	18	751	66	14	0.349
growth 158-198	1826	202	18	2068	315	13	0.506

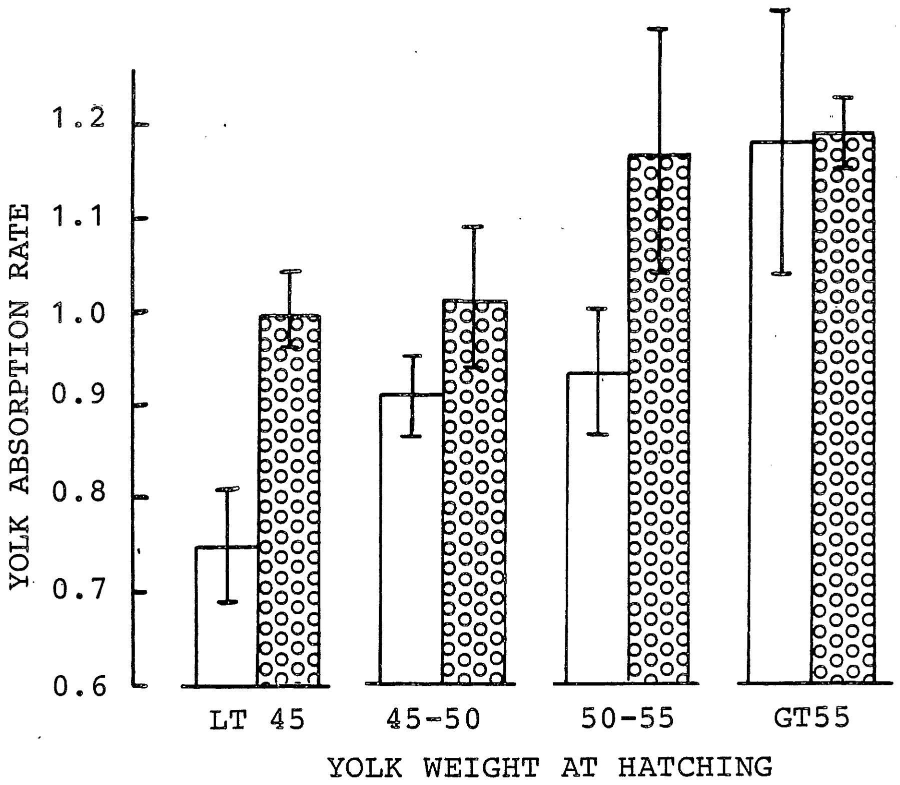

Fig. 1: Yolk absorption rate in different yolk weight groups. ATR, dotted bars; FSR, open bars. Vertical lines indicate standard error of mean.