シロギスにおける卵径と孵化率の関係

誌名	日本水産學會誌
ISSN	00215392
著者	柏木, 正章 阪木, 英幸 高橋, 健夫
巻/号	53巻12号
掲載ページ	p. 2105-2110
発行年月	1987年12月

Nippon Suisan Gakkaishi 53(12), 2105–2110 (1987)

A Relationship between Egg Size and Hatching Rate in Japanese Whiting *Sillago japonica*

Masaaki Kashiwagi,* Hideyuki Sakaki,* Takeo Takahashi,* and Toshio Iwai*

(Accepted May 6, 1987)

The diameter, percentages of total hatch, and percentages of viable hatch of eggs of Japanese whiting *Sillago japonica* were determined for 85 days during the spawning season from early July to late September, and then these relationships were traced.

The diameter varied periodically during the season: it showed the largest size in the early and late part of the season and became smallest in size in the middle of the season. The daily maximum and daily mean percentages of total hatch were almost always above 50% and not rich in variety, but those of viable hatch showed some variations and often decreased below 50%. The diameter had statistically significant correlations with both percentages of viable hatch ($p<0.01$), but little with those of total hatch. Namely, the larger eggs had a tendency to produce a higher percentage of viable larvae than the smaller eggs. Besides this, the diameter and both percentages of viable hatch also had significant correlations with the water temperature ($p<0.01$).

Japanese whiting *Sillago japonica* is distributed widely in the waters off Japan (Except Hokkaido) and furnishes an important catch for both fisheries and recreational fishing located there. We have been conducting a study of the evaluation of egg quality of the fish for the purpose of mass production of the healthy juvenile fish.

In the previous paper,[1] we reported that the egg diameter varied periodically during the spawning season. This result led us to the question as to what kind of relationship existed between the size and hatchability of the eggs. Hence, this paper determines the hatching rate of eggs during almost all of the spawning season and tried to clarify its relationship to the periodical variation of the diameter.

Materials and Methods

The adult fish, 10 females and 20 males were caught from the mouth of Ago Bay, Mie Prefecture, in early and mid June 1985, then reared in the outdoor concrete tank (2.0 m long × 1.5 m wide × 0.5 m depth) of the Fisheries Research Laboratory, Mie University, at the same bay. They were well fed with thawed sand eel once a day. The tank was lighted entirely by natural light of which the direct ray was intercepted by the roof and three walls of a shed. The inflow of sea water varied between 30 to 60 *l*/min. Water temperature and chlorinity in the tank were observed at 1400 h every day. The chlorinity was decided by the methods of titration with silver nitrate. The eggs spawned naturally were collected every hour with the net set at the overflow outlet of the tank during the spawning season.

For determination of the hatching rate, an average of 75 (range 27–193) eggs, 2 to 8 cell-stages collected hourly were put into two 30 mm diameter test tubes with 50 m*l* water, and the tubes were soaked in the tank to obtain the same temperatures as natural conditions. Then two replicates of percentages of both total and viable hatch were counted and averaged. Here, the objects of observation for a viable hatch were limited to the normal larvae hatched without any abnormality such as the deformities of backbone and tail.

The egg diameter was measured every day on 30 eggs collected at the peak time of spawning.

Results

General Aspects of the Spawning

The adult fish spawned almost every day during the period from June 23 to September 27, though the number of spawners decreased from the initial 30 to the final 15 (4 females and 11 males) caused by death or escape. This period is well in accord

* Faculty of Fisheries, Mie University, 2–80, Edobashi, Tsu 514, Japan (柏木正章, 阪木英幸, 高橋健夫, 岩井寿夫: 三重大学水産学部).

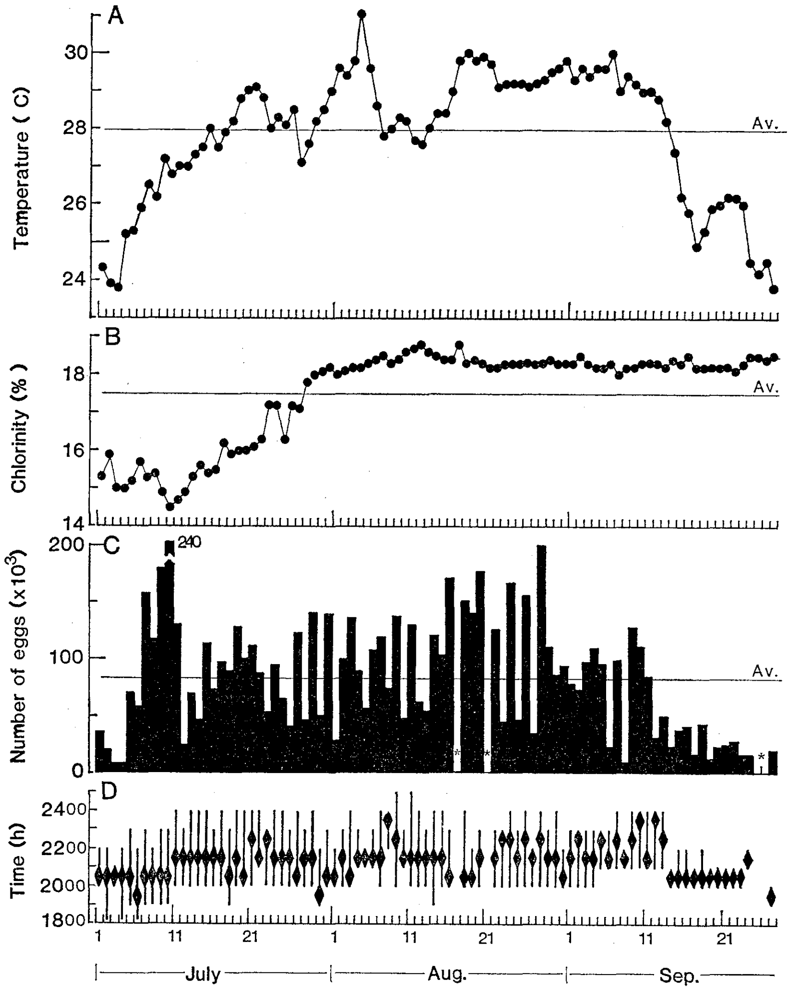

Fig. 1. The variations of water temperature (A), chlorinity (B), number of eggs spawned (C), and spawning time (D) during the spawning season. Asterisk in (C) showing the days not spawned. In (D), both ends of vertical bar showing the beginning and end times: black rhomb showing the peak time for the maximum number of eggs spawned.

with the spawning season mentioned in other[2,3] and the previous papers.[1,4] The number of spawned eggs showed a considerable decrease on late July to early August against the periods before and after that. All of the observations were carried out for 85 days starting from July 1. The temperature and chlorinity varied between 23.8 and 31.0°C, and between 14.5 and 18.8‰, respectively (Fig. 1-A and -B).

Although the daily spawning time varied between one and five hours during the period from 1800 to 0100 hours, the greater part of eggs spawned were collected for one hour at the peak time of spawning (Fig. 1-D). And the spawning time varied periodically during the season, *e.g.*, the peak time showing the earliest time of 1800–2100 hours in early July lagged behind to the latest time of 2000–2300 hours in late July, but was advanced after a further period of about 60 days and reverted to about its initial time of 1900–2100 hours in mid and late September. This periodical variation had statistically significant correlations with both the fluctuations of water temperature (r=0.478, $p<0.001$) and chlorinity (r=0.248, $p<0.05$). The relationship between time and temperature is also in agreement with that in the previous paper.[4]

Relationship between Size and Hatching Rate of the eggs

The egg size varied periodically during the season, *e.g.*, the daily mean diameter showing the

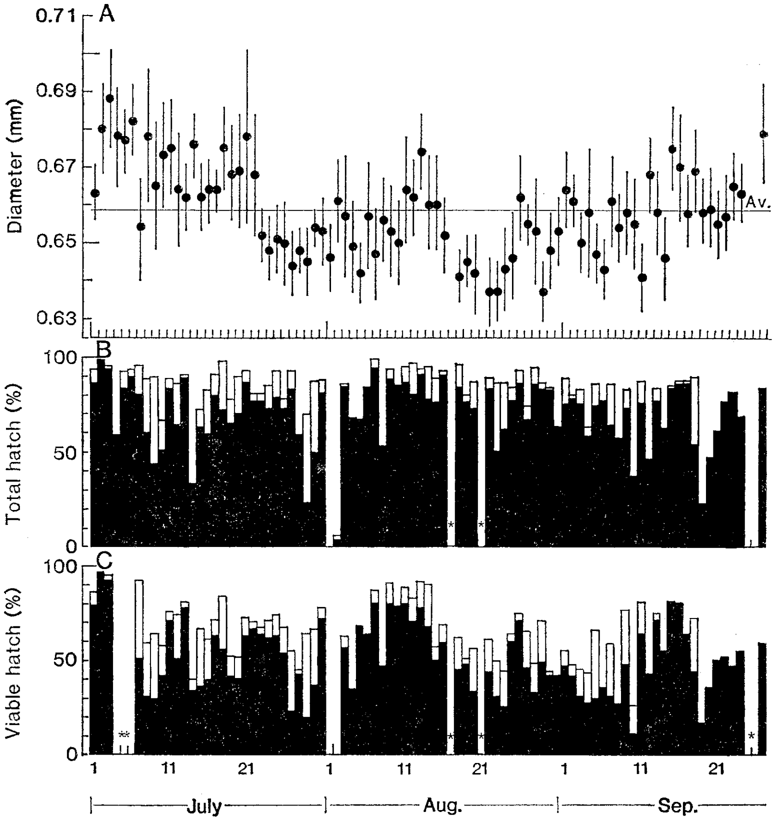

Fig. 2. The variations of diameter (A), percentages of total hatch (B), and percentages of viable hatch (C) of the eggs during the spawning season. In (A), each dot and vertical bar showing the daily mean and standard deviation. Symbols in (B) and (C): □ the daily maximum percentage, ■ the daily mean percentage, * the days not spawned, ** the days of missing data.

largest size of 0.66–0.69 mm in early July became gradually smaller and reached the smallest size of 0.63–0.67 mm in mid August, but became larger after that and reverted to about its initial size of 0.65–0.68 mm in late September (Fig. 2-A). This periodical variation had significant inverse correlations with both fluctuations of water temperature and chlorinity ($p<0.001$, Fig. 3). The connection between the diameter and number of spawned eggs per one female could not be determined here because some spawners escaped from the tank during the spawning season.

Fig. 2-B shows the results of percentages of viable hatch as the daily maximum and daily mean both which were almost above 50% and not rich in variety during the season. The averages and standard deviations for the season were 79.0±19.2% and 69.8±19.5%, respectively. There was not a big difference between the maximum and the mean, because the former were mostly observed with the eggs collected at the peak time when the greater part of eggs was spawned. Both variations of maximum and mean percentages had little correlations with that of the egg diameter (Fig. 4).

On the other hand, Fig. 2-C shows the results of daily maximum and daily mean percentages of viable hatch both which show some variations and often decrease below 50%, and have the averages of 61.0±19.8% and 50.4±20.1%, respectively, though there is not a big difference between the two as in the case of total hatch. Both variations of maximum and mean percentages had significant correlations with that of the egg diameter ($p<0.05$ and $p<0.01$, Fig. 5). Namely, the larger eggs had a tendency to produce a higher percentage of viable larvae than the smaller eggs. In this connection, notable decreasing of percentages of viable hatch frequently occurred during the periods from mid to late July, and from late August to early September, of which almost all the days had some changeable temperatures higher

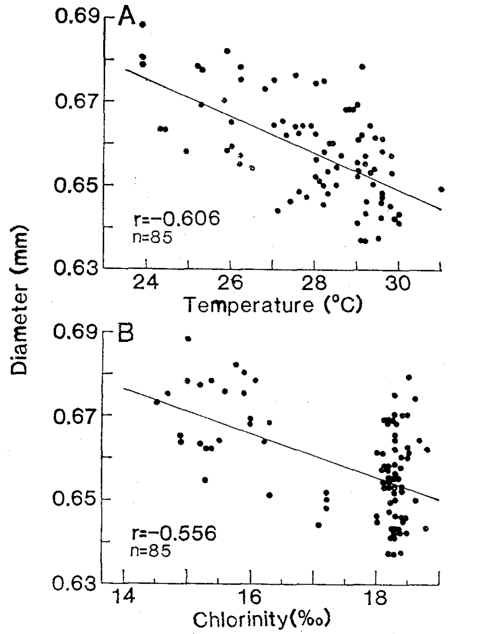

Fig. 3. The relationship between water temperature and egg diameter (A), and between chlorinity and the diameter (B). The least-squares regression for (A) is $y=0.7787-0.0043x$ ($p<0.001$): that for (B) is $y=0.7483-0.0051x$ ($p<0.001$).

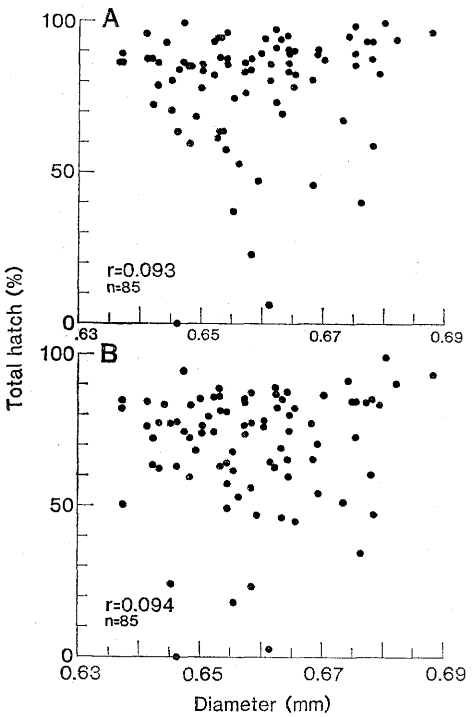

Fig. 4. The relationship between egg diameter and percentages of total hatch of which the daily maximum (A) and the daily mean (B).

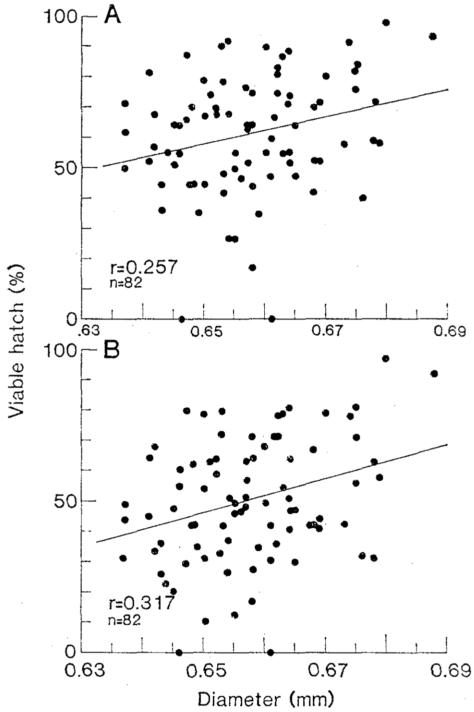

Fig. 5. The relationship between egg diameter and percentages of viable hatch of which the daily maximum (A) and the daily mean (B). The least-squares regression for (A) is $y=-234.8871+449.8404x$ ($p<0.05$): that for (B) is $y=-319.3572+562.1459x$ ($p<0.01$).

than 29°C, but relatively stable chlorinity of around 18.3‰ (except mid July). The days of temperature higher than 29°C were 33 out of 85 spawning days. Both variations of maximum and mean percentages had significant correlations with that of the temperature ($p<0.01$) but not with that of chlorinity (Fig. 6).

Discussion

About the relationship between size and hatchability of fish eggs, there are few papers comparable to the present paper, because those pepers differ extremely in opinions with the fish species and their spawning conditions, *i.e.*, one of them is that larger eggs are of better hatchability than smaller eggs as reported on rainbow trout *Salmo gairdneri*,[6-8] and the others are that no relationship or the reverse relationship can be found on the rainbow trout,[9] chum salmon *Oncorhynchus keta*,[10] and red sea bream *Pagrus major*.[11]

The results obtained in this study revealed that the percentages of viable hatch, both daily

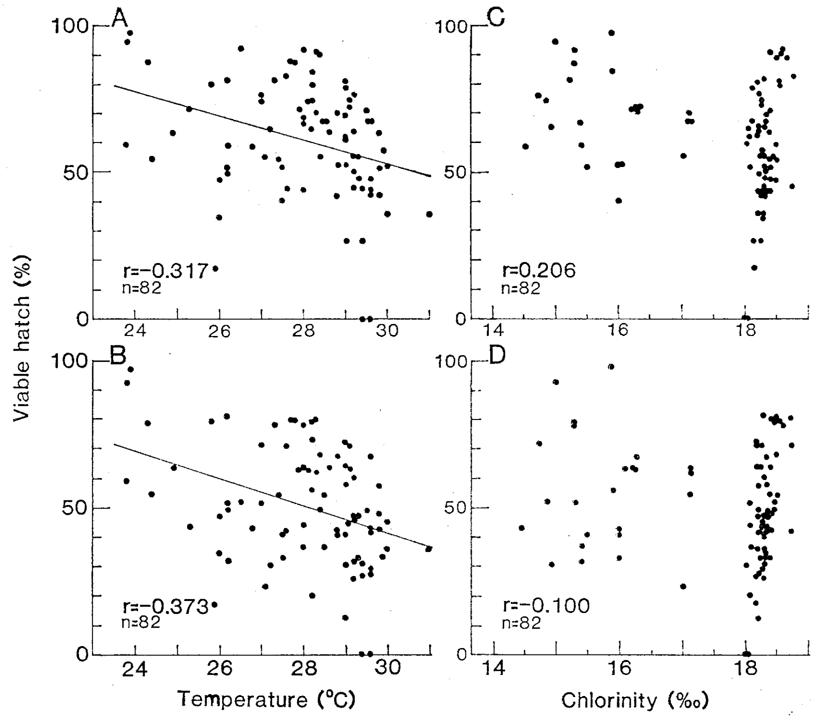

Fig. 6. The relationship between water temperature and percentages of viable hatch of which the daily maximum (A) and the daily mean (B), and between chlorinity and percentages of viable hatch of which the daily maximum (C) and the daily mean (D). The least-squares regression for (A) is $y=169.6858-3.8783x$ ($p<0.01$): that for (B) is $y=179.9019-4.6214x$ ($p<0.001$).

maximum and mean had highly significant correlations with the water temperature but not with the chlorinity, though the egg diameter had similar correlations with both environmental variables. Therefore, the temperature should be the first consideration with the relationship between egg size and its hatchability.

Previously, Lee[5] and We[1] reported for the present species that the egg diameter varied periodically in inverse correlation with the temperature. The result in this study follows this relationship. This is also recognized in the other species such as Atlantic herring *Clupea harengus*,[12] Cornish pilchard *Sardina pilchardus*,[13] Japanese anchovy *Engraulis japonica*,[14] whiting *Merlangus merlangus*,[15] turbot *Scophthalmus maximus*,[16] and sole *Solea solea*.[17]

On the other hand, both daily maximum and mean percentages of viable hatch also varied in inverse correlation with the temperature, particularly they showed a notable decrease at almost all days which have the temperature higher than 29°C. This temperature level seems to be equivalent to the upper limiting level for 50% viable hatch as shown in the linear regression analysis between the viable hatch and the temperature. On this subject, Kumai and Nakamura[3] noted that for the same species, although the spawning temperature ranged from 21 to 30.5°C, its optimum level narrowed down limits from 26 to 29°C. Hiramoto[18] and we[2] observed that the number of spawned eggs decreased considerably on late July and/or early August which had the highest temperature of 29 to 30°C during the season. The like observations applied to the present study. Koga *et al.*[19,20] also confirmed the same phenomenon, and then suggested that the hatchability had a tendency to be related to the number of eggs spawned. It is well-known that for the rainbow trout and ayu *Plecoglossus altivelis*[21] the upper limiting temperature for the spawning caused a sharp decline of hatchability. In this study, the days of temperature higher than 29°C were 33 out of 85 spawning days.

From all these consideration, it would seem perhaps most fitting to say that, for the results in this study, the higher temperature in the middle part of the spawning season exerts a very great influence on both miniaturizing of egg size and decline of its viable hatchability, and as a natural consequence it produces the highly significant correlation between the two egg characters. And it may be reasonable to assume that the disadvantages of hatchability in the middle season are balanced or compensated for by the long-range season from late June to late September or early October.

To explain more clearly the variations of egg quality during the season, it is highly desirable to decide both limiting and optimum temperatures for egg hatching in relation to the spawning temperature.

Acknowledgements

We express our sincere thanks to Dr. S. Kimura and Mr. A. Nakano, of the Fisheries Research Laboratory, Mie University, for their assistance.

References

1) M. Kashiwagi, F. Nakamura, Y. Okada, and N. Yamada: *Aquiculture*, **33**, 134–138 (1985).
2) H. Kumai and M. Nakamura: *Mem. Fac. Agr. Kinki Univ.*, No. 10, 39–43 (1977).
3) H. Kumai and M. Nakamura: *Nippon Suisan Gakkaishi*, **44**, 1055 (1978).
4) M. Kashiwagi, N. Yamada, Y. Okada, and F. Nakamura: *Nippon Suisan Gakkaishi*, **50**, 2135 (1984).
5) C.-S. Lee: *Mar. Ecol. Prog. Ser.*, **4**, 361–363 (1981).
6) G. A. E. Gall: *Calif. Fish Game*, **60**, 26–35 (1974).
7) H.L. Kincaid, W.R. Bridges, and B. von Limbach: *Trans. Am. Fish. Soc.*, **106**, 621–628 (1977).
8) R. W. Pitman: *Prog. Fish-Cult.*, **41**, 202–204 (1979).
9) J. R. C. Springate and N. R. Bromage: *Aquaculture*, **47**, 163–172 (1985).
10) T. D. Beacham and C. B. Murray: *Can. J. Fish. Aqua. Sci.*, **42**, 1755–1765 (1985).
11) T. Watanabe, T. Koizumi, H. Suzuki, S. Sato, T. Takeuchi, N. Yoshida, T. Kitajima, and Y. Tsukashima: *Nippon Suisan Gakkaishi*, **51**, 1511–1521 (1985).
12) G. Hempel and J. H. S. Blaxter: *J. Cons. perm. int. Explor. Mer*, **31**, 170–195 (1967).
13) A. J. Southward and N. Demir: in "The early Life History of Fish" (ed. by J. H. S. Blaxter), Springer-Verlag, New York, 1974, pp. 53–68.
14) T. Asami: *Cont. Nankai Reg. Fish. Res. Lab.*, No. 1 (Cont. No. 19), 1–17 (1953).
15) J. R. G. Hislop: *J. Cons. perm. int. Explor. Mer*, **36**, 119–127 (1975).
16) P. J. Bromley, P. A. Sykes, and R. R. Howell: *Aquaculture*, **53**, 287–293 (1986).
17) R. G. Houghton, J. M. Last, and P. J. Bromley: *J. Cons. perm. int. Explor. Mer.*, **42**, 162–165 (1985).
18) Y. Hiramoto: *Aquiculture*, **24**, 14–20 (1976).
19) F. Koga, K. Watanabe, and T. Osumi: Business Rep. Fukuoka Pref. Fish. Exp. St., 140–145 (1978).
20) F. Koga, K. Watanabe, and T. Osumi: Business Rep. Fukuoka Pref. Fish. Exp. St., 91–98 (1979).
21) K. Sakai: in "Maturation and Spawning in Fishes" (ed. by Japan. Soc. Sci. Fish.), Koseisha-Koseikaku, Tokyo, 1974, pp. 100–112.