MEASURING THE EFFECT OF AN ECO-CONSERVATION AREA ON AQUATIC LIFE

MESURE DES EFFETS D'UNE ZONE D'ECO-CONSERVATION SUR LA VIE AQUATIQUE

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Abstract

There has been a growing interest in going back to a semi-natural canal construction technology. The Gente River was rehabilitated using on eco-friendly canal design. Specifically, on average of 80% of the weed-rampant soil riverbed was covered with concrete and the rest with cobbles. The level of flow velocity is not much of a problem for *Punitions sinensis*, known locally as Tomiyo, survival, but to make it easier for Tomiyo to propagate, a 100m-long eco-conservation area was created halfway down the canal in March 2000. This study was aimed at tracking how the aquatic life like waterweeds and Tomiyo fared in this new environment.

The growth curve obtained at the end of the surveys for all the waterweed species occurring in the quadrates section indicated that two years and half after the completion with a coverage rate of 78.1% the community climax had been reached with Nagaemikuri as a predominant species. Another survey for the Gente River proper, revealed that five years after the eco-friendly renovation the climax had been reached with a coverage rate of 65.6%. These results mean that the waterweeds in the eco-conservation area were restored twice as fast as those in the renovated canal. The marking survey was conducted six times over period of time 18 to 47 months after the completion of the area. The results revealed that the density of Tomiyo under the waterweeds ranged from 2.6 to 8.2 fish/㎡. These levels of density are far exceeding the average 2.2 fish/㎡ in the pre-renovation stream.

From these results we might conclude that the eco-conservation area serves well to preserve a good enough environment for waterweeds and Tomiyo to propagate in.

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Résumé et conclusion

Un intérêt croissant se manifeste pour le retour à une technologie de construction de canaux semi-naturelle. La rivière Gente a été réhabilitée au moyen d'une conception de canal respectueuse de l'environnement. Spécifiquement, 80% en moyenne du sol couvert de plantes du lit de la rivière a été revêtu de béton, et le reste de galets. Le niveau de la vitesse d'écoulement ne constitue pas vraiment un problème pour la survie de *Punitions sinensis,* appelé localement Tomiyo, mais afin de faciliter sa propagation, une zone d'éco-conservation longue de 100 m a été créée à mi-chemin en aval du canal en mars 2000. Cette étude avait pour objet de suivre la manière dont la vie aquatique, représentée par les plantes aquatiques et le Tomiyo, se porte dans ce nouvel environnement.

La courbe de croissance obtenue à la fin des études pour toutes les espèces de plantes aquatiques trouvées dans la section à quadrilatères indique que deux ans et demi après l'achèvement, le climax de la communauté a été atteint avec un taux de couverture de 78,1%, et avec Nagaemikuri comme espèce prédominante. Une autre étude sur la rivière Gente elle-même a révélé que cinq ans après la rénovation respectueuse de l'environnement, le climax a été atteint avec un taux de couverture de 65,6%. Ces résultats montrent que les herbes aquatiques dans l'aire d'éco-conservation ont été restaurées deux fois plus rapidement que celles du canal rénové. L'étude de marquage a été effectuée six fois sur la période allant du 18^{e} au 47^{e} mois après l'achèvement de la zone. Les résultats ont révélé que la densité du Tomiyo sous les plantes aquatiques se situait entre 2,6 et 8,2 individus/m^2. Ces niveaux de densité dépassent de loin la moyenne de 2,2 individus/m^2 dans le courant avant la rénovation.

Ces résultats pourraient nous permettre de conclure que la zone d'éco-conservation est fort utile pour préserver un environnement satisfaisant pour la propagation des plantes aquatiques et du Tomiyo.

1. Introduction

An inflow of water can be seen into the Gente River (Table 1), an agricultural drainage canal that flows north into the tip of the Shogawa Fan in the western part of Toyama Prefecture, and there is a thriving ecosystem in the area. Based on the plant community, of which Nagaemikuri is the predominant species, this is said to be the western edge of the part of Japan inhabited by concentrated numbers of Tomiyo（Hokuriku Bureau of MAFF 1999）. In the present project, three kilometers of the overall river length were renovated using the neo-natural river construction method, with the goal of preserving the drainage function and conserving the ecosystem. Additionally, in order to encourage propagation of Tomiyo, a 102-meter eco-conservation area (hereafter referred to as a "wand") was created in the

midstream part of the river. This report describes the state of the habitat of waterweeds, which are crucial for Tomiyo propagation, in the wand in the Gente River, as well as the results of the wand that are helping to conserve the ecosystem, with the objective of confirming transitions taking place in the vegetation and Tomiyo population.

Table 1. Design specification of the Gente River

(Spécifications de conception pour la rivière Gente)

Items		Values	
Length	3,000m	Bottom width	3.3~5.1m
Bottom slope	1/500	Design velocity	1.45~1.92m/s
Revetment height	1.0~1.2m	Design capacity	6.04~18.25 m^3/s
		Return period	15 years

Ecosystem of the Gente River Prior to the renovation carried out using the neo-natural river construction method in the Gente River, 15 species of aquatic vegetation and two species of aquatic bryophytes were confirmed (Hokuriku Bureau of MAFF 1999). Of these, Nagaemikuri and Baikamo, which are known as barometers of the clean flow, are the predominant species. In the Red Data Book kept by the Ministry of the Environment, Nagaemikuri (Figure 1) is indicated as being threatened by extinction.

Tomiyo (Figure 2), which is characteristic of the fish in the Gente River, lives only in the effluent seepage areas, and is listed as a vulnerable species in the Toyama Prefecture Red Data Book. In order to spawn, fish build their habitat amidst the stalks of waterweeds such as Nagaemikuri, so the presence of waterweeds is crucial to the propagation of Tomiyo. Because of these and other factors, it was first necessary to ascertain how well the aquatic vegetation had been restored when deciding whether or not to provide a wand.

Figure 1. *Sparganium japonicum*, locally Nagaemikuri
(*Sparganium japonicum*, appelée localement Nagaemikuri)

Figure 2. *Pungitius sinensis,* locally Tomiyo
(*Pungitius sinensis,* appelé localement Tomiyo)

Thanks to an abundant supply of effluent seepage, the stream provides a comfortable habitat for 17 species of fish and 17 species of waterweeds. An adult Tomiyo is about 5.4cm in length

Construction of the wand In order to preserve the drainage function and conserve the ecosystem of the Gente River, the neo-natural river construction method was used, employing a combination of flat blocks and frame blocks filled with pebbles. The population density of Tomiyo tends to decrease at flow velocities of 0.50 m/s or more (Hokuriku Bureau of MAFF 1999). Based on the results of a water balance survey involving 100 measurements taken in the midstream of the Gente River, it was found that the average flow velocity was distributed over a range of 0.15 to 0.99 m/s, depending on the flow conditions, and with the neo-natural river construction method, even if Tomiyo are able to inhabit the river at that range of flow velocities, the speed is slightly fast for propagation, and it would be hard to say that the water flow environment is optimum. Given that, in order to better conserve the ecosystem for Tomiyo and other species, we provided a wand in the midstream of a 3-kilometer stretch of the Gente River, and completed it in March 2000 (Figure 3).

In the wand, we extended the width of the river by 3.3 m (a surface area of 337 m^2) on the right bank over a length of 102 m and filled it in with gravel. The left bank side (the river proper) was constructed according to the neo-natural river construction method, using concrete blocks. To facilitate a

survey of the ecosystem, a section of quadrates with a flow length of 27 m and a width of 3.3 m was provided in the center of the wand. The section of quadrates consisted of 10 unit quadrates.

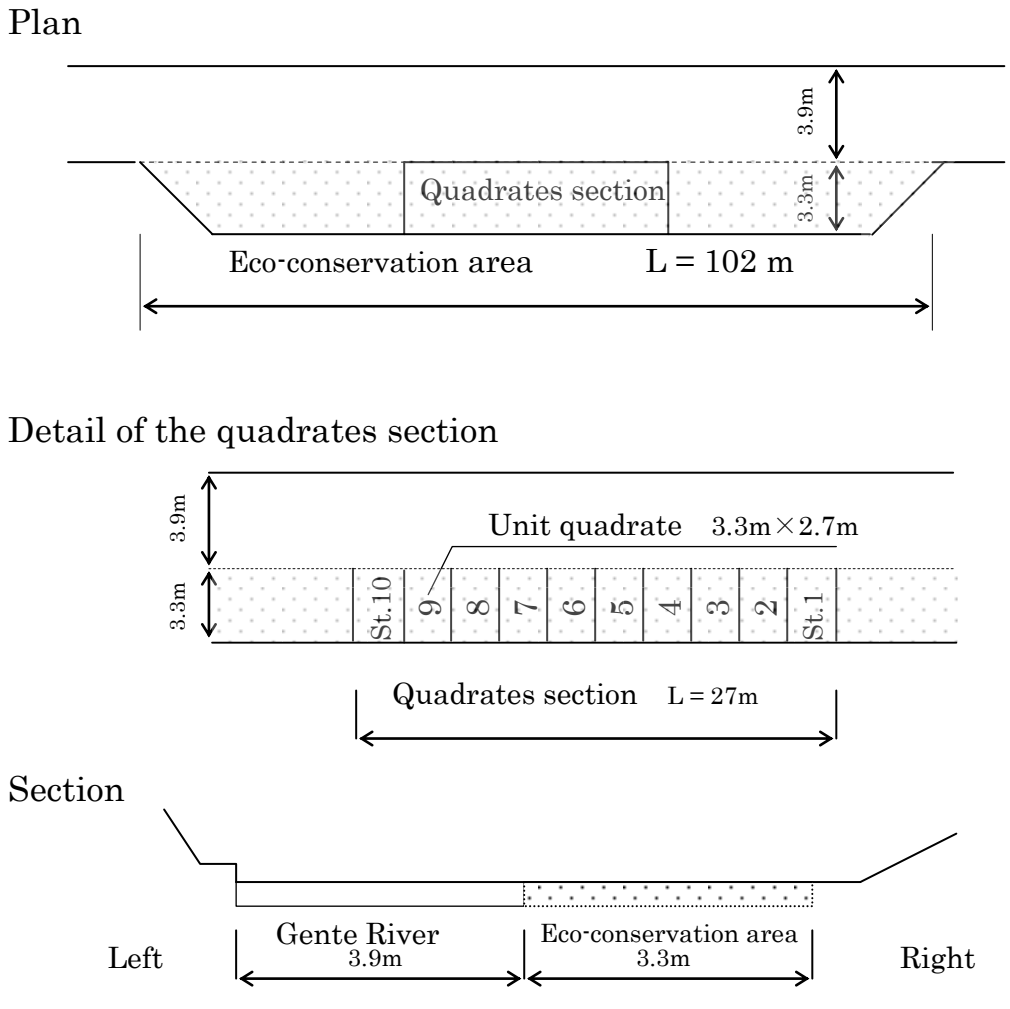


Figure 3. Specification of the eco-conservation area (wand)
(Spécification de la zone (*wand*) d'éco-consevation)

The running flow environment of the wand Vegetation surveys were conducted a total of seven times between August 2000, five months after construction was completed, and July 2002, with a flow environment survey being carried out at the same time. Because of the gravel paving and the

waterweeds vegetation, the wand had a large roughness coefficient, and the flow velocity was relatively slow, being distributed over a range of 0.22 to 0.49 m/s. The level of oxygen saturation was in a range of 83 to 118%, indicating that the water quality is clear. Conceivable reasons for this include an inflow of unconfined groundwater, carbon dioxide assimilation of the aquatic vegetation, and an aeration effect due to the wide channel of the wand.

2 ．Aquatic vegetation survey

The survey method Starting from August 2000, five months after construction of the wand was completed in March 2000, vegetation coverage rate surveys were carried out a total of seven times over a two-year period. The surveys were conducted as described below (Figure 4).

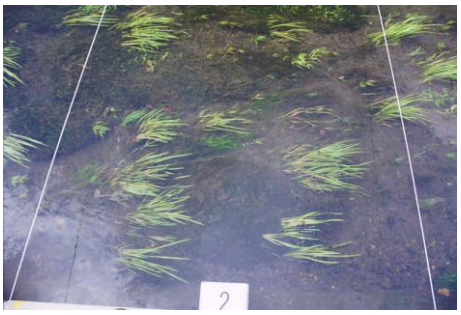
① The boundaries of the unit quadrate were marked with vinyl tape.

② Using a stepladder, the river surface of the unit quadrate was photographed at a height of approximately 3 meters above the water surface (a NikonU2 28-85 mm was used).

③ Image editing software was used to correct distortion in the images.

④After the images were printed, the various types of waterweeds were circled with colored pens to differentiate them.

⑤A planimeter was used to measure the circled surface area.



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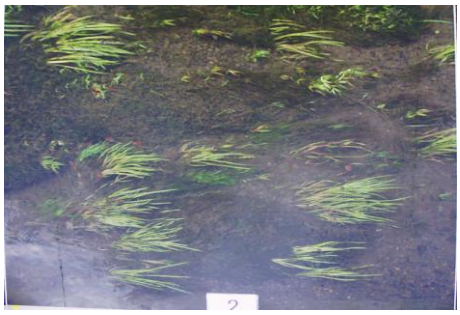

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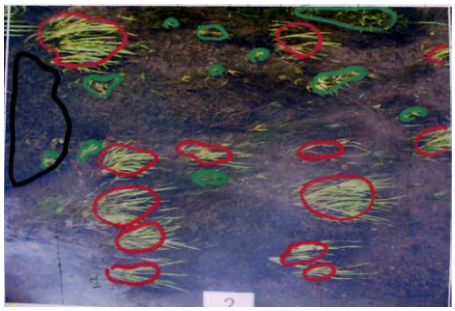

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Figure 4. Sequential order for the analysis of the coverage rates of waterweeds over the riverbed at the unit quadrate

(Séquence pour l'analyse des taux de couverture des plantes aquatiques sur le lit de la rivière au niveau du quadrilatère unitaire)

Results and discussion (1) Figure 5 shows transitions in the species making up the communities. In the first observation conducted in August 2000, five months after construction was completed, Nagaemikuri made up 50% of the total population, while Kokanadamo made up 30% and Yanagitade made up 20%. Nagaemikuri is the predominant species native to the Gente River. Kokanadamo is a naturalized plant that is resistant to changes in the environment, and it propagates primarily in cut algae, with early-stage growth being extremely fast. Yanagitade propagates by means of seeds and also has a fast initial growth rate. The state of the initial biomass in the primary transition period immediately after construction is as mentioned above, but eventually, as subterranean stems took hold, Nagaemikuri biomass increased, and 1.5 years after construction, in August 2001, Nagaemikuri became the predominant species.

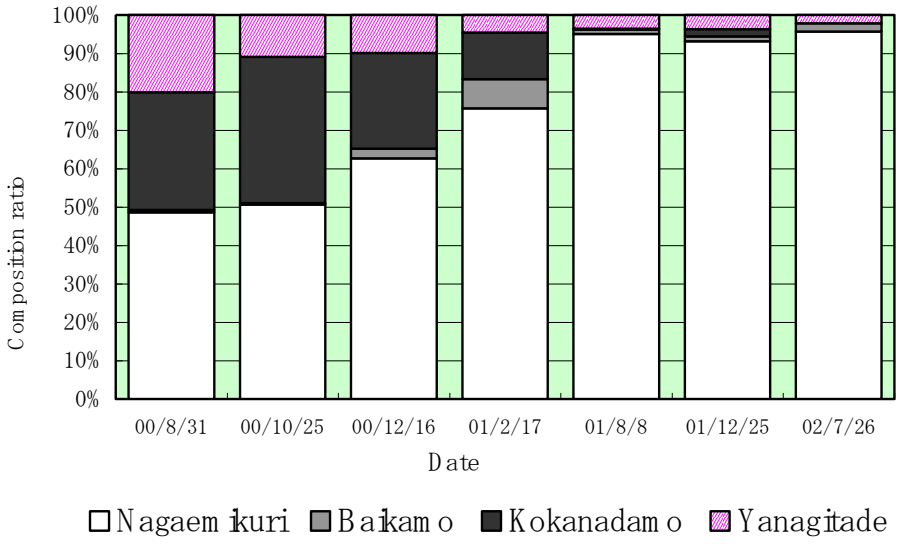

Figure 5. Changes in waterweeds composition ratio at the quadrates section of the eco-conservation area(wand)

(Variations du taux de composition des plantes aquatiques dans la section à quadrilatères de la zone (*wand*) d'éco-conservation.)

(2) Figure 6 shows these transitions in coverage rates. In trends in the coverage rates of the total waterweeds and Nagaemikuri, it was possible to accurately express the logarithm type of each using the approximation curve formula, with the formula for total waterweeds as shown in Formula (1).

Growth curve of total waterweeds

$$y = 28.4\mathrm{Ln}(x) - 114.2 \quad \cdots\cdots (1)$$

Here, y is the coverage rate (%) of the total waterweeds, and

x is the number of days elapsed following construction (days).

2000/8/31 to 2002/7/26 ($152 \leqq x \leqq 633$)

The coefficient of correlation r is 0.99

In the 2002 portion of the curve, the rate of change is smaller, so the coverage rate of 78.1% for July 2002 (two years and four months after construction) indicates that a climax had largely been reached in which Nagaemikuri had become the predominant species. According to the results of a vegetation survey (Hirose et al. 2001) of the river proper conducted separately on the area downstream from the wand (using the neo-natural river construction method), a climax had largely been reached in the fifth and sixth years after the completion of construction, with Nagaemikuri as the predominant species. In other words, the tendency toward a climax with Nagaemikuri as the predominant species closely resembled that of the wand, but the wand reached that climax point more than twice as quickly.

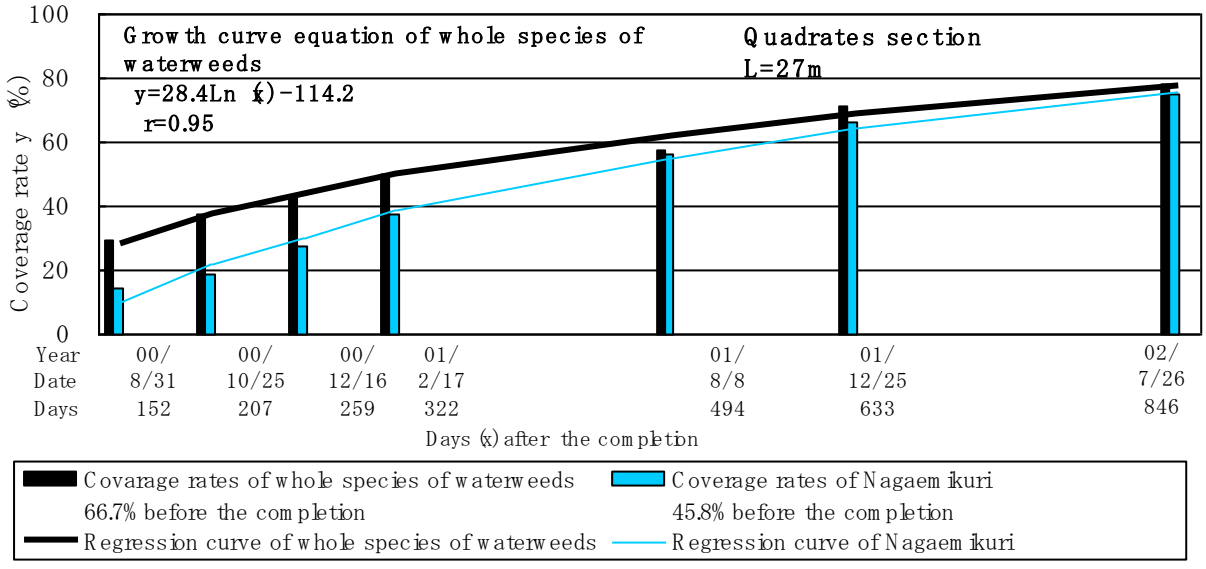

Figure 6. Changes in the coverage rates of waterweeds over the lined bottom at the

quadrates section of the eco-conservation area(wand)

（Variations du taux de couverture des plantes aquatiques sur le fond revêtu dans la section à quadrilatères de la zone (*wand*) d'éco-conservation）

3 . Surveys of Tomiyo

One year and six months after the wand was completed, the vegetation coverage rate had exceeded 60%, and the river was close to a state of climax with Nagaemikuri as the predominant species, so an attempt was made to statistically estimate the number of surviving Tomiyo, targeting the entire wand. Normally, instances of birth, inward migration, death, and outward migration occur among individual populations of animals living in physically open spaces such as the wand. Such individual populations are referred to as open populations. We attempted to estimate the population of Tomiyo aggregating in this location using the Jolly-Seber marking method that is the most widely used method for estimating populations of open populations. Surveys were conducted a total of six times over a three-year period starting from 2001, with two surveys being carried out each year, one in the February spawning period and one in the September growth period.

Method by which Tomiyo were captured

(1) A triangular gauze net, made of mesh, measuring 1.2 m on the lower side of the opening, was used to capture Tomiyo. A gauze net is a fishing net of very fine mesh used for shirasu fish.

(2) Because Tomiyo are normally found in the shadows of the waterweeds, we placed the lower side of the opening in the net against the river bottom on the downstream side of a clump of waterweeds. In order to make sure the net and river bottom were in firm contact, the waterweeds in that area had been cut the previous day.

(3) Standing on the upstream side of the clump of waterweeds, three of the researchers chased Tomiyo out from the shadows of the waterweeds, driving them into the net and capturing them.

(4) The number of captured fish was counted.

The approach behind using the Jolly-Seber method of marking (Jolly 1965, Itoh et al. 1992)

With the marking method, the size of the population is estimated from the total number of fish that were marked (marked fish) and the percentage of marked fish in the sample. This requires a minimum measurement period of three days (three times). Both marking and counting are carried out on the first

and second days, and only counting is carried out on the third day. If these counting results can be obtained, the size of the population for the second day can be estimated.

The survey procedure

(1) The first day of the marking survey

a. The number of captured fish was counted.

b. The primary marks for the first day were marked.

c. The fish were released.

(2) The second day of the marking survey

d. The captured fish were sorted into those without marks and those with primary marks, and the number of captured fish in each category was counted

e. The secondary marks for the second day were marked.

f. The fish were released.

(3) The third day of the marking survey

g. The captured fish were sorted into those with no marks, those with primary marks, those with secondary marks, and those with both primary and secondary marks, and the number of captured fish in each category was counted.

h. The fish were released.

The marking method Marking was done by injecting a fluorescent color on the left side of the body of Tomiyo. The marks were around five mm in length, making them long enough to distinguish, and the visible fluorescent elastomer made by Northwest Marine Technology Inc was used for the fluorescent marking (Figure 7).

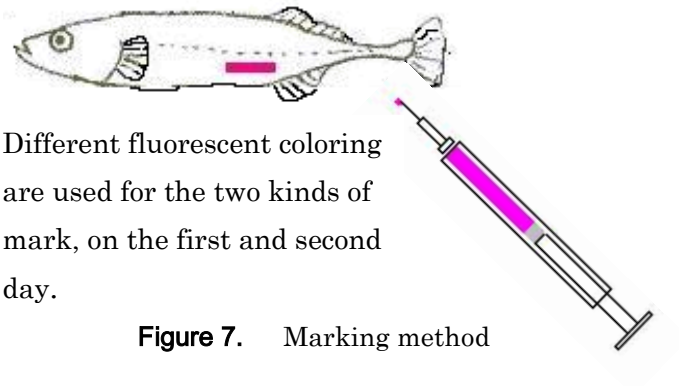

Figure 7. Marking method

(Méthode de marquage)

Results and discussion Figure 8 shows the estimated population density per surface area of the waterweeds, calculated from the estimated population of Tomiyo obtained from the survey results, along with the standard deviation, the flow velocity at the time of the survey, and the vegetation coverage rate.

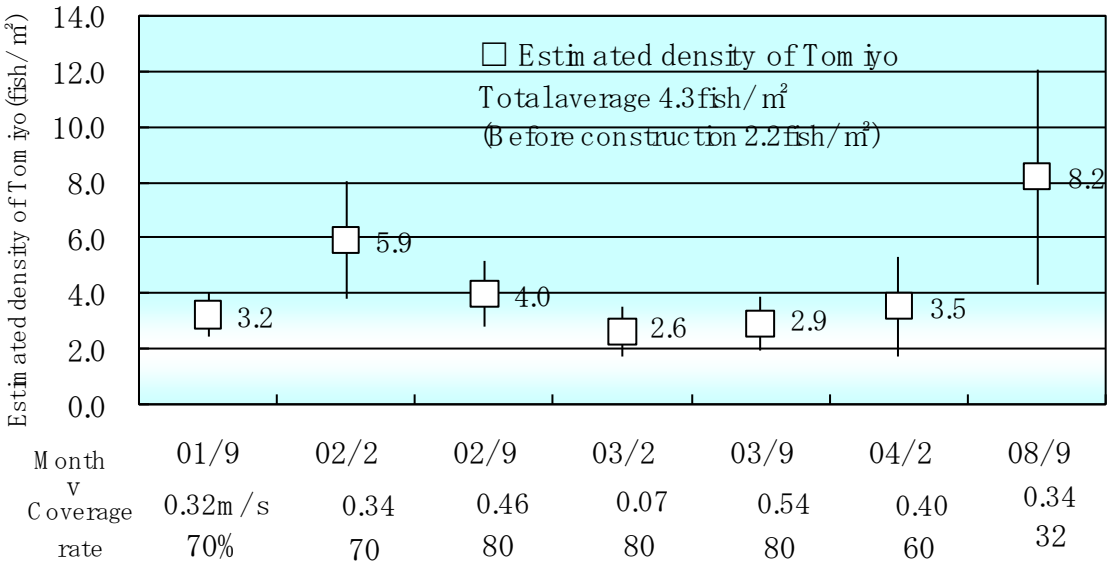

Figure 8. Estimated density of Tomiyo under the waterweeds at the eco-conservation area(wand) completed in March 2000. A vertical line represents a standard deviation
(Densité estimée du Tomiyo sous les plantes aquatiques dans la zone (*wand*) d'éco-conservation achevée en mars 2000. Les lignes verticales représentent les écarts types.)

The results of a marking survey conducted on Tomiyo over a three-year period starting a year and a half after construction of the wand showed an estimated Tomiyo population ranging from 703 to 1,394 fish, with the estimated density per surface area of waterweeds ranging from 2.6 to 5.9 fish/m^2. In a survey conducted in September 2008, eight years and six months after construction of the wand, the estimated population density was high, at 8.2 fish/m^2. The survey conducted in that year was carried out after a large outflow of water, so the coverage rate was low, at 30%, because of cut algae. When the vegetation coverage rate is high, the standard deviation tends to be low, with the opposite also being true; a low coverage rate tends to mean a high standard deviation, but the population is found to be stable

within a range of 2.6 to 8.2 fish/m^2 (average: 4.3).

In September 1997, the Hokuriku Bureau of Ministry of Agriculture, Forestry and Fishery conducted ten random captures, each of which was done in about 1m^2 of waterweeds in a 3-kilometer extension of the Gente River, in areas that were not renovated using the neo-natural river construction method, meaning the five water areas of A (110 m), B (140 m), C (300 m), D (650 m) and E (240 m) where the canal bottom consists of soil, with total length of 1,440 m. The results showed a population density for Tomiyo ranging from 1.9 to 2.4 fish/m^2 (average: 2.2) per surface area of waterweeds （Hokuriku Bureau of MAFF 1999）.

In addition, in 2007, the eighth year after construction using the neo-natural river construction method, the results of a survey of captured Tomiyo conducted at the 80 unit quadrates of 2 m^2, that were placed at intervals of 10 m along an 800-meter stretch between sections M_1 to M_4 of the farm road bridge in the midstream part of the river proper showed the average population density per surface area of waterweeds to be 1.7 fish/m^2 (Hirose et al. 2008).

Specifically, comparing conditions prior to and after the construction of the wand, Tomiyo population density was close to double following construction, and compared to the Gente River proper where the neo-natural river construction method was used, the population was found to be far more dense as well.

4. Conclusion

In a wand 102 m in length that was provided in the midstream part of the Gente River in order to facilitate propagation of Tomiyo fish, the coverage rate of the aquatic vegetation demonstrated a tendency to increase rapidly after the construction was carried out, and at a point two years and four months after the construction, Nagaemikuri reached a climax as the predominant species, at 78.1%. The speed at which this climax was reached was more than double that of the Gente River proper, where construction was done using the neo-natural river construction method.

With respect to Tomiyo fish, based on a survey conducted using the Jolly-Seber method of marking, the estimated population density per surface area of waterweeds was 2.6 to 5.9 fish/m^2 during the first three years after construction, and was 8.2 fish/m^2 after 8.5 years, averaging 4.3 fish/m^2. Thus, the estimated population density approximately doubled compared to the average of 2.2 fish/m^2 prior to the construction. The population density was also far larger than the average density of 1.7 fish/m^2 in the eighth year following the neo-natural river construction in the river proper.

Based on the above, the wand is creating an environment where aquatic vegetation and Tomiyo fish can grow and thrive, and together with the neo-natural river construction method used for the river proper, can be expected to play an important role in conserving the ecosystem of the Gente River.

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