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# Difference in Performance of Three Ear-hanging Methods in Scallop Farming

Takeshi HAMADA[1], Nariharu YAMASHITA[2], Shunsuke TAKAGI[3] and Shunji NATSUME[4]

## Abstract

In scallop farming, ear-hanging consists of attaching scallops to polyethylene twine. Recently it has become very important for scallop farmers to achieve high labor productivity for ear-hanging. This activity is roughly divided into three attachment methods, called *Tegusuzuri*, *Loop* and *Agepin* in Japan. In this study, the time for performing the attachment tasks was measured, and differences in the performance of different workers and the three attachment methods were analyzed. The results of motion analysis indicated that the number of elemental motions differed between different attachment methods. Statistical analyses of performance time showed significant difference between different workers, no significant difference between *Tegusuzuri* and *Loop*, and significant difference between *Agepin* and the other attachment methods. Therefore, it was concluded that labor productivity of ear-hanging depends not only on the attachment method used, but also on the performance of the attachment workers.

**Key words**: Scallop aquaculture, Attachment methods, Labor productivity, Motion analysis

## Introduction

Scallop (*Patinopecten* (*Mizuhopecten*) *yessoensis*, JAY) aquaculture has been an important industry in Japan, especially in Hokkaido and Aomori prefecture. The cultured scallop yield has been less than 100 thousand tons per year until 1985, but exceeded 200 thousand tons in 1992. The yield has increased rapidly since the ear-hanging method became widely used in the 80's (Miyazawa et al., 1994). Ear-hanging comprises the attachment of juvenile scallops (shell height: 55～80 mm) to polyethylene twines after drilling a hole at the ear. The attachment of juvenile scallops to polyethylene twines, as shown in Fig. 1, is roughly divided into three methods: by using artificial catgut that is tied to the polyethylene twine at 120 mm intervals, called *Tegusuzuri* method in Japanese; by using artificial catgut passing through loop codes that are attached to the polyethylene twine at 120 mm

[1] *Institute of Fisheries Management Technology*
(水産経営技術研究所)
[2] *Laboratory of Fishing Production System, Division of Marine Environment and Resources, Graduate School of Fisheries Sciences, Hokkaido University*
(北海道大学大学院水産科学研究科環境生物資源科学専攻生産システム学講座)
[3] *Department of Marine Production System Science, Faculty of Fisheries, Hokkaido University*
(北海道大学水産学部海洋生産システム学科)
[4] *Hokkaido University Forests, Faculty of Agriculture, Hokkaido University*
(北海道大学農学部附属演習林)

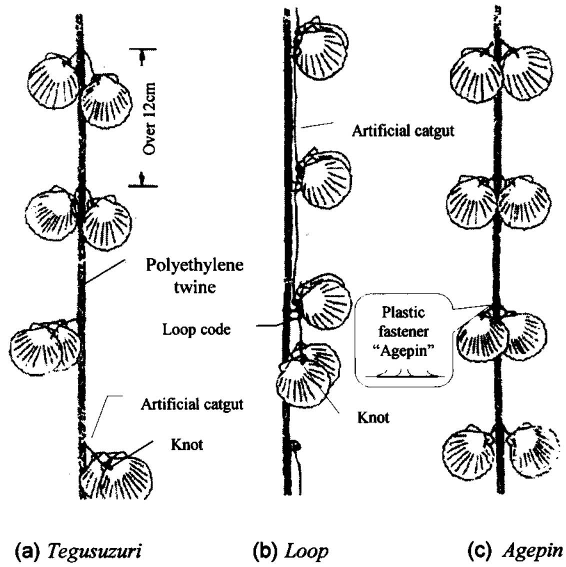


Fig. 1. Three typical methods of ear-hanging.

intervals, called *Loop* method; by using plastic fasteners that are attached to the polyethylene twine at 120 mm intervals, called *Agepin*. Attachment must be done by human hands.

It is very important for scallop farmers to know the performance of attachment, because they need to improve work efficiency of the attachment.
Hamada et al. (1996) measured performance of attachment to estimate the optimal number of workers for ear-hanging. However, in that study, the performance time only for *Tegusuzuri* was measured.

In this study, performance time not only of *Tegusuzuri* but also *Loop* and *Agepin* methods were measured, and the differences in performance of different workers and different attachment methods were analyzed. Lastly, the authors consider the factors that influence labor productivity of ear-hanging.

## Materials and Methods

*Measurements*

Attachment is usually conducted in the scallop farmer's shed. The authors videotaped five workers with a wide-angle lens as they performed attachment in the shed. *Tegusuzuri*, *Loop* and *Agepin* method were videotaped in Mori town and Shikabe town, Hokkaido; and in Yokohama town, Aomori prefecture, respectively. The five workers employing *Tegusuzuri*, *Loop* and *Agepin* methods were defined as A1～A5, B1～B5 and C1～C5, respectively.

The performance time for the attachment was estimated using,

$$T=\frac{t_2-t_1}{X}$$

Where $t_1$ and $t_2$ are the times of attaching the first scallop and the last scallop to the polyethylene twine respectively ; $X$ is the number of scallops attached to the polyethylene twine.

*Statistical analysis*

Chi-square test analyzed normality of $T$ data of all workers. One-way ANOVA tested differences in $T$ data among the five workers employing *Tegusuzuri*, *Loop* and *Agepin* methods. If the mean $T$ of performing each attachment was significantly different, Scheffe's multiple comparison was used.

The difference between the three attachment methods was tested using Kruskal-Wallis test. Differences within each attachment method were tested using Wilcoxon's rank sum. For all tests, the probability of 0.05 was statistically significant.

## Results and Discussion

*The performance of the workers*

The distributions of $T$ data of the five workers employing each attachment method are shown in Fig. 2. The Chi-square test indicated the normality of all workers. The one-way ANOVA indicated that the mean $T$ were significantly different for the five workers of *Tegusuzuri* ($P = 4.14 \times 10^{-4}$), *Loop* ($P = 8.74 \times 10^{-7}$), and *Agepin* ($P = 4.08 \times 10^{-2}$). Scheffe's multiple comparisons indicated that differences in the mean $T$ between the workers, except for A2 and A4, A4 and A5, B1 and B5, C1 and C3, C4 and C5, were significant.

These statistical results indicated that attachment performance differed with the workers. It is thought that this difference is attributable to factors like age of the workers, years of experience and sex of the workers. Further study is needed to examine these factors.

*Comparison between the three attachment methods*

Table 1 shows the elemental motions involved in attaching eight scallops to a polyethylene twine for each method. The *Agepin* method requires fewer elemental motions than the *Tegusuzuri* or *Loop* methods. *Agepin* is the simplest of the attachment methods.

Difference in $T$ data between the three attachment methods was significant using the Kruskal-Wallis test ($P = 1.41 \times 10^{-2}$). The one-sided test of Wilcoxon rank sum indicated that differences in $T$ data between *Tegusuzuri* and *Agepin* ($P = 2.34 \times 10^{-2}$), and between *Loop* and *Agepin* ($P = 3.63 \times 10^{-3}$) were significant, but the difference between *Tegusuzuri* and *Loop* was not significant ($P = 0.109$). Therefore, the *Agepin* method is faster than any other attachment method.

## Conclusion

In this study, difference in the performance time between *Agepin* and other attachment methods was revealed. *Agepin* was the fastest of the attachment methods. Therefore, if scallop farmers change from the former attachment methods (*Tegusuzuri* or *Loop*) to *Agepin*, the labor productivity (= the number of ear-hung scallops/the number of the workers/the actual working time) of ear-hanging will

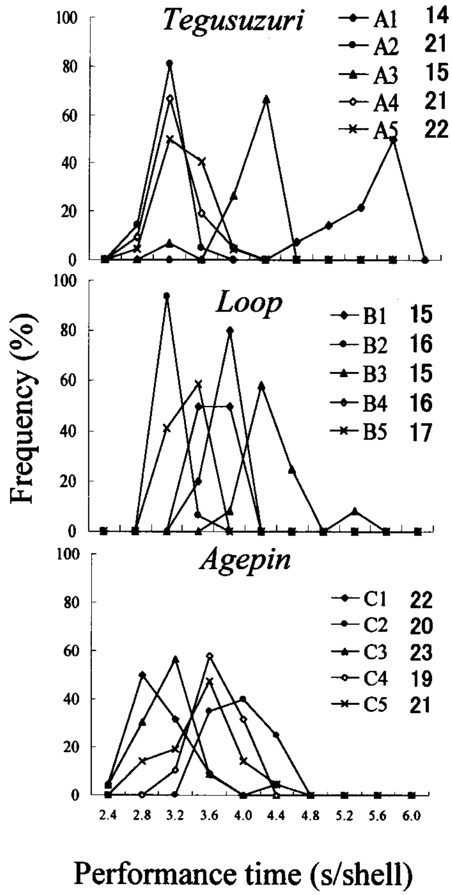


Fig. 2. Distribution of *T* data of the five workers for the three attachment methods. The figures in the graphs are the numbers of samples.

increase. However, the level of labor productivity depends on the workers whom the scallop farmers employ, because, as mentioned in results and discussion, performance differed significantly between the workers.

In conclusion, labor productivity of ear-hanging activities depends not only on the attachment method, but also on the performance of the attachment workers.


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Table 1. The elemental motions of attaching eight scallops to the polyethylene twine in three attachment methods

| Number of elemental motions | Tegusuzuri | Loop | Agepin |
|---|---|---|---|
| 1 | Taking a scallop | Taking a scallop | Taking a scallop |
| 2 | Passing artificial catgut through a hole of the ear | Passing artificial catgut through a hole of the ear | Passing Agepin through a hole of the ear |
| 3 | Taking a scallop | Tying a knot at the end of artificial catgut | Taking a scallop |
| 4 | Passing artificial catgut through a hole of the ear | Passing artificial catgut through a loop code | Passing Agepin through a hole of the ear |
| 5 | Tying a knot | Taking a scallop | Taking a scallop |
| 6 | Taking a scallop | Passing artificial catgut through a hole of the ear | Passing Agepin through a hole of ear |
| 7 | Passing artificial catgut through a hole of ear | Taking a scallop | Taking a scallop |
| 8 | Taking a scallop | Passing artificial catgut through a hole of the ear | Passing Agepin through a hole of the ear |
| 9 | Passing artificial catgut through a hole of the ear | Passing artificial catgut through a loop code | Taking a scallop |
| 10 | Tying a knot | Taking ascallop | Passing Agepin through a hole of ear |
| 11 | Taking a scallop | Passing artificial catgut through a hole of the ear | Taking a scallop |
| 12 | Passing artificial catgut through a hole of the ear | Taking a scallop | Passing Agepin through a hole of the ear |
| 13 | Taking a scallop | Passing artificial catgut through a hole of the ear | Taking a scallop |
| 14 | Passing artificial catgut through a hole of the ear | Passing artificial catgut through a loop code | Passing Agepin through a hole of the ear |
| 15 | Tying a knot | Taking a scallop | Taking a scallop |
| 16 | Taking a scallop | Passing artificial catgut through a hole of the ear | Passing Agepin through a hole of the ear |
| 17 | Passing artificial catgut through a hole of the ear | Taking a scallop | |
| 18 | Taking a scallop | Passing artificial catgut through a hole of the ear | |
| 19 | Passing artificial catgut through a hole of the ear | Passing artificial catgut through a loop code | |
| 20 | Tying a knot | Taking a scallop | |
| 21 | | Tying a knot at the end of the artificial catgut | |

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