International Council
for the Exploration of the Sea

C.M. 1981/M:16
Anadromous and Catadromous
Fish Committee

THE EFFECTS OF LIGHT ON THE MORTALITY OF DIFFERENT PIGMENTED ATLANTIC SALMON (SALMO SALAR) EGGS

By

Ole Torrissen and Krisna R. Torrissen

Institute of Marine Research,
Matre Aquaculture Station,
N-5198 Matredal, Norway.

Present
by
Dag Møller

1965; Peterson et al,1966; Schmidt and Baker,1969; Johnson et al, 1977; Torrissen,1978) and factors affecting the deposition of carotenoids in the meat (Seurman et al,1969; Torrissen and Brækkan,1969). The metabolism of astaxanthin in salmonid fishes during sexual maturation, such as mobilization of the pigments in the flesh and the deposition of it in the egg and skin, indicates that the pigments have a function in reproduction.

One of the main functions of carotenoids is to act as a protective agent to prevent cells from undergoing damage due to a photodynamic action (Krinsky,1971). The light protection seems not to be necessary in nature since the natural spawning Atlantic salmon deposits the eggs in gravel. However, if the pigments protect the eggs against harmful effect of light it has important aspects in hatchery routines.

This experiment was carried out to confirm the accepted statement that salmonid eggs are sensitive to light and to see the effect of astaxanthin concentration on the survival of eggs exposed to different light sources.

MATERIALS AND METHODS

Six lots of recently fertilized Atlantic salmon eggs selected for a wide variation in astaxanthin concentration were obtained from Austevoll Aquaculture Station. They were incubated in two hatchery troughs at Matre Aquaculture Station. Each hatchery trough contained 6 trays divided into 4 compartments. The troughs were supplied 8 l freshwater per min with an average temperature of 5.7^{o}C. The water depth in the trays was 0.10 m.

ABSTRACT

Carotenoid pigments can protect cells and tissue against harmful effect of visible light. It has been assumed that the astaxanthin in Atlantic salmon (Salmo salar) eggs might have a similar effect.

In this experiment portions of different pigmented Atlantic salmon eggs were exposed to light of different wavelengths, white light (colour temperature:7400 K), yellow light (colour temperature:2700 K) and long waved uv-light (310-420 nm) 8 hours per day. The control groups were kept dark.

All kinds of light showed harmful effect, and the mortality rate was high in all groups exposed to light. A mortality of 50% was observed after 18 days, 71 days and 93 days in the eggs exposed to the white light, the uv-light and the yellow light respectively.

The mortality rate increased with increasing amout of astaxanthin in the eggs in the groups exposed to light. In the groups kept dark, there was no effect of the amout of pigment on the survival of the eggs. It seems that the astaxanthin in Atlantic salmon eggs has no effect in protection against harmful effect of light.

INTRODUCTION

There are no firmly established function of astaxanthin and other red carotenoids in salmonid fishes. The main effort of work in this field has been testing the effects of different pigment sources on the meat quality (Phillips et al,1945; Deufel,

a heavy mortality occurred in the groups of eggs which were incubated under white light. The T_{50} (number of days before passing 50% mortality) was 18, and none eggs reached the hatching stage. In comparison with the control groups kept in darkness, the eggs exposed to uv-light showed a slight increase in mortality rate during the green egg stage, followed by a rapid increase at the first period of the eyed egg stage, the T_{50} was 71. Yellow light did not influence the mortality rate until the eyed egg stage. However, the mortality rate increased at the end of the eyed egg stage, mainly due to premature hatching. The T_{50} was 93 and about 30% of the eggs survived.

In Fig.3, the total mortality of the egg-groups incubated under different light sources is shown as a function of astaxanthin concentration in the eggs. Except for group 1, the mortality rate increased with increasing pigment concentration in both eggs exposed to uv-light and yellow light. The similar effect is also observed in the eggs exposed to white light, the T_{50} seemed to decrease with increasing astaxanthin concentration (30,17,17,14, 15 and 15 in groups 1,2,3,4,5 and 6 respectively). The groups incubated in darkness, except group 1, showed a relatively low mortality rate, and there was no effect of the pigmentation on the survival of the eggs. The eggs in group 1,which had lowest astaxanthin concentration,however, showed a high mortality. This probably due to slightly over ripe eggs and not to the amout of pigment. The general hatching results at Matre Aquaculture Station support this hypothesis. A total mortality rate below 10% is usually achieved in eggs of similar pigmentation.

The protein retention (Table I) was at the same level in the eggs incubated dark and exposed to yellow light.

Three central overhead light sources were provided by 6 of 40 W Philips standard tubes,"white light" from 2 TL/57 tubes providing a colour temperature of 7400°K,"yellow light" from 2 TL/27 tubes providing a colour temperature of 2700°K and longwaved uv-light (310-420 nm) from 2 TL/08 tubes. The spectral energy distribution for the white light and yellow light and the relative spectral energy distribution for the uv-light are shown in Fig.1. Each light area was shielded from illumination of its neighbours and the hatchery room by black polyethylene curtains surrounded from the ceiling to the troughs.

The light sources were placed 1.0 m above the water surface and each light source covered an area of 3 trays (12 compartments). Another 12 compartments were kept completely dark by covering the 3 trays.

Two parallel groups of 300-400 eggs from the 6 different egg lots were incubated in darkness (control groups) and under each light source which illuminated the eggs 8 hours per day.

Dead eggs were picked out and counted every second day. At the start of the experiment, the astaxanthin content of the eggs was determined using the method described by Lambertsen and Brækkan (1971). The protein contents of the newly fertilized eggs and newly hatched yolk sacked fry were determined by the Kjeldahl method.

RESULTS AND DISCUSSION

The concentration of astaxanthin in the egg-groups is shown in Table I. The average cumulative mortality rate among the groups illuminated and kept dark is shown in Fig.2. Within a few days,

Perlmutter,A. and White,E.,1962. Lethal effect of fluorescent light on the eggs of the brook trout. Prog.Fish-Cult.,24: 26-30.

Peterson,D.H.,Jager,H.K. and Savage,G.M.,1966. Natural coloration of trout using xanthophylls. Trans.Am.Fish.Soc.,95:408-414.

Phillips,A.M.,Tunison,A.V.,Shaffer,H.B.,White,G.K.,Sullivan,M.W., Vincent,C.,Brockway,D.R. and McCay,C.M.,1945. The nutrition of trout. Cortland Hatchery Report No.14. Fish.Res.Bull. No.7. New York State Conservation Dep.,Albany,N.Y.,pp 17-21.

Schmidt,P.J. and Baker,E.G.,1969. Indirect pigmentation of salmor and trout flesh with cantaxanthin. J.Fish.Res.Board Can., 26:357-360.

Seurman,L.,Martinsen,C. and Little,A.,1979. The effect of dietary lipid and pigment concentration in the feed of Salmo gairdneri on sensory characteristics and objective measurements of the fish muscle tissue. In: J.E.Halver and K.Tiews (Editors), Finfish Nutrition and Fishfeed Technology, Proc.World Symp., H.Heenemann GmbH & Co,Berlin,Vol.II,pp 401-414.

Torrissen,O.,1978. Pigmentering av laksefisk. Hovedfagsoppgave i ernæringsbiologi, Universitetet i Bergen,Bergen,133 pp.

Torrissen,O. and Brækkan,O.R.,1979. The utilization of astaxanthin-forms by rainbow trout (Salmo gairdneri). In: J.E.Halver and K.Tiews (Editors), Finfish Nutrition and Fishfeed Technology, Proc.World Symp., H.Heenemann GmbH & Co,Berlin, Vol.II,pp 377-382.

Weir,R.A. and McCauley,R.W.,1973. Incubation of lake trout embryos under fluorescent lights. Prog.Fish-Cult.,35:179-180.

The results in this study generally correspond to data from the literature. The light of high intensity is harmful to eggs, and causes high mortality and premature hatching, especially the light in the blue band spectrum (Perlmutter and White,1962; MacCrimmon and Kwain,1968; Bieniarz,1973; Wier and McCauley,1973). However, yellow light does not seem to influence the protein retention and thereby the size of the fry.

In contrary to the general light protecting effects of carotenoids (Krinsky,1971), high astaxanthin level makes the eggs more sensitive to illumination.

REFERENCES

Bieniarz,K.,1973. Effect of light and darkness on incubation of eggs,length,weight and sexual maturity of sea trout (Salmo trutta L.),brown trout (Salmo trutta fario L.) and rainbow trout (Salmo irideus Gibbons). Aquaculture,2:299-315.

Deufel,J.,1965. Pigmentierungsversuche mit cantaxanthin bei regenbogenforellen. Arch. Fischerweiss.,16:125-132.

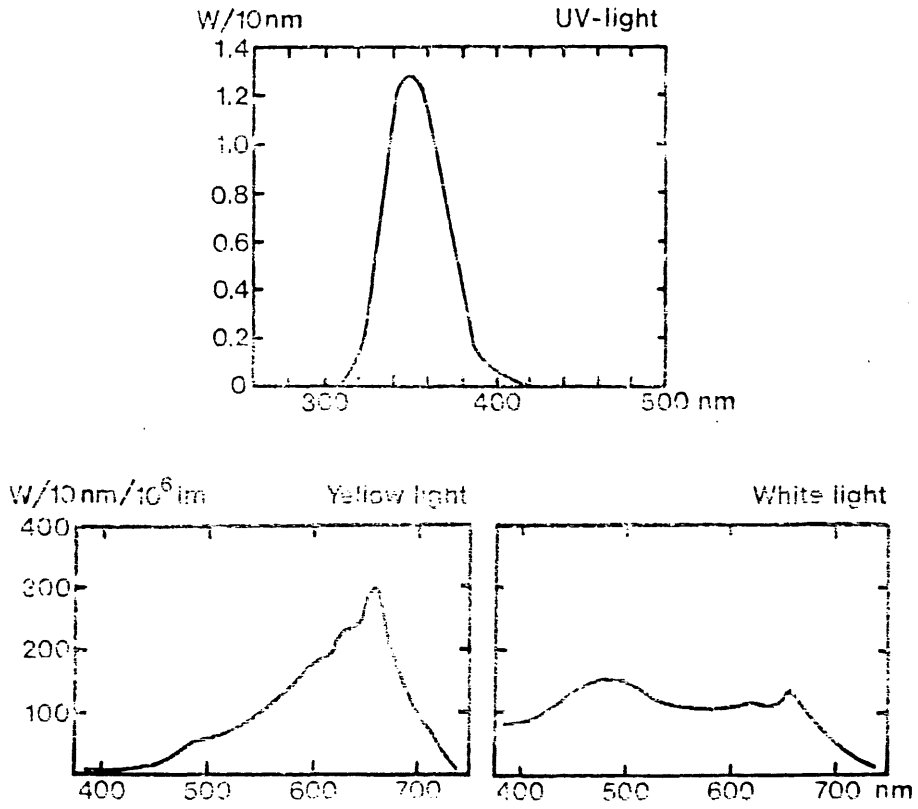
Johnson,E.A.,Conklin,D.E. and Lewis,M.J.,1977. The yeast Phaffia rhodozyma as a dietary pigment source for salmonids and crustaceans. J.Fish.Res.Board Can.,34:2417-2421.

Krinsky,N.J.,1971. Function. In: O.Isler (Editor), Carotenoids, Birkhauser Verlag, Basel, pp 669-716.

Lambertsen,G. and Brækkan,O.R.,1971. Method of analysis of astaxanthin and its occurrence in some marine products. J.Sci.Fd.Agric.,22:99-101.

McCrimmon,H.R. and Kwain,W.,1969. Influence of light on early development and meristic characters in rainbow trout, Salmo gairdneri Richardson. Can.J.Zool.,47:631-637.

Figure 1: Relative spectral energy distribution of the uv-light and spectral energy distribution of the yellow and the white lights.



Product information,
Philips, 1978

Table I: Astaxanthin concentration and protein retention of the eggs incubated in darkness and exposed to yellow light.

Group	ug Astaxanthin per g	Protein retention	
		Eggs incubated in darkness	Eggs exposed to yellow light
1	0.18	85.6	90.2
2	2.10	90.5	88.6
3	2.28	93.4	90.0
4	3.00	92.1	92.2
5	5.27	97.7	91.5
6	5.52	86.4	89.1
$\bar{X}$		90.8	90.2

$$\text{Protein retention} = \frac{\text{mg Protein/fry at hatching}}{\text{mg Protein/egg at incubation}} \times 100$$

Not enough material was available for protein examination of the eggs incubated under white light and uv-light at hatching.

Figure 2: Average cumulative mortality of Atlantic salmon eggs incubated in darkness and illuminated 8 h per day under "white light", "uv-light" and "yellow light".

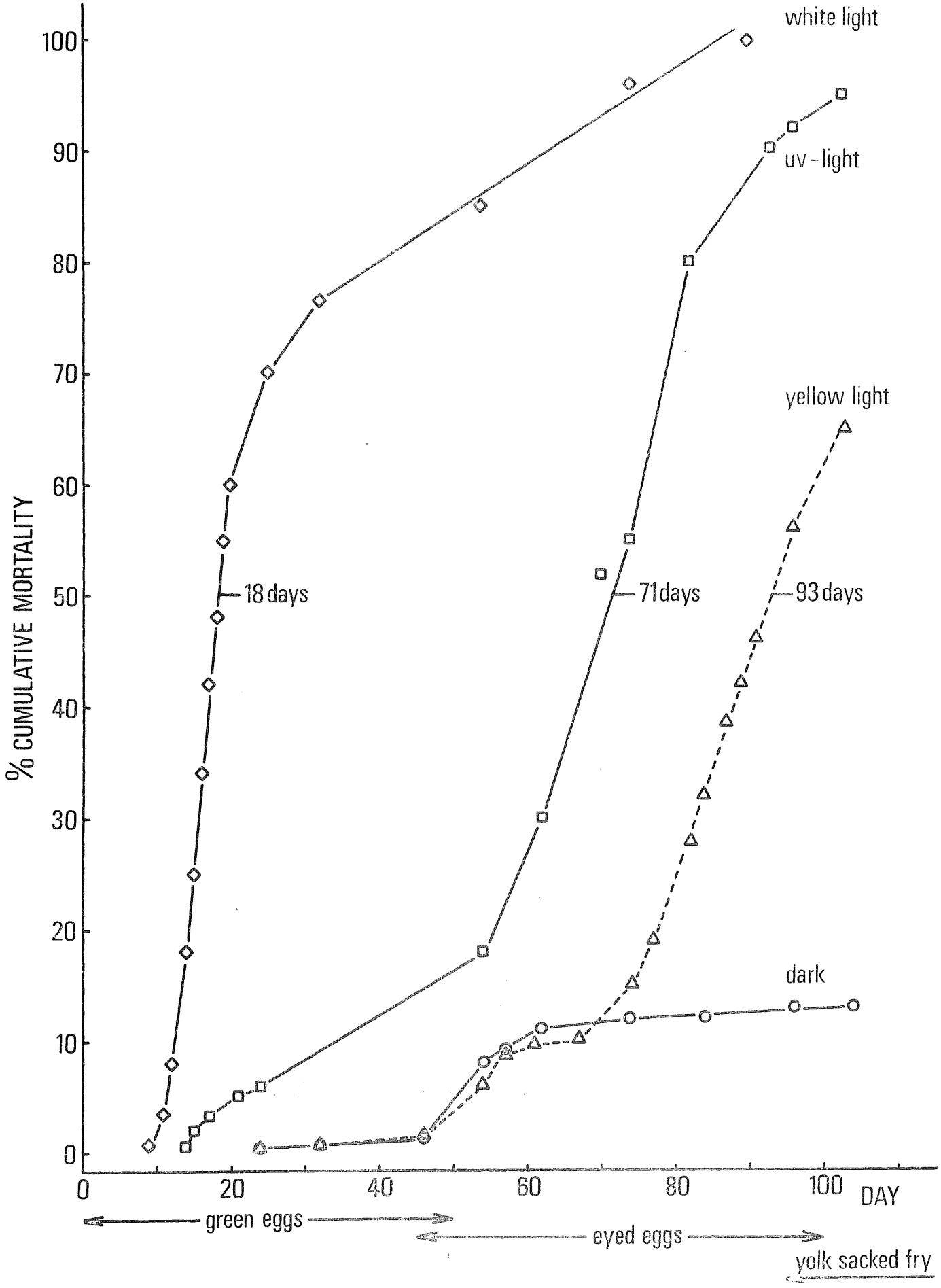


Figure 3: Total mortality rate of Atlantic salmon eggs with different astaxanthin concentration incubated in darkness and illuminated under "white light", "uv-light" and "yellow light".