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THE EFFECT OF CAROTENOIDS ON THE DEVELOPMENT OF ROE AND ON GROWTH RATE OF ATLANTIC SALMON FRY

by

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ABSTRACT

Different pigmented Atlantic salmon (Salmo salar) eggs were used to study the effect of carotenoids on survival of eggs and alevins. There was no correlation between the carotenoid level in the eggs and rate of survival.

Diet supplemented with astaxanthin and cantaxanthin promoted the growth rate in the early startfeeding period.

INTRODUCTION

No function of xanthophylls in salmonid fishes have so far been documented by adequate scientific data.

The metabolism of xanthophylls, astaxanthin and cantaxanthin support the hypothesis that they have a specific function in reproduction. Young salmonids increase the efficiency of pigment deposition with increasing the body weight and at the time of sexual maturation, these pigments are mobilized and concentrated in the roe and in the skin of the males.

Tacon (1981) reviewed the possible functions of carotenoids and summarized the purposed functions as follow :

- Eggs astaxanthin functions as a fertilization hormone.
- Cantaxanthin enhances growth rate, maturation rate and fecundity.
- It has effects on mortality rate during embriological development, especially on the ability to tolerate stringent environmental conditions.
- It has a possible respiratory function under conditions where oxygen is limited.

These experiments were carried out in order to see the relationship between the concentration of the pigments and the mortality rate of Atlantic salmon (Salmo salar) eggs.
The effect on growth rate of astaxanthin and cantaxanthin supplementation in the startfeeding diet was also investigated.

MATERIALS AND METHODS

Experiment I : Newly fertilized Atlantic salmon (Salmo salar) eggs were obtained from Austevoll Aquaculture Station and a commercial fish farm, Torris-laks, Halsa.

Eggs from 74 individual females were incubated separately in hatchery troughs containing 7 trays. The troughs were supplied with about 10 l/min of freshwater, ranging in temperature from 7.4° to 5.0°C.

Carotenoid concentrations (astaxanthin and cantaxanthin) were determined by extraction in acetone until colourless and the absorption at 476 nm was measured in isopropanol (Torrissen, unplublished data), $E^{1\%}_{1cm}$ = 2260.

Dead green eggs picked at the early eyed egg stage, dead eyed eggs, alevins died during hatching, dead alevins and the duration of hatching period were recorded.

Experiment II : Pooled lots of startfeeding ready Atlantic salmon fry were divided into 18 fish tanks (1.5 x 1.5 x 0.4 m^3) with about 15000 fish in each.

Each fish tank was supplied with about 10 l/min of freshwater (80-90% recirculated), ranging in temperature from 10° to 14°C.

A commercial available dry pelleted feed, EWOS ST40 No.1, was used as the basis diet and diet for the 6 control groups. Two experimental diets were prepared by adding 30 mg/kg of synthetic astaxanthin and 30 mg/kg of synthetic cantaxanthin respectively to the basis diet. The synthetic astaxanthin and cantaxanthin (Corophyll red) were delivered by Hoffman La Roche, Basle Switzerland. The stabilized products were dissolved in warm water, 60°C (1:10 w/w) and sprayed on the basis diet. Each of the experimental diet was fed to 6 parallel groups.

Samples of 50 to 100 fry were collected every week, dried at 100-105°C, and the dry weight was measured.

Analysis of variance was used for statistically calculations (Steel and Torrie, 1960).

RESULTS

Experiment I : The experimental data from this experiment is shown in Table 1. There was no correlation between the carotenoid concentration and the rate of survival of green eggs, mortality rate of eyed eggs, mortality rate of alevins during hatching, mortality rate of alevins and the duration of hatching period, neither the groups from Austevoll Aquaculture Station nor the groups from Torris-laks.

Experiment II : The average body weight of the fry during the experimental period is shown in Fig.1. The dry body weight of the fry given astaxanthin supplemented diet were significantly higher than the control groups after 3 weeks of feeding ($P < 0.05$), and after 4 weeks the groups given cantaxanthin supplemented diet were significantly heavier than the control groups ($P < 0.05$).

There was no significant difference among the groups given astaxanthin and cantaxanthin supplemented diets.

DISCUSSIONS

The data of Experiment I is based on two lots of eggs, from Austevoll Aquaculture Station and Torris-laks. Within each lot, the brood fish was given identical feed and general rearing conditions. The pigment level in all groups were relatively high and the variation was limited, between 5.0 to 16.0 µg/g. The variation is due to individual variation and this might be too low to show any effect of pigmentation on the development of eggs and alevins. The lowest pigment concentration of 5.0 µg/g might be too high to be a limitation on development.

Great variation in the rate of survival is a general phenomenon of eggs from farmed Atlantic salmon. It is necessary to have a great number of samples to be able to detect any effect of carotenoids. More work has to be done in order to draw any conclusion.

The promoting effect of astaxanthin and cantaxanthin on the growth rate of Atlantic salmon fry is interesting. As Tacon (1981)

mentioned, most of the live food organisms for early stages of important fish species contains significant concentrations of astaxanthin and cantaxanthin. Steven (1949) found no loss of carotenoids during the development of eggs and alevins of brown trout (Salmo trutta). This observation, but with Atlantic salmon (Salmo salar) was also found at Matre Aquaculture Station (unplublished data).

It is indicated that carotenoids tentatively have main function at the early feeding period. Except for the unspecific growth promotion effect, the biological effect of carotenoids in fishes is unknown. More investigations are necessary.

REFERENCES

Steel, R.G.D. and J.H. Torrie, 1960. Principles and Procedures of Statistics. McGraw-Hill Book Company, Inc., New York, 481 pp.

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TABLE 1. DEVELOPMENT AND CAROTENOID CONSENTRATION IN GROUPS OF ATLANTIC SALMON (Salmo salar) EGGS HATCHED AT MATRE AQUACULTURE STATION THE SPRING 1982.

Locality	Carotenoides µg/g	% Eyed eggs obtained	% Mortality of eyed eggs	% Mortality during hatching	% Mortality of alvins	Duration of hatching (days)
Austevoll	9.5	52	9.6	3.11	0.14	21
Aguaculture	7.4	33				
	9.2	65	6.1	2.45	0.11	21
Station	8.3	68	7.2	3.04	0.10	21
	8.1	100	1.2	0.24	0.01	11
	13.8	58	2.2	2.40	0.06	5
	6.4	75	1.5	0.93	0.31	10
	8.1	59	3.9	1.31	0.03	17
	7.5	27	37.2	15.62	0.57	7
	8.1	33	1.2	0.27	0.55	8
	6.8	44	2.8	0.97	0.52	14
	7.7	89	1.8	0.20	0.00	9
	10.2	94	1.2	0.55	0.09	14
	8.7	86	4.7	10.10	0.04	28
	8.5	76	0.4	0.10	0.00	7
	7.7	86	0.8	0.06	0.00	7
	6.7	100	11.8	1.65	0.11	18
	7.2	100	1.1	0.14	0.00	14
	7.2	55	0.6	0.20	0.07	10
	6.7	100	3.9	0.76	0.00	14
	9.8	95	1.5	0.20	0.00	9
	7.8	100	0.3	0.19	0.00	11
	6.5	96	0.7	0.09	0.00	7
	8.6	95	1.5	0.22	0.00	4
	6.5	100	0.3	0.05	0.04	4
	7.8	82	0.6	0.09	0.00	4
	9.9	84	1.5	0.17	0.08	11

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Locality	Carotenoides µg/g	% Eyed eggs obtained	% Mortality of eyed eggs	% Mortality during hatching	%Mortality of alvins	Duration of hatching (days)
Austevoll	8.6	100	0.8	0.48	0.00	13
Aquaculture	8.7	100	0.7	0.30	0.00	9
	9.5	79				
Station	9.1	100	1.6	0.52	0.00	6
	10.5	100	0.5	0.44	0.00	6
	9.9	91	0.6	0.33	0.00	9
	7.9	96	0.3	0.07	0.00	13
	7.8	88				
	6.9	100	0.3	0.15	0.00	7
	7.3	97	0.8	0.14	0.00	8
	6.6	70	0.5	0.19	0.00	11
	9.6	88	0.3	0.21	0.00	11
	8.1	30	1.3	0.44	0.00	11
	5.6	87	0.4	0.11	0.00	11
	9.3	57	1.8	0.63	0.00	8
	7.9	75	1.0	0.26	0.00	11
	5.5	84				

TABLE 1. DEVELOPMENT AND CAROTENOID CONSENTRATION IN GROUPS OF ATLANTIC SALMON (Salmo salar) EGGS HATCED AT MATRE AQUACULTURE STATION THE SPRING 1982.

Locality	Carotenoides µg/g	% Eyed eggs obtained	% Mortality of eyed eggs	%Mortality during hatching	% Mortality of alvins	Duration of hatching (days)
Torris - laks	8.9	100	14.9	5.47	0.22	4
	10.0	95	0.3	0.79	0.03	5
	9.9	100	0.1	0.07	0.00	3
	9.2	95	0.1	0.09	0.00	4
	10.9	79	7.9	3.64	0.42	7
	16.4	100	0.1	0.15	0.05	3
	12.5	100	0.3	0.07	0.00	4
	11.0	80	0.5	0.86	0.07	5
	13.2	100	0.3	0.12	0.00	5
	13.3	100	0.1	0.00	0.00	4
	15.2	100	0.3	0.20	0.00	5
	11.4	92	0.0	0.07	0.02	5
	5.0	91	0.1	0.04	0.00	5
	13.9	100	0.1	0.07	0.00	5
	11.0	93	0.1	0.05	0.00	7
	14.8	86	0.2	0.10	0.00	7
	10.2	94	0.1	0.08	0.00	5
	10.3	93	0.1	0.05	0.00	8
	11.2	80	1.3	0.71	0.00	8
	8.8	93	1.5	0.47	0.00	8
	11.2	79	0.2	0.07	0.00	5
	15.0	100	0.2	0.04	0.00	5
	14.3	100	0.1	0.09	0.00	5
	11.3	100	0.2	0.04	0.00	5
	9.2	100	0.6	0.06	0.00	5
	11.8	100	0.2	0.07	0.00	7
	9.4	94	0.2	0.06	0.00	7
	14.2	100	0.1	0.00	0.00	4
	12.5	100	0.1	0.04	0.00	4
	8.5	100	0.2	0.01	0.00	4

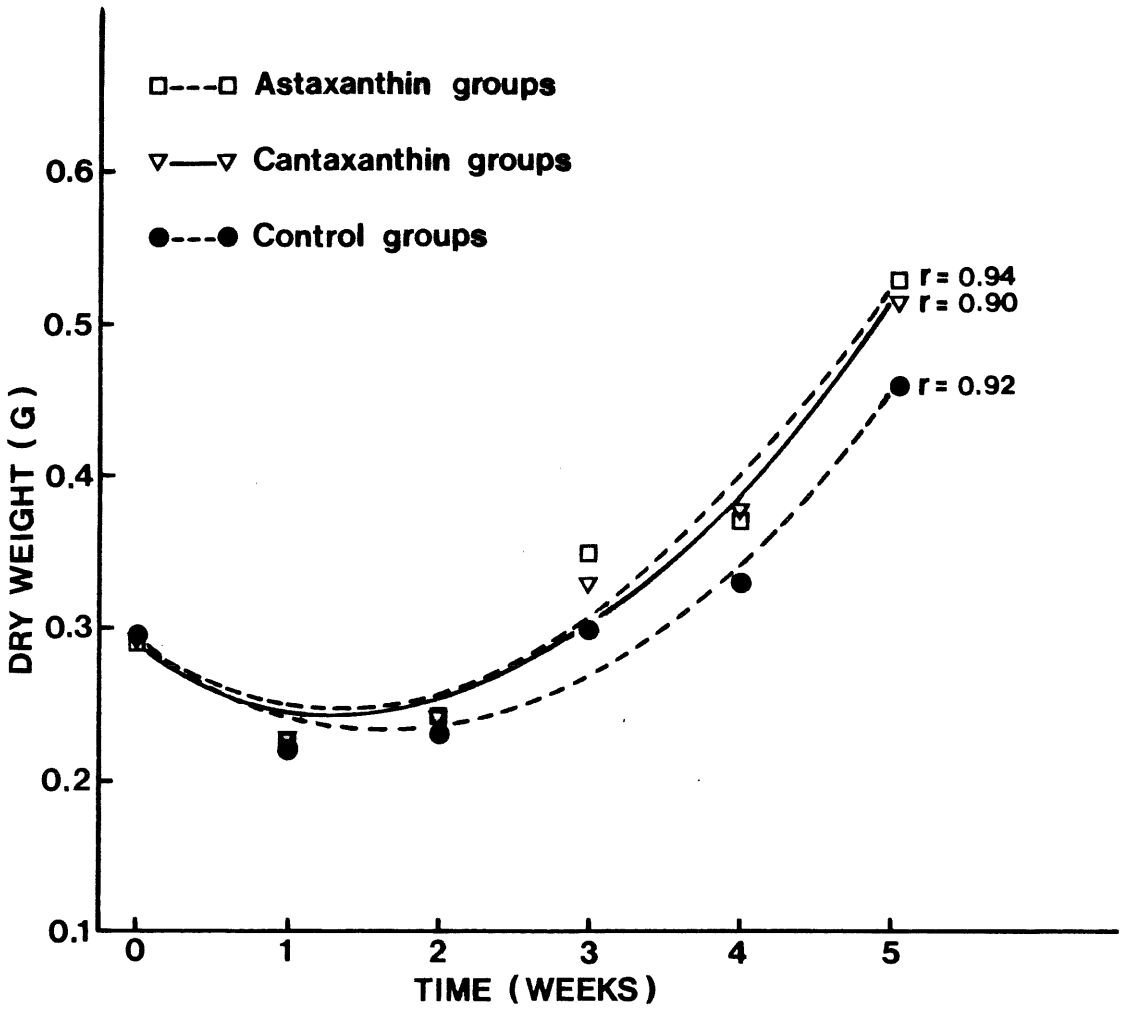

Figure 1. The average dry body weight of 6 replications of Atlantic salmon fry given 30 mg astaxanthin per kg feed, 30 mg cantaxanthin per kg and without carotenoid supplementation.

$Y_{astaxanthin} = 0.028 - 0.00527X + 0.00204X^2$, $S_{xy} = 0.0038$

$Y_{cantaxanthin} = 0.028 - 0.00564X + 0.00207X^2$, $S_{xy} = 0.0047$

$Y_{control} = 0.028 - 0.00645X + 0.00198\ X^2$, $S_{xy} = 0.0034$

Y= dry weight in g, X= time in weeks , S_{xy}= standard error of estimate.