SPECIES COMPOSITION AND THE EFFECTS OF WATER LEVEL FLUCTUATION ON WATERBIRD POPULATION AT INMAGYI WETLAND IN MYINMU TOWNSHIP, SAGAING REGION

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Abstract

The species composition and the effects of water level fluctuation on waterbird population was determined by using fixed radius point count method at Inmagyi Wetland in Myinmu Township, Sagaing Region. A total of 31 waterbird species belonging to 27 genera, 12 families and seven orders were recorded in study areas. The study was conducted from July 2016 to June 2017. Out of 31 species, 19 species were residents and 12 species were winter visitors. Three globally Near Threatened species, Spot-billed Pelican *Pelecanus philippensis*, Painted Stork *Mycteria leucocephala* and Black-headed Ibis *Threskiornis melanocephalus* were observed during the study period. The study area was divided into two habitats, that is, marshy swamp and open water body to study the effects of water level fluctuation on waterbird population. The result of the Pearson's test indicated that negative correlation ($r = -0.171$) was observed between water level and waterbird population in marshy swamp habitats and almost no correlation ($r = 0.005$) was observed in open water body habitat. However the population of waterbirds in marshy swamp were significantly different from open water body. This study revealed that Inmagyi Wetland has habitat heterogeneity and seasonal fluctuation of water level that had attracted residents and winter visitors of waterbird species to perform various activities such as feeding, roosting and breeding.

Keywords: Water level, Waterbirds, Wetlands, Marshy swamp, Open water body

Introduction

Wetlands are fringe habitats between terrestrial and aquatic ecosystems (Beury *et al*., 2008). Wetlands are highly important habitat for

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diverse fauna including mammals, birds, fishes, reptiles, amphibians, and aquatic invertebrates (Nelson *et al*., 2000).

Wetland is defined as area of marshes, fen, peat land and water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including areas of marine water where the depth of water at low tide does not exceed six meter. Wetlands are major breeding, nesting, and migration staging areas for waterfowls and shorebirds (Ramsar convention, 2010).

"Waterbirds" refers to the bird species that entirely depend on wetlands for a variety of activites such as foraging, nesting, loafing, and moulting. Moreover, the term waterbird is used to refer to birds that live on or around water. Some water birds are more terrestrial or aquatic than others and their adaptations include webbed feet, bills and legs adapted to feed in water and the ability to dive from the surface or the air to catch prey in water (Rajpar and Zakaria, 2011).

Waterbirds not only constitute the most prominent group which attract people to wetlands, but also are good bioindicators and useful models for studying a variety of environmental problem (Urfi *et al*., 2005). The species richness and relative abundance of birds depend upon wetland characteristics such as size, water level, quality of water, availability and distribution of food resources, presence of suitable roosting and nursery sites (Wiens, 1989) (cited by Sharma and Manakshi, 2012).

Water level fluctuation in wetlands can be caused by seasonal flooding, tides, and agricultural irrigation or drawdown. The effect of water level fluctuation on water-birds varies among groups and seasons. Generally, water level fluctuation creates habitats with diverse water depths changing in time and space. This provides more foraging opportunities and consequently supports a high species richness and abundance of waterbirds. Water level

fluctuation, however, may create "ecological traps" and be detrimental for the breeding, brood-rearing, and molting of waterbirds (Kaminski *et al.,* 2006).

Inmagyi Wetland is the natural agricultural wetland and one of the flooded plain in Myinmu Township, Sagaing Region. The water level in the catchment area of Inmagyi Wetland peaked during the rainy season but the water level decreased gradually in cold season and the lowest water level occurred in the dry season. Thus the water level fluctuated greatly seasonally in Inmagyi Wetland. Rajpar and Zakaria (2011) indicated that the water level is a major factor that influenced the waterbird species composition and relative abundance directly and indirectly. This study investigates the species composition and the effects of water level fluctuation on waterbird population at Inmagyi wetland.

Materials and Methods

Study Area and Study Sites

Inmagyi Wetland is located in Myinmu Township, Sagaing Region and situated between 21° 50' 48.85" and 21° 52' 36.81" N, and 95° 26' 48.25" to 95° 27' 53.83"E (Plate 1). The total surface area of Inmagyi Wetland is about (8.64) km^2, one of the flooded plains directly connected with the Ayeyarwady River. The water depth of Inmagyi Wetland is approximately 5 m in the rainy season and reduces with a water depth about 1 m in the dry season. The study area embodied two major aquatic habitats based on the fluctuation of water level namely, (i) marshy swamp and (ii) open water body (Plate 2).

Study period

Field surveys were conducted at Inmagyi Wetland from July 2016 to June 2017.

Field Technique

The field survey was conducted twice a month. Birds were observed by using a binocular. The bird photos were taken with digital camera. Bird watching was undertaken two times during the period from 6:30 am to 10:30 am in the morning and from 3:30 pm to 5:30 pm in the evening. Bird watching and counting were carried out using a boat and also walking along marshy swamp. Bird census was made by using point count method (Hutto *et al.*, 1986). Twenty four point count stations at 200 m interval apart from each other were established in marshy swamp (12 stations) and open water body (12 stations).

Foraging Behaviour

Foraging behaviour of the waterbird species was recorded on direct observations during every field surveys. The waterbirds were grouped based on foraging behaviour and habitats use such as 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) according to Chan-Woo *et al.* (2006), and based on visual observations.

Water Level

The changes of water level in two habitats were measured by measuring tape with a heavy sinker attached and biweekly measurements were simultaneously taken at six sampling points. The water level was recorded in feet and inches, later on, were converted into meter scale.

Identification and classification

Identification of the bird species was made according to King and Dickinson (1975), Smythies (2001) and Robson (2015). Birds were listed in the classification systems proposed by Bird Life international checklist Version 8 (2015).

Analysis of data

The effects of water level fluctuation on waterbirds population were determined by direct observation. In addition, the correlation between water level and waterbird population was determined using Pearson's correlation coefficient in order to understand the effects of water level on waterbirds population.

Pearson Correlation

$$\mathbf{r} = \frac{\sum(\mathbf{X}-\bar{\mathbf{X}})(\mathbf{Y}-\bar{\mathbf{Y}})}{\sqrt{[\sum(\mathbf{X}-\bar{\mathbf{X}})^2][\sum(\mathbf{Y}-\bar{\mathbf{Y}})^2]}}$$

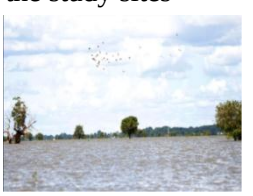
Comparison using ***t***-test to determine the significant difference of waterbird population between the two habitats (Zar, 2010).

$$t = \frac{(\bar{x}_1-\bar{x}_2)}{\sqrt{\left[\frac{(n_1-1)s_1^2+(n_2-1)s_2^2}{(n_1+n_2-2)}\right]\left(\frac{n_1+n_2}{n_1 n_2}\right)}}$$

(Source: Google Earth, 2016)

Plate 1. Location map of the study sites

A. Marshy Swamp Area



B. Open Water Body

Plate 2. Different habitats in the study

Results

A total number of 10,729 waterbird individuals accounted from 31 species, 27 genera, 12 families and seven orders were recorded from the two habitats, namely marshy swamp and open water body at Inmagyi Wetland. All the 31 species were recorded in the marshy swamp area and in which, 22 species included in open water body (Table 1).

Species Composition of Orders and Families in the Study Area

The seven orders of waterbirds were recorded in Inmagyi Wetland such as Anserifromes, Podicipediformes, Gruiformes, Ciconiiformes, Pelecaniformes, Suliformes and Charadriiformes throughout the study period. The four families were included in Charadriiformes, three families in Pelecaniformes, and one family in Anseriformes, Podicipediformes, Gruiformes, Ciconiiformes and Suliformes. Maximum number of species were observed in family Ardeidae (eight) followed by Charadriidae (four), Anatidae and Scolopacidae (three in each), Podicipedidae, Rallidae, Cioniidae, Threskiornithidae and Phalacrocoracidae (two in each) and Pelecanidae, Recurivirostridae and Jacanidae (one in each) (Table 1).

During the study period, the highest composition of species was found in order Pelecaniformes (35.48%), followed by Charadriiformes (29.03%), Anseriformes (9.68%), Podicipediformes, Gruiformes, Ciconiiformes and Suliformes (6.45%) (Figure. 1).

Out of the 31 species recorded, 19 species were residents and 12 species were winter visitors. A total of 19 species were found in all study sites. Spot-billed Pelican *Pelecanus philippensis*, Painted Stork *Mycteria leucocephala* and Black-headed Ibis *Threskiornis melanocephalus* happened to be Near Threatened species according to IUCN Red List (2015) (Table 1).

Foraging groups of waterbirds

The highest number of individuals recorded was shorebirds (7662 birds) followed by diving birds (1570 birds) and in dabbling ducks (1497 birds) in both study habitats (Table 2).

In marshy swamp area, 22 species were shore birds (Sb), six species were diving birds (Di) and three species dabbling duck (Db) according to foraging behavior of waterbirds. The highest number of individuals recorded also happened to be shorebirds (6719 birds) followed by dabbling ducks (903 birds) and in diving birds (363 birds) (Table 2, Fig. 2). However, in the open water body, only 22 species were recorded, including 13 species of shore birds (Sb), six species of diving birds (Di) and three species of dabbling duck (Db). The highest number of individuals recorded were diving birds (1207 birds) followed by shorebirds (943 birds) and dabbling ducks (594 birds) (Table 2, Fig. 3).

Water Level

The water level in the marshy swamp habitat varied due to the variation in the amount of rainfall and the entry of water from the catchment area of Inmagyi Wetland. The highest water level recorded was (1.829 m) in July 2016 and the lowest (0.025 m) in May 2017. In open water body, the highest water level 4.572 m was recorded in July 2016 and the lowest water level 0.305 m was observed in May 2017 due to low rainfall (Table 3).

Correlation between Water Level and Waterbird Population

The results of Pearson's test revealed negative correlation between water level and waterbird individuals in marshy swamp habitat ($r = -0.171$) and no correlation ($r = 0.005$) in open water body habitat.

Relationship between the Monthly Mean Water Level and the Number of Waterbirds in Marshy Swamp and Open Water Body

Lower population of waterbirds was found in July, August and September when the water level higher. The higher population of waterbirds were found in October, November, December and January with lower water level (Fig. 4 and 5)

According to ***t*-**test, the population of waterbirds between marshy swamp and open water area was significantly different. Thus the highest waterbird population was observed in marshy swamp area than the open water area (Table 4).

Table 1. Status of the waterbird species recorded at Inmagyi Wetland

Order	Scientific name	Common name	IUCN Redlist	Status
Anseriformormes	**Anatidae**			
	Dendrocygna javanica	Lesser Whistling-duck	LC	R
	Tadorna ferruginea	Ruddy Shelduck	LC	WV
	Anas poecilorhyncha	Indian Spot-billed Duck	LC	R
Podicipediformes	**Podicipedidae**			
	Tachybaptus ruficollis	Little Grebe	LC	R
	Podiceps cristatus	Great Crested Grebe	LC	R
Gruiformes	**Rallidae**			
	Amaurornis phoenicurus	White-breasted Waterhen	LC	R
	Fulica atra	Common Coot	LC	WV
Ciconiiformes	**Ciconiidae**			
	Mycteria leucocephala	Painted Stork	NT	WV
	Anastomus oscitans	Asian Openbill	LC	WV
Pelecaniformes	**Threskiornithidae**			
	Threskiornis melanocephalus	Black-headed Ibis	NT	WV
	Plegadis falcinellus	Glossy Ibis	LC	WV
	Ardeidae			
	Nycticorax nycticorax	Black-crowned Night-heron	LC	R
	Ardeola grayii	Indian Pond-heron	LC	R
	Ardeola bacchus	Chinese Pond-heron	LC	R
	Bubulcus ibis	Cattle Egret	LC	R
	Ardea cinerea	Grey Heron	LC	R
	Ardea alba	Great White Egret	LC	R
	Ardea intermedia	Intermediate Egret	LC	R
	Egretta garzetta	Little Egret	LC	R
	Pelecanidae			

Order	Scientific name	Common name	IUCN Redlist	Status
Suliformes	*Pelecanus philippensis*	Spot-billed Pelican	NT	R
	Phalacrocoracidae			
	Microcarbo niger	Little Cormorant	LC	R
	Phalacrocorax carbo	Great Cormorant	LC	R
Charadriiformes	**Recurvirostridae**			
	Himantopus himantopus	Black-winged Stilt	LC	WV
	Charadriidae			
	Pluvialis fulva	Pacific Golden Plover	LC	WV
	Charadrius dubius	Little Ringed Plover	LC	WV
	Vanellus cinereus	Grey-headed Lapwing	LC	R
	Vanellus indicus	Red-wattled Lapwing	LC	R
	Jacanidae			
	Hydrophasianus chirurgus	Pheasant-tailed Jacana	LC	R
	Scolopacidae			
	Gallinago gallinago	Common Snipe	LC	WV
	Actitis hypoleucos	Common Sandpiper	LC	WV
	Tringa glareola	Wood Sandpiper	LC	WV

Table 2. Individuals of foraging groups of waterbird recorded at Inmagyi Wetland

Foraging group	Scientific name	No. of individuals		
		Open Water	Marsh Swamp	Total
Dabbling Ducks	*Dendrocygna javanica*	287	216	503
	Tadorna ferruginea	73	357	430
	Anas poecilorhyncha	234	330	564
		594	**903**	**1497**
Diving waterbirds	*Tachybaptus ruficollis*	31	18	49
	Podiceps cristatus	12	2	14
	Pelecanus philippensis	6	3	9
	Microcarbo niger	1014	270	1284
	Phalacrocorax carbo	41	25	66
	Fulica atra	103	45	148
		1207	**363**	**1570**
Shorebirds	*Mycteria leucocephala*	22	283	305
	Anastomus oscitans	96	1235	1331
	Threskiornis melanocephalus	75	627	702
	Plegadis falcinellus	0	685	685
	Nycticorax nycticorax	118	482	600

Foraging group	Scientific name	No. of individuals		
		Open Water	Marsh Swamp	Total
	Ardeola grayii	37	81	118
	Ardeola bacchus	42	63	105
	Bubulcus ibis	77	979	1056
	Ardea cinerea	44	63	107
	Ardea alba	56	134	190
	Ardea intermedia	38	74	112
	Egretta garzetta	170	232	402
	Himantopus himantopus	0	373	373
	Pluvialis fulva	0	79	79
	Charadrius dubius	0	181	181
	Vanellus cinereus	94	203	297
	Vanellus indicus	74	168	242
	Hydrophasianus chirurgus	0	104	104
	Gallinago gallinago	0	198	198
	Actitis hypoleucos	0	202	202
	Tringa glareola	0	149	149
	Amaurornis phoenicurus	0	124	124
		943	**6719**	**7662**

Table 3. Monthly water level (m) of the two study sites at Inmagyi Wetland

Months	Marsh Swamp			Open Water Body		
	Minimum water level (m)	Maximum water level (m)	Mean water level (m) (Mean ± SD)	Minimum water level (m)	Maximum water level (m)	Mean water level (m) (Mean ± SD)
July, 2016	1.219	1.829	1.448 ± 0.231	1.981	4.572	3.226 ± 1.031
August, 2016	0.914	1.676	1.168 ± 0.284	1.829	4.267	2.896 ± 0.978
September, 2016	0.610	1.524	0.991 ± 0.383	1.676	3.658	2.515 ± 0.816
October, 2016	0.305	1.372	0.686 ± 0.406	1.524	2.743	2.184 ± 0.559
November, 2016	0.152	0.914	0.457 ± 0.273	1.219	2.438	1.930 ± 0.498
December, 2016	0.127	0.610	0.326 ± 0.183	0.914	1.524	1.118 ± 0.249
January, 2017	0.102	0.457	0.220 ± 0.150	0.762	1.219	0.914 ± 0.161

Months	Marsh Swamp			Open Water Body		
	Minimum water level (m)	Maximum water level (m)	Mean water level (m) (Mean ± SD)	Minimum water level (m)	Maximum water level (m)	Mean water level (m) (Mean ± SD)
February, 2017	0.089	0.305	0.171 ± 0.088	0.610	0.914	0.754 ± 0.099
March, 2017	0.076	0.203	0.135 ± 0.047	0.508	0.762	0.669 ± 0.109
April, 2017	0.051	0.076	0.064 ± 0.014	0.457	0.610	0.533± 0.083
May, 2017	0.025	0.051	0.030 ± 0.010	0.305	0.457	0.432 ± 0.062
June, 2017	0.152	0.457	0.254 ± 0.124	0.610	1.372	1.041 ± 0.280

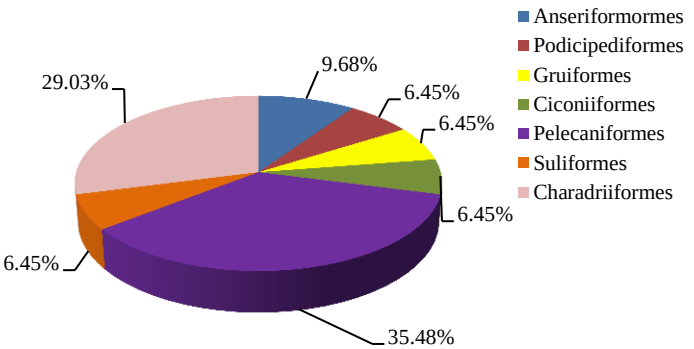


Figure 1. Species composition of waterbird species in different orders at Inmagyi

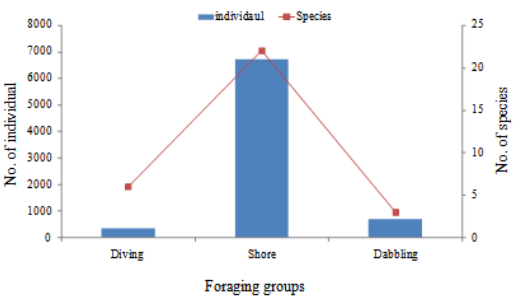


Figure 2. Comparison on the foraging groups of waterbird species and individual in Marshy Swamp at Inmagyi Wetland

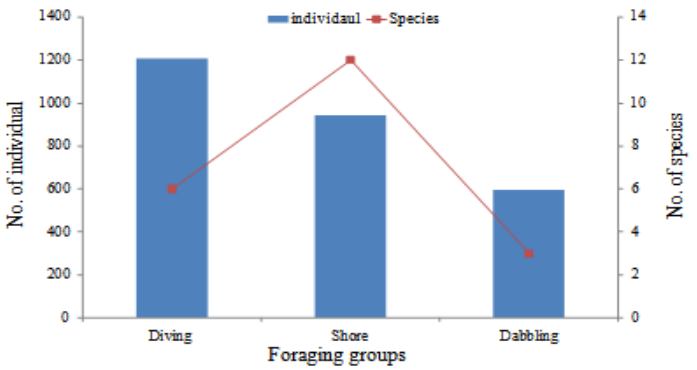


Figure 3. Comparison on the foraging groups of waterbird species and individual in Open water body at Inmagyi Wetland

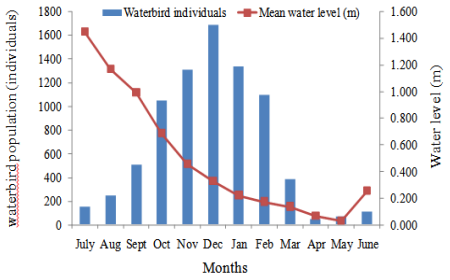


Figure 4. Relationship between the monthly mean water level and the number of waterbird individuals in Marshy Swamp at Inmagyi Wetland

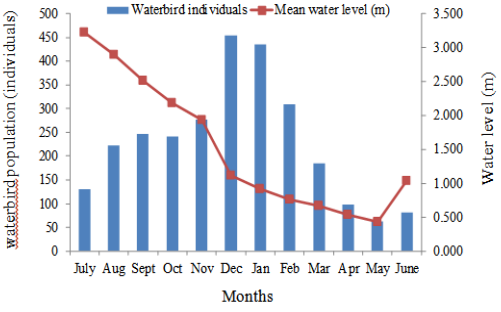


Figure 5. Relationship between the monthly mean water level and the number of waterbird individuals in Open Water Body at Inmagyi Wetland

Discussion

The water level of Inmagyi Wetland is dependent upon incoming water resource and precipitation. In present study, two habitats were allocated namely marshy swamp and open water habitats to study the waterbirds that thrive in the wetland.

Ma *et al.* (2007) stated that the difference in bird composition was related to habitat preferences. In the present study, all the total of 31 species of waterbirds recorded were encountered in marshy swamp and only 22 species in open water habitat. Therefore, marshy swamp harboured more waterbird species compared to open water, and is alluded to the foraging habit and habitat preference of these waterbirds.

Desgranges *et al.* (2006) examined wetland birds' response to water level fluctuation and revealed that wetland bird species were significantly associated with hydrological context. In the present study, the highest population of waterbird were found in October, November, December and January with lower water level while the lower population of waterbird were found in July, August and September when the water level higher. It indicated that the population of water birds and water levels were inversely proportional in both habitats except in dry season.

Bitterns and herons also preferred scattered emergent vegetation especially along the water body edges for foraging (Rajpar and Zakaria, 2014). In the present study, gregarious shore bird species like Asian Openbill and Cattle Egret, Glossy Ibis and Black-headed Ibis were highest number of individuals and are therefore relatively abundant in marshy swamp area. These waterbirds were carnivorous species and depend on marshy swamp area (Mistry and Mukherjee, 2015). It may be suggested that the shallow water offers crucial foraging sites for wading birds such as herons, egrets and storks because obtaining food is easily accessible.

In the present study, diving and dabbling ducks were found in both marshy swamp and open water body. The diving waterbirds such as Little Grebe, Great Crested Grebe, Common Coot, Little Cormorant and Great Cormorant preferred open water habitat for foraging sites. Especially, Cormorant species were mostly roosted on the trees which were sparsely composed in open water. Chan-Woo *et al.* (2006) revealed that diving birds were abundant in higher water level. Diving waterbirds feed in deeper water depth than other waterbirds. Saygili *et al.* (2011) reported that Cormorants, Grebe and Coots for feeding in open water, but mostly preferred the small "islands" in the lake.

Mortsch (1998) and Poiani *et al.* (1995) has reported that lower water level caused the changes in aquatic vegetation composition and structures and as a result, affected the grass and shrub communities. In the study period, the water level was gradually receded along the water body edges of Inmagyi Wetland to transform into marshy swamp, agricultural fields and small grasslands and shrubs appeared in these areas. The fluctuation in water level might alter the habitat characteristic that could cause prompt changes in fishes, amphibians, invertebrates and waterbird communities. Therefore, it indicated that the changes of water level influence the physical structure of habitat, the availability and accessibility of food and the presence of safe roosting or breeding sites for waterbirds.

Rajpar and Zakaria (2011) indicated that weak linear corelationship between water level and waterbird abundance in marshy swamp and negative linear correlation in open water body. Marshall (1997) also indicated that a negative relationship between lake water level and waterbird abundance, with highest waterbird numbers when water levels were lowest was found. In the present study, weak negative correlation was observed between the water level and population of waterbirds in marshy swamp and no correlation in open water habitats. It is assumed that this is due to the seasonal fluctuations of water level in both study habitats.

The results of ***t***-test revealed that, the population of waterbirds in marshy swamp was more significant difference than open water area. It may be suggested that shallow water area or marshy swamp area provided more food resources by the presence of fishes, amphibians, a variety of insects, invertebrate fauna and aquatic plants are the major component of waterbirds diet principally for cormorants, grebes, storks, ducks, plovers, sandpipers, stilts and egrets etc.

The present study indicated that the population of waterbirds was depended by their food supply and water level in habitat. The Inmagyi Wetland supports at least 12 migratory species of waterbirds and most of the shore birds used as foraging ground and breeding habitat in marshy swamp area. Therefore, the protection and monitoring of ecosystem of Inmagyi wetland should be carried out so as to control changes in the state of wetland especially on resident and migratory waterbird species.

Conclusion

The present study indicated that the marshy swamp habitat supported higher waterbird population as compared to open water body. The waterbird populations were directly influenced by the availability of foraging habitats and have preference to wetland habitat with surface water that supply suitable prey organisms for foraging. Therefore, the increase or decline of the waterbird species was found to be associated with the water level and the availability of the food resource changes in both marshy swamp and open water body habitats.

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