Characteristic of Ecosystem of an Artificial Vegetated Floating Island

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Abstract

The Artificial Floating Island (AFI) was constructed near Tsuchiura Port on Lake Kasumigaura. It measures 92m long by 9.5m wide, consisting of 40 smaller segments. Initially, six aquatic plants were vegetated on this structure. After three years, an abundant Common Reed community was established, producing a standing crop of 4,047kg dry weight for the whole AFI. The AFI also attracted fish and other aquatic animals, including aquatic insects that were more numerous than in control areas. Although the number of species of terrestrial insects was almost the same in all waterside stations, its population in the AFI was smaller than those in other control stations, especially since ground surface insects could hardly be found due to the surface condition of no soil.

1 Introduction

The artificial floating island(AFI) constructed at the shoreline of Lake Kasumigaura in

1993 has had almost a stable fauna and flora during the past three years. The purpose of this structure was described as follows;

1.Having large aquatic plants grow densely on the AFI to help purify water.

2.Improvement on the ecological diversity by providing habitat space.

3.An aesthetic variation to an otherwise monotonous artificial lake edge.

For the purpose mentioned above, the AFI was constructed on the shoreline of Lake Kasumigaura, in the designated area close to Tsuchiura Port. The structure measured 9.5 by 92 meters, and consisted of 40 smaller segments anchored to each other for having the necessary flotation. Each segment was 20.25m^2(4.5m x 4.5m) braced by stainless steel with diagonal supports for durability, and internally attached with 10cm thick special urethane cushion as a root base for vegetation. This urethane cushion had some cuts on the surface for supporting initial rhizome. For a fish habitat, the artificial reef was also placed on the bottom of the lake under the AFI.

Six species of aquatic plants were initially introduced(Fig.3). Common Reed is now dominant (Fig.6), and Great Reed Warbler and Moorhen also inhabit the space. The AFI also attracts game fish, such as black bass and bluegill, providing a good fishing point. This explains the different ecosystem the AFI has from other places in the lake. In the lakeside area, the housing units placed close to the lake edge allow a little greenbelt, and many of the insects flying from other districts seem to swarm to the AFI.

To grasp this phenomenon firmly and precisely, we carried out the investigation

between 1994 and 1996 regarding fish, insects, benthos, vegetation and sediments, both in and outside the AFI.

2 Methods and Materials

Fish

Fish was surveyed in October 1994, and set-nets and dip-nets were used for sampling. Set-nets were placed beside the AFI and two other outside stations as a control. Dip-nets were used at 20 stations around the AFI.

Insects and spiders

Insects and spiders were surveyed in July 1996. Terrestrial insects were sampled by sweeping-nets in the AFI and three outside control stations (Fig.3, St.1, 2, 3). Aquatic insects were sampled by dip-nets around the AFI and two outside stations (Fig.3, St. E, F). They were also sampled by the underwater light traps in two stations (Fig.3, St. A, B) in the AFI and one outside station (Fig.3, St. E).

Vegetation

The AFI was divided into five blocks for vegetation. Each block having eight segments each was planted respectively with Water Oat (*Zizania latifola* T.), Cattail (*Typha latiforia* L.), Roughseed Bulrush (*Scirpus triangulatus* Roxb.), Bur Reed (*Sparganium erectum sub* sp. *sloloniferum* H.), Yellow Iris (*Iris pseudacorus* L.), and Common Reed (*Phragmites communis* T.). The survey

was carried out in November 1996 on the characteristics of flora, vegetation succession, and the standing crop. The coverage and group sociability of vegetation by the Braun-Blanquet method were surveyed for all 40 segments, as well as the coverage rate of the dominant species.

The population density was also surveyed for the dominant species. Common Reed, Water Oat, Cattail and Yellow Iris were selected as the main species. The population of these species in the quadrat of 50cm by 50cm was surveyed at three different points in each community. The same method was taken for each of the native communities of Common Reed and Water Oat in the nearby river plain as a control. The sample of dry weight was prepared by cutting the emerged part of dominant plants within the quadrat of 30cm by 30cm at five points with a different density on the AFI. The same method was taken for non-dominant species. The standing crop of vegetation was calculated by multiplying an average dry weight with a coverage rate of each species in a segment.

3 Results

Fish

The results for fish were shown in Table 1. Seven species with a total count of 267 were caught by set-nets beside the AFI. It also included 16 crustaceans. The fish primarily sampled consisted of bluegill (*Lepomis macrochirus)*, with a count of 198, and *Rhodeous ocellatus ocellatus* followed with a count of 31. On the other hand, the fish caught at the control stations were very few and only included one black bass

(*Micropterus salmoides salmoides*) at St. 1, and one bluegill and one shrimp (*Macrobrachium nipponense*) at St. 2.

The aquatic animals caught around the AFI were 2 species of fish with a total count of 122 and shrimp numbering 373. Among them goby (*Tridentiger Kuroiwae brevispinis*) was dominant with a count of 118, followed by four bluegill. As shown in this data, AFI can be seen to attract various species of fish and crustaceans.

The reason for catching fewer fish by dip-nets than by set-nets was because dip-nets can easily miss fast swimming fish such as bluegill.

Insects and spiders

The results on terrestrial insects and spiders were shown on Tables 2 and 3.

There were 53 species of terrestrial insects (total count 238) and 18 spiders (total count 40) caught in the AFI. In control areas, 101 species (total count 478) of terrestrial insects and 20 species (total count 88) of spiders were caught in St.1, while 43 species (total count 377) of insects and 11 species (total count 25) of spiders in St.2, and 75 species (total count 373) of insects and 70 species (total count 87) of spiders in St.3were also caught.

To sum up, as for terrestrial insects, St.1 had the highest number of species, and other stations had almost the same number. The total count was the highest in St.1, while the AFI had the lowest number. As for spiders, St.1and St.3 had almost the same count and the highest number of species, and the AFI came next. The surveyed point on the AFI and St.3 were both covered by Common Reed community so that

the species found in these areas had similarity, but more count was confirmed in St.3.

The soil is considered to be responsible for these results. That is, in the environment without soil, such as in the AFI, most insects are unable to generate and carry on their life cycle. Hence, it should be considered that most insects found in the AFI have flown from outside.

St.1 was set up in an open space in the middle of a housing area. Various grass and trees were prospering and provided an appropriate habitat for the insects, which seems to have contributed to the largest number of species and population observed there. St.2 was set up in Watercress field which had a special inhabiting condition so that the species observed there were limited

The result for aquatic insects were shown in Table 4. Two Asian dragonfly (*Ischnura asiatica*), two Gamushi (*Hydrophilidae* sp.), and one mosquito (*chironomidae* sp.) were caught in the dip-net, while three Asian dragonfly and 806 mosquitoes were caught by the underwater light trap in the AFI. In the control areas, 31 mosquitoes were caught by the underwater light trap in St. E. As shown in the data, the confirmed aquatic insect species were only a few, compared to those of terrestrial ones, and a large portion of its population was mosquitoes. These aquatic insects were mainly confirmed in the AFI, which also characterizes this structure as their primary habitat.

Benthos

The results for Benthos were shown in Table 5 but turned out to be a monotonous

distribution with only 5 confirmed species. *Tubificidae* sp. were the most numerous with 72 in the AFI, 5 in St. C, 1 in St. D. Mud snail (*Cipangopaludina japonica*) followed with 18 in the AFI. Benthos were found a lot under the AFI. However, the conditions of control areas were essentially sterile with almost no biological activity, primarily affected by the degradation of sediments. It was also noticeable that the dead shells of Mud snail spread out on the bottom of the lake under the AFI.

Vegetation

The dominant species on the AFI was Common Reed. Other species found on it were Water Oat, Yellow Iris, and Mizosoba (*Polygonum thunbergii*). Besides these, 20 species were confirmed, such as Cattail, Runner Reed (*Phragmites japonica*), or Gishigishi (*Rumex japonicus*). The seasonal factors are thought to be responsible for the small number of confirmed species. In other word, many therophythes had already been dead and rotten by the time the investigation was held in early winter.

Out of six species initially planted on the AFI, Common Reed and Water Oat had become dominant. Cattail and Yellow Iris created a small community in some of the segments. There remained some Roughseed Bulrush, but Bur Reed disappeared completely. There were also 17 species thriving from outside.

Vegetation structure created in all 40 segments was the variation of Common Reed community and assorted into four types, that is, Common Reed itself, Common Reed-Water Oat, Common Reed-Yellow Iris, and Common Reed-Mizosoba. The

typical structure of Common Reed community is shown in Fig. 4. The dominant species of vegetation on the AFI were Common Reed, Water Oat, Runner Reed, and Yellow Iris. The population density of each species is as follows:

The average density of Reed was 106 shoots/2500cm^2 which is three times as dense as that of its native community (39 shoots/2500cm^2), 47 shoots/2500cm^2 for Water Oat which is almost as dense as that of its native community (49 shoots/2500cm^2), and 77 shoots/2500cm^2 for Runner Reed and 32 shoots/2500cm^2 for Yellow Iris.

The dry weight per 1m^2 for each species was Reed, 8.72kg; Water oat, 4.62kg; Mizosoba, 1.29kg; Cattail, 7.36kg; Yellow Iris, 2.35kg; and other weeds, 2.94kg.

The area of the AFI measures 810m^2, and the total standing crop for whole AFI was calculated at 4,074kg dry weight with approximately 75% Common Reed. The standing crop per 1m^2 on the AFI was about 5kg.

Sediments

The results for sediments were shown in Table 6. Sediments were composed of dominant fine sand with a mixture of clay and some gravel. Coarse sand and gravel were found more in the sediment under the AFI.

COD was not as high as between 1.8-9.1mg/g(dry). T-S was as low as between 0.02-0.08mg/g(dry). I.L. was also as low as between 1.3-4.6%.

This shows that the sediment environment had not been seriously degraded.

4 Discussion.

The AFI as a habitat for aquatic plants.

The composition of vegetation on the AFI has greatly changed since it was first installed in 1993. Only Common Reed and Water oat thrived dominantly out of six initial species, and it was either because four other species could not adapt to the habitat or were swept by these dominants. While taking into account the biological property, Roughseed Bulrush and Bur Reed were regarded to be non-adaptable to the vegetative environment of the AFI, and Cattail and Yellow Iris were regarded to be inferior in thriving to others.

This should advise us of the importance of selecting aquatic plants with high adaptation to a new environment, as well as with a symbiotic combination when they are introduced in such a special environment like the AFI.

The nearly whole area of the AFI is now covered by the Common Reed community. The communities such as Common Reed, Water Oat, and Cattail are commonly observed in the riversides and lake sides, and regarded as the parameter for the highest degree of naturalness. Seventeen species of wild weeds were also observed , and Mizosoba and *Polygonum lapathifolium* produced a large crop. They are also the parameter for a relatively high degree of naturalness. Therefore, although the initial vegetation of this AFI had been man-made, the period of three years turned its structure very closely into one which resembles a natural condition.

The root material of the AFI was netted mat and did not contain any soil. However, dead grass that had accumulated and decomposed on the AFI has been

providing the root condition some similarity to that of the soil in the past three years. The water eutrophication has progressed around the AFI, which provides necessary nutriments for the growth of vegetation. Moreover, the AFI continuously moves by waves produced by the wind and boats so that the root mats are well ventilated by oxygen. Therefore the AFI for the plants is believed to have similar environmental conditions with that of water cultivation. The vegetative environment has proved to be quite good by the fact that the standing crop per $1m^2$ of the AFI was as much as 5.0kg compared to that of the native community, 1.3kg.

The AFI as a habitat for aquatic animals

From the results obtained from the investigation in October 1993, the AFI proved its great efficiency for attracting aquatic animals. It was greatly contributed by the environmental change caused by the AFI, that is, the complication of the space created by the AFI provided those life forms a favorable habitat. The area of the installed AFI is surrounded by quite a monotonous environment with a wide expanse of shallow water, the flat bottom of the lake, and the paralleled artificial lake edge. Plus, water quality and sediments were seriously deteriorated by eutrophication. Such an environment could hardly provide either a safe nesting habitat or food for aquatic animals and could only allow specific fish to inhabit with a small population. There assumed to be no existence of aquatic insects. Thus, the installation of the AFI made a great change and played a significant role as a home for creatures so that many of them have started nesting. Particularly the results on aquatic insects showed

a very characteristic phenomenon, that is, there existed extremely high numbers of mosquitoes despite the few number of confirmed species (four species). Many species of mosquitoes are used for indication of α-mesosaprobic and polysaprobic, and this result should reflect the degradation of water.

In addition, the transparency of water in the area of the AFI was only 20cm and had little scattering lights, which made the subsurface water of the AFI a dark world. The bottom of the AFI was plain and flat with no roots of aquatic plants sticking out, which apparently is inadequate for sustaining life.

Sediments and benthos

The distribution of benthos was well reflected by the condition of the sediments. There were fewer benthos in the area with silt and high ignition loss, and more in the area with sandy gravel and low ignition loss. However, only five species were confirmed and *Tubificidae* sp. had the largest population, which pictured the simplification of diversity of benthos. *Tubificidae* sp. were also concentrated on the bottom of the lake under the AFI, and its order was as fairly low as between 30-40inds/0.1m^2. The deterioration of sediments can not be judged by these results, but the distribution of benthos tells its serious condition as a habitat. As the extremely low transparency shows, it may also be affected by the bottom condition of no penetrating light.

The AFI as a habitat for terrestrial insects

The lake side which the AFI is next to is well maintained with lawn and a walk way. Not many terrestrial insects are observed here, except *Atractomorpha lata.* On the other hand, the vegetation of the AFI characterizes the typical water front vegetation that has dominant Common Reed or Water Oat, and ground surface weeds of Yellow Iris , Mizosoba, and *Bidens frondosa*. The species of terrestrial insects and spiders observed in the AFI reached almost the same number as in the control, but fewer in count.

The species composition of terrestrial insects and spiders in the AFI resembled that of St.3 which has a similar vegetation. Therefore, the fauna in the AFI is surmised to have reached a stable stage in extent, but not with ground surface insects.

5 Conclusion

The conclusion of this paper is as follows;

1. The AFI is providing a stable vegetation structure and a variety of habitat space.

2. A few species are generating on the AFI due to the lack of soil.

3. Not many insects are flying to the AFI because of its residential surroundings and lack of natural environment.

References

1. Hoeger, S., *SCHWIMMKAMPEN Germany's artificial floating island*, Jour. Soil and Water Conservation, July-August, 1988

2.Nakamura, K. & Shimatani, Y. et al., *The ecosystem of an artificial vegetated island, Ukishima, in Lake Kasumigaura*. Proceeding Vol.1 of the 6th Int. Conf. of Lakes-Kasumigaura'95, 1995

3.Song, X et al., *Bio-production and water cleaning by plant grown with floating culture system.* Proceeding Vol.1 of the 6th Int. Conf. of Lakes-Kasumigaura'95, 1995