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GROWTH OF SEA BASS, *DICENTRARCHUS LABRAX*, L., LARVAE AS INFLUENCED BY TEMPERATURE

RAST LARVI LUBINA, *DICENTRARCHUS LABRAX* (LINEAUS, 1758) U ODNOSU NA TEMPRATURU

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The growth of sea bass larvae, as well as their yolk sac absorbtion rate within the 9.3—17.5°C temperature range, was analysed. Mathematical approximations of relation of growth curves exponents and larval yolk sac resorption to temperature are given.

INTRODUCTION

Temperature is of extreme importance for the development of the youngest fish stages, particularly for that of fish eggs and larvae. Whereas the data on the influence of temperature on egg and postlarval development were available, studies of the influence of this parameter on larvae were given far less attention.

Nevertheless the problem of production of sea bass juveniles has been studied by a number of authors (Alessio, 1976; Alessio *et al.*, 1972; Barnabe, 1976; Barahona-Fernandez *et al.*, 1977; Boulineau, 1974; Devauchelle, 1976; Girin *et al.*, 1975; Lumare e Villani, 1973) and their semi-industrial production has been estabilished in some of the European countries (Italy, France), published reports on temperature influence on sea bass larval stages are very poor.

The time of transition of larvae from passive to an active feeding, upon the yolk sac reserves have been consumed up is in closest connexion with the temperature of the medium. This stage is one of the most critical stages in fish life. Any late food supply, even of not more than few hours, may decimate a complete larval stock (Spectorova, *et al.*, 1974). Therefore, the studies on temperature influence on larval development is one of the indispensable conditions not only for the better knowledge of their biology but for the elimination of the causes of their mortality, as well.

MATERIAL AND METHODS

3-year-old parent fish material was reared in cages and fed on pelleted food. The acclimatization was carried out in plastic tanks with an open circulation system of sea water of 37—38‰, 3.5 kg/m^3 density for a month's period. The acclimatization temperature ranged from 11.5 to 12.5°C.

The induced spawning was carried out by HCG hormone injected intramuscularly at the base of dorsal fin. A dose of 1500 IU/kg was given twice 48 hours apart. Eggs were spontaneously spawned already after the second treatement. No hormone tretment was applied to males since they were completely sexualy mature. The eggs were then incubated in the thermostatic chamber at five temperatures: 9.3, 11.0, 13.1, 15.0 and 17.5°C. The lowest temperature was that of the thermostatic chamber, and higher temperature levels were reached by water thermostates. Water was maintained at approximately 37.5‰ salinity level by adding distilled water every day. The experiment was carried out under 14 hour photoperiod thus that the incubation basins were illuminated by two flourescent lamps of 20W installed 50 cm above the water surface. The experiment on the effects of temperature on larval development was carried out under the same conditions. Growth of larvae was observed by daily sampling of 5—10 individuals and taking their total body length. However, their mean lengths were used for further computations. In addition, the yolk sac resorption rate in function of time and temperature was also observed. The yolk sac resorption rate expressed as the area of an ellipse in mm^2 was calculated by taking both the longer and shorter diameter of the yolk sac.

RESULTS AND DISCUSSION

Larval development, from hatching to yolk sac resorption, covered 13 or 4 days, depending on temperature (Fig. 1). The distribution of mean larval lengths in relation to time has already shown their growth not to be linear.

The most frequently applied equation for larval growth calculation was that of Farris (1960):

$$l_t = K \log t \qquad (1)$$

where l_t is the length in time t and K constant. However, some earlier investigations showed that larval anchovy growth may be better approximated by von Bertlanffy's (1938) equation than by the equation (1) (Regner, 1979). At the same time, from the empirical data on sea bass larval lengths in relation to time, a deccelrated growth is observed immediatley upon hatching. Thereupon the growth is suddenly accelerated to be once again deccelerated after the mouth is open. All this is indicative of the fact that larval sea bass growth curve is of sigmoid shape, what may be best observed at the lowest temperature of 9.3°C (Fig. 1).

Therefore, von Bertalanffy's equation in its original form was used for the sea bass larval growth approximation:

$$l_t = A - (B\, e^{-ct}) \qquad (2),$$

as well as Gompertz equation of the form:

$$l_t = a\, e^{-be^{-ct}} \qquad (3).$$

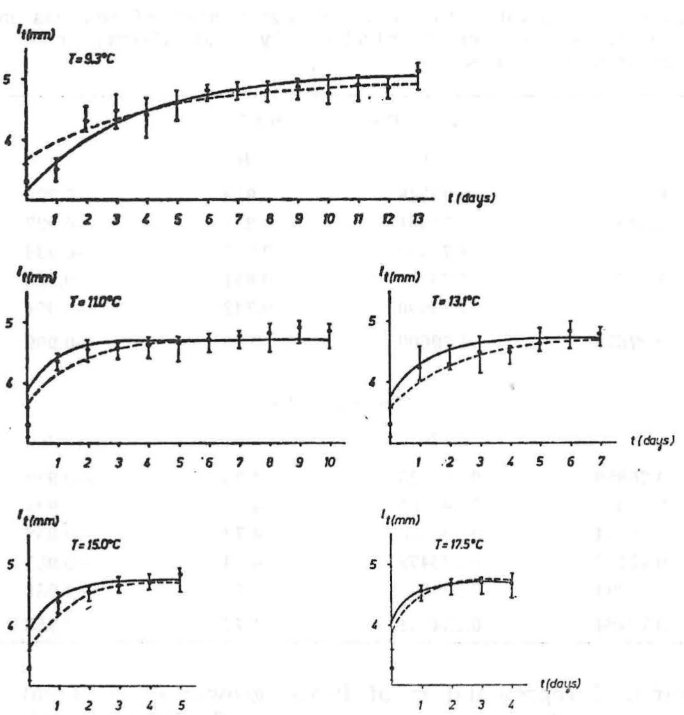

Fig. 1. Sea bass larval growth as influenced by temperature (unbroken line — von Bertalanffy curve; dashed line — Gompertz curve).

In both equations l_t is larval length in time t, A and a are asymptotes, while B, b and c are constants. Parameters of the equation (2) were determined by a derivation of length as related to time with larval length. A semigraphical method described by Regner (1980) was applied in equation (3).

To test which of these equations gives better approximation of larval length, correlation coefficients for each temperature were separately calculated for the pairs:

$x = e^{-ct}$; $y = l_t$ for equation (2) and

$x = t$; $y = \ln(\ln a - \ln l_t)$ for equation (3).

The results obtained are given in Table 1.

According to the data from Table 1 it is evident that correlation coefficients are high in both equations. Majority of these correlation coefficients are significant for the 99% significance level. Still, since the correlation coefficients of Gompertz equation are somewhat higher, it may be concluded that this equation gives somewhat better approximation of sea bass larval growth. This is shown in Fig. 1.

Table 1. Values of constants and statistical significance of sea bas larval growth approximated by von Bertalanffy and Gompertz equations at different temperatures

von Bertalanffy					
T°C	*c*	*A*	*B*	*r*	*P*
9.3	0.28258	5.09548	1.918	—0.790	0.01
11.0	1.05084	4.71401	0.831	—0.927	0.01
13.1	0.78562	4.72400	0.915	—0.938	0.01
15.0	1.13793	4.75830	0.851	—0.933	0.01
17.5	1.62691	4.69000	0.732	—0.954	0.05
X	0.97678	4.79600	1.049	—0.909	

Gompertz					
T°C	*c*	*b*	*a*	*r*	*P*
9.3	0.26856	0.291728	4.95	—0.930	0.01
11.0	0.67006	0.248080	4.71	—0.933	0.01
13.1	0.51964	0.268868	4.73	—0.956	0.01
15.0	0.91198	0.263479	4.74	—0.983	0.01
17.5	1.30294	0.200552	4.74	—0.961	0.01
$\overline{X}$	0.73464	0.254541	4.77	0.953	

The graphical representation of larval growth of different fish species shows that the growth curves of pacific sardine *Sardinops caerulea* (Lasker, 1964), herring, *Clupea harengus*, (Blaxter and Hempel, 1963), pilchard, *Sardina pilchardus*, (Blaxter, 1969), northern anchovy, *Engraulis mordax* (Kramer and Zweifel, 1970), common grey mullet, *Mugil cephalus* (Kuo and Shehadeh, 1972) and plaice, *Pleuronectes platessa* (Ryland *et al.*, 1975) are very similar to those of sea bass, what indicates that they may be, as well, given by von Bertalanffy and Gompertz equations. On the contrary, the data on the flatfishes *Scopthalmus maximus* and *Scopthalmus rhombus* (Jones, 1972) were the only data on linear fish growth available.

The exponent *c* values show an increase with temperature increase in both equations (Table 1). On the contrary, *A* and *B* in equation (2) and *a* and *b* in equation (3) were found to decrease with the temperature increase. At the same time, the relations between the above mentioned parameters and temperature are linear. Therefore linear equations were calculated for each of them. The following results were obtained:

equation (2)

$$c = 0.1352\ T - 0.805; \quad P < 0.05$$
$$A = 5.271 - 0.036\ T; \quad r = -0.688; \quad P\ \text{n.s.}$$
$$B = 2.245 - 0.05\ T; \quad r = -0.825; \quad P\ \text{n.s.}$$

equation (3)

$$c = 0.11353\ T - 0.76168; \quad r = 0.931; \quad P < 0.05$$
$$b = 0.3644 - 0.00834\ T; \quad r = -0.792; \quad P\ \text{n.s.}$$
$$a = 5.045 - 0.021\ T; \quad r = -0.662; \quad P\ \text{n.s.}$$

In all of these equations T is temperature in °C.

Only the positive relation of c exponents to temperature is statistically significant. Linear and statistically significant correlation of c exponents and temperature indicate that larval growth is accelerated with temperature increase. On the other hand it makes possible the growth rate estimation for any given temperature within the 9.3—17.5°C range (Fig. 2).

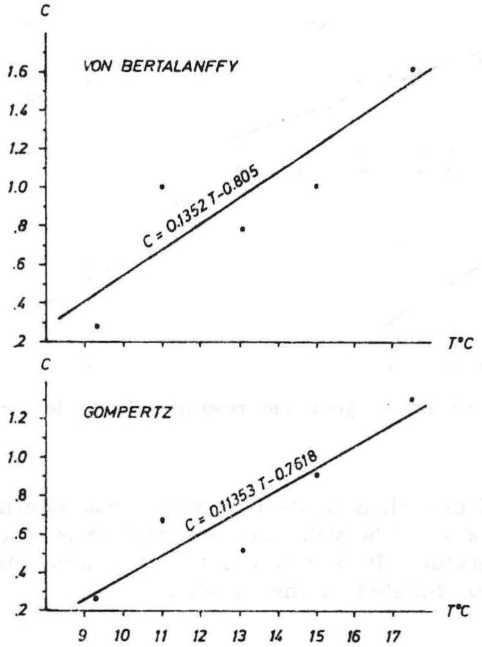

Fig. 2. Relation of c values of von Bertalanffy and Gompertz curves to temperature

The relations between the growth rate coefficients were studied on plaice *(Pleuronectes platessa)* larvae by Ryland *et al.*, (1975) using the equation (1). However, they found the growth rate coefficient values to decrease at higher temperatures. Jones (1972) came to the similar conclusions for the larvae of flatfishes *(Scophthalmus maximus* and *Scophthalmus rhombus).* On the basis of these author's data higher temperatures at which larval growth was studied may be concluded to be within the limits of the upper pesimum of temperature valence. With respect to the fact that linear relation was found for sea bass larvae, it may be concluded that 9.3—17.5°C temperature range is within the wider limits of the optimum for parents' adaptation temperature, between 11.5 and 12.5°C which is, at the same time, the fertilization temperature.

Even though not statistically significant negative relations of *A* and *B* values in equation (2) and *a* and *b* in equation (3) to temperature indicate that at higher temperatures sea bass larvae transform into postlarvae et somewhat lower mean lengths.

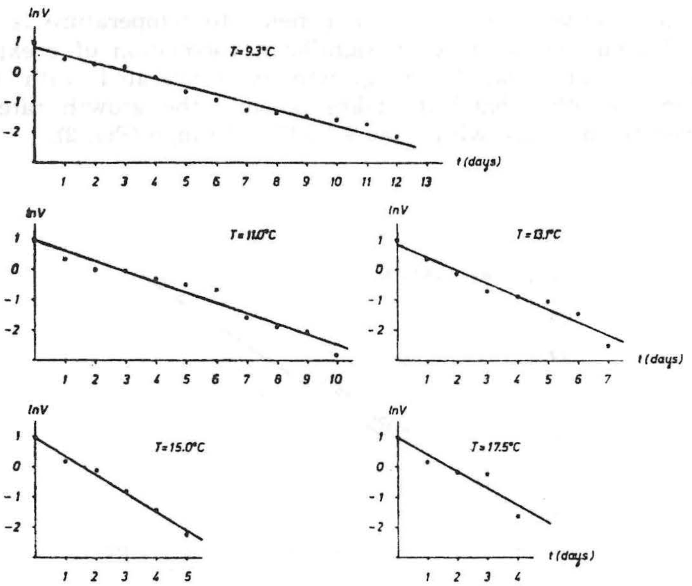

Fig. 3. Relation of yolk sac resorption rate to temperature

Sea bass larval growth is in its first stages characterized by the intensive consumption of yolk sac. The yolk sac consumption is in close connexion with the medium temperature. It was found that the absorption rate in function of time may be approximated by the equation:

$$V_t = a\,e^{-nt} \qquad (4),$$

where V_t is the yolk sac area (in mm^2) in time t, and a and n are constants. Significance of this equation was tested by calculating the corelation coefficients from its linearized form for each temperature for the pairs:

$$x = t; \qquad y = \ln V_t$$

The results obtained are given on the following table:

Table 2. Values of n and statistical significance of equation (4) for sea bass larvae

T°C	n	r	P
9.3	0.2595	—0.982	0.01
11.0	0.3433	—0.980	0.01
13.1	0.4350	—0.980	0.01
15.0	0.6205	—0.996	0.01
17.5	0.5599	—0.942	0.05

As it may be seen from Table 2, high and statistically significant correlation coefficients were obtained for all of the temperature levels. This indicates that the yolk sac resorption may also be well approximated by equation (4). Like in growth rate coefficients, the exponent n increases with

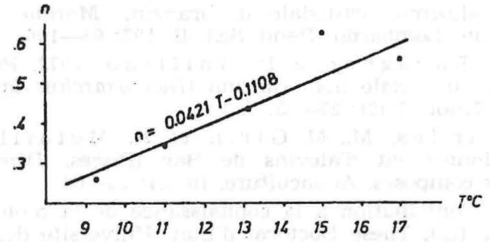

Fig. 4. Relation of n values of yolk sac resorption curve to temperature

temperature in the case of yolk sac absorption, as well (Table 2). At the same time, the exponent n shows linear relation to temperature (Fig. 4). Thus it may be given by a linear equation:

$$n = 0.0421\ T - 0.1108; \quad r = 0.912; \quad P < 0.05$$

where n is the exponent value, and T temperature. Thus, the yolk sac absorption rate may be estimated for any temperature value within the 9.3—17.5°C range. Similar relation of the yolk sac absorption rate to temperature was established in plaice *(Pleuronectes platessa)* larvae by Ruland, *et al.* (1975).

CONCLUSIONS

Sea bas larval growth as a function of time may be well approximated by von Bertalanffy and Gompertz equations. However, with respect to somewhat higher correlation coefficient obtained by Gompertz equation it appears to give a somewhat better approximation of sea bass larval growth. It was also observed that the yolk sac absorption rate as a function of time may be approximated by an exponential equation.

Exponents of all the applied equations show positive and significant linear correlation with temperature. Linearity of this relation indicates that all the temperatures at which sea bass larval growth was examined were within the limits of an temperature optimum to which the parent stock was adapted and fertilization carried out.

REFERENCES

Alessio, G. 1976. Techniche e metodiche generali di riproduzione artificiale della spigola, *Dicentrarchus labrax* (L.), Osteichthyes, Serranidae. I.C.S. Rapp. techn. int., 4: 1—20.

Alessio, G., P. Bronzi, G. Gandolfi e B. Schreiber, 1973. Primi risultati sulla riproduzione artifiziale di branzini, *Morone labrax* (L.) in aque salmastre. Istituto Lombardo (Rend. Sc.), B. 107: 93—106.

Arcarese, G., G. Ravagnan e P. Ghittino, 1972. Primi risultati positivi di fecondazione artificiale nel branzino (*Dicentrarchus labrax*) su vasta scala. Rev. It. Piscic. Ittiol., 7 (2): 27—33.

Barahona-Fernandes, M., M. Girin et R. Metailler, 1977. Expériences de conditionnement d'alevins de Bar (Pisces, *Dicentrarchus labrax*) à divers aliments composés. Aquaculture, 10 (1): 53—63.

Barnabe, G. 1976. Contribution a la connaissance de la biologie du Loup, *Dicentrarchus labrax* (L.). These Doctorat d'Etat. Universite des Sciences et Techniques du Languedoc : 425 p.

Bertalanffy von L. 1938. A quantitative theory of organic growth (Inquiries on growth laws. II). Human biology, 10 (2): 182—213.

Blaxter, J. H. S. 1969. Experimental rearing of pilchard larvae, *Sardina pilchardus*. J. mar. biol. Ass. U. K., 46: 219—234.

Blaxter J. H. S., and G. Hempel, 1963. The influence of egg size on herring larvae (*Clupea harengus* L.). Journ. Cons. int. Explor. Mer, (28) (2): 211—240.

Boulineau, F. 1974. Ponte naturelle et ponte induite hormonalement chez *Dicentrarchus labrax* (L.) en captivité. Colloque sur l'Aquaculture. Actes de colloques CNEXO, 1: 151—160.

Devauchelle, N. 1976. Analise quantitative et qualitative de pontes naturelles de Bar (*Dicentrarchus labrax*) en captivité. Rapp. D. E. A. Fac. Sci. Brest Ronéo: 56p.

Farris, D. A. 1960. The effect of three differente types of growth curves on estimation of larval fish survival. Journ. Cons. int. Explor. Mer, 25 (3): 295—306.

Girin, M., M. M. Barahona-Fernandes and A. Le Roux, 1975. Larval rearing of Sea Bass *Dicentrarchus labrax* (L.) with a high survival. ICES doc C. M. 1975/G, 14: 8p.

Jones, A. 1972. Studies on egg development and larval rearing of turbot, *Scophthalmus maximus* L., and brill, *Scophthalmus rhombus* L., in the laboratory. J. mar. biol. Ass. U. K., 52 (4): 965—986.

Kramer, D., and J. R. Zweifel, 1970. Growth of anchovy larvae (*Engraulis mordax* Girard) in the laboratory as influenced by temperature. Cal. Coop. Ocean. Fish. Inv., Reports, 14: 84—87.

Kuo, G. — M., and Z. H. Shehadeh, 1972. A preliminary report on development, growth and survival of laboratory reared larvae of the grey mullet, *Mugil ceaphalus* L. The Grey Mullet. Report No. 01-72-76-1: 123—150.

Lasker, R. 1964. An experimental study of the effect of temperature on incubation time, development and growth of Pacific sardine embrios and larvae. Copeia, 1964, 2: 399—405.

Lumare, F., e P. Villani, 1973. Richerche sulla riproduzione artificiale ed allevamento delle larvae in *Dicentrarchus labrax* (L.). Boll. Pesca Piscic. Idrobiol., 28 (1): 71—75.

Regner, S. 1979. Ekologija planktonskih stadija brgljuna, *Engraulis encrasicolus* (Linnaeus, 1758), u srednjem Jadranu. Doktorska disertacija, Beograd, : 186p.

Regner, S. 1980. On semigraphic estimation of parameters of Gompertz function and its application on fish growth. Acta Adriat., 21 (1): 227—236.

Ryland, J. S., J. H. Nichols and A. M. Sykes, 1975. Effects of temperature on the embrionic development of the plaice, *Pleuronectes platessa* L., (Teleostei). J. Exp. Mar. Biol. Ecol., 18 (2): 121—137.

Spectorova, L. V., T. M. Aronovich, S. I. Doroshev and V. P. Popova, 1974. Artificial rearing of the Black Sea turbot larvae (*Scophthalmus maeoticus*). Aquaculture, 4 (4): 329—340.

RAST LARVI LUBINA, *DICENTRARCHUS LABRAX* (LINEAUS, 1758), U ODNOSU NA TEMPRATURU

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KRATAK SADRŽAJ

Ispitivanja utjecaja različitih temperatura na brzinu rasta vršena su na larvama lubina dobivenim induciranim mrijestom. Jaja i larve su inkubirane na pet temperatura, od 9.3 do 17.5°C. Svakodnevnim uzorkovanjem 5—10 larvi mjerena je njihova totalna dužina, a za daljnja izračunavanja upotrebljene su srednje vrijednosti svakog uzorka. Osim totalne dužine mjerena je i površina žumančane kesice.

Rast larvi u funkciji vremena aproksimiran je pomoću Von Bertalanffy-jeve jednažbe oblika:

$$l_t = A - (Be^{-ct})$$

gdje je l_t dužina u vremenu *t*, *A* je asimptota, *B* i *c* su konstante, i Gompertz-ove jednadžbe oblika:

$$l_t = ae^{-be^{-ct}}$$

gdje je *a* asimptota, dok su *b* i *c* konstante.

Iako su za obje jednažbe dobiveni visoki i statistički signifikantni koeficijenti korelacije, pokazalo se da Gompertz-ova jednadžba ipak nešto bolje aproksimira rast larvi lubina.

Ispitivanja odnosa eksponenata (c) obiju jednadžbi prema temperaturi pokazala su da njihove vrijednosti rastu sa temperaturom. To znači da se unutar raspona temperatura od 9.3 do 17.5°C povišenjem temperature rast ubrzava. Ovaj odnos je linearan i statistički signifikantan, što omogućuje izračunavanje brzine rasta larvi za bilo koju temperaturu.

Smanjenje površine žumančane kesice u funkciji vremena može se prikazati eksponencijalnom jednadžbom, oblika:

$$V = ae^{-nt}$$

gdje je *V* površina žumančane kesice u vremenu *t*, dok su *a* i *n* konstante. I ovdje su dobiveni visoki i signifikantni koeficijenti korelacije. Također je utvrđeno da i u ovom slučaju vrijednosti eksponenata rastu s temperaturom, te da je taj odnos, kao i kod rasta larvi, linearan.