Early Growth of Cultured Larval Haddock, *Melanogrammus aeglefinus*

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Haddock, *Melanogrammus aeglefinus* 자어의 초기성장

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ABSTRACT : The objective of this study was to examine the early growth of haddock, *Melanogrammus aeglefinus* larvae from a series of reared specimens for provide information to developmental biology and more information on the aspect of aquaculture in the larvae of this species. Larvae were reared in the laboratory and sampled periodically for developmental study until 67 days after hatching. An increase in total length of fish indicated continuous growth, described by the growth expression of the type $TL=3.5374e^{0.0536X}$(r^2=0.8759, where TL is total length and X is at days after hatching) and $BW=0.0002e^{0.1858X}$(r^2=0.8671, where BW is body weight and X is at days after hatching), respectively. Pattern of body depth and pectoral fin length are instantaneous growth which expression of the type $BD=0.3545e^{0.0778X}$, r^2=0.9563(where BD is body depth and X is at days after hatching) for body depth growth and the type $PL=0.0111e^{0.1591X}$, r^2=0.9194(where PL is pectoral fin length and X is at days after hatching) for pectoral fin length growth. The relationship of body depth and total length expressed as BD=0.2397X−0.5735(r^2=0.9957, where BD is body depth and X is total length), and pectoral fin length and total length is PL=0.1929X−1.3767(r^2=0.9882, where PL is pectoral fin length and X is total length) pectoral fin length against body depth simultaneously recorded for juvenile haddock(PL=0.8117BD−0.9718, r^2=0.9814, where PL is pectoral fin length and BD is body depth). Relationship of body depth and body weight was expressed the type of $BD=-9.4734X^2+19.046X+1.3672$, r^2=0.941(where BD is body depth and X is body weight), and pectoral fin length and body weight expressed the type of $PL=6.379X^2+14.023X+0.3774$, r^2=0.9494(where PL is pectoral fin length and X is body weight). From this point view, growth characteristics of juvenile haddock in this experiment may be useful to establish a successful culture technique for rearing larval haddock.

Key words : Haddock, *Melanogrammus aeglefinus*, Early growth, Aquaculture, Growth expression.

요 약 : 본 연구의 목적은 부화후 67일 동안 대서양산 Haddock, Melanogrammus aeglefinus 치어의 초기성장을 조사하여, 본 종의 발생생물학과 양식 측면에서의 정보 제공하고자 한다. 전장성장은 $TL=3.5374e^{0.0536X}$(r^2=0.8759, TL은 전장이며, X는 부화 후 표본시일), 체중성장은 $BW=0.0002e^{0.1858X}$(r^2=0.8671, BW는 체중이며, X는 부화 후 표본시일)로 각 성장들은 지속적인 성장을 보였다. 체고와 가슴지느러미 길이는 연속적인 성장을 보여 체고성장은 $BD=0.3545e^{0.0778X}$(r^2=0.9563, BD는 체고이며, X는 부화 후 표본시일)였으며 가슴지느러미 길이성장은 $PL=0.0111e^{0.1591X}$(r^2=0.9194, PL은 가슴지느러미 길이이며, X는 부화 후 표본시일). 전장에 대한 체고의 상관관계식은 BD=0.2397X−0.5735(r^2=0.9957, BD는 체고이며, X는 전장)이었으며 전장에 대한 가슴지느러미 길이의 상관관계식은 PL=0.1929X−1.3767(r^2=0.9882, PL은 가슴지느러미 길이이며, X는 전장)이었다. 체고에 대한 가슴지느러미 길이성장은 PL=0.8117BD−0.9718(r^2=0.9814, PL은 가슴지느러미 길이이며, BD는 체고)이었다. 체중에 대한 체고는 $BD=-9.4734X^2+19.046X+1.3672$($r^2$=0.9041, BD는 체고이며, X는 체중)로, 체중에 대한 가슴지느러미 길이는 $PL=-6.379X^2+14.023X+0.3774$($r^2$=0.9494. PL은 가슴지느러미 길이이며, X는 체중)이었다. 본 연구결과의 Haddock 치어 초기성장 특성은 Haddock 치어 사육에 도움이 될 것이다.

INTRODUCTION

The haddock, *Melanogrammus aeglefinus* a cold-water

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gadoid fish is found in the Atlantic Ocean, generally inhabit cool-temperate to subarctic waters from inshore regions to the edge of the continental shelf(Coad, 1995). Haddock has attracted interest as a candidate species for commercial aquaculture and restoration efforts in the northest U.S. and the Maritime Provinces of Canada(Buckley *et al.*, 2000). This species rapidly grows and can be reared in salmon cages(Matthew, 1998). While some have been known about ecology, enhancement of growth, developmental morphology of haddock larvae and morphology of haddock adults(Rechard and Carleton, 1986; Coad, 1995; Roy and Lall, 2003; Trippel and Neil, 2003), little is known about their early growth.

The characteristics of fish growth, although in many ways resembling those of the growth of higher vertebrates, possess interesting differences that should be made explicit (Weatherley and Gill, 1987). Furthermore, the particular characteristics of growth in fishes have implications for fish population biology that appear rather unique and which should be borne in mind by ecologists and those concerned with aquaculture and fishery management. So an understanding of the basic biology of this fish is essential. In this report, the early growth of larval and juvenile haddock were described from a series of reared specimens to provide early developmental biology and more information on the aspect of aquaculture in the larvae and juvenile of this species.

MATERIALS AND METHODS

Haddock larvae were hatched and reared at the National Research Council's Aquaculture Research Station, Sandy Cove, Nova Scotia, Canada. According to the method of Park and Johnson(2002) and Park *et al.*(2003), filtered and UV-treated water(Salinity, 32‰) was supplied to each tank at a flow rate of 4L min^{-1} in a flow through system, with a water renewal rate of once every hour. Hatched larvae were held on a 12-h dark/12-h light photoperiod with the light intensity at the water surface between 40 and 60 Lx. Dissolved oxygen levels and water temperature were monitored each day and averaged 10±2 mg/L and 12±2℃, respectively.

Larvae were maintained on a diet of *n*-3 HUFA enriched rotifers(*Brachionus plicatilis*) and *Artemia* at the third instar stage and weaned to a dry food diet(Biokyowa™, Kyowa Hakko Kogyo, Tokyo, Japan, 400～700 μm). Larvae and juveniles were removed from larvae rearing tank until 67 days after hatching periodically(Sampled everyday from 1 day after hatching to 22 days after hatching, sampled every second day from 24 days after hatching to 40 days after hatching, and sampled every third day from 43 days after hatching to 67 days after hatching). Total length, pectoral fin length and body depth for 50 freshly sampled larvae at different stages were measured to the nearest 0.01 cm with an 1/20 mm dial vernier caliper, and body weight for the same samples as measured by pectoral fin length and body depth, were weighed to the 0.01 g with an electric balance(Shimadzu, JPIAW 320, Japan). Prior to measurement, the larvae were anaesthetized with 300 ppm lidocaine-HCl/$NaHCO_3$ at 18℃.

Growth in total length, pectoral fin length, body depth and body weight of fish were investigated by Von Bertalanffy(1938) growth expression. Relationship of body depth and pectoral fin length with total length, and body weight were calculated by Gompertz(Zhang, 1991) growth expression. Also, relationship between pectoral fin length and body depth was calculated.

RESULTS AND DISCUSSION

Fig. 1 shows growth in total length and body weight of haddock from 1 day after hatching to 67 days after hatching. Fig. 1 presents arithmetic growth curves of total length and body weight, described by the growth expression $TL=3.5375e^{0.0536X}$, $r^2=0.8759$(where TL is total length and X is at days after hatching), $BW=0.0002e^{0.1858X}$, $r^2=0.8671$(where BW is body weight and X is at days after hatching), respectively.

Growth in both total length and body weight were accelerated until 67 days after hatching. The first scholar to give much attention to early growth of haddock was Downing and Litvak(1999) who determined the influence of light intensity on growth and survival of larval haddock. In the research, they show the pooled regression of stan-

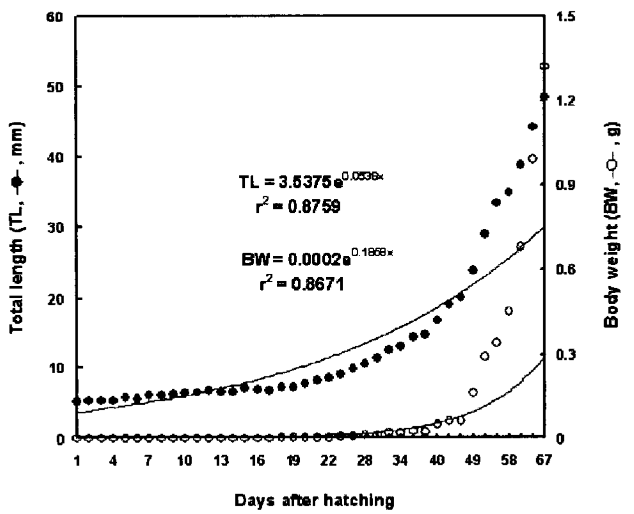

Fig. 1. Early growth in total length and body weight of haddock from 1 day after hatching to 67 days after hatching.

dard length as a function of time is described by the equation SL(pooled)=$4.1732e^{0.0077XD}$(p=0.0001, r^2=0.52, where D is day).

The growth trends in body depth and pectoral fin length of haddock from 1 day after hatching to 67 days after hatching are shown in Fig. 2 Growth pattern of body depth and pectoral fin length are instantaneous growth which expression of the type BD=$0.3545e^{0.0778X}$, r^2=0.9563 (where BD is body depth and X is at days after hatching) for body depth growth and the type PL=$0.0111e^{0.1501X}$, r^2=0.9194 (where PL is pectoral fin length and X is at days after

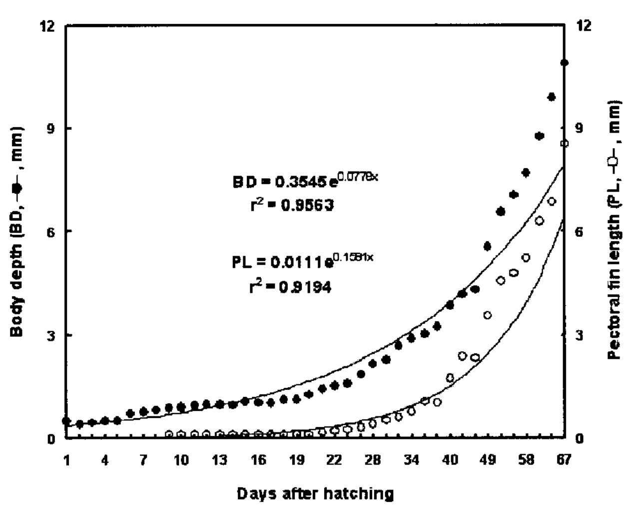

Fig. 2. Early growth in body depth and pectoral fin length of haddock from 1 day after hatching to 67 days after hatching.

hatching) for pectoral fin length growth. A close study on the growth of larval haddock was made already by Trippel and Neil(2003) and it revealed that enhancement of growth of juvenile haddock was achieved through photomanipulation.

The relationships of the growth of the parts of the body of an organism to that of the whole creature is an important aspect of growth biology(Weatherly and Gill, 1987). Huxley(1932) noted that many problems of relative growth could be considered simply as instances of allometric growth, describable in terms of the expression he referred to as the simple "heterogony formula" $y=ax^b$, where the constant a denotes the value of y when x=1; i.e. the fraction of x which y occupies when x equals unity. Huxley's analyses have permitted at least partial interpretation of a variety of puzzling phenomena. They have indicated that, commencing with a certain ground plan of an animal, constant differences in growth rate of the weight or dimensions of different organs, tissues, or parts of the body (e.g. head, limb), can produce bizarre shifts from that plan as the animal increases in bulk.

The most important factor will be the magnitude of the slope constant b. In certain instances, abrupt but quite simple shifts in b values can account for otherwise baffling changes in patterns of relative growth. At the particular levels of analysis on which he concentrated, Huxley(1932) elucidated the nature of growth patterns in a wide variety of organisms and their bodily parts, suggesting that the solution of many growth problems depended on identification of regions of differential growth termed "morphogenetic fields" and the application of his analytical techniques.

The expression for the relationship of body depth and total length is BD=0.2397X − 0.5735(r^2=0.9957, where BD is body depth and X is total length), and pectoral fin length and total length is PL=0.1929X − 1.3767(r^2=0.9882, where PL is pectoral fin length and X is total length)(Fig. 3). Body depth and pectoral fin length against corresponding total length values, for which the correlations are very high.

Fig. 4 shows pectoral fin length against body depth simultaneously recorded for juvenlie haddock (PL=0.8117BD − 0.9718, r^2=0.9814, where PL is pectoral fin length and

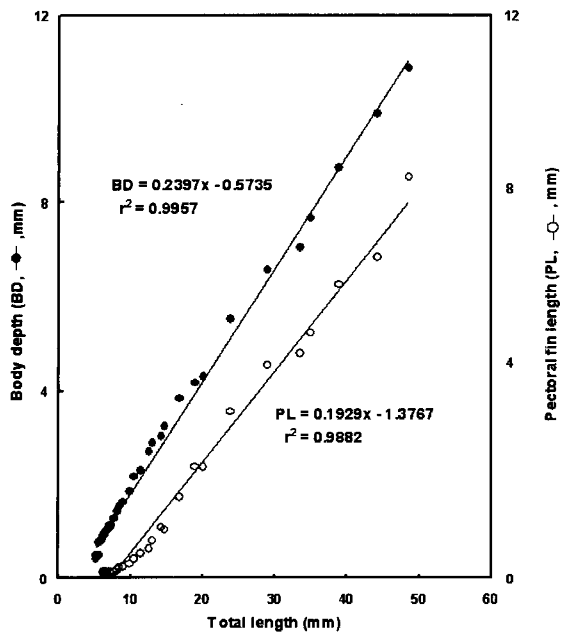

Fig. 3. Relationship of body depth and pectoral fin length with total length in larval haddock.

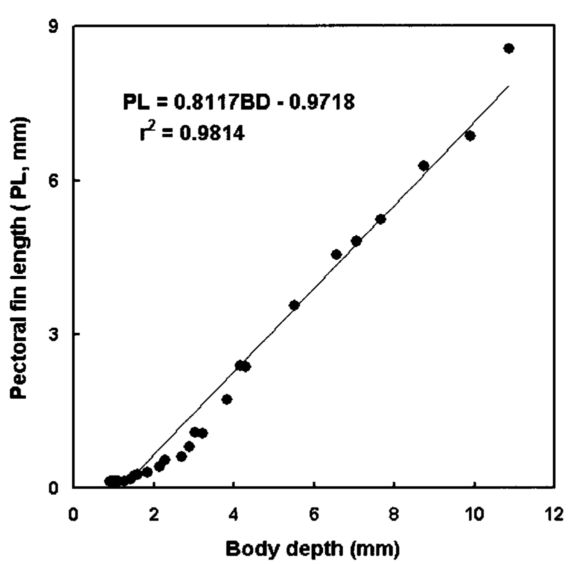

Fig. 4. Relationship between pectoral fin length and body depth in larval haddock.

BD is body depth). It also plots the pectoral fin length against corresponding body depth, for which the correlation is very high.

It is obviously desirable to have some expression for the relationship of weight and length in fish since so much of what is meant by growth implies change in relative magnitude of these variables(Weatherley and Gill, 1987). In this study, relationship of body depth and body weight expression the type of BD=$-$9.4734X^2+19.046X+1.3672, r^2= 0.941(where BD is body depth and X is body weight), and pectoral fin length and body weight expressed the type of PL=$-$6.379X^2+14.023X+0.3774, r^2=0.9494(where PL is pectoral fin length and X is body weight)(Fig. 5). The growth of both body depth and pectoral fin length for body weight growth had proportionately decreased. It must be noted that how the increment of body depth and pectoral fin length gradually decrease at high values of body weight (Fig. 5).

Weatherley and Gill(1987) suggests that unless there is definite and fairly profound change in the shape of an organism as its linear dimensions increase, relationships of weight against length will reveal a power curve of exponential form whose slope may differ considerably between species, between populations, or seasonally for the same populations. However, because its slope and shape characteristics are sensitive to the relatively high variability in weight at any particular length, this simple form of representation of weight against length is not usually regarded as a very useful biometrical indicator.

One of the most critical determinants for successful aquaculture of finfish is the ability to obtain a consistent

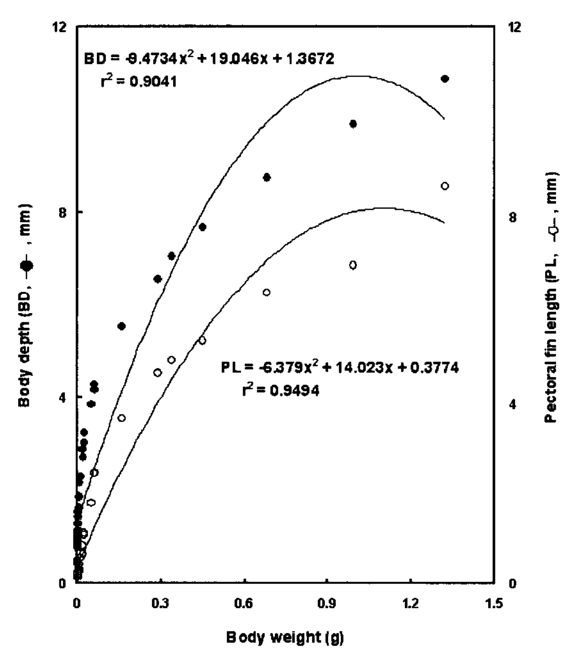

Fig. 5. Relationship of body depth and pectoral fin length with body weight in larval haddock.

supply of larvae or juveniles(Buckley *et al.*, 2000). From this point of view, growth characteristics of juvenile haddock in this experiment may be useful to establish a successful culture technique for rearing larval haddock. In respect of this point, there is room for further investigation of growth in larval haddock under various environmental conditions.

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