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WATER LEVEL FLUCTUATION AND HABITAT USE PATTERN OF WINTERING WATERBIRDS IN THE JUNAM RESERVOIR AREA, SOUTH KOREA

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Abstract: Water level fluctuation and changes of wintering waterbird community at the Junam Reservoir areas (Junam Reservoir, Dongpan Reservoir, Samnam Reservoir) were investigated from October 2002 to March 2005. To analyse the relationship between water level fluctuation and habitat use pattern of waterbirds, the annual water level was measured at Dongpan Reservoir; and wintering waterbirds in the area were annually monitored. Most waterfowls (ca. 6000 individuals) utilized the Junam Reservoir for feeding and resting ground in the early winter (October to middle December). However, waterbirds moved to the Dongpan Reservoir since December, after the decrease of water level. During winter 2002/2003, a number of dabbling ducks (r^2 = 0.97), swans and geese (r^2 = 0.99), and shorebirds (r^2 = 0.95) had significant relationship with the decrease of water depth; while relationship with diving waterbirds (r^2 = 0.63) was relatively low. In 2003/2004 only swans and geese (r^2 = 0.90) were highly influenced by the water level, however other groups were not affected by water level changes because of relatively low fluctuation. In 2004/2005, diving waterbirds (r^2 = 0.62) and shorebirds (r^2 = 0.62) showed weak relationship with water depth. Relatively, the seasonal 2003/2004 and 2004/2005 did not have sufficient summer rainfall and also the regulation of water level was not good for sustainable waterbird habitats. To maintain the Dongpan Reservoir as a waterbirds wintering ground, not only systematic regulation of water level, in wintering season, but also the regulation of summer water level, is very important for food plant growth and animal food sources such as benthos and fish.

Keywords: Waterbird, Dabbling Duck, Shorebird, Water Level, Habitat Use Pattern, Junam Reservoir Area

INTRODUCTION

Wetlands are recognized as one of the most important ecosystems in the world (Mitsch & Gosselink 1993). They are one of the most productive ecosystems and support various biotic communities including diverse plants and animals that are adapted to shallow and often dynamic water regimes (Weller 1999). Wetlands are vital habitats for many waterbird species (Dugan 1990); and loss of these habitats generally increases waterbirds competitive interaction between individuals, mortality rate (Goss-Custard & West 1997) and severe consequences of their populations. Therefore, loss of wetlands has significantly increased the importance of those that remain to wetland-dependant organisms such as

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waterbirds (Taft *et al.* 2002). However, many wetlands around the world are slowly diminishing or under threat (Mitsch & Gosselink 1993; Davis & Hirji 2003), despite growing public demand for wildlife conservation and the ratification of the Ramsar Convention by many countries (Guillemain *et al.* 2002). There are few exact figures available on the extent of wetlands loss worldwide, although experts estimated that half of the world's wetlands have disappeared since 1990 (Munro & Holdgate 1991; Davis & Hirji 2003).

Fortunately, wetland restoration is carried out all around the world for different purposes such as habitat and species enhancement, water quality improvement, and environmental protection (Mitsch & Gosselink 1993). A number of restoration projects are focused on the goal of attracting diverse and abundant waterbird communities by providing a diversity of foraging habitats (Fredrickson & Reid 1986; Velasquez 1992; Laubhan & Fredrickson 1993; Reid 1993).

Korean peninsula is located in the middle of the East Asian-Australian Flyway. Accordingly, large area of the wetland is utilized as stopover and wintering site for waterbirds (Barter 2002). During the wintering season, Korean peninsula is an important waterfowl wintering ground. The birds usually breed in Russian Siberia, Mongolia and Northern China over winter in Korea from October to early March (Lee & Rhim 2002).

Until 1970s the lower part of the Nakdong River basin had well developed riverine wetlands in the waterside of main channel and its tributaries. However, large area of the wetlands vanished due to cultivation, embankment and other human activities. Consequently, about 90% of the total riverine wetlands loss occurred in the Nakdong River basin (Son & Jean 2003). Nevertheless, its estuary and several remaining inland wetlands are still the most important waterbirds wintering ground in the Korean peninsula (Cultural Heritage Administration 2001).

The Junam Reservoir Area (total area of three reservoirs, 602 ha) lies in the middle of the East Asian-Australian Flyway and is an important wintering ground for waterbirds. These reservoirs were constructed in 1920s to source water for nearby rice paddies. This area is used for an alternative habitat rather than Nakdong River Estuary and Woopo Wetland for waterbirds. Diverse waterfowls utilize the reservoirs as feeding and resting ground because of the shallow water depth (ca. 30~200 cm) with various water plants, fishes, invertebrates and relatively little human disturbances (Yoon & Kim 1989). According to the Biodiversity Management Plan, the Ministry of Environment has established two conservation methods for wintering waterbirds. The regulation of water level for supply of food to wintering waterfowls in the Dongpan Reservoir and the preparation of winter barley fields after rice harvest as a waterfowl food source were conducted for the better waterbirds habitat (Lee *et al.* 2006). However, consequences of water level management had not been evaluated, and there was no guideline for the regulation of water level and effect.

In this study, we evaluated the waterbird habitat use patterns at the Junam Reservoir Area. The relationship between water level regulation in Dongpan Reservoir and waterbird utilization were evaluated. The optimal water level management for maximizing utilization of waterbirds was proposed for the reservoir area.

MATERIALS AND METHOD

Study Area

Geographically, the study site is located in the middle of the East Asian-Australian Flyway (128° 40' E, 35° 18' N). The Junam Reservoir area consists of three separate reservoirs (Junam Reservoir, 285 ha; Dongpan Reservoir, 242 ha; Samnam Reservoir, 75 ha). Originally, these areas were formed after the glacial period, due to the accumulation of sediment caused by the rise in sea level (Kown 1976). Three reservoirs were constructed at a natural riverine marsh by installing dike for water supply to rice paddies in 1920s (Cultural Heritage Administration 2001), and the reservoirs are connected to the Nakdong River main channel through the Ju-chun stream (Fig. 1). Most of the lands around the reservoirs are used for rice and orchard cultivation. The depth of three subdivided reservoirs are very shallow (ca. 30~200 cm); and various water plants, fishes and invertebrates are found in the area (Yoon & Kim 1989; Hahm *et al.* 1999). In winter, a large number of waterbirds use this area as a feeding and roosting ground. Internationally important waterbirds such as White-naped Crane *Grus vipio* (30–70), Eurasian Spoonbill *Platalea leucorodia* (4–12), Baikal Teal *Anas formosa* (5,000–10,000) and Swan Goose *Anser cygnoides* (5–10) utilize this area (Cultural Heritage Administration 2001). Therefore, the Junam Reservoir area was designated as a Waterbird Conservation Area. However, the urbanization and shrinkage of rice paddies had an impact on the birds' habitats. Fortunately, various approaches for winter bird protection are currently implemented by the central and local government.

Data Collection and Field Survey

Air temperature data of the reservoir area was obtained from the Korea Meteorological Administration. Monitoring waterbird community was conducted at three subdivided reservoirs, biweekly from October 2002 to March 2005. Point count method (Bibby & Burgess 1992) was adopted at 10 sites. Waterbird observations were made with a zoom telescope (magnification ×25–×60, NIKON) and binoculars (10 × 42, SWAROVS KI).

Since 2001, the Ministry of Environment regulated the water level in Dongpan Reservoir during winter. Dongpan Reservoir water level was monitored in the three points (Fig. 1). We installed wooden ruler in the measure point and water level changes were measured biweekly simultaneously with waterbird monitoring.

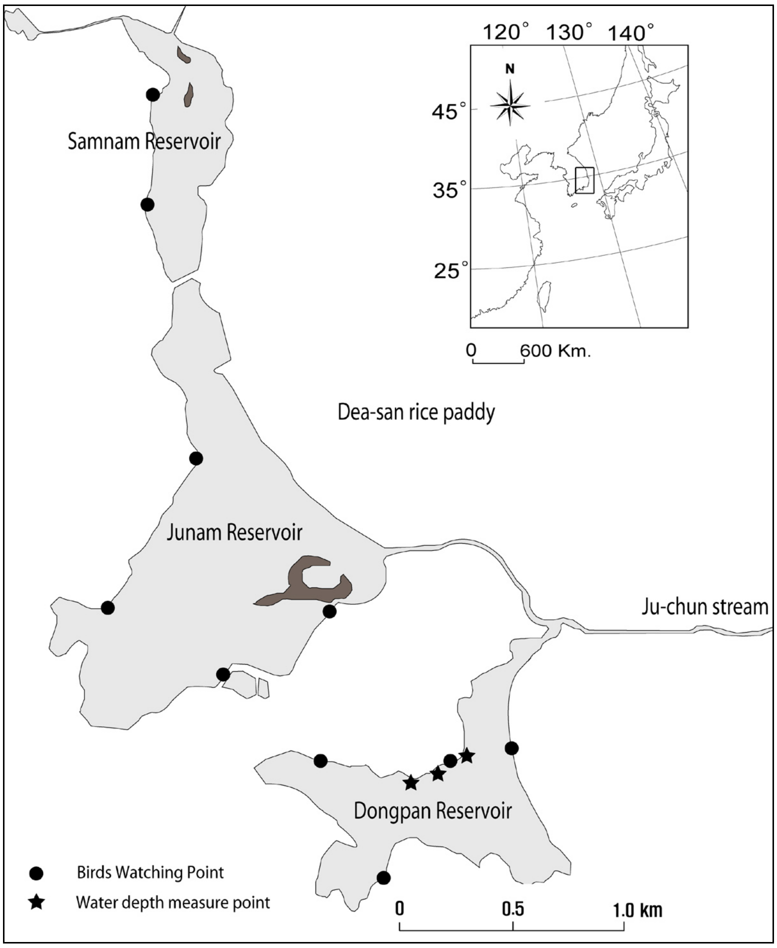


Figure 1: Junam Reservoir area and the location of study site (dark shaded area in Junam Reservoir is an island).

Classification of Waterbirds

We classified observed species into four behaviour-type groups as the following; swan and geese (large Anatidae species that require large habitat), dabbling duck (small or middle size of Anatidae species that require shallow wetland for feeding), diving waterbird (includes all kinds of waterbird species that can dive for feeding) and shorebird (wader species and are not good at swimming) (Table 1). In particular, we analysed the relationship between water level fluctuation and the habitat use of wintering birds in Dongpan Reservoir.

Table 1: Important species observed in Dongpan Reservoir and classification of foraging group.

Swan and geese	Dabbling duck	Diving waterbird	Shorebird
Whooper Swan *Cygnus cygnus*	Common Shelduck *Tardona tardona*	Great Cormorant *Phalacrocorax carbo*	Black-crowned Night Heron *Nycticorax nycticorax*
Tundra Swan *Cygnus columbianus*	Mallard *Anas platyrhynchos*	Little Grebe *Tachybaptus ruficollis*	Striated Heron *Butorides striatus*
Bean Goose *Anser fabalis*	Spot-billed Duck *Anas poecilorhyncha*	Pochard *Aythya ferina*	Cattle Egret *Bubulcus ibis*
White-fronted Goose *Anser albifrons*	Northern Shoveler *Anas clypeata*	Baer's pochard *Aythya baeri*	Great Egret *Egretta alba modesta*
	Common Teal *Anas crecca*	Tufted Duck *Aythya fuligula*	Little Egret *Egretta garzetta*
	Bikal Teal *Anas formosa*	Common Goldeneye *Bucephala clangula*	Grey Heron *Ardea cinerea*
	Falcated Teal *Anas falcata*	Smew *Mergus albellus*	Oriental White Stork *Ciconia boyciana*
	Garganey *Anas querquedula*	Moorhen *Gallinula chloropus*	Eurasian Spoonbill *Platalea leucorodia*
	Gadwal *Anas strepera*	Coot *Fulica atra*	Black-faced Spoonbill *Platalea minor*
	Eurasian Wigeon *Anas penelope*		
	Pintail *Anas acuta*		

RESULTS AND DISCUSSION

Weather

Inter-annual variation of monthly average air temperature at the study area showed slight difference, whereas monthly rainfall had high variation (Fig. 2). Air temperature in summer (June–August) was high (20–26°C) and mild (10–4°C) in winter (November–January). In winter 2002/2003 particularly from October to January, relatively low air temperature persisted compared with other wintering seasons. During the study period, rainfall was concentrated from April to September in each year. The highest rainfall was observed in August 2002 with more than 700 mm [Fig. 2(B), arrow]. In Korea, more than 50% of rainfall concentrated during summer with monsoon and 3~5 typhoons (Park *et al.* 2002).

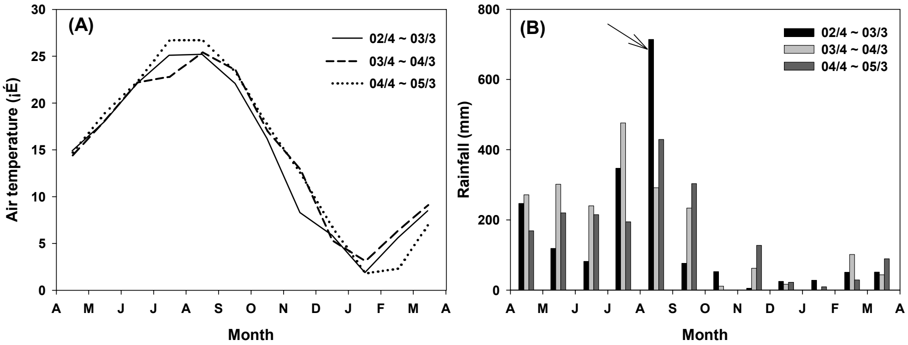


Figure 2: Air temperature (A) and rainfall (B) at the Junam Reservoir area from April 2002 to March 2005 (arrow, high rainfall).

Water Level Fluctuation and Waterbird Changes in Junam Reservoir Area

Water level fluctuations in Junam and Sannam Reservoirs were low, while large variation was observed in Dongpan Reservoir during the study period [Fig. 3(A)]. Every year, two occasions of entire water drain-off were occurred at the Dongpan Reservoir. The first was observed from June to August 2003 and the second was from June to November 2004 [Fig. 3(A), shadow area]. During winter 2002/2003, water level was maintained about 100 cm depth until mid-December. The impoundment was drained for the food supply of waterbirds from mid-December 2002 to January 2003. From February 2003, water level increased rapidly. In April, another drainage was observed because of water supply for rice paddies. From late August 2003, water level recovered rapidly up to 60 cm and was maintained for two months. From mid-November 2003 to mid-January 2004, winter dry-off was observed again. From April 2004 compared to the previous year, water level declined very rapidly and a very large exposure of the bottom could be found. The reservoir bottom was exposed for five months, from July to November 2004. Water level increased again from December to the next April.

In the Junam Reservoir area, the number of waterbirds was significantly different seasonally [Fig. 3(B)]. During wintering season, more than 6000 individuals of waterbird utilized the area for feeding and roosting, even though there was slight inter-annual variation. In 2002/2003 wintering season, the highest number of wintering birds was counted (ca. 13000) in early January 2003. Total wintering waterbirds were 5000~8000 individuals in 2003/2004, and the abundance decreased in 2004/2005. The high variation of abundance in 2002/2003 would be due to the assemblage of Bikal Teal *Anas formosa* (ca. 5500 individuals). Total wintering waterbirds decreased significantly from March in every year due to the northern migration of wintering birds.

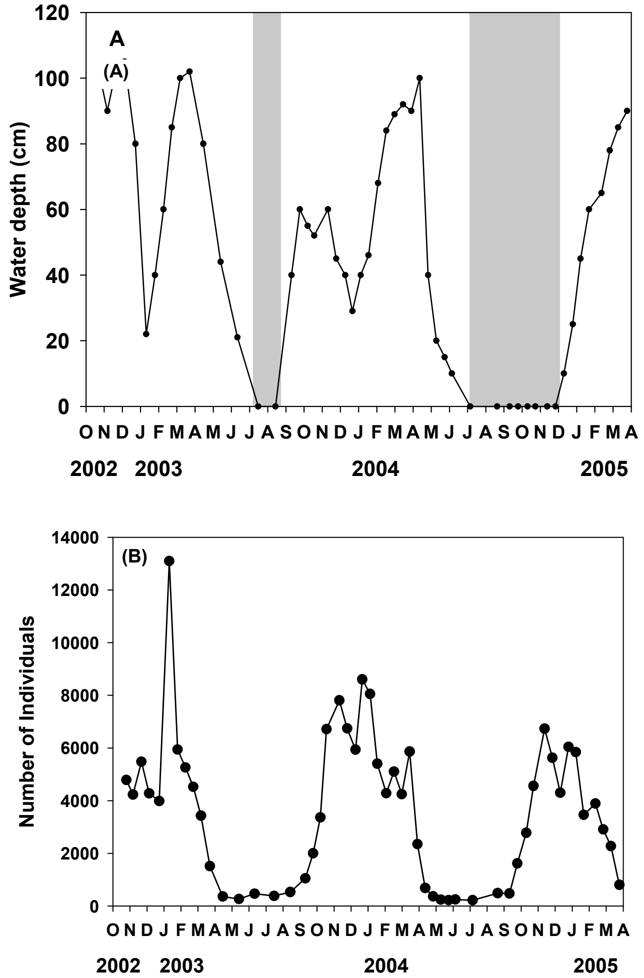


Figure 3: Water level fluctuation (A) at Dongpan Reservoir and seasonal changes of waterbird (B) in Junam Reservoir area from October 2002 to March 2005 (shadow period, exposure of reservoir bottom).

Waterbird Population in Three Reservoirs

There were different patterns in habitat occupancy by the waterbirds in the three reservoirs. The most dynamic changes of waterbirds were found at Dongpan Reservoir (Fig. 4). In this reservoir, wintering population significantly increased according to the water level decrease after late December 2002. The waterbird abundance increased at the Dongpan Reservoir with the decrease of waterbirds in the Junam Reservoir. Waterbird population at the Samnam Reservoir was relatively stable compared to the other two reservoirs. Similar pattern of distribution was observed during the 2003/2004 wintering season, and the inter-annual variation of the waterbirds distribution at the Junam Reservoir was small. However, wintering population of 2004/2005 at the Dongpan Reservoir was small compared to the past two winters (Fig. 4).

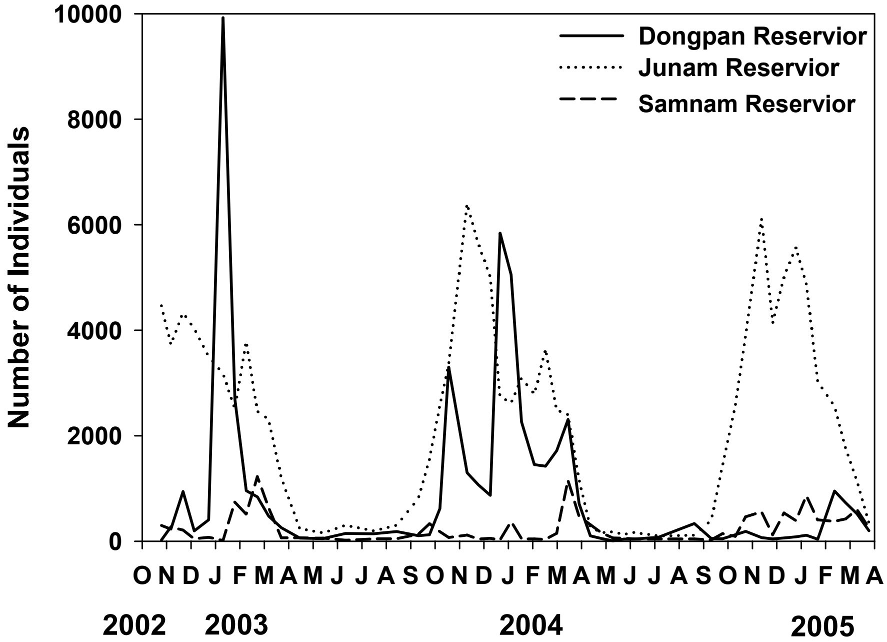


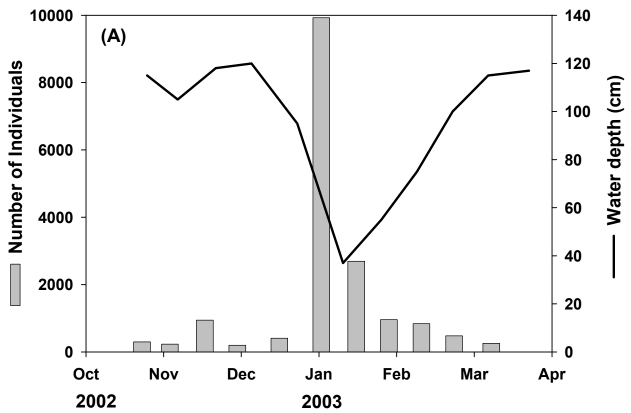
Figure 4: Seasonal changes in waterbird abundance at each reservoir from October 2002 to March 2005 in Junam Reservoir area.

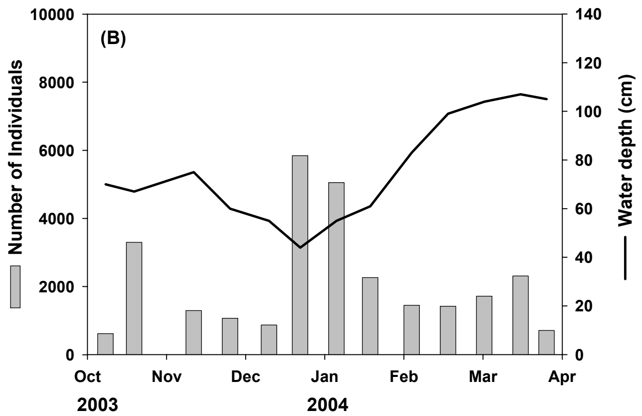
Water Level and Wintering Waterbirds in Dongpan Reservoir

Waterbirds habitat utilization was significantly influenced by the fluctuation of water level in the Dongpan Reservoir during the three wintering seasons (Fig. 5). During wintering seasons in 2002/2003 and 2003/2004, water level was controlled. In 2002/2003 wintering season, water level was maintained at 100–120 cm in the early winter. When the water in the reservoir was drained out, waterbird population increased very rapidly at 405–9924 individuals in December 2002 and January 2003. After mid-January 2003, the water level started to increase for water supply of rice field, and waterbird population decreased obviously [Fig. 5(A)].

During 2003/2004 wintering season, the water level was sustained below 70 cm from October 2003 to late January 2004. In this period, more than 1000 individuals were observed compared to 2002/2003 wintering season. After November 2003, the water level decreased gradually, whereby the depth reached about 50 cm; waterbird population increased up to 6000 individuals [Fig. 5(B)].

In 2004/2005 wintering season, water level fluctuation showed significant difference from those of 2002/2003 and 2003/2004. From June to late November 2004, bottom of the Dongpan Reservoir was exposed to the air due to the prolonged drought [Fig. 3(A)], and the water level increased from December 2004 when the reservoir gate was closed. In contrast to 2002/2003 and 2003/2004, only a small number of waterbirds utilized the Dongpan Reservoir although gradual increase of water level in this reservoir. After February 2005, slight increase of the waterbirds was observed due to the appearance of diving waterbirds [Fig. 5(C)].





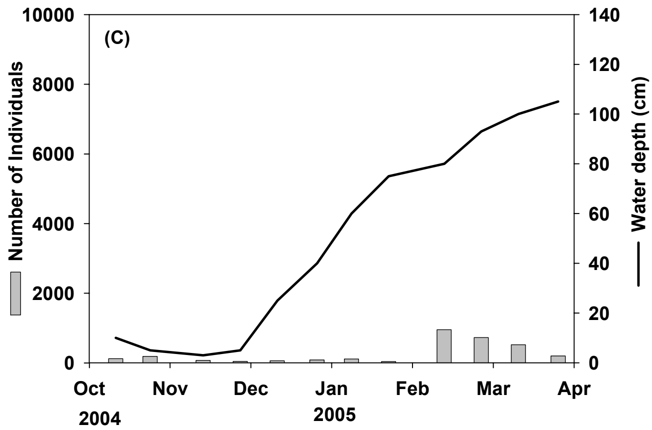


Figure 5: Water level fluctuation and changes in wintering population at Dongpan Reservoir during the wintering season (A, 2002/2003; B, 2003/2004; C, 2004/2005).

Water level is one of the most important factor for various kind of wetland wildlifes. Waterbirds rely on water regime and they can select habitat by migrant waterbirds during the non-breeding season for availability of food, safe roosting sites and the degree of disturbance (Ens *et al.* 1994; Piersma 1994). They also respond quickly to declines in water level, this includes many shorebirds (e.g. stilts, sandpipers and plovers), dabbling ducks, egrets and herons (Weller 1999). Besides the size of a wetland, (Baldassarre & Bolen 1994; Hoyer & Canfield 1994; Suter 1994), trophic status and/or shallowness are also major factors influencing waterbird richness and abundance (Colwell & Taft 2000). Therefore, the concentration of dabbling duck, geese and swan in the Dongpan Reservoir during the low water level period had obvious link to water level for abundant food sources. In this wintering season, most waterbirds in the reservoir showed foraging activity. However, in summer 2004, high air temperature was maintained compared to the other two years [Fig. 2(A)]. The high air temperature not only influenced the evaporation of the reservoir water but also water supply to the adjacent rice fields. Summer rainfall (839 mm) in 2004 was much less than 2002 and 2003 (1143 and 1008 mm, respectively) [Fig. 2(B)]. The bottom of Dongpan Reservoir was exposed to the air about six months during the 2004 summer and fall (Fig. 3). Various kind of waterbird food sources such as aquatic plants, benthos and fishes were completely eliminated due to the lack of water.

Water Level and Four Waterbird Groups in Dongpan Reservoir

The relationship between four waterbird groups and water level fluctuation in Dongpan Reservoir showed different variation in each wintering season. Dabbling duck, swan and geese preferred the low water level, whereas diving waterbirds were abundant in higher water level (Fig. 6).

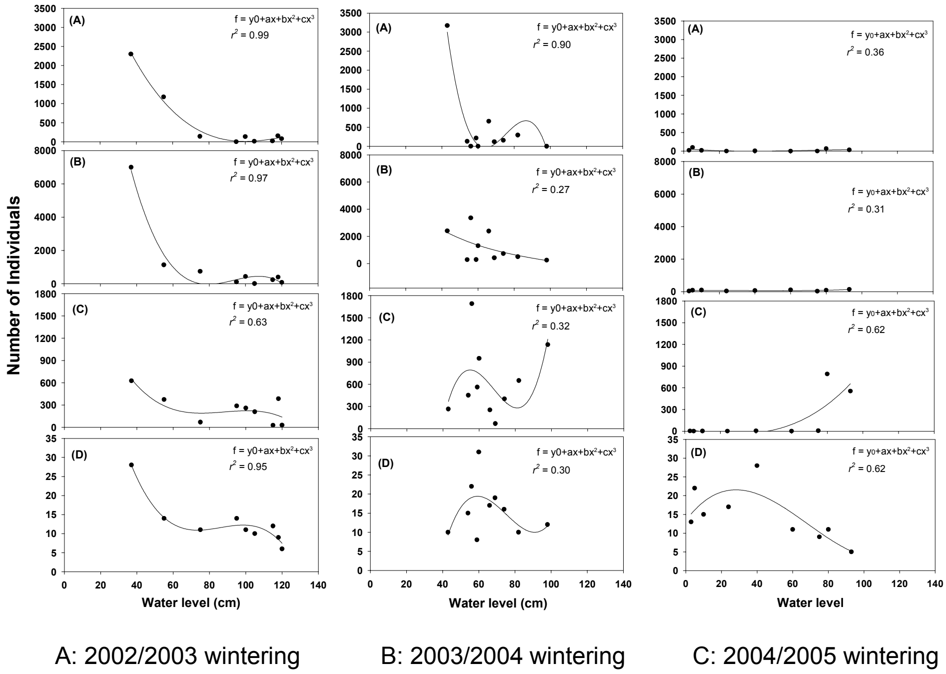


Figure 6: Water level fluctuation and habitat use of four waterbird groups in Dongpan Reservoir. (A) swan and geese, (B) dabbling duck, (C) diving waterbird and (D) shorebird.

During the 2002/2003 wintering season, water level had significantly influenced swan and geese (r^2 = 0.99), dabbling ducks (r^2 = 0.97), and shorebirds (r^2 = 0.95). In this wintering season, about 2400 individuals of swan and geese concentrated in the Dongpan Reservoir during the low water level period (ca. 40 cm). Large number of dabbling ducks (ca. 7000) utilized the reservoir during the low water level, and Baikal Teal *Anas formosa* occupied about 70% of the total of dabbling ducks [Fig. 6(A–B)]. Diving waterbirds showed weak relationship between water level and population (r^2 = 0.63) than other waterbird groups, and this waterbird group prefers a wider range of water level [Fig. 6(A–C)]. Only small number of shorebirds used this reservoir during the winter season. In 2003/2004 wintering season, water level fluctuation was much lower than other winters. Only swans and geese were significantly affected by the fluctuating water level (r^2 = 0.90). Most of the dabbling ducks utilized the reservoir when the water level was about 40–70 cm. Diving waterbirds and shorebirds did not show a significant relationship to water level change [Fig. 6(B)]. In the 2004/2005 wintering season, diving waterbirds and shorebirds showed slight influence by water level; whereas dabbling ducks, swans and geese were not influenced by water level [Fig. 6(C)].

Wetland-dependant waterbirds such as Podicipediformes, Ciconiiformes, Anseriformes and Charadriiformes need proper water level. For managed wetlands, the most important goals are attracting diverse and abundant waterbird communities by providing a diversity of foraging habitats (Velasquez 1992; Reid 1993). However for waterbirds, access to these resources is constrained by water depth (Elphick & Oring 1998; Isola *et al*. 2000) and depths required for foraging vary widely among species (Taft *et al.* 2002). Consequently, the manipulation of wetland's water depth can be a valuable tool in providing habitat for multiple species of waterbirds. Large number of dabbling duck, swan, geese and shorebird used the Dongpan Reservoir habitat as feeding ground during the low water level (30–40 cm) in the wintering season [Fig. 6(A)]. Large waterbirds such as swans and geese used the area mainly as feeding ground where the water level is deeper than 40 cm [Fig. 6(B)]. Generally, diving waterbirds feed in deeper water depth than dabbling ducks (Taft *et al.* 2002). In this reservoir diving waterbirds were not impacted by water level than dabbling duck, swan and geese [Fig. 6(A & B)]. For management of waterbirds, the distribution and abundance of resources such as seeds, tubers and invertebrates are critical to this end (Krapu & Reinecke 1992; Davis & Smith 1998; Sanders 2000). In Dongpan Reservoir, the proper regulation of water level during summer is one of the most important tools for supporting food sources. Therefore, 2004/2005 winter water level regulation was not important for waterbirds.

Many animal populations are limited by their food supply, and their distribution is often influenced by food abundance (Newton 1980; Ntiamoa-Baidu *et al.* 1998; Krebs 2001). In the Dongpan Reservoir, water level regulation is a very important issue for waterbirds' feeding and roosting. Firstly, the minimum water level (20–40 cm) should be maintained during the plant growing season (summer) as a provision of food source, such as benthos and fish, for waterbirds in the reservoir. Secondly, in order to make the three reservoirs as the possible alternative habitats and to keep sustainable wintering ground, the water level should be decreased gradually during wintering season (December–February) to maintain the food sources for wintering birds.

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