西日本における冬期飛来水鳥の分布に及ぼす環境要因*

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Effect of Environmental Factors on the Distribution of Wintering Waterfowls

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Summary

CHAPTER I　Introduction

Habitat selection is a function of biological requirements and habitat availability. On the other hand, the use of available habitats is a function of several factors including food requirements, social status, and disturbances (Johnson 1980). As natural wetlands decline, artificial environments such as sewage lagoons, stock ponds and reservoirs take on greater importance as waterfowl habitat (Baldassarre & Bolen 1994). There are many differences in habitat requirements among waterfowl species. Therefore, it is important for wildlife managers to identify special habitat requirements of different waterfowl species in order to make some representative ecosystems in these artificial environments. The present study concentrated on the environmental variables that affect the distribution of wintering waterfowl in artificial environments such as dam lakes and irrigation ponds during the winter season.

CHAPTER Ⅱ　Materials and Methods

The study was conducted in five parts. 1) The first part of the study investigated the factors affecting the distribution of waterfowl in 64 irrigation ponds in the Saijo basin, Higashi Hiroshima, central Japan (34^{o}22'N, 132^{o} 44' E) during January in 1998 and 1999, when waterfowl populations are most stable. 2) In the second part of the study, domesticated flightless mallards were released to five of these irrigation ponds in October 1999. These ponds were previously unused by the migrating waterfowl. This experiment was carried out to observe the affect of hetero-species on attracting migrating waterfowl to ponds. 3) Third part of the study concentrated on the factors affecting mallards and their behavioral responses in five irrigation ponds of Saijo basin from October 1999 to March 2000. Mallards were selected because they were the most abundant waterfowl species in

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Higashi-Hiroshima. The five ponds were selected because they received the highest mallard use in 1998 and 1999. 4) Fourth part of the study was carried out in five large artificial dam lakes from September 1999 to March 2000. Yasaka dam lake is located in Ogata cho, Otake City, Hiroshima Prefecture (34° 14' N, 132° 9' E). Haji dam lake is located in Yachiyo cho, Takada gun, Hiroshima Prefecture (34° 38' N, 132° 37' E). Hattabara dam lake is located in Kozan cho, Sera gun, Hiroshima Prefecture (34° 35' N, 133° 8' E). Shimachigawa dam lake is located in Shinnanyo City, Yamaguchi Prefecture (34° 10' N, 131° 47' E). Takasezeki dam lake is located in Nakaku cho, Hiroshima City, Hiroshima Prefecture (34° 25' N, 132° 33' E).

The factors affecting the waterfowl in these dam lakes and their nocturnal movement was studied. 5) Fifth part of the study investigated the activity budgets and the factors affecting mallards at the Hattabara dam lake from November 2000 to March 2001. The Hattabara dam lake was selected because it was easy to observe the waterfowl due to narrowness and lack bank vegetation, which obstructs the view. Mallards were studied from September 1999 to March 2000 because they were the dominant waterfowl species in the Hattabara dam lake.

Waterfowl census

In the first part of the study waterfowl in the irrigation ponds were surveyed by waterfowl point count method of Koskimies & Vaisanen (1991). Sampling day was divided in to three sessions: sunrise-10.30, 10.31-14.30, 14.31-sunset (Bergen & Smith 1989). Each pond was surveyed for thirty minutes in each session in January. Any pond used by waterfowl during the three counts was considered as a used pond.

In the second and third parts of the study, sampling dates were divided in to the three same sessions. Each pond was observed for a period of one hour in each sampling session per month from October 1999 to March 2000. Point count method was used to record the waterfowl.

In the fourth part of the study, waterfowl in the five dam lakes were recorded from a boat (Mori et al.2000) and by round count method (Poysa & Nummi 1992). Waterfowl in each dam lake was counted once a month, between 8:00 and 12:00. In the fifth part of the study, mallards at Hattabara dam lake was observed by round count method.

Nocturnal movement

Departure and arrival of waterfowls in ponds were recorded in each month with the aid of lighting equipment consisting of powerful hand-held flashlights or car lights if possible in ten irrigation ponds of the Saijo basin from September 1999 to March 2000.

Nocturnal censuses of the waterfowl in all artificial dam lakes were carried out in December 1999 on moonlit nights with the aid of adjustable floodlights mounted on the boats and powerful hand-held flashlights. Nocturnal movement of mallards at the Hattabara dam lake and their foraging sites were recorded at each month from November 2000 to March 2001 on moonlit nights. Flight direction of mallards at dusk was determined with the aid of 25 (8 binoculars. Once the flight direction was clarified, mallards were observed about 500 m down the flight path. The procedure was repeated until their foraging sites were located.

Habitat data

The 64 irrigation ponds in the Saijo basin were divided into two categories as ponds in residential areas and ponds in forested areas using a 1/25,000 scale topographical map and visually assessing the surrounding environment.

In the dam lakes, the percentage of the shoreline bordered by trees was mapped in the field (Elmberg et al. 1993). Data on surrounding terrestrial vegetation (i.e. forest and grass cover) were obtained from vegetation maps. Data on water parameters (pH, chemical oxygen demand (COD), biological oxygen demand (BOD), total

nitrogen (TN), total phosphorous (TP), dissolved oxygen (DO), suspended solids (SS), chlorophyll) and water level fluctuations were obtained from the dam management offices. The number of anglers and boaters were recorded at each survey.

Disturbances

Any event causing waterfowl to modify their activities were identified as a disturbance in the ponds of the Saijo basin. A questionnaire on hunting was distributed among the members of the hunting club of Higashi Hiroshima to record the hunting disturbances.

The number of anglers, boaters and other factors, which were likely to disturb the waterfowl in the five dam lakes, were recorded monthly from November 1999 to March, 2000. Five factors (anglers, boaters, pedestrians, helicopters and natural) were identified as most likely to disturb the mallards (Morten et al. 1989) in the Hattabara dam lake from November 2000 to March 2001.

Food availability

Benthose and nektonic animals were recorded at ten selected irrigation ponds from November 1999 to March 2000. Benthose were recorded using a core sampler with an area of 25cm. Nektonic animals were recorded using 3.8-liter glass activity traps (Whitman 1974). Presence and absence of the water plants was recorded at the same time. Benthose and nektonic animals in all reservoirs were recorded using the same method from November 1999 to March 2000 and from November 2000 to March 2001 at the Hattabara dam lake. Animals caught were preserved in 70% alcohol returned to the laboratory sorted, identified.

CHAPTER III Results and Discussion

1) Frequency of non-hunting disturbances was higher in ponds located in residential areas than ponds in forests (χ^2=4.44, *df*=1, p<0.05 in 1998, χ^2=5.0, *df*=1, p<0.05 in 1999). However, waterfowl preferred ponds in residential areas (residential ponds) to ponds in forests (forest ponds) (*F* test, p<0.01, in 1998, *F* test, p<0.01, in 1999). Waterfowl numbers were positively correlated with the area of the ponds, which were used by the waterfowl (*Kendall's tau* =0.407, p<0.05 in 1998, *Kendall' s tau* =0.375, p<0.05 in 1999). Forest ponds contained 35 % of the total surface water area compared to 65% of surface water area in residential ponds. However, less than expected number of waterfowl used the forest ponds in both years (χ^2 =567, *df*=1, p<0.001 in 1998, χ^2=506, *df*=1, p<0.001 in 1999).

Shooting was possible only in the ponds located in forests. Shooting was prohibited in residential areas. Therefore, ponds in residential areas could have been safe ponds from the waterfowl's point of view. Waterfowl were probably able to recognize the difference between hunting and non-hunting disturbances. Therefore, although waterfowl wintering in the Saijo basin preferred large ponds, they were unable to use the large ponds in forests even due to the potential risk of hunting.

2) The above hypothesis was further confirmed by the experiment of releasing domesticated flightless mallards to ponds in the forests. Migrating waterfowl were attracted to four of the five ponds in October and November when domesticated mallards habitated. When the hunting season started in mid November the migrating waterfowl promptly vacated the forest ponds. This confirmed that most important factor affecting the geographical distribution of migrating waterfowl in the Saijo basin ponds is the hunting pressure.

3) Mallards behaved differently among the five irrigation ponds studied from October 1999 to March 2000. They behaved differently even in the same pond among months apparently in response to availability of food

and disturbances. One pond was used as a resting site during the day and as a foraging site during the night from December to February. Another pond was used as a foraging site during the day and as a resting site during the night in November. The same pond was used only as a resting site from December to March. The remaining three ponds were used primarily for resting during the daytime. Mallards in these three ponds displayed a pattern of nocturnal movement, generally leaving the ponds at dusk and returning in the morning.

4) Twelve waterfowl species were recorded in the five dam lakes from November 1999 to March 2000. Out of these mallard and the mandarin ducks were the most abundant species. Therefore, the factors affecting these two species were further analyzed.

Mandarin duck densities in the dam lakes were significantly correlated with the shoreline bordered by trees (Kendall's *tau* = 0.582, $p<0.001$). Mandarin duck densities in the dam lakes were also affected by the decrease in the water level (Kruskal-Wallis test, H =7.46, $p<0.05$). Overhanging branches and dense vegetation along the shoreline provided with suitable resting cover and shelter for mandarin ducks. Receding water levels made resting cover unavailable by exposing these sites. The most notable response to a decline in water level was to move into sites with abundant cover such as those found in pools of the inflow rivers. Since it is practically impossible to maintain constant water levels in dam lakes, we suggest that small adjacent impoundments with sufficient cover should be built to attract mandarin ducks to artificial reservoirs.

5) Activity patterns of mallards at the Hattabara dam lake, varied among the months, apparently in response to declining water levels and human disturbances. Mallards spent 67.9, 15.9 and 14.8% of the time for resting, preening, and locomoting. Less than1% of the time was spent for each of feeding, alert, agonistic and courtship activities. Resting was the primary activity of mallards throughout winter. Resting was highest ($p<0.05$) during the mid day and evening, locomotion and courtship was highest during morning ($p<0.05$). Mallards used a site near the dam for resting during the day, which was off limits to boaters and sport fisherman. During the night, they used the shallow areas for feeding, which were inaccessible during the daytime due to human disturbances. The water level decreased sharply from December to January and the shallow feeding areas dried up. Mallards responded by leaving the dam lake at dusk to feed in the adjacent ponds that adjoined the main inflow river. 95% of the pond area was covered by 2-3 m tall common reeds (*Pharagmites australis*) and were inaccessible to the mallards. Appropriate management of the ponds may improve the chances for Hattabara dam lake being a rich habitat for waterfowl in the future.

CHAPTER IV　General Discussion

64 irrigation ponds were studied in the Saijo basin. Out of these, ponds in residential areas were small compared to ponds in forests. The ponds in the residential areas also had a higher rate of disturbances. Paradoxically migrating waterfowl of the Saijo basin preferred ponds that were situated in residential areas to ponds in forests. It is possible that waterfowl are capable of habituating to frequent and regular non-hunting disturbances, which helped them to occupy the ponds in residential areas. Hunting was the most critical factor on the distribution of waterfowl in Saijo basin. Potential risk of shooting caused waterfowl to forgo using the ponds in forests. Therefore, it would be extremely helpful to the migrating waterfowl if few ponds in the residential areas could be declared as restricted areas.

Water level fluctuation and shoreline covered by trees are the most important factors affecting the mandarin ducks in the artificial dam lakes. Ducks adapt in several ways to small changes in water level within the

natural fluctuation patterns of ponds, rivers and natural lakes (Markham 1982). However, they have difficulty in coping with large water level variations found in artificial reservoirs (Reitan and Sandvik 1996). Mandarin ducks have developed behavioural adaptations to cope with the water level fluctuations in dam lakes. For example, when the resting cover in dam lakes was rendered useless by decreasing water levels, the ducks moved to the inflow rivers. Small pools with overhanging branches provided the ducks with suitable resting sites. However, these sites were out of the protected areas and mandarin ducks always flew towards the dam lakes when disturbed. Since it is practically impossible to maintain constant water levels in dam lakes, we suggest building small adjacent impoundments with sufficient cover to attract mandarin ducks. The ponds of the Hattabara dam lake are covered with common reeds. Thus, most of the ponds are useless as feeding habitats to the mallards. Uprooting some of these plants would provide mallards with an important feeding area during the winter and would also be helpful in attracting large number of waterfowls.