

# Wintering and migratory behaviour of Eurasian Bitterns *Botaurus stellaris* at Mai Po Nature Reserve, Hong Kong, China

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There is little documented information on the wintering and migratory behaviour of Eurasian Bittern *Botaurus stellaris* in East Asia. Surveys at Mai Po Nature Reserve, Hong Kong, China, between 2010 and 2012 have revealed new information on habitat use, social interactions and migratory habits of this species. Eurasian Bitterns appear to show a preference for roosting in wet *Phragmites* reedbeds, although during the day they forage in freshwater ponds with emergent vegetation dominated by *Schoenoplectus* club-rushes. Social interactions between Eurasian Bitterns were most regularly observed during March, in the period immediately prior to sunset and departure to roosting sites. Spring migration in Hong Kong peaks in the third week of March; migration is nocturnal in flocks of between 3–17 birds. Given the loss of wetland habitat throughout coastal and southern China, the wetland mosaic at Mai Po—in particular wet reedbeds and freshwater marsh with tall, emergent vegetation—offers a range of suitable habitats for wintering and migrant Eurasian Bitterns. These observations may be helpful to guide and enhance management techniques for wetlands elsewhere in East Asia to create a network of sites for this and other reedbed-dependent species.

## INTRODUCTION

Eurasian Bittern *Botaurus stellaris* is a migratory species in East Asia, with breeding populations in Russia, Mongolia and northern China wintering further south (Lansdown *et al.* 2000, Brazil 2009, Martínez-Vilalta *et al.* 2015). In Hong Kong, the species is an uncommon winter visitor and spring migrant found in larger reedbeds (Welch 2015). Globally, it is categorised Least Concern (BirdLife 2015); however in the east of its range, it is considered to have a conservation status of Regional Concern (Fellowes *et al.* 2002).

Whilst in Europe there are numerous accounts of the breeding and wintering behaviour of Eurasian Bitterns, together with their habitat and food preferences, there is very little published data on the species's behaviour in East Asia. In this paper our objective is to provide an overview of its wintering numbers and migratory behaviour at the most important site for the species in Hong Kong, describe the preferred foraging and roosting habitats, and give details of social interactions during spring migration.

### Distribution in East Asia

The breeding range in Asia extends from Central Asia to the far east of Russia, and includes north and north-east China and Japan (Brazil 1991, Lansdown *et al.* 2000, Brazil 2009, Martínez-Vilalta *et al.* 2015). In China, the Eurasian Bittern is known to breed in Xinjiang, Inner Mongolia and north-east provinces, wintering in western Xinjiang, south of the Yangtze River, and along the south China coast (Cheng 1987). It is nowhere common, but the increasing number of records from its wintering range suggests that populations are still fairly high (Lansdown *et al.* 2000). In Hong Kong, the number of records has steadily increased, probably as a result of increased observer effort (Welch 2015). Recent records have been from areas which support larger stands of reedbed, dominated by *Phragmites australis*, in the Deep Bay area—earliest autumn arrival date 12 September and latest spring departure date 16 May (Welch 2015). Historical records outside the Deep Bay area were generally between 15 March and 7 April when migratory behaviour was noted (Leader 1999), indicating that migrants also pass through Hong Kong (Carey *et al.* 2001). Cheng (1987) indicated that the species wintered along the length of the south China coast, although at the present time little suitable habitat remains there, particularly to the west of Hong Kong (J. Martinez pers. comm.).

To the west and south of Hong Kong, the Eurasian Bittern is a rare to scarce winter visitor in South-East Asia, including Thailand,

Myanmar and Cambodia, Laos and Vietnam (Wells 1999, Robson 2008, Martínez-Vilalta *et al.* 2015), and is considered to be a vagrant to Peninsular Malaysia, Singapore, Borneo and Philippines (Wells 1999, Kennedy *et al.* 2000, Robson 2008, Martínez-Vilalta *et al.* 2015). Little information is available about numbers and habitat use in its winter range.

## STUDY SITE

The study area was the Mai Po Nature Reserve (hereafter Mai Po), a 377 ha wetland (WWF-HK 2013) in the Mai Po Inner Deep Bay Ramsar Site, Hong Kong, China. The habitat in Mai Po is a mixture of impounded brackish water ponds, including traditionally managed shrimp ponds—locally called *gei wai*—and shallow freshwater ponds with islands and rain-fed ponds and marshes. It is located on the east side of the Ramsar Site (22.485°N 114.035°E) and has been managed by WWF-Hong Kong since 1983.

The site holds a number of reedbeds of differing sizes with a combined area of 29 ha (WWF-HK 2013), in addition to two other large areas of reedbeds in the Deep Bay area—about 48 ha at Nam Sang Wai and 11 ha at Lok Ma Chau (Arup 2013). These lie 1.5 km to the south and 4 km to the north-east of Mai Po respectively.

The main focus of this study was *Gei wai* 8, which lies on a north-west to south-east axis and is divided into two sections, *Gei wai* 8a to the south-east and *Gei wai* 8b to the north-west. *Gei wai* 8a is a rain-fed pond about 6 ha in area, including open water with bare islands and dense stands of emergent vegetation (up to 0.2 ha in area) along the western and northern sides. These stands of emergent vegetation are dominated by the club-rush *Schoenoplectus subulatus* but also contain other sedges, grasses and rushes. The water depth varies over the year, gradually falling during the dry season between October and April.

*Gei wai* 8b holds a 4.4 ha *Phragmites australis* reedbed, which is the largest continuous stand of reeds in Mai Po. The reedbed is divided by a vegetated bund, with one side operated as a wet reedbed (water depth about 15 cm during the dry season) and the other side as a dry reedbed (reedbed floor slightly above water level during the dry season). Water levels are controlled throughout the year by a sluice at the north end of the *gei wai* which allows water to be exchanged with intertidal estuarine water from the Inner Deep Bay. The area is not open to the public, although it is regularly visited as part of a constant-effort ringing study (WWF-HK & HKBRG 2008).

Surveys were also made at *Gei wai 23* at the south of Mai Po. This *gei wai* also holds an extensive *Phragmites australis* reedbed, most of which remains close to the water level throughout the year. The *gei wai* was operated as rain-fed at the time of the study, although occasionally with the addition of brackish water if the level dropped during the dry season. The climate of Hong Kong is distinctly monsoonal and despite its subtropical nature there are well-defined seasons associated with the cyclical advance and retreat of the East Asian monsoons (Carey *et al.* 2001). In winter, the continental high-pressure weather system over Siberia and Mongolia results in north or north-east winds that bring cool, dry air to Hong Kong (Dudgeon & Corlett 2004).

## METHODS

Five preliminary surveys were made in February and March 2010, followed by observations of roosting Eurasian Bitterns in two successive winter seasons 2010–11 and 2011–12. Since Eurasian Bitterns are winter visitors to Hong Kong, surveys were carried out at approximately 10-day intervals between 7 November and 19 April, covering the period during which the species is mostly seen at Mai Po. Additional observations of migratory behaviour were made during late March, a period when migrants have been recorded leaving Mai Po in earlier years. These observations of migrants were made only when weather conditions seemed suitable; evenings when windy or wet weather was likely to prevent migration were avoided.

Two surveyors positioned separately at *Gei wai 8* and *Gei wai 23* observed roosting behaviour simultaneously. Additional surveys of migratory behaviour in March were carried out by a single observer at *Gei wai 8* but otherwise followed the same methodology. Observations started 20 minutes before sunset, and continued until 15 minutes after sunset, by which time activity had usually ceased and it was often too dark to reliably observe birds. During each survey, the total number of birds, time of observation, direction of any movements and any evidence of roosting and/or migratory behaviour were recorded. Detailed notes on social interactions and behaviour were made from live observations and also from video recordings.

## RESULTS AND DISCUSSION

### Counts and numbers recorded

Between February 2010 and April 2012, 44 evening surveys were made with Eurasian Bitterns recorded in 24 of them (Table 1). During the first full winter season, none was seen in November 2010, with only one seen up to 7 December; contrasting with 2011, the second winter season, when up to eight individuals were regularly recorded during November and early December. In both seasons, there were few sightings in midwinter and it was not until late February or well into March before birds were recorded again. In the preliminary survey (spring 2010) and both main surveys (spring 2011 and spring 2012), peak numbers were recorded in the second half of March. A maximum count of 35 individuals was made on 19 March 2010, with 23 the high count for 2011 on 21 March and the 2012 high count of 12 on 20 March.

There was a significant difference in the number of records in autumn 2010 compared with 2011. The reason for this is not known, although the disturbance to the habitat caused by mechanical re-profiling of *Gei wai 8a* carried out during 2010 may have been a contributory factor. The peak in autumn records in November 2011 may have included a number of autumn migrants passing through Hong Kong; likewise, the peak in numbers observed during March was perhaps due to the arrival of spring passage migrants, or alternatively to a change in the species's behaviour prior to migration, making individuals easier to detect.

**Table 1.** Summary of Eurasian Bittern surveys between February 2010 and March 2012, showing dates and numbers observed.

Date	No.	Comments
Counts in pre-survey period		
24 February 2010	14	
2 March 2010	19	
15 March 2010	13	
19 March 2010	35	Migration noted
23 March 2010	23	
Counts in winter 2010–2011		
7 December 2010	1	
17 December 2010	3	
21 March 2011	23	Migration noted
3 April 2011	1	
Counts in winter 2011–2012		
7 November 2011	7	
15 November 2011	8	
19 November 2011	4	
22 November 2011	5	
29 November 2011	8	
7 December 2011	7	
12 December 2011	1	
22 December 2011	1	
2 January 2012	1	
9 January 2012	1	
31 January 2012	1	
27 February 2012	1	
13 March 2012	1	
20 March 2012	12	Migration noted
27 March 2012	10	
No. of days on which bitterns observed	24	
No Eurasian Bitterns were seen on the following 20 survey dates:		
Winter 2010–2011 (16 visits)		
10, 15 & 27 November; 29 December; 6, 16, 26 January; 5, 15, 25 February; 8, 16, 27, 31 March; 6, 19 April.		
Winter 2011–2012 (4 visits)		
9, 19 February, 7, 19 April		

It is not known whether individuals remain at Mai Po throughout the winter but are elusive and restrict their local movements, or whether the increase in sightings from late February is due to an influx of migrants from other parts of the wintering range. Leader (1999) suggested that both migrant and wintering Eurasian Bitterns occur during spring in Hong Kong. The present study also suggests that numbers in spring may be supplemented by migrants from other wintering grounds. However, information about other sites is scanty and there is a distinct lack of observations or records from more southerly areas. It should be noted that numbers of wintering Eurasian Bitterns at large wetland sites are often underestimated owing to the species's skulking nature and access difficulties for surveyors (Wotton *et al.* 2011), and there is also the probability that birds are less mobile or less obvious during the winter months. Although in Europe the species is known to become more obvious during harsh winter weather, particularly when freezing temperatures make food difficult to find in reedbeds, in Hong Kong temperatures do not fall so low and birds are therefore less likely to be forced into the open when searching for food.

### Habitat use

Birds were regularly observed during daytime and evening in the dense islands of emergent vegetation in *Gei wai 8a*. A maximum of 14 Eurasian Bitterns was recorded utilising this habitat on 24 February 2010. It was suspected that the birds were foraging and feeding in these dense club-rushes but this was never confirmed during the study.

Surveyors found that in the 20 minutes prior to sunset, the heads of Eurasian Bitterns slowly appeared above the vegetation

as the birds climbed up the stems and extended their necks so that the bill was pointing skywards, occasionally making definite head movements from side to side. Throughout surveys in the south of Mai Po, no Eurasian Bitterns were seen at dusk, despite the large area (about 7 ha) of largely dry *Phragmites* reedbed present there. The preferred habitat for night roosting was the wet reedbed of *Gei wai* 8b. A peak count of 15 birds roosting in the wet reedbed was made on 2 March 2010. Birds entered the roost between seven minutes before sunset and 18 minutes after sunset (mean = 7.21 minutes after sunset,  $\pm$  sd 7.35 minutes). Birds were silent as they moved into the reeds, although occasional calls were heard from within the reedbeds.

Although some authors report that feeding is often crepuscular or even nocturnal (Hancock & Kushlan 1984, Martínez-Vilalta *et al.* 2015), research from the UK suggests that feeding takes place during the day (Gilbert *et al.* 2005), and we assume that the habitats where Eurasian Bitterns were seen to appear after sunset were roosting sites. The majority of birds recorded coming to roost in *Gei wai* 8b arrived from the adjacent *Gei wai* 8a. During winter 2011–2012, fewer individuals were observed roosting in *Gei wai* 8b than in 2010–2011, with some remaining in *Gei wai* 8a. In 2010, *Gei wai* 8a was mechanically re-profiled and it is presumed that by 2011–2012 this habitat had matured to an extent that it was suitable for roosting—the tall vegetation there is now in standing water and structurally similar to the wet *Phragmites* reedbed in *Gei wai* 8b.

There is evidence to show that wintering Eurasian Bitterns save energy by not flying any further than necessary to feed (Harris 2006); birds feeding and roosting in *Gei wai* 8 demonstrated this behaviour. Harris (2006) also describes the use of wet reedbeds as communal roost sites to reduce the risk of predation; the tall stands of aquatic vegetation in the standing water of *Gei wai* 8a and 8b were presumably performing this function.

Flattened areas of *Phragmites* were observed in the wet reedbed, with body feathers found floating in the water underneath them (Plate 2), at locations where Eurasian Bitterns had been observed departing at sunrise, confirming overnight roosting. Flattening of vegetation by roosting wintering birds has been described in detail by Harris (2006).

### Spring migration

Definite nocturnal migration was observed on three dates during the survey period: 19 March 2010, 21 March 2011 and 20 March 2012 when groups of between 3–17 birds (mean flock size 13 birds) departed—flying northwards—minutes after sunset, on calm, warm evenings. Migration was observed on evenings which were clear, calm and warm, suggesting these weather conditions are conducive for departing Eurasian Bitterns. Although the species is solitary throughout the year (Martínez-Vilalta *et al.* 2015) it is known to travel in small flocks when on migration (Dement'ev & Gladkov 1968, Leader 1999, Carey *et al.* 2001). Twenty-four Eurasian Bitterns were recorded on 2 April 2005 at Nandagang, a coastal site on the Bohai Sea (COS 2005), some 1,800 km north of Hong Kong; although it is not known whether they actually migrated as a flock, it does indicate that during migration high numbers can be observed at a single site, and the date of this observation accords well with the dates of migration in Hong Kong.

Visible migration was preceded, shortly after sunset, by small flocks flying and calling at varying heights up to about 200 m above the *gei wai* and making wide circles up to about 1,000 m. These contact calls are discussed in depth elsewhere (Dement'ev & Gladkov 1968, Voisin 1991, Leader 1999, Brazil 2009) and are frequently referred to as 'gull-calling' (S. Wotton pers. comm.). In Hong Kong these calls are reminiscent of Black-crowned Night Herons *Nycticorax nycticorax*. Other individuals or small groups would then join the circling flock. The largest circling flock recorded was 20 birds, but not all of them departed northwards. Birds circled for

up to 12 minutes when part of the group broke away and departed, still calling, in a northerly direction. The remaining birds continued circling, before dropping back to the *gei wai*. These pre-migration flights are similar to those described as territorial circle flights late in the breeding season (Hancock & Kushlan 1984, Kushlan 2011).

It appeared that the species may also make a nocturnal passage on southbound autumn migration; the only record of an incoming Eurasian Bittern—on 11 November 2011—saw a single bird arrive high from the north, before purposefully dropping into *Gei wai* 8b within an hour of sunrise. Although not conclusive, it provides possible insight into the autumn migration of this species. Single birds have also been observed in November flying high over the reserve and calling, similar to the behaviour observed in spring (DS pers. obs.), although migrant flocks have not been recorded at Mai Po in autumn.

Nocturnal migration is not uncommon in ardeids (Voisin 1991, Martínez-Vilalta *et al.* 2015) and other species in Hong Kong that migrate overnight include Grey Heron *Ardea cinerea* (Stanton 2015), Yellow Bittern *Ixobrychus sinensis* (DS pers. obs.) and Schrenck's Bittern *Ixobrychus eurhythmus* (JAA pers. obs.). Diurnal migration by Eurasian Bitterns has also been recorded (Martínez-Vilalta *et al.* 2015), although usually during periods of dull or poor weather (Dement'ev & Gladkov 1968, Leader 1999).

Eurasian Bitterns usually departed from Hong Kong at dusk as a single species flock. On one occasion, however, five birds migrating north in a loose flock were joined by two Grey Herons that stayed with the group until it was out of sight.

### Social interactions

Social interactions between Eurasian Bitterns were most regularly observed during March, in the period immediately prior to sunset, the time of year when the species became more visible, either due to behavioural changes or increased numbers, than in midwinter.

Birds assumed an upright posture either at water level or 'perched' in the vegetation; the heads of several Eurasian Bitterns could be seen above the tops of the emergent vegetation (Plate 3) in the ten minutes before and after sunset. Individuals would occasionally tilt the head from side to side, giving the impression of observing their surroundings. Kushlan (2011) suggested this posture may allow the scanning of a larger feeding area. From time to time, birds fluffed up neck feathers and swayed their neck from side to side. Hancock & Kushlan (1984) describe this neck-fluffing as part of ardeid courtship display; but here it appeared to be an antagonistic display, given the proximity of other birds and the distance from the breeding grounds. This posture also is described in herons as a threat posture when the feathers are slightly erected, although when combined with neck swaying it may simply be to increase camouflage (Kushlan 2011). Fluffing of the neck was occasionally combined with wing-flapping and aggressive behaviour—erection of the crest and arching of the neck—towards other Eurasian Bitterns and larger waterbirds including Grey Heron and Oriental Stork *Ciconia boyciana*. Neck-fluffing and aggressive behaviour towards a smaller Little Egret *Egretta garzetta* is shown in Plate 4. Eurasian Bitterns, although tolerant of other Eurasian Bitterns when roosting communally (Harris 2006), have been known to defend their foraging territory vigorously (Kushlan & Hancock 2005, Harris 2006). This aggressive behaviour was not as demonstrative as that described by Voisin (1991), but Leader (1999) discussed the contradictory nature of the literature regarding social behaviour of Eurasian Bitterns. Most observers state that Eurasian Bitterns are a solitary, or essentially solitary, species (Voisin 1991, Martínez-Vilalta *et al.* 2015). The observations made during this study go to further strengthen the case that, at least in south China, Eurasian Bitterns do exhibit social interactions outside the breeding season and display a certain amount of tolerance to other individuals in relatively close proximity.

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**Plate 1.** Wet reedbed in *Gei wai 8b* favoured by roosting Eurasian Bittern *Botaurus stellaris*, 22 November 2011.

### Importance of Mai Po Nature Reserve and implications for management

These notes review the habitat preferences of wintering and migrating Eurasian Bitterns at Mai Po. The species is threatened mainly by the loss of *Phragmites* reed marshes, including the loss of coastal reedbeds owing to rising sea levels and the increasing frequency of extreme weather (Gilbert *et al.* 2010, BirdLife International 2015). And throughout East Asia, coastal habitats are under widespread pressure from development and reclamation (Stanton & Allcock 2011, Choi *et al.* 2012, Melville *et al.* 2013). Although Eurasian Bitterns are known to utilise other freshwater habitats, particularly on migration (Bibby 1981, Voisin 1991, Carey *et al.* 2001, Longoni *et al.* 2011, Martínez-Vilalta *et al.* 2015), given the paucity of any other suitable habitat along the south China coast, the wet reedbed and marsh areas in Mai Po are considered to be of regional significance as a wintering and migration site for this species. Although well-studied in Europe, an understanding of the species's habitat requirements in Hong Kong would help inform management of the site to benefit the species.

Based on observations of birds entering roosts at *Gei wai 8*, it appears that the presence of suitable emergent vegetation in shallow water is a requirement for the species. Although Eurasian Bitterns were recorded entering roosts in both *Phragmites* reeds and *Schoenoplectus* club-rushes at *Gei wai 8*, none was observed gathering to roost in drier areas of reedbed there, nor in the dry reedbed at *Gei wai 23*. This suggests that the presence of water underneath the roost site was more important than the plant species present. It is possible that this reduces the risk of predation by land-based predators, particularly mammals—at Mai Po the most likely predators are domestic dogs *Canis familiaris* and Leopard Cat *Prionailurus bengalensis*.

Eurasian Bitterns are often considered to prefer the presence of *Phragmites* reedbeds. At Mai Po, the species did appear to show some preference for this habitat as a roosting site, but most birds seen before entering roosts were using the stands of *Schoenoplectus* club-rushes in *Gei wai 8a*, and birds were often observed roosting in *Schoenoplectus* stands despite the presence of *Phragmites* nearby. *Schoenoplectus* shows some similarity to *Phragmites*, with strong vertical stems that can be manipulated to form a platform on which to roost, and it may also provide suitable conditions for Eurasian Bitterns, although this does not necessarily mean that the bitterns would use the site in the absence of extensive reedbeds. Wet reedbeds and *Schoenoplectus* are also important to Eurasian Bitterns for foraging. The fact that birds were present in the stands of emergent vegetation in *Gei wai 8a* suggests that this may be a particularly suitable habitat for foraging, particularly in the weeks prior to and during spring migration. Eurasian Bitterns are known



**Plate 2.** Eurasian Bittern roost. Note the bent *Phragmites* stems in the centre of the picture, 22 November 2011.

**Plate 3.** The head of Eurasian Bittern can be seen above the tops of the emergent vegetation, 24 December 2010.



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**Plate 4.** Neck-fluffing and aggressive behaviour is shown against a smaller Little Egret *Egretta garzetta*, 23 February 2014.



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to use stands of both *Phragmites* and *Schoenoplectus* throughout the day at Mai Po (DS pers. obs.), suggesting that both habitats provide suitable conditions for foraging. The structure of these two species may provide Eurasian Bitterns with suitable cover from potential predators, including the terrestrial ones mentioned above as well as potential aerial species such as Greater Spotted Eagle *Clanga clanga*, Eastern Imperial Eagle *Aquila heliaca* and Bonelli's Eagle *A. fasciata*.

Eurasian Bitterns are fairly eclectic and flexible in their choice of food, which is predominantly fish, amphibians and insects, but also small birds and mammals (Cramp & Simmons 1977). It has been suggested in other parts of the species's range that management of fish stocks (in all life stages) within wetlands is important for conservation of Eurasian Bitterns (Noble *et al.* 2004, Gilbert *et al.* 2007, Gurney 2007). Shrimps are also present in brackish *gei wai* and may provide food for the species. Management of fish at Mai Po includes removal of predatory species, notably snakehead *Channa* sp. in brackish *gei wai* to minimise predation of shrimps. The ecology of fishes and shrimps in the *gei wai* at Mai Po is poorly known at present (WWF-HK 2013), although fish diversity is dominated by tilapia *Oreochromis mossambicus* and *O. niloticus*, Grey Mullet *Mugil cephalus*, Spotted Snakehead *C. maculata* and Mosquito Fish *Gambusia affinis*; further study is warranted. In order to understand the ecology and habitat requirements of Eurasian Bitterns at Mai Po, it would be useful to know not only which species are present in the *gei wai* but also how their distribution varies with water depth, vegetation and salinity. Such information would also potentially benefit the management of the site for other threatened species such as Eurasian Otter *Lutra lutra* and Japanese Eel *Anguilla japonica*.

In the last decade the quality of reedbeds, particularly wet reedbeds, at Mai Po has declined as a result of natural succession and the colonisation by non-reed vegetation, particularly the climbers *Paederia scandens* and *Gymnanthera oblonga* and Mangrove Fern *Acrostichum aureum*, driven by siltation. The degradation of habitat through seral succession and inappropriate management has been cited elsewhere as a threat and limiting factor to Eurasian Bittern numbers in wetland sites (Newbery *et al.* 1999). Such decline in reedbed quality may impact the population of Eurasian Bitterns reliant on Mai Po as a wintering site or as a migration stopover. One of the objectives of the recent Mai Po Management Plan (WWF-HK 2013) is to enhance the condition of reedbeds on site by restoration of wet reedbeds. Based on the observations in this study, it is expected that these measures should benefit the species and it is hoped that these notes will help to guide management of other suitable wetland habitats in the wintering range of the Eurasian Bittern in China and East Asia. Given the wetland habitat loss throughout coastal and south China, the wetland mosaic at Mai Po offers a range of suitable habitats for wintering and migrant Eurasian Bitterns. Lessons learned from these observations could be applied to other managed wetlands elsewhere in East Asia to create a network of sites for this and other reedbed-dependent species.

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## REFERENCES

- Arup (2013) Agreement No. CE 53/2008 (CE). Planning and engineering study on development of Lok Ma Chau Loop – investigation. Environmental Impact Assessment Report to the Hong Kong S.A.R.
- Bibby, C. J. (1981) Wintering bitterns in Britain. *British Birds* 74: 1–10.
- BirdLife International (2015) Species factsheet: *Botaurus stellaris*. Downloaded from <http://www.birdlife.org> on 27/02/2015.
- Brazil, M. A. (1991) *The birds of Japan*. London: Christopher Helm.
- Brazil, M. (2009) *Birds of East Asia*. London: Christopher Helm.
- Carey, G. J., Chalmers, M. L., Diskin, D. A., Kennerley, P. R., Leven, M. R., Lewthwaite, R. W., Melville, D. S., Turnbull, M. & Young, L. (2001) *The avifauna of Hong Kong*. Hong Kong: Hong Kong Bird Watching Society.
- Cheng T. H. (1987) *A synopsis of the avifauna of China*. Beijing: Science Press.
- COS (2005) *China bird report 2004*. Beijing: China Ornithological Society.
- Choi C.-Y., Bai Q.-Q. & Chen Y. (2012) Southward migration phenology and impacts of aquaculture on shorebirds at the Dandong Yalu Jiang Estuarine Wetland National Nature Reserve, Liaoning, China. Oriental Bird Club conservation grant No. P956. Unpublished final report.
- Cramp, S. & Simmons, K. E. L., eds. (1977) *The birds of the western Palearctic*, 1. Oxford: Oxford University Press.
- Dement'ev, G. P. & Gladkov, N. A., eds. (1968) *Birds of the Soviet Union*. 2. Jerusalem: Israel Programme for Scientific Translation.
- Dudgeon, D. & Corlett, R. (2004) *The ecology and biodiversity of Hong Kong*. Hong Kong: Friends of the Country Park.
- Fellowes, J. R., Lau M. W. N., Dudgeon, D., Reels, G. T., Ades, G. W. J., Carey, G. J., Chan B. P. L., Kendrick, R. C., Lee K. S., Leven, M. R., Wilson, K. D. P & Yu Y. T. (2002) Wild animals to watch: terrestrial and freshwater fauna of conservation concern in Hong Kong. *Mem. Hong Kong Nat. Hist. Soc.* 25: 123–160.
- Gilbert, G., Tyler, G. & Smith, K. W. (2005) Behaviour, home-range size and habitat use by male Great Bittern *Botaurus stellaris* in Britain. *Ibis* 147: 533–543.
- Gilbert, G., Tyler, G. A., Dunn, C. J., Ratcliffe, N. & Smith, K. W. (2007) The influence of habitat management on the breeding success of the Bittern *Botaurus stellaris* in Britain. *Ibis* 149: 53–66.
- Gilbert, G., Brown, A. F. & Wotton, S. R. (2010) Current dynamics and predicted vulnerability to sea-level rise of a threatened Bittern *Botaurus stellaris* population. *Ibis* 152: 580–589.
- Gurney, M. (2007) Introduction of rudd *Scardinius erythrophthalmus* as food for bitterns *Botaurus stellaris* at Titchwell Marsh RSPB reserve, Norfolk, England. *Conserv. Evidence* 4: 4–5.
- Hancock, J. & Kushlan, J. (1984) *The herons handbook*. London & Sydney: Croom Helm.
- Harris, A. (2006) Roosting behaviour of wintering Eurasian Bitterns in the Lee Valley. *British Birds* 99: 174–182.
- Kennedy, R., Gonzales, P. C., Dickinson, E.C., Miranda, H. C. & Fisher, T. H. (2000) *A guide to the birds of the Philippines*. Oxford: Oxford University Press.
- Kushlan, J. A. (2011) The terminology of courtship, nesting, feeding and maintenance in herons. Available at [www.HeronConservation.org](http://www.HeronConservation.org).
- Kushlan, J. A. & Hancock, J. A. (2005) *The herons*. Oxford: Oxford University Press.
- Lansdown, R. V., Mundkur, T. & Young, L. (2000) Herons in east and southeast Asia. Pp.73–98 in J. A. Kushlan & H. Hafner, eds. *Heron conservation*. San Diego: Academic Press.
- Leader, P. J. (1999) Social and migratory behaviour in Eurasian Bittern. In: G. J. Carey, & S. L. Tai, eds. *Hong Kong Bird Report 1997*. Hong Kong: The Hong Kong Birdwatching Society.
- Longoni, V., Rubolini, D., Ambrosini, R. & Bogliani, G. (2011) Habitat preferences of Eurasian Bittern *Botaurus stellaris* booming in ricefields: implications for management. *Ibis* 153: 695–706.
- Martínez-Vilalta, A., Motis, A. & Kirwan, G. M. (2015). Eurasian Bittern (*Botaurus stellaris*). In J. del Hoyo, A. Elliott, J. Sargatal, D. A. Christie & E. de Juana, eds. *Handbook of the birds of the world alive*. Barcelona: Lynx Edicions. (retrieved from <http://www.hbw.com/node/52730> on 16/03/2015).
- Melville, D. S., Gerasimov, Y. N., Moores, N., Yu Y.-T. & Bai Q.-Q. (2013) Conservation assessment of Far Eastern Oystercatcher *Haematopus [Ostralegus] osculans*. *Internatn. Wader Studies* 20: 129–154.

- Newbery, P., Schäffer, N. & Smith, K. (1999) European Union Action Plans for 8 Priority Birds Species – Bittern. Downloaded from [http://ec.europa.eu/environment/nature/conservation/wildbirds/action\\_plans/docs/botaurus\\_stellaris.pdf](http://ec.europa.eu/environment/nature/conservation/wildbirds/action_plans/docs/botaurus_stellaris.pdf) on 10/06/2015.
- Noble, R. A. A., Harvey, J. P. & Cowx, I. G. (2004) Can management of freshwater fish populations be used to protect and enhance the conservation status of a rare, fish-eating bird, the bittern, *Botaurus stellaris*, in the UK? *Fish Manag. Ecol.* 11: 29.
- Robson, C. (2008) *A field guide to the birds of South-East Asia*. London: New Holland.
- Stanton, D. J. (2015) Flock size and nocturnal migration in Grey Herons *Ardea cinerea* at Mai Po Nature Reserve, Hong Kong. In J. Allcock, G. Chow & G. Welch, eds. *Hong Kong bird report 2013*. Hong Kong: Hong Kong Birdwatching Society.
- Stanton, D. J. & Allcock, J. A. (2011) Habitat characteristics and odonate communities at selected sites used by *Mortonagrion hirosei* Asahina (Zygoptera: Coenagrionidae) in Hong Kong. *J. Threatened Taxa* 3: 2242–2252.
- Voisin, C. (1991) *The herons of Europe*. London: Poyser.
- Welch, G. (2015) Systematic list in J. Allcock, G. Chow & G. Welch, eds. *Hong Kong bird report 2013*. Hong Kong: Hong Kong Birdwatching Society.
- Wells, D. R. (1999) *The birds of the Thai-Malay Peninsula*, 1. London: Academic Press.
- Wotton, S., Grantham, M., Moran, N. & Gilbert, G. (2011) Eurasian Bittern distribution and abundance in the UK during 2009/10 winter. *British Birds* 104: 636–641.
- WWF-HK (2013) *Mai Po Nature Reserve habitat management, monitoring and research plan: 2013–2018*. Hong Kong: World Wide Fund for Nature Hong Kong.
- WWF-HK & HKBRG (2008) Study into the avian value of different aged stands of *Phragmites australis* at Mai Po Nature Reserve. Joint report by the World Wide Fund for Nature Hong Kong and the Hong Kong Bird Ringing Group.
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