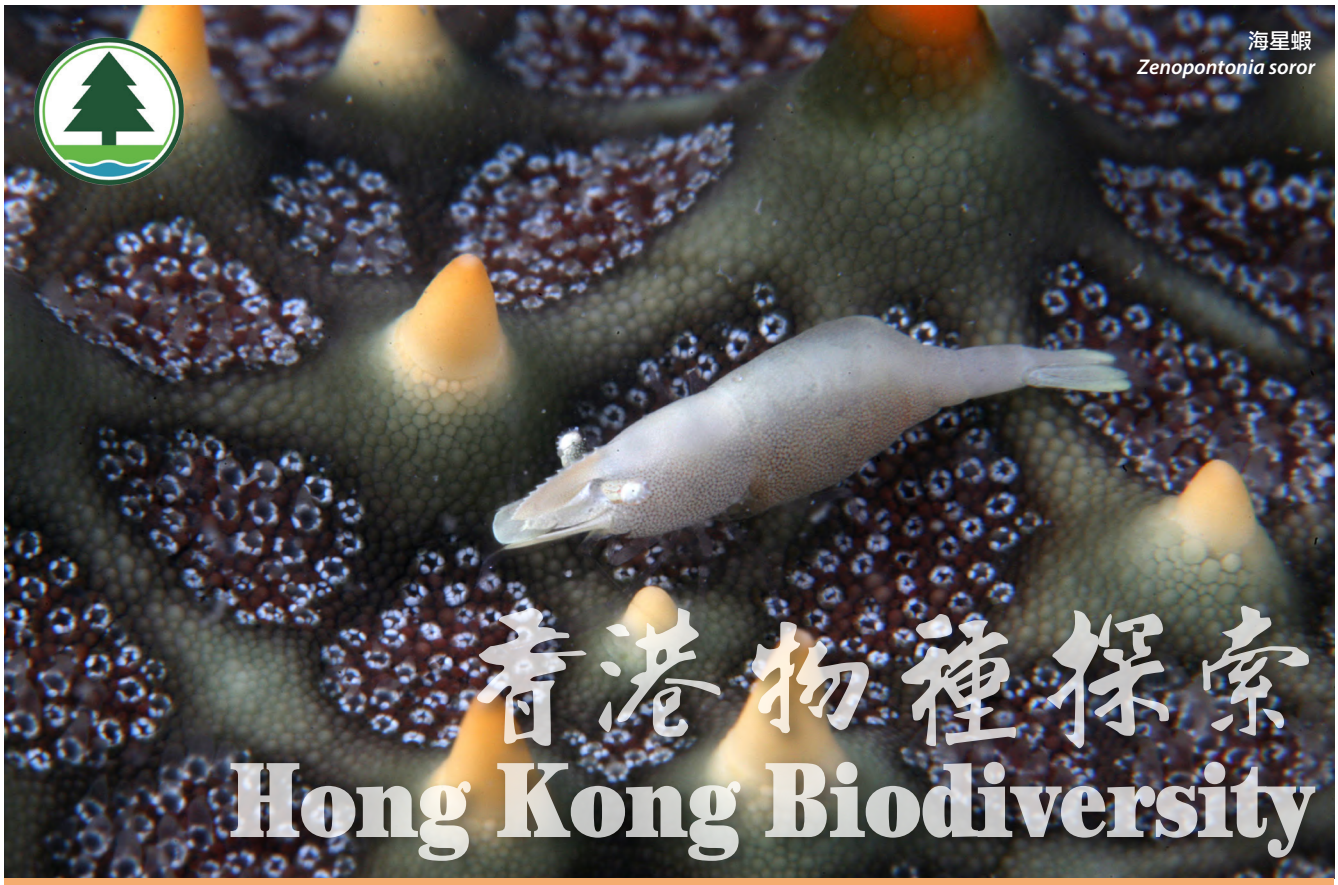

香港物種探索
Hong Kong Biodiversity

Agriculture, Fisheries and Conservation Department Newsletter

Issue No. 26 December 2020

www.hkbiodiversity.net

From the Editor

Time flies. Since the publication of the previous issue of this *Newsletter* in 2018, we have published species action plans for Incense Tree and Chinese Pangolin, updated species checklists for major groups of terrestrial and freshwater species, and formulated a risk assessment protocol for invasive alien species. Numerous experts on different taxa are striving to push ahead the laborious task of assessing the local status of species: scrutinising what we know and (more often) do not know about these species. All these work involved experts within AFCD and in other organisations. Over the past years, local researchers had also initiated dozens of projects related to biodiversity, with the support of the Environment and Conservation Fund and other funding agencies. One can learn about these encouraging developments that keep the momentum of Hong Kong's BSAP going, at the following website: www.afcd.gov.hk/bsap (see "Implementation"). While this *Newsletter* remains the channel to disseminate new findings on local wildlife by AFCD, we are developing an information hub to facilitate the sharing of biodiversity knowledge and expertise accumulated through the years. None of these would have been possible without the concerted efforts of the wider conservation community.

Jackie YIP

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Feature Article

Territory-wide Study on Roosting Sites of Ardeids in Winter 2019/20

Ivy W.Y. So and Sylvia N.F. Yuen
Bird Working Group

漁農自然護理署於2019-20年冬季進行了全港鷺鳥棲息地調查，調查覆蓋58個地點，共記錄得26個棲息地，並於各個棲息地分別錄得12至584隻鷺鳥棲息，而鷺鳥的品種數目則由1至6種不等。本文分析了鷺鳥棲息地的現況，並與以往比較，作為未來香港鷺鳥保育的參考。

Introduction

Ardeids are a major group of waterbirds in Hong Kong and are found in different kinds of wetlands e.g. marsh, farmland, fishpond, mangrove and other coastal habitats. Eighteen species of ardeids (including egrets, herons and bitterns) have been recorded in Hong Kong. A total peak count of over 3,500 egrets and herons were recorded at Deep Bay in winter 2019/20 (Anon. 2020a). Meanwhile, a total of 1,633 nests of colonial-nesting ardeids were counted at 22 egretries in summer 2019 in Hong Kong (Anon. 2020b).

Some species of ardeids, including Great Egret (*Ardea alba* 大白鷺), Little Egret (*Egretta garzetta* 小白鷺), Black-crowned Night Heron (*Nycticorax nycticorax* 夜鷺), Chinese Pond Heron (*Ardeola bacchus* 池鷺) and Eastern Cattle Egret (*Bubulcus coromandus* 牛背鷺), can be found in Hong Kong throughout the year and form communal roosts at night (or day for Black-crowned Night Heron). A smaller number of other ardeid species, including Grey Heron (*Ardea cinerea* 蒼鷺) and Intermediate Egret (*Ardea intermedia* 中白鷺), can sometimes be found at these communal roosts.

Systematic studies on night roosts of ardeids in Hong Kong are scarce. Lee et al. (2004) first reported 15 night roosts of ardeids in winter 2002/03. Mott MacDonald (2010) revisited some of the night roosts in winter 2008/09 and monitored the one at Wong Chuk Hang nullah from 2008 to 2009. The same roost was also studied in 2009, as reported in Stanton (2011) and Stanton & Klick (2018). It was reported that the number of ardeids supported by the Wong Chuk Hang night roost varied with season and peaked in winter (Mott MacDonald 2010; Stanton 2011). Other night roosts, such as those in Tai Shue Wan, Ap Lei Chau, Sha Tau Kok, Shan Pui River, Tam Kon Chau and Penfold Park; were surveyed occasionally for environmental impact assessments or related reasons (Mott MacDonald 2014; Mott MacDonald 2016; AEC Ltd. 2019a; AECOM 2019; AEC Ltd. 2020a; Mott MacDonald 2020).

Objectives

A territory-wide study was conducted to collect up-to-date information of ardeid roosting sites in Hong Kong. This was the first territory-wide study after Lee et al. (2004) to search for ardeids' roosts throughout the territory and to update the conditions of most of the previously known roosts.

Methods

The field work of this study was conducted from October 2019 to March 2020. The sites covered by this study included: egretries which were active in summer 2019, night roosts recorded in previous studies (e.g. Lee et al. 2004; Mott MacDonald 2010; AEC Ltd. 2020a), known roosting sites which had not been documented in literature, and potential roosting sites where considerable numbers of ardeids had been observed around evening hours. The study focused on communal night roosts of ardeids but day roosts of Black-crowned Night Heron were also surveyed if found. A total of 58 sites were covered in this study (Table 1 and *S1; Figure 1).

*Supplementary tables and figures can be found at https://www.afcd.gov.hk/english/publications/publications_con/pub_con_hkbio.html

Table 1. Roosting sites of ardeids recorded in winter 2019/20.

Roosting site	Date of survey	Number of night-roosting ardeids							Total (excluding BCNH)	Number of BCNH	Total number of ardeids	Remarks
		GE	IE	LE	CPH	ECE	GH	UnID				
Penfold Park *	17/1/2020	253 (43.3%)	0 (0%)	284 (48.6%)	47 (8.0%)	0 (0%)	0 (0%)	0 (0%)	584	0	584	Egretry in summer 2019.
Deep Bay- Shenzhen *#	20/1/2020	59 (11.2%)	0 (0%)	466 (88.3%)	0 (0%)	0 (0%)	3 (0.6%)	0 (0%)	528	0	528	Minimum count of night roost as some ardeids were observed flying along Shenzhen River towards this night roost but not counted in the survey due to limitation of vantage point.
Lok Ma Chau *#	6/3/2020	79 (18.3%)	0 (0%)	174 (40.4%)	47 (10.9%)	58 (13.5%)	44 (10.2%)	29 (6.7%)	431	0	431	Minimum count of ardeids due to limited view from vantage point.
Tai Po (Kwong Fuk Bridge) *	18/12/2019	82 (19.2%)	0 (0%)	331 (77.7%)	13 (3.1%)	0 (0%)	0 (0%)	0 (0%)	426	2	428	
Lo Wu *	23/12/2019	117 (28.2%)	0 (0%)	129 (31.1%)	21 (5.1%)	148 (35.7%)	0 (0%)	0 (0%)	415	0	415	
Ap Lei Chau *	1/12/2019	64 (15.6%)	0 (0%)	345 (84.4%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	409	0	409	
Fung Lok Wai *^#	21/2/2020	101 (28.8%)	0 (0%)	214 (61.0%)	0 (0%)	26 (7.4%)	10 (2.9%)	0 (0%)	351	48	399	Within Ramsar Site.
Sha Chau *^	9/3/2020	71 (42.3%)	0 (0%)	94 (56.0%)	0 (0%)	0 (0%)	1 (0.6%)	2 (1.2%)	168	165	333	Pacific Reef Heron found. Egretry in summer 2019. Site of Special Scentific Interest.
Tuen Mun Park *^	16/12/2019	16 (6.2%)	0 (0%)	235 (90.7%)	8 (3.1%)	0 (0%)	0 (0%)	0 (0%)	259	16	275	
Tam Kon Chau *#	22/1/2020	7 (3.1%)	0 (0%)	199 (87.3%)	20 (8.8%)	0 (0%)	2 (0.9%)	0 (0%)	228	0	228	Within Ramsar Site.
Tsuen Wan *	15/1/2020	8 (4.2%)	0 (0%)	184 (95.8%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	192	0	192	Pacific Reef Heron found.
Shenzhen Bay Bridge (Night Roost) *#	23/3/2020	16 (8.3%)	0 (0%)	77 (40.1%)	1 (0.5%)	80 (41.7%)	1 (0.5%)	17 (8.9%)	192	0	192	
Kai Tak *	13/12/2019	91 (54.2%)	0 (0%)	54 (32.1%)	2 (1.2%)	0 (0%)	21 (12.5%)	0 (0%)	168	0	168	
Tai O *	6/1/2020	26 (18.2%)	0 (0%)	116 (81.1%)	0 (0%)	0 (0%)	1 (0.7%)	0 (0%)	143	0	143	
Shan Pui River *#	11/12/2019	3 (2.9%)	0 (0%)	20 (19.2%)	78 (75.0%)	0 (0%)	3 (2.9%)	0 (0%)	104	0	104	Egretry in summer 2019.
Tai Po Sewage Treatment Works *	13/3/2020	45 (47.4%)	0 (0%)	48 (50.5%)	0 (0%)	0 (0%)	0 (0%)	2 (2.1%)	95	4	99	
New Yau Ma Tei Typhoon Shelter *	29/2/2020	60 (77.9%)	0 (0%)	5 (6.5%)	0 (0%)	0 (0%)	6 (7.8%)	6 (7.8%)	77	0	77	
Causeway Bay *	15/12/2019	11 (16.2%)	0 (0%)	54 (79.4%)	0 (0%)	0 (0%)	3 (4.4%)	0 (0%)	68	1	69	
Kowloon Park ^	8/1/2020	0	0	0	0	0	0	0	0	55	55	Egretry in summer 2019.
Lap Sap Chau *	22/11/2019	34 (73.9%)	0 (0%)	12 (26.1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	46	0	46	
Gei wai 15a, Mai Po Nature Reserve *^#	22/1/2020	0 (0%)	4 (23.5%)	0 (0%)	13 (76.5%)	0 (0%)	0 (0%)	0 (0%)	17	27	44	Within Ramsar Site. Site of Special Scentific Interest.
Tai Po (Tai Po River) ^	18/12/2019	0	0	1	0	0	0	0	1	40	41	
Sha Tau Kok *	9/12/2019	37 (94.9%)	0 (0%)	1 (2.6%)	0 (0%)	0 (0%)	1 (2.6%)	0 (0%)	39	0	39	
Shau Kei Wan *	25/12/2019	12 (42.9%)	0 (0%)	16 (57.1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	28	6	34	
Pui O *	18/3/2020	3 (23.1%)	0 (0%)	7 (53.8%)	0 (0%)	2 (15.4%)	0 (0%)	1 (7.7%)	13	0	13	A flock of ardeids flew to the direction of Mui Wo. Further investigation is needed to confirm the location of the night roost.
Sha Po *#	11/12/2019	6 (50.0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	6 (50.0%)	0 (0%)	12	0	12	
Total		**1201 (24.0%)**	**4 (0.1%)**	**3066 (61.4%)**	**250 (5.0%)**	**314 (6.3%)**	**102 (2.0%)**	**57 (1.1%)**	**4994**	**364**	**5358**	

Note: * = Night roost; ^ = Day roost; # = Roosting sites in Deep Bay

GE: Great Egret, IE: Intermediate Egret, LE: Little Egret, CPH: Chinese Pond Heron, ECE: Eastern Cattle Egret, GH: Grey Heron, BCNH: Black-crowned Night Heron, UnID: Unidentified species

Some ardeids could not be identified to species level during the surveys as it was too dark when they returned to the roosts, or they were mixed in large flocks. These unidentified individuals were probably Great Egrets or Little Egrets.

Pre-survey visits were conducted around sunset at some of the sites to confirm the existence or exact location of roosts. Flight paths were also followed to trace the exact location of some roosts. For sites where ardeid was not observed, further survey was not conducted. Repeated pre-visits were conducted in order to locate the night roosts for a few sites. With a lack of suitable vantage point near Mai Po Mangrove egretry, unmanned aircraft vehicle (UAV) was used to check the presence of any night roost at the site and to confirm the location of the roost at Deep Bay-Shenzhen close to the border (Figure 1). When using the UAV, a minimum distance of 100 m was kept between any birds and the UAV. The behavior of the birds was also monitored constantly to ensure they were not disturbed.

Each identified roosting site was visited once during the study period. Surveys commenced one hour before sunset, and data were recorded in 15-min intervals. Surveys finished when no birds were recorded returning to the roost in a 15-min period after sunset (as indicated on Hong Kong Observatory website), or when it became too dark for observation. Counts were conducted at vantage points with clear view of the roosting sites. Many communally roosting birds form aggregations in considerable numbers before they return to their final roost (Zahavi 1971). Consequently, locations of any pre-roosts observed in this study were also documented. The species and number of birds returning to the roost and pre-roost were recorded in each 15-min period. The species of trees used for roosting, the flight paths of the returning birds and the substrate of pre-roost were also recorded as far as possible. If Black-crowned Night Herons were observed during the survey, the flight path and the number of birds leaving the roost was also recorded. Though the night roost at Deep Bay-Shenzhen was located across the border, this roost was included in this study as some of the birds roosting there pre-roosted at commercial fishponds in Mai Po. Due to the remoteness of this roost, the species and number of birds using the site was counted from the pre-roost only.

Since Pacific Reef Heron (*Egretta sacra* 岩鷺) is not locally known to roost communally and most of the study sites were not typical habitat of this species, it was noted but not counted if observed at any roosts. Since aggregations of only a few birds may be temporary or random, only sites with ten or more ardeids were included in the analysis of this study. Similarly, only day roosting sites with ten or more Black-crowned Night Herons recorded were analysed.

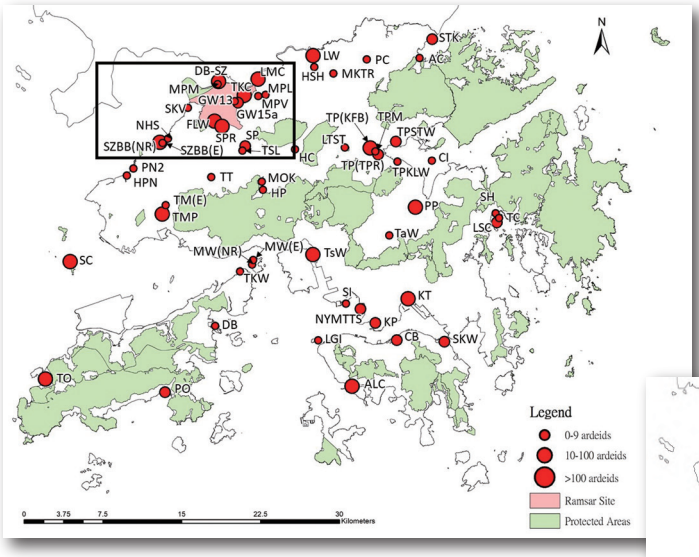


Figure 1. Survey sites for ardeid roosts in winter 2019/20. (Sites in Deep Bay enclosed in black frame. See Table 3 and S1 for full name of sites.)

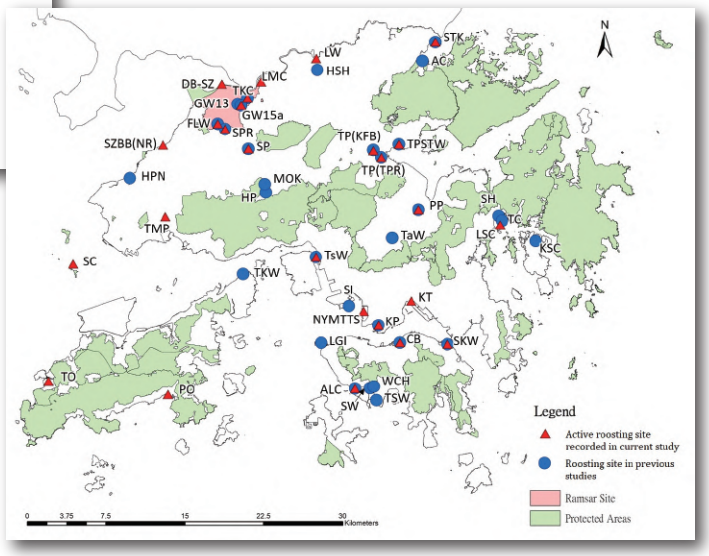


Figure 2. Location of roosting sites of ardeids recorded in the current and previous studies. (See Table 3 for details)

Results and Discussions

Roosting Sites

A total of 26 active roosting sites of ardeids (with ten or more birds) were recorded during the study period. Among these, 24 were used as night roosts and six as day roosts by Black-crowned Night Heron (Table 1), with four being simultaneously used as day and night roosting sites. Roosting sites were recorded throughout Hong Kong in both rural and urban areas (Table S2; Figures 1 - 3). All of the sites were located right next to (24 sites) or within 100 m from (2 sites) waterbodies, e.g. ponds, river, channel/nullah and sea. Eight of the 26 sites were located in the Deep Bay area. Three of the sites, namely Fung Lok Wai, Tam Kon Chau and *Gei wai* 15a of Mai Po Nature Reserve, were located within the Mai Po Inner Deep Bay Ramsar Site. Sha Chau and *Gei wai* 15a of Mai Po Nature Reserve were located within Sites of Special Scientific Interest. Other roosting sites were found outside protected areas.

The substrate on which the birds roosted on were trees, especially *Ficus* spp., at all of the sites except New Yau Ma Tei Typhoon Shelter where the birds were observed to roost on the vessels secured there (Table S2). The trees where the ardeids roosted on generally had relatively dense foliage. The night roosting birds landed on the periphery of the tree crown before moving inside the crown later on.

Figure 3. Photos of the roosting sites at (a) urban area - Tai Po (Kwong Fuk Bridge) and (b) rural area - Sha Chau.

Species Composition and Abundance

A total of seven species of colonial roosting ardeids were counted in this study, namely Great Egret, Intermediate Egret, Little Egret, Eastern Cattle Egret, Grey Heron, Chinese Pond Heron and Black-crowned Night Heron (Table 1). The most abundant species was Little Egret (3,066 individuals), followed by Great Egret (1,201 individuals), Black-crowned Night Heron (364 individuals) and Eastern Cattle Egret (314 individuals). Only four individuals of Intermediate Egrets were recorded. A total of 5,358 ardeids were recorded at the 26 roosting sites. The eight sites in the Deep Bay area accounted for 36.2% (1,938 individuals) of all the birds counted. Presence of Pacific Reef Heron was noted at a few sites.

The roosting site which supported the highest number of ardeids was Penfold Park (584 birds), followed by Deep Bay-Shenzhen (528 birds) and Lok Ma Chau (431 birds). Meanwhile, Pui O (13 birds) and Sha Po (12 birds) were used by the lowest numbers of ardeids (Table 1; Figure S1). The actual number of birds roosting at Deep Bay-Shenzhen would certainly be higher as some ardeids flew to the roost directly and could not be counted from the pre-roost in Mai Po.

All roosting sites supported multiple species of ardeids, except Kowloon Park where only Black-crowned Night Herons roosted during the day (Table 1; Figures S1 and S2). More than 60% of the sites (16 out of 26 sites) were used by three or four species. Lok Ma Chau and Shenzhen Bay Bridge (night roost) supported the greatest diversity at six species.

Little Egret and Great Egret were the most common species and roosted at 23 of the 26 roosting sites, followed by Grey Heron (13 sites), Chinese Pond Heron and Black-crowned Night Heron (10 sites). Eastern Cattle Egret was recorded at five sites in north and northwest New Territories and Lantau Island. Intermediate Egret was only found at *Gei wai* 15a of Mai Po Nature Reserve. In fact, this species is regarded as uncommon and is mainly found in the Deep Bay area.

Proportions of species varied considerably among roosting sites (Table 1; Figure S2). Most roosting sites were occupied by Little Egrets and Great Egrets. In particular, three sites were dominated by Great Egret (>70% at each site) and eight sites were dominated by Little Egret (>70% at each site). There were also a few other sites where other species (e.g. Chinese Pond Heron and Black-crowned Night Heron) were found dominating.

Pre-roosts of Night Roosts

Ardeids were observed to form pre-roosting aggregations at sites near 11 night roosts (Table S2). At these sites birds were observed to gather at the pre-roosts and flew to the final night roosting sites in large flocks, while some birds flew directly to the night roosts without gathering at the pre-roosts. Substrate of pre-roosts were variable. In addition to trees, ardeids also pre-roosted on breakwater, fishponds/ponds and river channel with shallow water and rocks.

All of these pre-roosting sites were in close proximity to the final night roosting sites (approximately 20 – 400 m; average at 110 m) except for the Deep Bay-Shenzhen where the pre-roost was over 2.5 km from the night roost.

Potential pre-roosts were recorded at several sites (Ha Pak Nai, Discovery Bay, Tai Po Kau Lo Wai, Pui O) where ardeids were seen to aggregate in large flocks and leave before sunset. The ardeids at Ha Pak Nai were traced to the night roost at Shenzhen Bay Bridge but the landing locations for the flocks at Discovery Bay and Tai Po Kau Lo Wai could not be traced. While a night roost was confirmed at Pui O, it was repeatedly observed that a separate flock gathered at Pui O and flew northeast at sunset. It is possible that these sites were pre-roosts, but since the ardeids were already there at the start of the surveys and no additional birds joined before the flocks left, it is also possible that these were only day roosts near foraging grounds.

Arrival Time and Returning Direction to Night Roosts/Pre-roosts

Since Black-crowned Night Heron behaved differently from other species (i.e. departed the roosting sites during and after the surveys), this species is not discussed here.

Table 2 shows the percentages of birds returning to the 24 night roosts and pre-roosts which were in close proximity to the night roosts in each 15-min period. On average, 51% of the birds returned within the hour before sunset and 39% within 30 min after sunset. The remaining 10% returned more than one hour before sunset, at 14 of the 24 sites.

Ardeids appeared to return to the night roosts or pre-roosts by flying over waterbodies, e.g. channels, ponds and sea. Hence the direction of return depended on the environment of each site. For example, at the night roost and pre-roost (which was located at a fishpond next to the roost) in Lok Ma Chau Ecological Enhancement Area, birds returned from fishponds to the east, west and south and Shenzhen River to the north and west (Figure 4a). At Tai Po (Kwong Fuk Bridge), birds returned from Lam Tsuen River to the east and west (Figure 4b).

Figure 4. Direction of flight of the returning ardeids at (a) Lok Ma Chau and (b) Tai Po (Kwong Fuk Bridge) night roosts.

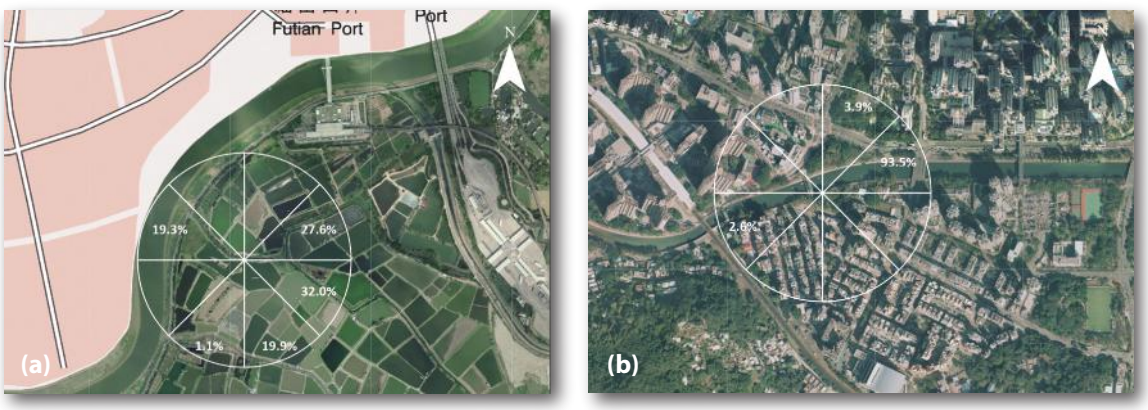


Table 2. Percentages of ardeids by arrival time to night roost.							
Location	Before start of survey	45-60 min before sunset	30-45 min before sunset	15-30 min before sunset	0-15 min before sunset	0-15 min after sunset	15-30 min after sunset
Penfold Park	0.0	6.0	29.3	40.9	21.1	2.7	0.0
Deep Bay- Shenzhen	0.0	6.3	0.4	5.5	51.5	25.9	10.4
Lok Ma Chau	4.6	4.9	10.4	21.8	31.1	25.3	1.9
Tai Po (Kwong Fuk Bridge)	1.4	1.6	9.9	16.4	51.2	17.8	1.6
Lo Wu	0.0	0.0	0.0	0.7	46.3	47.0	6.0
Ap Lei Chau	0.0	0.0	0.0	0.0	1.0	76.3	22.7
Fung Lok Wai	35.3	0.3	7.1	26.2	10.5	19.9	0.6
Sha Chau	3.6	0.0	7.1	10.7	21.4	46.4	10.7
Tuen Mun Park	6.2	0.0	5.8	9.7	52.9	24.7	0.8
Tam Kon Chau	0.0	0.4	0.0	0.9	19.7	32.5	46.5
Tsuen Wan	15.1	-2.6	1.0	16.7	51.0	3.6	15.1
Shenzhen Bay Bridge (Night Roost)	0.0	21.4	4.2	25.0	19.3	18.2	12.0
Kai Tak	6.5	3.6	5.4	10.1	39.3	32.7	2.4
Tai O	3.5	0.0	0.0	0.0	0.0	5.6	90.9
Shan Pui River	26.9	5.8	4.8	2.9	16.3	33.7	9.6
Tai Po Sewage Treatment Works	0.0	0.0	0.0	0.0	85.3	13.7	1.1
New Yau Ma Tei Typhoon Shelter	42.9	2.6	9.1	24.7	15.6	5.2	0.0
Causeway Bay	8.8	8.8	8.8	10.3	32.4	27.9	2.9
Lap Sap Chau	13.0	0.0	21.7	6.5	21.7	34.8	2.2
Gei wai 15a, Mai Po Nature Reserve	58.8	0.0	0.0	5.9	35.3	0.0	0.0
Sha Tau Kok	0.0	0.0	0.0	0.0	12.8	76.9	10.3
Shau Kei Wan	0.0	3.6	7.1	10.7	21.4	46.4	10.7
Pui O	0.0	23.1	0.0	0.0	38.5	38.5	0.0
Sha Po	8.3	0.0	25.0	8.3	33.3	66.7	-41.7
Average	**9.8**	**3.6**	**6.5**	**10.6**	**30.4**	**30.1**	**9.0**

Note: Negative values imply a net departure of ardeids during the specific period.

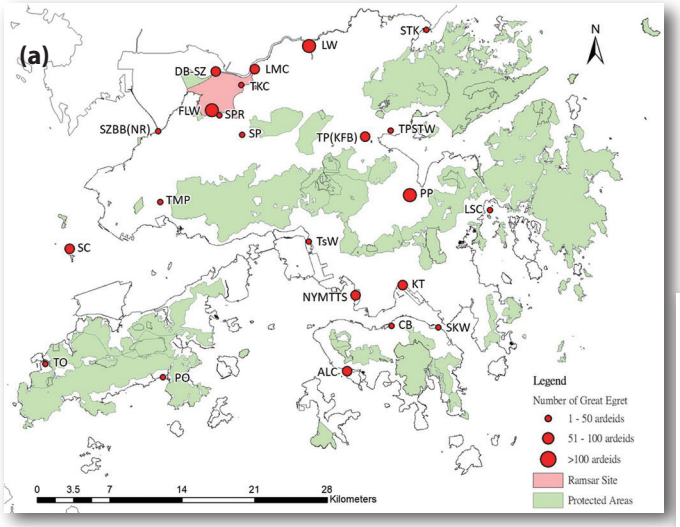
Distribution of Roosting Sites Compared with Egretries

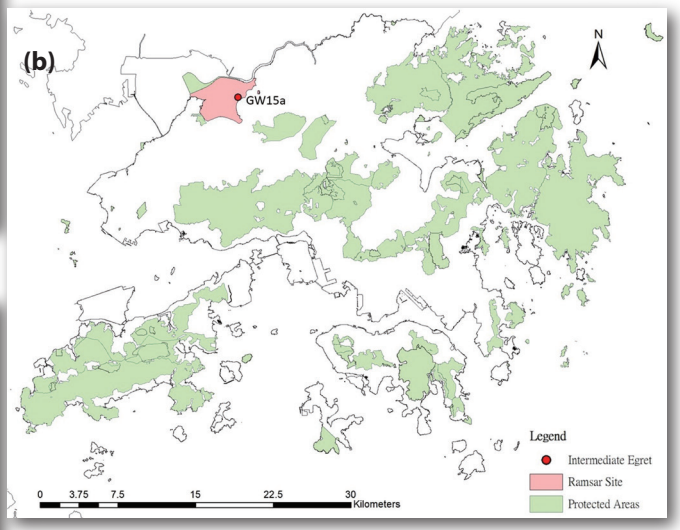
The 26 roosting sites found in this study were more evenly distributed geographically than the 22 active egretries recorded in 2019. While there were three roosting sites on Hong Kong Island, two on Lantau Island and one in Sai Kung, no egretry was found in these areas. A greater proportion of egretries (9 out of 22) occurred in Deep Bay area (Anon. 2020b) as compared with winter roosting sites (8 out of 26). The concentration of egretries in this area may reflect higher food availability for growing chicks and fledglings.

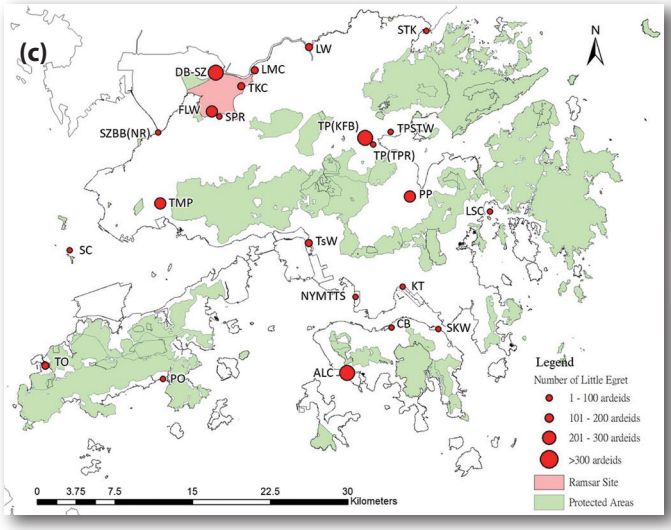
Among the 26 roosting sites, only four (Penfold Park, Sha Chau, Shan Pui River and Kowloon Park) were also used as egretries in summer 2019. At each of these sites, the species composition of nesting birds in summer and roosting birds in winter was similar. For four other roosting sites, egretries were found nearby. For example, the egretry and night roost at Shenzhen Bay Bridge were only about 200 m apart. The ardeids there used the bamboo grove for breeding and the mangrove nearby for roosting respectively. The other egretry-roosting site pairs included Mai Po Mangrove egretry and Deep Bay-Shenzhen night roost (about 200 m apart), Tai Po Market egretry and Tai Po (Kwong Fuk Bridge) night roost (about 580 m apart) and Tuen Mun egretry and Tuen Mun Park night roost (about 950 m apart). It is unclear but intriguing why ardeids used the same location for both breeding and roosting at some sites but used separate locations (albeit close to each other) at other sites.

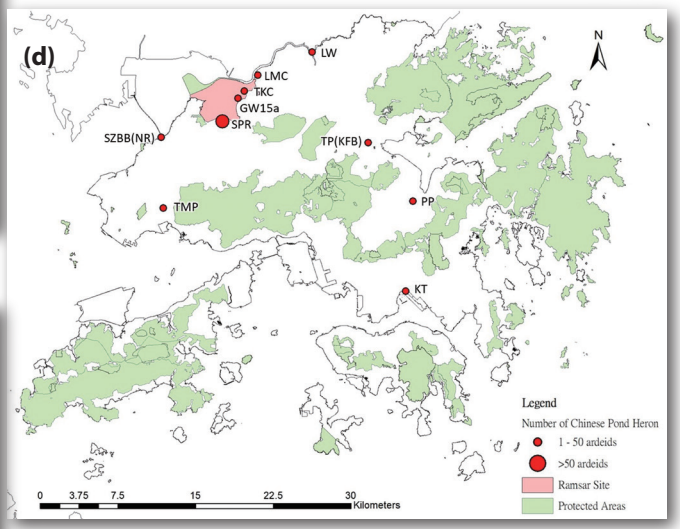
All roosting sites were found to be in close proximity (within 100 m) to some form of waterbodies, while a few egretries were relatively further away from water (e.g. Tai Po Market: 280 m from the nearest water channel; Tai Tong (Pak Sha Tsuen): 265 m from the nearest drainage channel).

Figure 5. Distribution of ardeid roosting sites in Hong Kong by species. (See Table 3 for full name of sites.)
(a) Great Egret, (b) Intermediate Egret, (c) Little Egret, (d) Chinese Pond Heron, (e) Eastern Cattle Egret









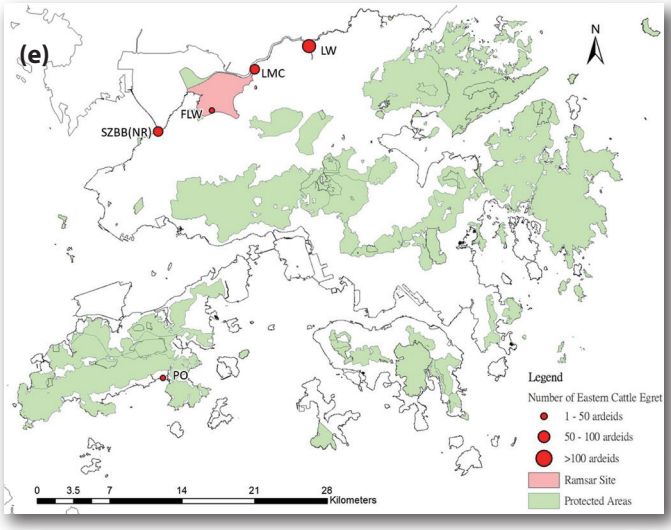
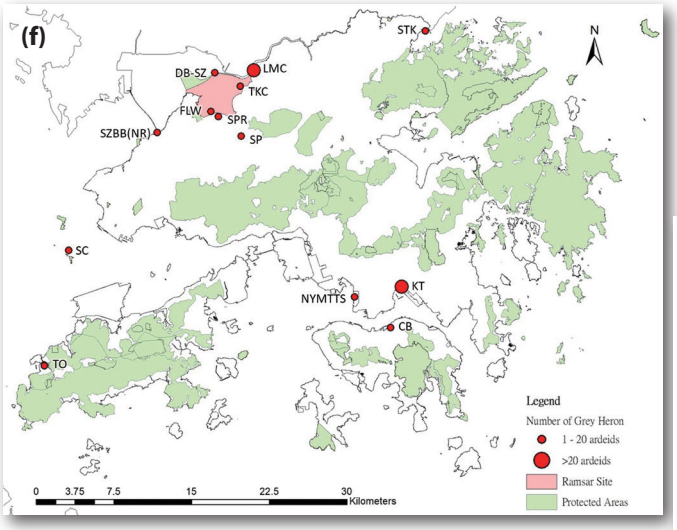
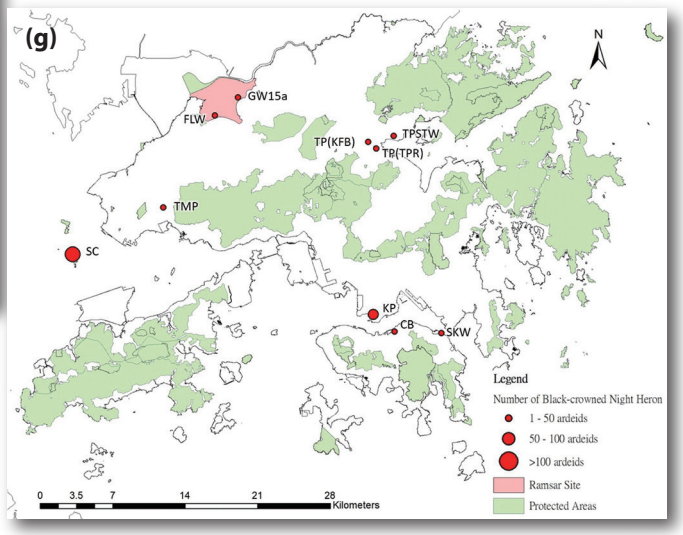


Figure 5(continued). Distribution of ardeid roosting sites in Hong Kong by species. (See Table 3 for full name of sites.) (f) Grey Heron, (g) Black-crowned Night Heron





Changes of Roosting Sites

Status of roosts:

The study found that some night roosts recorded in the past had been abandoned (e.g. A Chau and Ha Pak Nai) and some previously abandoned roosts were recolonised (Shan Pui River, Tam Kon Chau, *Gei wai* 15a in Mai Po and Tsuen Wan) (Table 3; Figure 2) . Other night roosts were found to be occupied throughout the previous and current studies (e.g. Causeway Bay and Fung Lok Wai).

Changes of roosting locations:

Some night roosts were recorded to have shifted to nearby locations (less than 400 m away) (Table 3). For example, the night roost at Tai Po (Kwong Fuk Bridge) was recorded on the north bank of Lam Tsuen River in 2017 and 2018 (AFCD unpublished data) but the ardeids moved to the south bank in the current study (Figure 6a). The Sha Tau Kok night roost was found near the town centre in 2014 (Mott MacDonald 2016), but no roosting ardeids were recorded at this location in Oct 2019 (Furgo 2019). In the current study, a night roost was found at the island near the coast of Sha Tau Kok in Dec 2019 (Figure 6b). Similar shifts in location also occurred at the Shan Pui River and Tai Po Sewage Treatment Works sites.

Changes of roosting location over longer distances was found in a number of sites including Sha Ha, Tai Wai and Wong Chuk Hang (Table 3). The night roost at Sha Ha recorded in 2003 (Lee et al. 2004) was found to have moved to Tai Chau in 2009 (Mott MacDonald 2010) and then to Lap Sap Chau in this study. While the night roost at Tai Wai was active for at least 3 years from 2017 to 2019 (AFCD unpublished data), this site was not used by the ardeids in Dec 2019. Extra survey revealed the birds foraging around Shing Mun River at Tai Wai and Sha Tin settled at Penfold Park for the night instead (Figure 7).

The reason for the change of roosting location is not known for most cases, as no obvious change of environment was observed. However, the change in roosting location at Wong Chuk Hang might have been induced by development (Mott MacDonald 2014).

Roosting community:

Species composition at some sites changed through time. For example, the night roost at Tai Po (Tai Po River) used by Little Egret in 2002 (Lee et al. 2004) became a day roost of Black-crowned Night Heron in Dec 2019. Eastern Cattle Egret was not recorded at Fung Lok Wai until 2020 (Lee et al. 2004 ; Mott MacDonald 2010).

In addition to the changes in species composition, the winter roost size could fluctuate considerably between years. For example, the number of ardeids roosting at Causeway Bay varied over the years: 95 in Jan 2003 (Lee et al. 2004); 216 in Jan 2009 (Mott MacDonald 2010); 27 in Jan 2019 (AFCD unpublished data); 69 in Dec 2019 (current study). Similar fluctuation was detected within an even shorter period of time. AFCD's surveys in Feb and Dec 2017 both recorded about 800 ardeids at Tai Po (Kwong Fuk Bridge). The number increased to over 1,200 in Dec 2018, and dropped to 428 only a year later, in Dec 2019. The fluctuation between years might be related to variation in population sizes of wintering ardeids in Hong Kong. Individual birds might also move between roosting sites. On the other hand, in some night roosts the number of birds recorded remained stable over the years, e.g. Ap Lei Chau (about 400 birds in 2013, 2018 and 2019) and Sha Ha/Tai Chau/Lap Sap Chau (about 40 birds in 2003, 2009 and 2019).

Table 3. List of roosting sites of ardeids recorded in the current and previous studies.

Roosting sites	Abbreviation	Status in previous studies	Status in current study	Remarks	References
A Chau	AC	Active in 2003	Inactive		Lee et al. 2004
Ap Lei Chau	ALC	Active in 2013, 2018 and 2019	Active	Ardeids from Wong Chuk Hang moved to Tai Shue Wan in 2012 and to Ap Lei Ap Lei Chau in 2013	Mott MacDonald 2014; AEC Ltd. 2019a; AFCD unpublished data
Causeway Bay	CB	Active in 2003, 2009 and 2019	Active		Lee et al. 2004; Mott MacDonald 2010; AFCD unpublished data
Deep Bay- Shenzhen	DB-SZ	N/A	Active		
Fung Lok Wai	FLW	Active in 2002 and 2008	Active		Lee et al. 2004; Mott MacDonald 2010
Gei wai 13, Mai Po Nature Reserve	GW13	Active in 2003 but inactive in 2009	Inactive		Lee et al. 2004; Mott MacDonald 2010
Gei wai 15a, Mai Po Nature Reserve	GW15a	Active in 2002 but inactive in 2009	Active		Lee et al. 2004; Mott MacDonald 2010
Ha Pak Nai	HPN	Active in 2003	Inactive		Lee et al. 2004
Ho Pui	HP	Active in 2003	Inactive		Lee et al. 2004
Ho Sheung Heung	HSH	Active in 2003	Inactive		Lee et al. 2004
Kai Tak	KT	Active in 2018	Active		AFCD unpublished data
Kau Sai Chau	KSC	Active in 2000/01 but inactive in 2004/05	Not surveyed		Black & Veatch Hong Kong Limited 2005
Kowloon Park	KP	Active in 2019	Active		AFCD unpublished data
Lap Sap Chau	LSC	N/A	Active	Ardeids from Sha Ha moved to Tai Chau and then to Lap Sap Chau	
Little Green Island	LGI	Active in 2009	Inactive	Only eight birds were recorded in 2009	Mott MacDonald 2010
Lo Wu	LW	N/A	Active		
Lok Ma Chau	LMC	Active in 2014-2019	Active		AEC Ltd. pers. comm.; AEC Ltd. 2016, 2017, 2018, 2019b and 2020b
Ma On Kong	MOK	Active in 2003	Inactive		Lee et al. 2004
New Yau Ma Tei Typhoon Shelter	NYMTTS	N/A	Active		
Penfold Park	PP	Active in 2002, 2006-08, 2019-20	Active	Ardeids from Tai Wai moved to Penfold Park in 2019	Lee et al. 2004; Carey 2009; Mott MacDonald 2020
Pui O	PO	N/A	Active		
Sha Chau	SC	N/A	Active		
Sha Ha	SH	Active in 2003 but inactive in 2009	Inactive	Ardeids from Sha Ha moved to Tai Chau and then to Lap Sap Chau	Lee et al. 2004; Mott MacDonald 2010

Table 3(continued). List of roosting sites of ardeids recorded in the current and previous studies.

Roosting sites	Abbreviation	Status in previous studies	Status in current study	Remarks	References
Sha Po	SP	Active in 2019	Active		AFCD unpublished data
Sha Tau Kok	STK	Active in 2014	Active	Slight location change recorded in late 2019	Mott MacDonald 2016
Sham Wan	SW	Active in 2013 but inactive in 2018	Not surveyed	Only eight Black-crowned Night Heron were recorded in 2013	Mott MacDonald 2014; AEC Ltd. 2019a
Shan Pui River	SPR	Acitve in Jun 2017, inacitve in Jul 2017 and active in 2018 and 2019	Active	Slight location change recorded in late 2018	AECOM 2019; AFCD unpublished data
Shau Kei Wan	SKW	Active in 2019	Active		AFCD unpublished data
Shenzhen Bay Bridge (Night Roost)	SZBB (NR)	N/A	Active		
Stonecutters Island	SI	Active in 2003	Inactive		Lee et al. 2004
Tai Chau	TC	Active in 2009	Inactive	Ardeids from Sha Ha moved to Tai Chau and then to Lap Sap Chau	Mott MacDonald 2010
Tai O	TO	N/A	Active		
Tai Po (Kwong Fuk Bridge)	TP (KFB)	Active in 2017 and 2018 and known to be active before 2017	Active	Slight location change recorded in late 2019	AFCD unpublished data
Tai Po (Tai Po River)	TP (TPR)	Active in 2002	Active		Lee et al. 2004
Tai Po Sewage Treatment Works	TPSTW	Acitve in 2019	Active	Only around 10 ardeids were recorded in early 2019; Slight location change recorded in late 2019	AFCD unpublished data
Tai Shue Wan	TSW	Active in 2009, 2012 and 2013 but inactive in 2015-2020	Not surveyed	Ardeids from Wong Chuk Hang moved to Tai Shue Wan in 2012 and to Ap Lei Chau in 2013	Mott MacDonald 2010, 2014, 2018a-c, 2019a-d and 2020b,c; MTR Corporation Limited 2012a-d and 2013; AUES 2016a,b and 2017a,b
Tai Wai	TaW	Active in 2017, 2018 and 2019 and known to be active before 2017	Inactive	Ardeids from Tai Wai moved to Penfold Park in 2019	AFCD unpublished data
Tam Kon Chau	TKC	Active in 2003, inactive in 2009 and active in 2019, 2020	Active		Lee et al. 2004; Mott MacDonald 2010; AEC Ltd. 2020
To Kau Wan	TKW	Active in 2002	Inactive		Lee et al. 2004
Tsuen Wan	TsW	Active in 2002 but inactive in 2009	Active		Lee et al. 2004; Mott MacDonald 2010
Tuen Mun Park	TMP	N/A	Active		
Wong Chuk Hang	WCH	Active in 2008, 2009, 2011, early 2012 but inactive in late 2012-2018	Not surveyed	Ardeids from Wong Chuk Hang moved to Tai Shue Wan in 2012 and to Ap Lei Chau in 2013	Mott MacDonald 2010; Stanton 2011; MTR Corporation Limited 2017; AEC Ltd. 2019a

Note: This table should not be regarded as an exhaustive list of roosting sites of ardeids recorded in Hong Kong.

Figure 6. Previous and current locations of roosting sites at (a) Tai Po (Kwong Fuk Bridge) and (b) Sha Tau Kok.

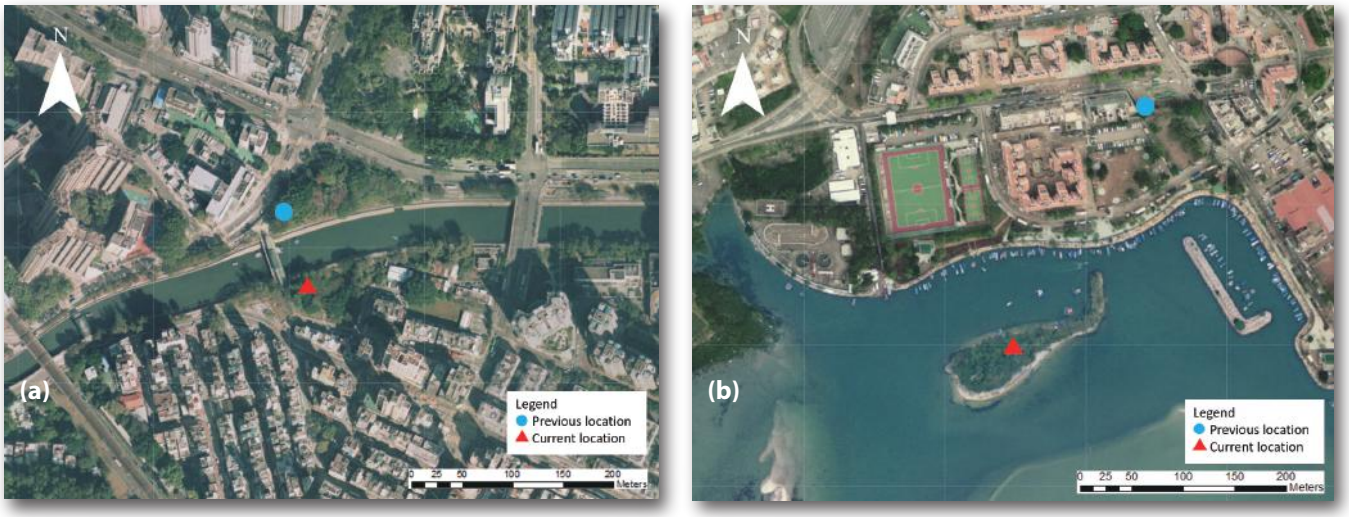


Figure 7. Roosting sites at Tai Wai and Penfold Park.

Conclusion

The current study represents the most comprehensive study in ardeid roosting sites in Hong Kong. A total of 26 roosting sites were recorded in this study. Despite some differences in habitats, all sites were found to be close to waterbodies. Many were occupied by multiple ardeid species, with varying species diversity and compositions. Over the years, species compositions, sizes and even locations of roosts could change.

The current study provides an overview of the ardeid roosting sites that may facilitate the conservation of ardeids in Hong Kong. Considering the dynamic nature of roosting sites, territory-wide survey could be carried out again in future, to help us better understand the pattern and potential causes of changes in the roosts over time.

Acknowledgements

The authors would like to thank all members of the Bird Working Group of AFCD, colleagues of the Nature Conservation Divisions and the Biodiversity Conservation Division, and Ms. Kathy Li, Ms. Sandra Chow and Mr. Felix Chan for their assistance in the collection of data. Thanks should also be given to the Hong Kong Bird Watching Society for the provision of information of the Tuen Mun Park and Fung Lok Wai night roosts. The assistance from Drainage Services Department by granting access to Tai Po Sewage Treatment Works for the surveys is highly appreciated. Thanks are also due to the Hong Kong Jockey Club, MTR Corporation Limited and AEC Ltd. for the provision of reports on Penfold Park and Lok Ma Chau Ecological Enhancement Area.

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Working Group Column

A Short Note on the Breeding of White-bellied Sea Eagle in Hong Kong

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Bird Working Group

漁農自然護理署自2002年起對全港的白腹海鵰進行繁殖調查，共記錄得25個繁殖點，每年平均有9對白腹海鵰繁殖及4隻幼鳥長成離巢。

Introduction

White-bellied Sea Eagle is one of the fourteen raptors (including owls) breeding in Hong Kong (Carey et al. 2001; Tang & Chow 2017). It is listed as vulnerable in the Red List of China's Vertebrates (Jiang et al. 2016) and is of regional concern (Fellowes et al. 2002). The Agriculture, Fisheries and Conservation Department has been conducting surveys on this species in Hong Kong since 2002. Methodology of this long-term monitoring can be found in So & Lee (2010). This article provides an update on the major findings of the monitoring.

Nesting sites

A total of 25 nesting sites were recorded during the breeding seasons from 2002/03 to 2019/20 (Figure 8). The majority were located in eastern waters, around Hong Kong Island and east of Lantau Island. The only nest in western waters was at Lung Kwu Chau. About half (13) were located inside protected area, i.e. Country Parks, SSSIs and Special Areas. Most other nests were located in remote areas with little human disturbance. All nests were constructed on natural substratum (i.e. tree and rock surface of cliff), except the nest at Tin Wan, which was found on a cable tower (Table 4).

Table 4. Summary of nesting sites of White-bellied Sea Eagle in Hong Kong from 2002/03 to 2019/20.

Nesting site	Nesting substratum	Occurrence in protected area	Remarks
Bluff Head	Tree	No	Nest has moved within site.
Bluff Island	Cliff surface	Site of Special Scientific Interest & Ung Kong Group Special Area	
Chi Ma Wan Peninsula	Tree	Lantau South Country Park	Nest has moved within site.
Crooked Island	Tree	Plover Cove (Extension) Country Park & Kat O Chau Special Area	More than one nest have been recorded in some breeding seasons. Nests have moved within site.
Green Island	Tree	No	Nest has moved within site.
Jin Island	Cliff surface / Tree	No	Nest has moved within site.
Lamma Island	Tree	No	Nest has moved within site.
Lung Kwu Chau	Tree	Sha Chau and Lung Kwu Chau Marine Park& Site of Special Scientific Interest	
Ninepin Island	Tree	Site of Special Scientific Interest & Ninepin Group Special Area	
Penny's Bay	Tree	No	
Port Island	Tree	Site of Special Scientific Interest & Plover Cove (Extension) Country Park	
Round Island	Tree	No	Nest has moved within site.
Sham Chung	Tree	Sai Kung West Country Park	Nest has moved within site.
Shek Kwu Chau	Tree	No	Nest has moved within site.
Steep Island	Tree	Clear Water Bay Country Park	Nest has moved within site.
Stonecutter Island	Tree	No	
Sung Kong	Tree	No	Nest has moved within site.
Sunshine Island	Tree	Site of Special Scientific Interest	Nest has moved within site.
Tai Ngam Hau	Tree	Ma On Shan Country Park	
Tin Wan (Aberdeen)	Cable Tower	No	
Tsang Pang Kok	Cliff surface	Sai Kung East Country Park	Nest has moved within site.
Tsim Chau	Tree	No	
Wang Chau	Cliff surface	Ung Kong Group Special Area	More than one nest have been recorded in some breeding seasons.
Yeung Chau (Plover Cove)	Tree	Ma Shi Chau Special Area	
Yeung Chau (Sai Kung)	Tree	No	More than one nest have been recorded in some breeding seasons. Nests have moved within site.

White-bellied Sea Eagle tends to use the same nests year after year (del Hoyo et al. 1994) and nests can be occupied for decades (Marchant & Higgins 1993). Nevertheless, in Hong Kong, nests have moved to a different tree or a different spot on cliff within 15 nesting sites across breeding seasons from observations since 2010. The distance of movement in a nesting site ranged from approximately 40 m to 1 km. For some cases, such movement was likely due to the existing nest being destroyed by adverse weather or broken tree branches or overgrown by climbers. However, for some other cases, there was no obvious cause. At Crooked Island, Yeung Chau (Sai Kung) and Yeung Chau (Plover Cove), the pair moved between two or three nests for multiple times over the years. At three nesting sites, i.e. Crooked Island, Yeung Chau (Sai Kung) and Wang Chau, two nests were recorded simultaneously in some breeding seasons (Figure 9). The pair of nests in each of these sites were in close proximity and a single pair of White-bellied Sea Eagles were observed at each site during those seasons.

Figure 8. Location and number of active breeding years of White-bellied Sea Eagle nesting sites in Hong Kong from 2002/03 to 2019/20.

1: Crooked Island, 2: Port Island, 3: Yeung Chau (Plover Cove), 4: Sham Chung, 5: Tsim Chau, 6: Tsang Pang Kok, 7: Yeung Chau (Sai Kung), 8: Tai Ngam Hau, 9: Wang Chau, 10: Bluff Island, 11: Jin Island, 12: Steep Island, 13: Ninepin Island, 14: Sung Kong, 15: Bluff Head, 16: Round Island, 17: Stonecutter Island, 18: Tin Wan, 19: Lamma Island, 20: Green Island, 21: Penny's Bay, 22: Sunshine Island, 23: Chi Ma Wan Peninsula, 24: Shek Kwu Chau, 25: Lung Kwu Chau

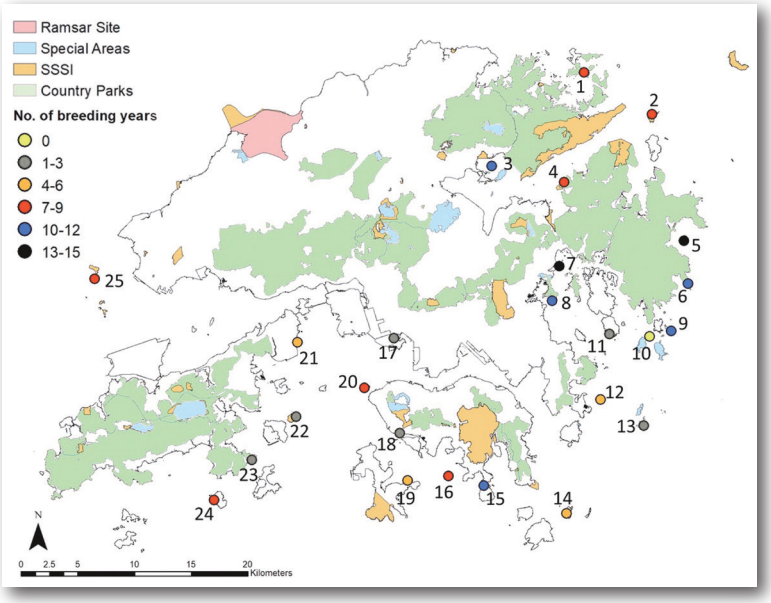
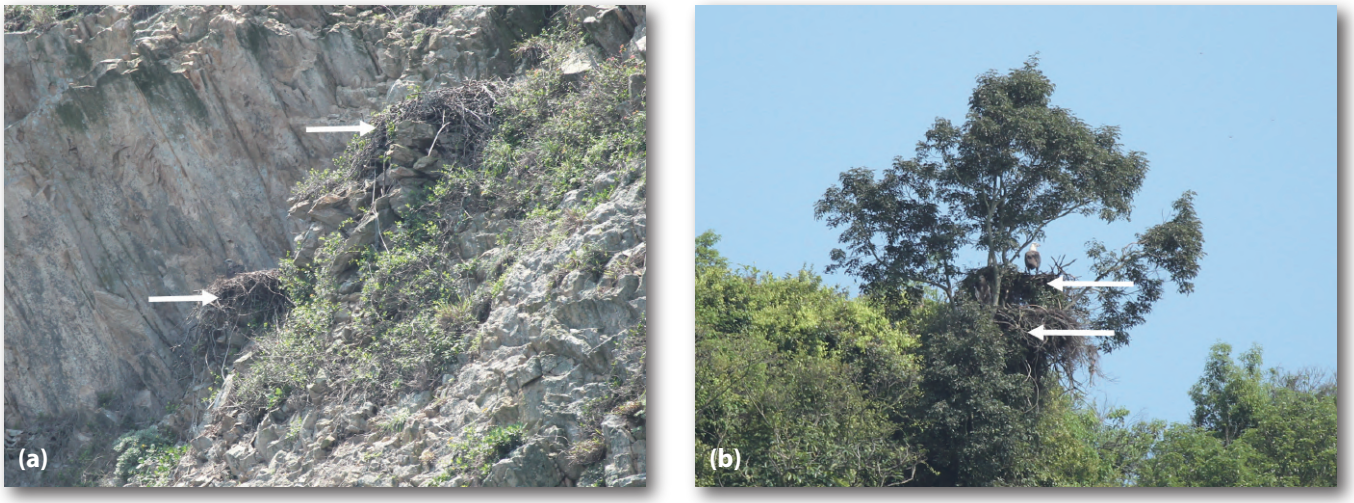


Figure 9. Two nests found at (a) Wang Chau (April 2012); and (b) Crooked Island (April 2012) respectively.



Breeding success

The nest on cable tower at Tin Wan was excluded from the discussion below as it was subject to human management for public safety.

From 2002 to 2020, the number of breeding pairs recorded each year ranged from 6 to 12 pairs (average: 9 pairs). The annual number of breeding pairs which successfully produced fledglings ranged from 0 to 7 pairs (average: 3 pairs), corresponding to success rates of 0 to 87.5% (average: 34.1%) (Table 5; So & Lee 2010). The average number of fledglings produced in Hong Kong was 4 individuals per year. Over the 18 years, the breeding seasons in 2013/14, 2015/16, 2016/17 and 2019/20 failed completely and no fledgling was produced. A possible cause for this failure may be the low temperatures during the breeding season. A lowest temperature of 3.1°C was recorded in Jan 2016 (sixth coldest day since 1957; HKO 2016) while a prolonged period of cold weather occurred in Feb 2014.

Table 5. Breeding success of White-bellied Sea Eagle from 2009/10 to 2019/20.

	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19*	2019/20
No. of active breeding pairs	7	12	10	10	7	9	8	7	12	9	12
No. of successful breeding pairs (%)	3 (42.9%)	7 (58.3%)	5 (50%)	5 (50%)	0 (0%)	3 (33.3%)	0 (0%)	0 (0%)	4 (33.3%)	5 (55.6%)	0 (0%)
Total no. of fledglings produced	3	11	6	6	0	3	0	0	5	5	0
% of successful pairs producing 1 fledgling	100	42.9	80	80	-	100	-	-	75	100	-
% of successful pairs producing 2 fledglings	0	57.1	20	20	-	0	-	-	25	0	-

* The nest at Bluff Island found in summer 2019 was not included
# Data for 2002/03 to 2008/09 can be found in So & Lee (2010)

Usage of nesting sites

Particular nesting sites were not used every single year. For example, the Tsim Chau and Yeung Chau (Sai Kung) sites were active in 14 out of the 18 seasons. The nest at Bluff Island first found in summer 2019 was not in use in the 2019/20 breeding season although an eagle was observed at this site. Nesting sites at Penny's Bay, Tai Ngam Hau and Stonecutters Island were abandoned for over 5 years with no breeding activity or occupied territory observed.

The species generally starts to breed approximately at an age of six and has a life expectancy of about 30 years (Marchant & Higgins 1993; Parks and Wildlife Service Tasmania 2011). Nesting site fidelity in Hong Kong is unknown, i.e. it was uncertain if the eagle pairs were using the same nesting sites over the monitoring period.

The way forward

The department would continue the long-term monitoring of breeding White-bellied Sea Eagle in view of its conservation interest in Hong Kong.

Acknowledgements

The authors would like to thank all members of the Bird Working Group of AFCD, colleagues in the Nature Conservation Divisions and the Biodiversity Conservation Division, Mr. Wellem W.W. Cheng, Miss Ester Y.T. Cheung, Mr. Caleb W.K. Choi, Mr. M.Y. Tang as well as others involved in the collection of data.

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Habitat Characteristics of Fireflies in Hong Kong

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香港多元化的自然環境，孕育著不同品種的螢火蟲。這些螢火蟲生活習性不盡相同，大部分只生活於特定的自然生境中。本文介紹香港各種螢火蟲棲息地，並強調維護生境多樣性對保育螢火蟲的重要性。

Introduction

Fireflies are a group of soft-bodied beetles in the families of Lampyridae and Rhagophthalmidae under the insect order Coleoptera. Situated in the humid subtropical region with hilly topography, Hong Kong's diverse natural habitats are home to numerous firefly species. Many of the species require very specific environmental settings, and only a few are habitat generalists. are habitat generalists. Based on the observations from surveys conducted by the Beetle Working Group of the Agriculture, Fisheries and Conservation Department, this article examines the habitats used by the fireflies in Hong Kong.

Diverse morphological features and ecology of fireflies

The fireflies in Hong Kong, comprising about 30 species (Yiu 2017), display diverse morphological characteristics and ecology among genera and even species. While it is widely perceived that fireflies are water-dependent, only *Aquatica* species are regarded as truly aquatic as their larvae have abdominal gills for breathing in water (Fu et al. 2010); although many people believe that fireflies only appear at night, there are diurnal species such as *Pyrocoelia sanguiniventer* which is most active during the daytime; while some think that fireflies are seen only in summer, there are in fact winter species such as *Diaphanes lampyroides* of which adults emerge between November and January. Given the wide range of unique morphological and ecological adaptations of fireflies, it is not surprising that the habitat requirements are diverse among different species.

Major firefly habitats in Hong Kong

1. *Stream margins/ riversides*

Natural freshwater streams and the riparian zones are rich in biodiversity. *Pygoluciola qingyu* is one of the hill stream inhabitants found throughout Hong Kong. The larvae crawl on wet boulders or mossy rocks along streams, and are sometimes immersed in shallow water. They move slowly in search of food such as dead bodies of insects and live preys such as ants (Fu & Ballantyne 2008). Adults perch on riparian vegetation and emit lights as part of courtship. Tai Po Kau, having ample hill streams, is a typical locality for *P. qingyu*.

Fig. 10(a) Freshwater stream and riparian vegetation

Fig. 10(b) Adult of *Pygoluciola qingyu*

2. *Freshwater ponds, marshes and slow flowing waterbodies*

Lentic or slow flowing waterbodies like ponds and marshes are typical habitats for the aquatic firefly *Aquatica leii* in Hong Kong. The larvae are entirely water dependent and have abdominal gills for breathing in water (Fu et al. 2010); they feed on aquatic creatures such as snails (Fu et al. 2006). Males fly above waterbodies and surrounding areas to search for mates. Females lay eggs on the stems or leaves of aquatic plants above the water surface. *A. leii* is not restricted to natural habitats and has also been recorded in man-made habitats such as a landscaped pond in Tai Po Kau, concrete ditches at a farmland in Sai Kung, flooded agricultural fields in Kam Tin and fishpond fringes in Tsim Bei Tsui.

Fig. 11(a) Freshwater marsh

Fig. 11(b) Adult of *Aquatica leii*

3. *Wet grasslands*

Wet grasslands in Hong Kong have usually been evolved from abandoned agricultural fields through ecological succession. They consist of mainly herbaceous plants and short shrubs. Such wetlands are often cut across by or next to small slow-flowing streams and can retain large amounts of water in soil, especially during the wet season. *Abscondita terminalis* is a typical dweller of this habitat type. Larvae which are active on wet soil prey on small insects like ants and consume them dead or alive (Ballantyne et al. 2013). Adult males fly actively above vegetation displaying flashing signals, while the females perch on tall grass and signal response flashes. The abandoned fields at Sha Lo Tung is a typical locality of this species in Hong Kong. Other localities include Wu Kau Tang and Sheung Tong.

Fig. 12(a) Wet grassland at Wu Kau Tang

Fig. 12(b) Adult of *Abscondita terminalis*

4. *Mangrove/ mangrove associates*

Intertidal mangal communities, influenced by both tidal seawater and freshwater, support rich biodiversity by providing important habitats to both coastal and terrestrial species. In Hong Kong, *Pteroptyx maipo* is the only firefly species that depends on mangal ecosystem. The males of *P. maipo*, like other *Pteroptyx* species in tropical regions, have deflexed elytral apices which help them clamp the female during mating (Ballantyne et al. 2011; Cheng et al. 2010). While the larvae feed on snails found on the tidal mudflats, the adults inhabit short vegetation in the vicinity. The males fly over the vegetation and emit lights for courtship, whereas the females perch on the lower part of the vegetation producing response light signals. Although mangrove/ mangrove associates are distributed in many coastal areas of Hong Kong, this species is restricted to the landward fringe of the mangal ecosystem along the shoreline of Deep Bay including Mai Po, Hong Kong Wetland Park and Sheung Pak Nai.

Fig. 13(a) Mangroves in Hong Kong Wetland Park

Fig. 13(b) Adult of *Pteroptyx maipo*

5. *Dense Woodlands*

Woodlands that have no direct association with waterbodies are also home to several terrestrial fireflies. Secondary forests in the territory with diverse native trees and understorey vegetation are highly productive habitats with thriving wildlife, including several terrestrial fireflies- *Stenocladius bicoloripes, Diaphanes citrinus* and *D. lampyroides*. The larvae of these species prey on earthworms that are ubiquitous in forest soil. Interestingly, all these nocturnal species inhabiting dense forests are "dry season species" with adults emerging in autumn or winter. The secondary forests in many Country Parks throughout the territory are typical habitats for these species.

Fig. 14(a) Dense forest

Fig. 14(b) Adult of *Diaphanes citrinus*

Fig. 14(c) Larva of *Stenocladius bicoloripes* feeding on an earthworm

6. *Grasslands and shrublands at woodland fringe in high altitudes*

As altitude increases and temperature drops, vegetation becomes sparse toward the summit. Despite being less rich in wildlife, these relatively open highland grasslands and shrublands are preferred by *Lamprigera taimoshana*. This species, like other *Lamprigera* species, is characterised by its huge, elongated and flat larvae measuring up to 4cm. This species has larviform females. Larvae feed on a wide range of preys including earthworms. The highlands on Tai Mo Shan and Sunset Peak are typical localities of this species (Yiu 2017).

Fig. 15(a) Shrubland at high altitude

Fig. 15(b) Larva of *Lamprigera taimoshana*

Habitat generalists

In contrast with the majority of the firefly species in Hong Kong that are habitat specialists, some species appear to be habitat generalists that occur in a variety of habitats. For instance, the rather solitary male *Pyrocoelia analis* can be seen flying over a wide range of open lowland areas such as village environs, fishponds and coasts; it is even occasionally found in urban areas as it could be attracted by anthropogenic lightings. It was spotted at a roadside walkway and a landscaped area in Yuen Long town centre. *Rhagophthalmus motschulskyi*, which feeds on millipede, is also considered a habitat generalist as it is recorded in various habitats from forest fringes, lawns, river banks to fishpond margins.

Fig. 16(b) Adult of *Pyrocoelia analis*

Fig. 16(b) Adult of *Rhagophthalmus motschulskyi*

Conclusion

Understanding the habitat characteristics is an important step in the conservation of fireflies and their habitats in Hong Kong. Based on the surveys conducted over the past 10 years, it has been revealed that fireflies in Hong Kong use a diverse range of habitats throughout the territory. Many species are habitat-specific and require specific environmental settings for survival. Therefore, particular considerations must be given to maintaining habitat diversity for the conservation of the rich firefly fauna of Hong Kong.

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Scarabaeinae in Hong Kong: The First Record of Tribe Deltochilini, Genus *Panelus* and Three Species (*Panelus parvulus* , *Panelus tonkinensis* and *Onthophagus vigilans*), and the Updated Species Checklist

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漁農自然護理署甲蟲工作小組與中國科學院動物研究所為早前在香港甲蟲多樣性聯合考察中找到的蜣螂進行鑑定，發現在香港屬首次記錄的角蜣螂族（Deltochilini）及泛蜣螂屬（*Panelus*），以及三個新記錄種：微泛蜣螂（*Panelus parvulus*）、越南泛蜣螂（*Panelus tonkinensis*）及戒微嗡蜣螂（*Onthophagus vigilans*）。本文旨在就上述蜣螂的主要鑑別特徵和分佈作出簡短的描述，並更新香港的蜣螂亞科名錄。

Introduction

Scarabaeinae (Coleoptera: Scarabaeidae) is a globally distributed dung- or detritus-feeding beetle sub-family. It serves various important ecological functions, such as nutrient cycling, secondary seed dispersal and parasite suppression, through the consumption of faeces and manipulation of soils. In 2018, the Beetle Working Group of the Agriculture, Fisheries and Conservation Department (AFCD) and the Institute of Zoology of the Chinese Academy of Sciences (CAS) jointly published an article on Scarabaeinae from Hong Kong (with the first comprehensive catalogue) in *Zoological Systematics* (Cheung et al. 2018). Recently, AFCD and CAS have confirmed the identification of another 3 species of Scarabaeinae, namely *Panelus parvulus*, *P. tonkinensis* and *Onthophagus vigilans*. It is also the first time that tribe Deltochilini and genus *Panelus*, which *P. parvulus* and *P. tonkinensis* belong to, are recorded in Hong Kong. This article describes the key morphological features and distribution of these newly recorded species, and presents the updated species checklist of Scarabaeinae in Hong Kong that comprises 14 genera and 54 species.

Panelus parvulus Waterhouse, 1874

Two specimens of *P. parvulus* were collected from Ma On Shan and Tai Mo Shan in June 2017 and September 2018, respectively. Like other species of the genus *Panelus*, *P. parvulus* is a tiny species of about 2.6 mm long. Its body is reddish brown and is slightly oval. It can be distinguished from other *Panelus* species by its pronotum which is densely punctate without depression on the basal part. Besides Hong Kong, *P. parvulus* was previously recorded in Fujian, DPR Korea and Japan.

Fig 17. *Panelus parvulus* (a) dorsal view; (b) ventral view and (c) lateral view.

Panelus tonkinensis Paulian, 1939

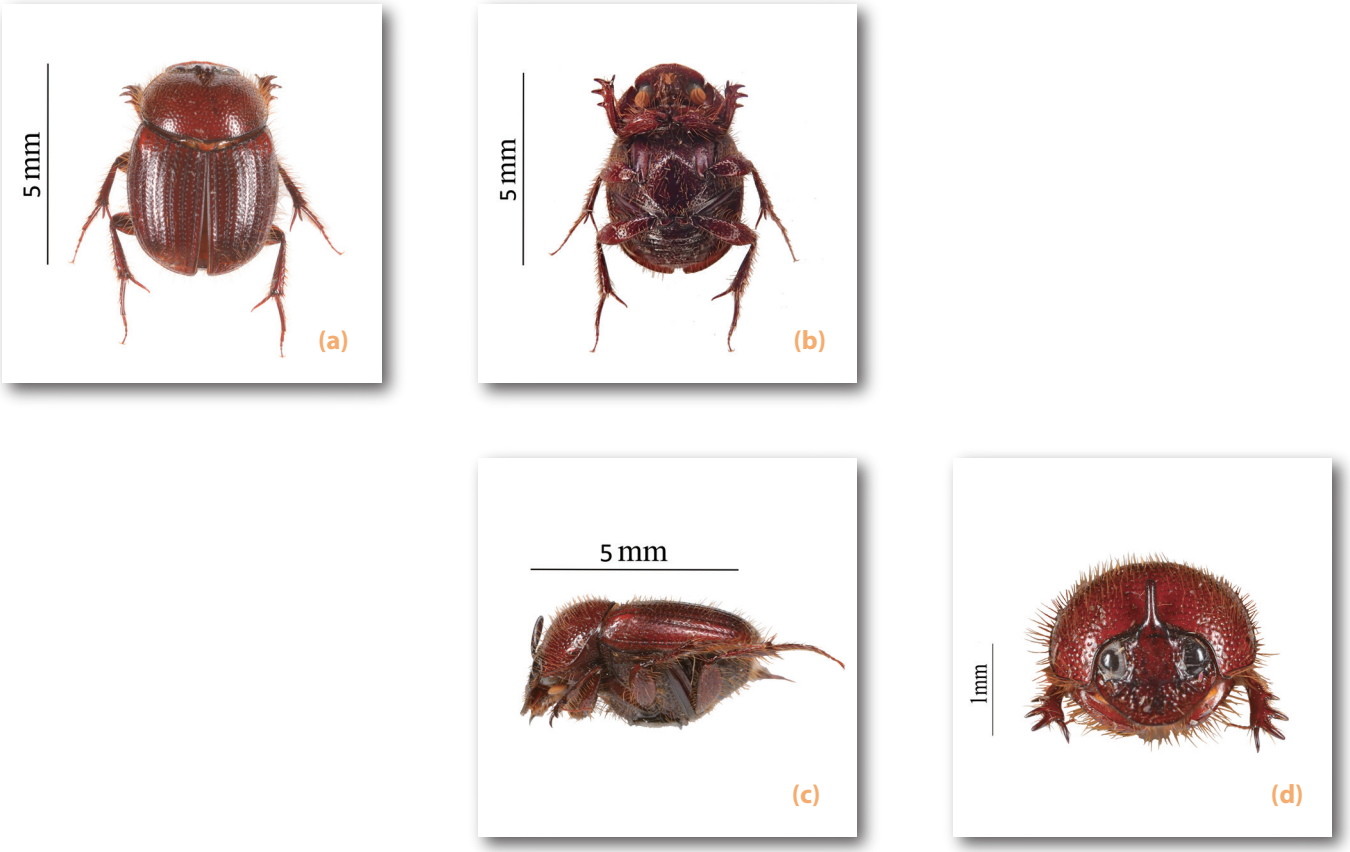
A specimen of *P. tonkinesis* was collected from Tai Mo Shan in April 2013. *P. tonkinesis* is also a tiny species with oval body, but it is remarkably smaller (2 mm) and darker (blackish brown) when compared with other *Panelus* species. Apart from Hong Kong, there were also previous records in Taiwan, Yunnan and Vietnam.

Fig 18. *Panelus tonkinensis* (a) dorsal view; (b) ventral view and (c) lateral view.

Onthophagus (*Micronthophagus*) *vigilans* Boucomont, 1921

A specimen of *O. vigilans* was collected from Tei Tong Tsai in June 2019. *O. vigilans* is about 5.5 mm long. It has brown hairy body and large compound eyes. A distinctive feature of this species is the strongly curved carina (for male, even protruding as a prominence) on forehead. Besides Hong Kong, *O. vigilans* was previously recorded in Yunnan, Bangladesh and Nepal.

Fig 19. *Onthophagus vigilans* (a) dorsal view; (b) ventral view; (c) lateral view and (d) front view.



Species Checklist of Scarabaeinae

To date, with the addition of *P. parvulus*, *P. tonkinensis* and *O. vigilans* reported in this article, a total of 14 genera and 54 species of Scarabaeinae have been recorded in Hong Kong. The updated species checklist of Scarabaeinae in Hong Kong is given in Table 6.

Table 6. List of Scarabaeinae recorded in Hong Kong.

Species	Chinese Name	Reference
Tribe Deltochilini Lacordaire, 1856		
Panelus parvulus Waterhouse, 1874	微泛蜣螂	Present article
Panelus tonkinensis Paulian, 1939	越南泛蜣螂	Present article
Tribe Coprini Leach, 1815		
Catharsius molossus Linnaeus, 1758	神農潔蜣螂	Yiu (2006)
Copris (s. str.) *confucius* Harold, 1877	孔聖糞蜣螂	Aston & Yiu (2008d)
Copris (s. str.) *punctatus* Gillet, 1910	密點糞蜣螂	Cheung et al. (2015)
Copris (s. str.) *sinicus* Hope, 1842	中華糞蜣螂	Yiu and Yip (2011)
Copris (s. str.) *szechouanicus* Balthasar, 1958	四川糞蜣螂	Leung et al. (2018)
Copris (s. str.) *tripartitus* Waterhouse, 1875	三叉糞蜣螂	Aston & Yiu (2008d)
Copris (Sinocopris) ochus Motschulsky, 1860	車糞蜣螂	Aston & Yiu (2008d)
Microcopris propinquus Felsche, 1910	近小糞蜣螂	Leung et al. (2018)
Microcopris reflexus Fabricius, 1787	擬小糞蜣螂	Aston & Yiu (2008d)
Paracopris cariniceps Felsche, 1910	龍首異糞蜣螂	Aston & Yiu (2008d)
Tribe Gymnopleurini Lacordaire, 1856		
Paragymnopleurus melanarius Harold, 1867	黑裸蜣螂	Aston & Yiu (2008d)
Tribe Oniticellini Kolbe, 1905		
Liatongus pugionatus Boheman, 1858	短齒利蜣螂	Aston & Yiu (2008a)
Liatongus vertagus Fabricius, 1798	犬利蜣螂	Aston & Yiu (2008d)
Oniticellus cinctus Fabricius, 1775	帶丁蜣螂	Aston & Yiu (2008d)
Tibiodrepanus sinicus Harold, 1868	中華前脛蜣螂	Aston & Yiu (2008d)
Tribe Ontini Laporte, 1840		
Onitis excavatus Arrow, 1931	掘凹蜣螂	Cheung et al. (2011)
Onitis falcatus Wulfren, 1786	鐮凹蜣螂	Aston & Yiu (2008d)
Onitis intermedius Frivaldszky, 1892	媒凹蜣螂	Cheung et al. (2015)
Onitis subopacus Arrow, 1931	暗凹蜣螂	Cheung et al. (2018)
Tribe Onthophagini Burmeister, 1846		
Caccobius (*Caccophilus*) *brevis* Waterhouse, 1875	短凱蜣螂	Cheung et al. (2015)
Caccobius (*Caccophilus*) *unicornis* Fabricius, 1798	獨角毛凱蜣螂	Aston & Yiu (2008d)
Onthophagus (s. str.) *hastifer* Lansberge, 1885	矛嗡蜣螂	Aston & Yiu (2008b)
Onthophagus (s. str.) *roubali* Balthasar, 1935	羅氏嗡蜣螂	Leung et al. (2018)
Onthophagus (*Colobonthophagus*) *armatus* Blanchard, 1853	武截嗡蜣螂	Aston & Yiu (2008c)
Onthophagus (*Colobonthophagus*) *lunatus* Harold, 1868	鐮截嗡蜣螂	Aston & Yiu (2008c)
Onthophagus (*Colobonthophagus*) *tragus* Fabricius, 1792	公羊截嗡蜣螂	Aston & Yiu (2008c)
Onthophagus (*Furconthophagus*) *dapcauensis* Boucomont, 1921	華南叉嗡蜣螂	Aston & Yiu (2008b)
Onthophagus (*Gibbonthophagus*) *luridipennis* Boheman, 1858	黃翅駝嗡蜣螂	Aston & Yiu (2008b)
Onthophagus (*Gibbonthophagus*) *proletarius* Harold, 1875	裔駝嗡蜣螂	Aston & Yiu (2008b)
Onthophagus (*Gibbonthophagus*) *rectecornutus* Lansberge, 1883	直駝嗡蜣螂	Aston & Yiu (2008c)
Onthophagus (*Gibbonthophagus*) *taurinus* White, 1844	羯駝嗡蜣螂	Aston & Yiu (2008b)
Onthophagus (Matashia) lenzi Harold, 1874	冷氏后嗡蜣螂	Cheung et al. (2018)
Onthophagus (Micronthophagus) vigilans Boucomont, 1921	戒微嗡蜣螂	Present article
Onthophagus (*Paraphanaeomorphus*) *argyropygus* Gillet, 1927	銀衍亮嗡蜣螂	Aston & Yiu (2008b)
Onthophagus (*Paraphanaeomorphus*) *trituber* Wiedemann, 1823	隆衍亮嗡蜣螂	Aston & Yiu (2008b)
Onthophagus (*Parascatonomus*) *anguicorius* Boucomont, 1914	蛇角帕嗡蜣螂	Aston & Yiu (2008b)
Onthophagus (Parascatonomus) horni Balthasar, 1935	宏氏帕嗡蜣螂	Bai (2008)
Onthophagus (*Parascatonomus*) *miyakei* Ochi et Araya, 1992	米氏帕嗡蜣螂	Yiu & Yip (2011)
Onthophagus (*Parascatonomus*) *nitidus* Waterhouse, 1875	亮帕嗡蜣螂	Aston & Yiu (2008b)
Onthophagus (*Parascatonomus*) *tricornis* Wiedemann 1823	三角帕嗡蜣螂	Yiu et al. (2014)
Onthophagus (*Serrophorus*) *sagittarius* Fabricius, 1775	箭鋸嗡蜣螂	Aston & Yiu (2008c)
Onthophagus (*Serrophorus*) *senex* Boucomont, 1914	衰鋸嗡蜣螂	Aston & Yiu (2008c)
Onthophagus (*Serrophorus*) *seniculus* Fabricius, 1781	壽鋸嗡蜣螂	Aston & Yiu (2008c)
Onthophagus brutus Arrow, 1931	笨重嗡蜣螂	Cheung et al. (2015)
Onthophagus convexicollis Boheman, 1858	凸嗡蜣螂	Aston & Yiu (2008a)
Onthophagus coracinus Boucomont, 1914	黑嗡蜣螂	Aston & Yiu (2008c)
Onthophagus orientalis Harold, 1868	東方嗡蜣螂	Aston & Yiu (2008c)
Onthophagus tricolor Boucomont, 1914	三色嗡蜣螂	Cheung et al. (2018)
Onthophagus tritinctus Boucomont, 1914	三彩嗡蜣螂	Aston & Yiu (2008b)
Tribe Scarabaeini Latreille, 1802		
Scarabaeus (Kheper) erichsoni Harold, 1867	艾氏蜣螂	Bai (2008)
Tribe Sisphini Mulsant, 1842		
Sisyphus (*Neosisphyus*) *bowringi* White, 1844	保氏新西蜣螂	Aston & Yiu (2008d)
Sisyphus (s. str.) *indicus* Hope, 1831	印度西蜣螂	Bai (2008)

Acknowledgements

The authors would like to thank Prof. Bai Ming of CAS for verifying the identification of the scarabaeines reported in and reviewing the manuscript of this article.

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