Bull. Korean Fish. Soc. 18(4), 353~368, 1985 韓水誌 18(4), 353~368, 1985

Laboratory Tagging Experiment of Sea Urchin, *Hemicentrotus pulcherrimus* (A. Agassiz)

Sung-Bum HUR, Sung-Kyoo YOO
Department of Aquaculture, National Fisheries University of Pusan, Nam-gu, Pusan 608, Korea
and
Sum RHO
Yosu Hatchery, Fisheries Research and Development Agency, Yosu 542, Korea
(Received January 20, 1985)

Tagged and untagged sea urchins, *Hemicentrotus pulcherrimus* (A. Agassiz) were reared for 84 days in the laboratory. Vinyl tape and trapall paper were used as tag materials. The natural mortality, mortality by predation and shedding rate of tags of the tagged groups were examined, and the results were compared with those of untagged control group. The results of Chi-square test of natural mortality between tagged and control groups were very significative, however, the comparison between the two tagged groups was insignificative. No effect of tag attachment seems to be present at the point of natural predation by starfish, and χ^2-test between two the tagged groups on the loss rate of tags showed also insignificance. The mortality shortly after tagging seems to be negligible, and the distinct decreasing effect on growth due to tag attachment was not revealed because of insufficient individuals and rearing periods.

Introduction

For the purpose of fisheries stock assessment, *e. g.*, biomass, survival and mortality rate, migration, *etc.*, marking or tagging technigues are widely used. However, the errors caused by marking or tagging itself should be compensated, and two types of errors can be classified in this case. Type A errors affect the estimate of the rate of fishing, but not the estimate of total mortality and survival. In this category can be placed the death of any considerable individuals or the loss of their tags shortly after marking or tagging, and incomplete reporting of marks or tags. Type B errors include those which affect the estimate of total mortality, but not the estimate of the rate of fishing. Here belong any loss of tags from fish which occurs at a steady instantaneous rate throughout the whole period of the experiment, extra mortality among tagged or marked fish and emigration of fish from the fishing area (Ricker, 1975).

Though sea urchin, *Hemicentrotus pulcherrimus*, is one of the most important fishery stocks at the intertidal zone of Korea, its stock structure is not yet fully known. Accordingly, this experiment was carried out in laboratory to reveal the effect of the errors at tagging experiment of sea urchin, *Hemicentrotus pulcherrimus*, in field.

Marking experiment of sea urchin was perfected at first by Moore (1935). He adopted the attaching tags with an elastic band around the test, but found unsuitable because of loss. Sinclair (1959) used nylon line or brass line which was threaded through holes drilled in the spine of *Phyllacanthus parvispinus*. However, this technique was also found impracticable because of loss of the spine. The

external dyeing method (Swan, 1961) which is suitable for the individual marking of small numbers or mass marking where individuals need not to be ascertained, but does not allow individual marking of a large number of animals. Coloured vinyl tube (2 *mm*×1.7 *mm* dia.) was used in the tagging of *Hemicentrotus pulcherrimus* by Fuji (1962). The similar method using nylon monofilament and electric high speed drill was attempted, and no interference in normal behavior or growth seemed to occur due to the marking process (Ebert, 1965). Kobayashi and Taki (1969) used the tetracycline as a internal marking method, and this technique was adopted by Pearse and Pearse (1975) and Ebert (1977, 1980, 1982). But this method can not be used to mark individually, and the reporting of recovered sea urchin from the local fishermen is hard to expect. Besides these problems, as sea urchin uptakes the marking material, tetracycline, it seems to be unsuitable for long periods of marking experiment.

Considering the techniques mentioned above, the external individual tagging method seems to be adquate in Korean intertidal zone where the commercial sea urchin fishery is very active. In this study, the tagged sea urchins are reared in the laboratory with the untagged ones as control group, and the effects of tag attachment and tagging itself are evaluated.

Materials and Methods

One hundred thirty-five sea urchins were collected at the rocky intertidal zone near the Institute of Marine Sciences, National Fisheries University of Pusan. According to body sizes, the specimens were devided into 3 groups. large, medium and small group. Two types of tag material were selected. One is trapall paper, and the other vinyl tape which was used in dual-track. The dimensions of all tags were unified at 1×2.5 *cm*. In the case of trapall paper, the serial number of tag was marked with dark pencil, and dualtrack was used in case of vinyl tape tag. Fishing line(0.3 *mm* dia.) was used for the attachment of tag to sea urchin.

After removal of debris of shells or algae from sea urchin, the specimen was placed on filter paper for *ca.* 1 min, and then the test diameter and body weight are measured to read 0.1 *mm* and 0.01 *g*. precision. Soon after two small vertical holes were made instantly at the outside of ambulacral zone with a needle(1 *mm* dia.), and the tag was attached with fishing line through the holes. The mean weights of trapall paper and vinyl tape tags were 30 *mg* and 85 *mg*, respectively, Fishing line varied from. *ca.* 6 to 8 *mg* according to the size of sea urchin. To avoid desiccation, sea urchin was kept in wet state except for weighing procedure. Table 1. shows the number and mean body weight of sea urchins for the experiment.

On the other hand, considering natural condition, five starfish, *Asterina pectinifera*, with mean body weight of 26 *g* were also prepared as the natural enemy. All tagged and untagged sea urchins and starfish were stocked, and reared at the same time in a raceway culture tank of 1 m^3 water volume. The turnover rate per day was 0.5, and the tank was cleaned once a week. The daily water temperature was recorded. Ample air and food, *i.e.*, *Ulva pertusa*, *Sargassum sagamianum*, *Sargassum thunbergii*, *Zanardinula cornea*, *Chondrus* sp. *etc.*, were continuosly supplied during the experiment

Table 1. Number and mean body weight of sea urchin, *Hemicentrotus pulcherrimus*, used in the study

Size group	Vinyl tape		Trapall paper		Control	
	No.	Weight±S.D (*g*)	No.	Weight±S.D (*g*)	No.	Weight±S.D (*g*)
15~27 *g* (L)	15	19.35±3.30	15	18.29±2.81	15	19.92±3.38
8~13 *g* (M)	15	10.91±0.87	15	10.98±1.46	15	10.85±0.87
3~ 5 *g* (S)	15	4.91±0.44	15	4.79±0.64	15	4.72±0.50

*L, large; M, medium; S, small

Table 2. Mortality and shedding of tag during the rearing period by tagging group

Mortality	Size group	Vinyl tape		Trapall paper		Control	
		No.	%	No.	%	No.	%
Natural mortality	15~27*g*	7	47	5	33	4	27
	8~13*g*	6	40	6	40	1	7
	3~ 5*g*	7	47	6	40	2	13
	Sub total	20	44	17	38	7	16
Mortality by starfish	15~27*g*	2	13	3	20	—	—
	8~13*g*	0	0	3	20	—	—
	3~ 5*g*	2	13	2	13	—	—
	Sub total	4	9	8	18	4	9
Shedding of tag	15~27*g*	1	7	2	13	—	—
	8~13*g*	0	0	1	7	—	—
	3~ 5*g*	2	13	1	7	—	—
	Sub total	3	7	4	9	—	—
	Total	27	60	29	64	11	24

period. The tag serial number or test diameter of the dead individual during 84 days of rearing periods (June 28~September 19, 1984) were kept. At the end of experiment test diameter, body weight and gonad index (gonad weight/body weight×100)of all survived sea urchins determined.

Results and Discussion

The number of dead individuals and mortality rate after 84 days of rearing period are shown in Table 2. At the standpoint of natural mortality, vinyl tape tagging gave higher mortality than trapall paper tagging, and the mortality of former group was 2.75 times that of the control group. The result of Chi-square test for independance(Schwartz, 1975) of mortalities between vinyl tape and control group is very significative ($\chi^2=8.94$, $p<0.01$). The result between trapall paper and control is also significative ($\chi^2=5.68$, $p<0.05$). However, the comparasion between two tagged groups, Trapall paper and vinyl tape, shows insignificance. Taking survival rates of the control group as 100%, those of vinyl tape and trapall paper tagged groups decreased to 66.7% and 73.8%, respectively. The higher survival rate in trapall paper group seems to have been caused by light tag weight of the material. On the other hand, five starfish were all survived, and the number of sea urchin preyed on by starfish was the highest in trapall paper tagged group. Those of control and vinyl tape group were the same. The results of χ^2-test among the groups revealed insignificance. In consequence, no effect of tag attachment seems to be present at the point of natural predation by starfish.

The comparison between two tagged groups on the loss rate of tags during the rearing period shows insignificance. The mortality of type B erros of Ricker (1975) can be compared with the sum of natural mortality, mortality by starfish and shedding of tag in Table 2. In that case, the mortalities by vinyl tape and trapall paper tagging are 60% and 64%, respectively. Although the value of χ^2-test of these two groups is not significative, the χ^2-test between control and tagged groups shows high significance (control: vinyl tape, $\chi^2=14.58$, $p<0.01$; control: trapall paper, $\chi^2=11.66$, $p<0.01$). Therefore, the decreased survival rate by type B mortality of vinyl tape and trapall paper tagged groups were calculated as 52.6% and 47.4%, respectively.

The gonad index and mean growth rate of survived sea urchins after 84 days of rearing are computed as shown in Table 3. The growth rates by individual of control group were not able to know, and that of trapall paper group (12.28%) was a little higher than that of vinyl tape group (11.96

Table 3. Mean growth rate and gonad index of survived sea urchins by tagging groups

Type of tag	No. of survived	Mean body weight ± S.D(*g*) Initial(A)	Final(B)	Mean growth rate(%) ((B−A)/A)×100)	Gonad index
Vinyl tape	17	11.76±5.41	12.93±5.48	11.96±8.80	11.81±3.33
Trapall paper	16	10.45±5.00	11.37±4.94	12.28±9.87	10.99±3.67
Control	34	?	12.38±6.73	?	12.46±3.15

Table 4. Number of dead individuals, shedding of tag and mean water temperature during the rearing period

Rearing period	Natural mortality			Mortality by starfish			Shedding of tag		Mean water temp. ±S.D. (°C)
	Trapall paper	Vinyl tape	Control	Trapall paper	Vinyl tape	Control	Trapall paper	Vinyl tape	
June 28～July 4			1		1				18.3±0.37
July 5～11				1				2	18.8±0.38
July 12～18								1	20.5±0.67
July 19～25							1		21.9±1.02
July 26～Aug. 1						1	1		24.5±0.44
Aug. 2～8	1			1					23.1±1.10
Aug. 9～15		1					2		23.9±0.58
Aug. 16～22		1		1					25.1±1.34
Aug. 23～29	1	2							25.4±0.74
Aug. 30～Sept. 5	2	2	1			1			23.8±1.64
Sept. 6～12	9	10	3	4	1	1			21.8±0.36
Sept. 13～19	4	4	2	1	2	1			21.6±0.49
Total	17	20	7	8	4	4	4	3	

%). These values are however not significative in Student's *t*-test. With regard to gonad index, that of control group is the highest, and that of trapall paper group the lowest. The results of student's *t*-test, among these 3 groups show insignificance.

Although the adverse effect on growth due to tag attachment should exist in theory, the results of the research which do not which do not show any distinct difference can de attributable to insuffcient size of samples and short rearing period.

On the other hand, the first dead individual of tagged sea urchins by natural mortality appeared on the 37th day after stocking, and only 3 individuals died upto the 58th day. The first loss of tag of vinyl tape appeared on the 10th day after stocking, and that of trapall paper on the 23th day. The majority of dead sea urchins by natural mortality occurred at the end of rearing period. Therefore, the relative high mortality of the sea urchin in this study seems to be caused by the deterioration of water quality at the last period of the experiment. Taking into consideration the results of Table. 4, it seems that the type A mortality could be negligible.

Fuji (1962) reported that natural mortality of tagged sea urchin, *Hemicentrotus pulcherrimus*, was 3.4 times as high as that of untagged sea urchin, however, the rearing period (8～24 days) was too short to reveal the mortality type B. On the other hand, nine individuals among 137 tagged sea urchins died within the first day after stocking. Comparing this result with that of present research, the mortality type A was much higher in his study.

Referring to results of Glynn (1968) on the desiccation tolerance of five littoral sea urchin species, and the preliminary experiment for the present study the mortality type A seems to depend greatly on the condition of desiccation of sea urchin at tagging procedure.

Conclusion

In spite of tagging experiments of sea urchin by many authors, the effects of mortality type A and B have not been fully investigated. Therefore, the

results of this study can not extensively be compared with the others. Though 84 days for this experiment are not enough, for the selection of tag material for sea urchin tagging experiment, vinyl tape seems to be better than trapall paper. The latter has the merit because of light tag weight which is important to decrease the mortality type B. However, sea urchin often grazes the tag tself and the serial number written by dark pencil becomes vague after some months with high shedding rate of tag. The death of sea urchin or shedding of tags shortly after tagging seems to be negligibleif the sea urchins are well dealt with skilled technique avoiding desiccation.

With respect to type B mortality, the survival rate with vinyl tape tag is calculated as 66.7%, and the effect of type B mortallty on growth rate is not fully understood because of the short research period and insufficient size of the sample.

Acknowledgements

We express our heartful thanks Mrs. Hyun-Jun Kim and Eun-Sub Cho, graduate student of National Fisheries University of Pusan for their skillful assistances in sampling, tagging and rearing of the sea urchins. We wish to acknowledge Korea Science and Engineering Foundation for the financial support of the researcch.

References

Ebert, T.A. 1965. A technique for the individual marking of sea urchins. Ecology 46, 193—194.

Ebert, T.A. 1977. An experimental analysis of sea urchin dynamics and community interactions on a rock jetty. J. Exp. *Mar. Biol. Ecol.* 27, 1—22.

Ebert, T.A. 1980. Estimating parameters in a flexible growth equation, the Richards function. Can. J. Fish. Aqua. Sci. 37, 687—692.

Ebert, T.A. 1982. Longevity, life history, and relative body wall size in sea urchins. Ecol. Monog. 52(4), 353—394.

Fuji, A.R. 1962. A new tagging method for the sea urchin, *Hemicentrotus pulcherrimus*(A. Agassiz). The Aguiculture. 10(1), 11—14(in Japanese).

Glynn, P.W. 1968. Mass mortalities of echinoids and other reef flat organisms coincident with midday, low water exposures in Puerto Rico. Mar. Biol. 1, 226—243.

Kobayashi, S. and J. Taki. 1969. Calcification in sea urchins. I. A tetracycline, investigation of growth of the mature test in *Strongylocentrotus intermedius*. Calc. Tiss. Res. 4, 210—223.

Moore, H.B. 1935. A comparison of the biology of *Echinus esculentus* in different habitats. Part Ⅱ. J. Mar. Biol. Assoc. U.K. 20, 109—128.

Pearse, J.S. and V.B. Pearse. 1975. Growth zones in the echinoid skeleton. Amer. Zool. 15, 731—753.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Canada 191, Ottawa, 382 pp.

Schwartz, O. 1975. Méthods statistigues à l'usage des médicins et des biologistes. Flammarion Médecine Sciences, Paris, 318 pp.

Sinclair, A.N. 1959. Observations on the behavior of sea urchins. Aust. Mus. Mag. 13(1), 3—8.

Swan, E.F. 1961. Some uses of colored materials in marine research. Turtox News. 39(12), 290—293.

말똥성게, *Hemicentrotus pulcherrimus*(A. Agassiz)의 室內標識放流 實驗

許聖範 · 柳晟奎 · 盧暹*
釜山水產大學 養殖學科. *水產振興院 麗水種苗培養場
(1985년 1월 20일 수리)

비닐테이프와 trapall 紙를 사용하여 90尾의 말똥성게, *Hemicentrotus pulcherrimus*(A. Agassiz)에 표지를 부착시켰다. 對照群으로 표지를 부착시키지 않은 말똥성게 45尾와 害敵으로서 별불가사리 5尾를 동시에 수용하여 1984년 6월 28일부터 9월 19일까지 84일간 실험실에서 사육시켰다. 標識附着에 따른 自然死亡, 별불가사리에 의한 포식율, 표지탈락율등을 標識群別로 조사하여 대조군과 비교 분석했다. χ^2-test의 결과 표지군과 대조군의 자연사망율은 높은 有意性이 보이나 두 표지군 사이에서는 유의성이 없었다. 표지부착여부는 害敵의 포식율에 영향을 주는것으로 보이지 않으며 표지 탈락율에 대한 두 표지군 사이의 χ^2-test 역시 有意性이 없는 것으로 나타났다. 표지부착 직후에 일어나는 死亡率(type A)은 표지 附着時 성게의 乾燥를 조심하면 무시될 수 있는것으로 판단된다. 標識附着狀態에 따른 모든 사망율 (type B)은 비닐테이프의 경우 47.4%, trapall 紙의 경우 52.6%였다. trapall 紙는 標識가 가벼운 利點은 있으나 표지 자체가 성게에 의해 攝取될수 있고 표지의 일련번호가 쉽게 소멸될수 있는 점으로 보아 성게類의 표지방류에는 비닐테이프가 적합한 것으로 판단된다.