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Feature Article

Roost Censuses of Cave Dwelling Bats of Hong Kong

香港穴棲性蝙蝠調查

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Mammal Working Group

漁農自然護理署於過去兩年的夏季和冬季，在香港各主要的四十多個洞穴內進行了兩次洞棲性蝙蝠調查，當中包括引水隧道、荒廢的礦洞、海蝕洞和大型的排水溝等，共發現十一種蝙蝠，其中霍氏鼠耳蝠數目稀少和分佈狹窄，被列為可考慮優先加強保育的洞穴性蝙蝠物種。

Introduction

Bats spend more than half of their lives in day roosts and their roosting behavior is species-specific. Some inhabit several types of roost while others specialize in only one type of roost. Among the 26 recorded species in Hong Kong (Shek and Chan, 2006), 14 bat species aggregate in caves such as water tunnels and abandoned mines as their day roosts (Fig. 1). Roost census is ideal to record such cave dwelling species, as it is possible to estimate colony sizes and composition of bats in each cave.

At past, the distribution and status of most bat species were poorly known in Hong Kong. Ades (1999) found that many species were only recorded in one to three localities. To better understand the bats and their roosting sites in Hong Kong, a long term monitoring program by AFCD was launched in 2002. The roost census is part of the baseline ecological survey for monitoring the cave dwelling bats in Hong Kong.

Fig 1. Roost of bats in cave, the Himalayan Roundleaf Bat (*Hipposideros armiger* 大蹄蝠) in a water tunnel in Sai Kung.

Contents

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Methods

Direct roost censuses of bats were done in their day roosts, included all major water tunnels, abandoned mines, sea caves, drainage culverts and air raid shelters, in summer (June to August 2004) and winter (December 2004 to February 2005) (Fig. 2). The number of settled individuals, usually in clusters or aggregations, was counted or estimated by determining the cluster densities in selected areas and extrapolating these by the total area of the colony covered by the settled bats. For flying individuals, the number of individuals passing through a reference point was counted. In most caves, the data were further confirmed by the nightly emergence counts and harp trap surveys.

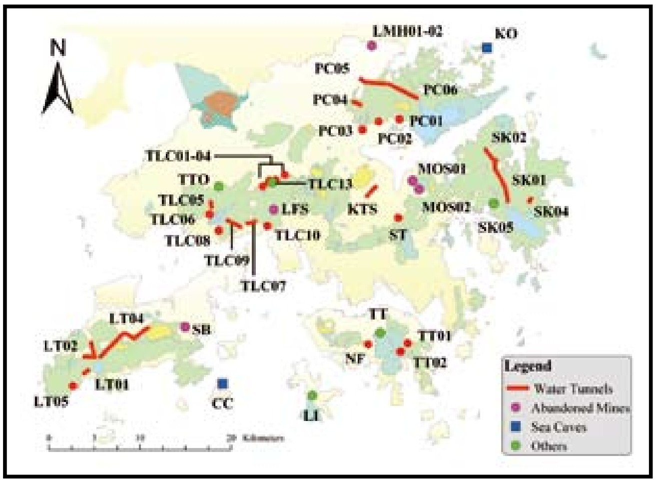

Fig 2. Site surveyed in the winter and summer censuses in 2004-05.

Species identification generally followed the keys by Shek (2004). The Rufous Horseshoe Bat (*Rhinolophus rouxi sinicus* 魯氏菊頭蝠, 華東亞種), however, has been upgraded to an independent species as Chinese Horseshoe Bat (*R. sinicus* 中華菊頭蝠) (Thomas, 1997). Owing to the unclear status of the Common Bent-winged Bat (*Miniopterus schreibersii* 長翼蝠) of Hong Kong, all larger bent-winged bat with forearm length exceeded 46 mm was considered as the Greater Bent-winged Bat (*M. magnater* 大長翼蝠) in this survey.

Based on the percentage of the species out of the grant total of individuals of all bat species (% of species) and the percentage of sites at which the species were recorded (% of sites), the status of species is classified as follows:

	% of species	% of sites
Very Common	> 5 %	> 30%
Common	> 5 %	10 – 30 %
Uncommon	0.1 – 5 %	> 10 %
Rare	< 0.1 %	< 10 %

To reduce disturbance to the bats, each visit was limited to two persons, and caves were visited no more than once per month, as bats subject to frequent disturbance may be forced to wake up from hibernation or torpor, perhaps leading to increased mortality by depletion of energy reserved, especially during winter when food supply is limited.

Results

Species Comparison

At least 11 species of bat were recorded in this study. The total number of individuals and number of sites at which a species was recorded were shown in Table 1. The total number of bats recorded in the summer and winter censuses were 12,987 and 21,178 respectively. The Himalayan Roundleaf Bat (*Hipposideros armiger* 大蹄蝠) was the most abundant species in the summer census whereas the Leschenault's Rousette (*Rousettus leschenaulti* 棕果蝠) was most abundant in the winter census. In both censuses, Chinese Horseshoe Bat was the most widely distributed species. The status of 11 species recorded in the censuses are ranked in Table 1, in which, the Horsfield's Bat (*Myotis horsfieldi* 霍氏鼠耳蝠) was the only rare cave dwelling species in Hong Kong that was found in the water tunnels in Shek Kong and Nam Chung.

Table 1. Bat species recorded in the winter and summer censuses in 2004-05.

Species Name	Site *		Estimated number**		Status #
	Summer	Winter	Summer	Winter	
Himalayan Roundleaf Bat	20 (66.7%)	19 (45.2%)	4332 (33.6%)	4392 (20.7%)	Very Common
Pomona Roundleaf Bat	11 (36.7%)	15 (35.7%)	1962 (15.2%)	3739 (17.7%)	Very Common
Chinese Horseshoe Bat	21 (70.0%)	25 (59.5%)	1744 (13.5%)	1416 (6.7%)	Very Common
Leschenault's Rousette	5 (16.7%)	10 (23.8%)	870 (6.7%)	8828 (41.7%)	Common
Greater Bent-winged Bat	9 (29.0%)	24 (57.1%)	1879 (14.6%)	1439 (6.8%)	Common
Rickett's Big-footed Bat	5 (16.7%)	7 (16.7%)	1527 (11.8%)	258 (1.2%)	Common
Lesser Bent-winged Bat	4 (13.3%)	13 (31.0%)	309 (2.4%)	457 (2.2%)	Uncommon
Intermediate Horseshoe Bat	11 (36.7%)	18 (42.9%)	144 (1.1%)	431 (2.0%)	Uncommon
Least Horseshoe Bat	8 (26.7%)	20 (47.6%)	39 (0.3%)	163 (0.8%)	Uncommon
Chinese Myotis	9 (30.0%)	15 (35.7%)	86 (0.7%)	47 (0.2%)	Uncommon
Horsfield's Bat	3 (9.9%)	1 (4.8%)	5 (0.04%)	8 (0.04%)	Rare

* Total number (percentage) of sites at which the species was recorded.

** Estimated number of individuals of the species (percentage of the species out of the grant total of individuals of all bat species) recorded.

See text for details on status.

Site Comparison

A total of 42 sites were visited in the surveys. More sites were visited during the winter census because some caves were inaccessible during the rainy season, i.e. summer. The water tunnels SK01 (Sai Wan) and KTS01 (Kau To Shan) scored the highest number of bats in the summer and winter censuses respectively. The Himalayan Roundleaf Bat and Leschenault's Rousette were the major species found in these two tunnels. Highest number of species were recorded in the water tunnel SK02 (Pak Sha O) with nine and eight species in the summer and winter censuses respectively.

Water tunnels situated in nearby areas was considered as a single tunnel system in this study. Data obtained from the water tunnels in Sai Kung (SK01-02), Kau To Shan (KTS01-02), Shek Kong (TLC01-04), Lantau North (LT01-02) and Plover Cove (PC01-03) were thus grouped in the site comparison (Table 2). Both Sai Kung and Kau To Shan tunnel systems scored high abundance and species richness of bats are ranked as the key roost caves (water tunnels) of bats in Hong Kong. For the four abandoned mines, the abundance and species richness were relatively lower than that of water tunnels, and the bats found were usually dominated by one or two species (Table 3). Over 1,000 individuals of Pomona Roundleaf Bat (*Hipposideros pomona* 小蹄蝠) were found in Lin Fa Shan while the Lin Ma Hang mine was the major roost for two bent-winged bats: the Lesser Bent-winged Bat (*Miniopterus pusillus* 南長翼蝠) and Greater Bent-winged Bat.

Table 2. Major water tunnel systems surveyed in the study.

Water Tunnel	Site Reference	No. of Species in Summer / Winter	Abundance in Summer / Winter	Major Species (Summer / Winter) *
Sai Kung	SK01-02	9 / 8	3486 / 2712	Himalayan Roundleaf Bat (56.9% / 75.8%), Rickett's Big-footed Bat (26.4% / 4.9%), and Greater Bent-winged Bat (7.5% / 9.8%)
Kau To Shan	KTS01-02	9 / 9	1533 / 7039	Leschenault's Rousette (34.2%/ 87.3%), Himalayan Roundleaf Bat (24.7% / 9.3%), and Pomona Roundleaf Bat (34.2% / 2.8%)
Shek Kong	TLC01-04	7 / 9	1429 / 1169	Chinese Horseshoe Bat (31.3% / 49.9%), Himalayan Roundleaf Bat (47.7% / 22.8%), and Greater Bent-winged Bat (5.2% / 12.6%)
Lantau North	LT01-02, 04	9 / 9	611 / 1320	Pomona Roundleaf Bat (39.8% / 32.3%), Greater Bent-winged Bat (20.9% / 10.2%), and Himalayan Roundleaf Bat (11.6% / 23.9%)
Plover Cove	PC01-03	5 / 9	928 / 1096	Himalayan Roundleaf Bat (80.6% / 3.2%), Pomona Roundleaf Bat (18.6% / 70.8%), and Greater Bent-winged Bat (0% / 7.4%)
Nam Chung **	PC05-06	-- / 9	-- / 957	Himalayan Roundleaf Bat (-- / 52.5%), Pomona Roundleaf Bat (-- / 21.1%), and Greater Bent-winged Bat (-- / 7.8%)

* Percentage of individuals of the species out of the total number of bat in the tunnel.

** The site was inaccessible during summer due to the strong currents.

Table 3. Abandoned mines surveyed in the study.

Abandoned Mines	Site Reference	No. of Species in Summer / Winter	Abundance in Summer / Winter	Major Species (Summer / Winter) *
Lin Ma Hang	LMH01-02	3 / 6	1146 / 898	Greater Bent-winged Bat (81.7% / 73.3%), Lesser Bent-winged Bat (17.5% / 24.1%), and Chinese Myotis (0.8% / 0.7%)
Lin Fa Shan	LFS01-02	3 / 6	1396 / 1593	Pomona Roundleaf Bat (29.7% / 70.3%), Chinese Horseshoe Bat (21.5% / 70.3%), and Himalayan Roundleaf Bat (0% / 7.7%)
Silvermine Bay	SB	4 / 6	318 / 407	Himalayan Roundleaf Bat (51.9% / 57.5%), Pomona Roundleaf Bat (39.9% / 22.1%), and Chinese Horseshoe Bat (6.3% / 1.7%)
Ma On Shan	MOS01-02	1 / 3	2 / 72	Chinese Horseshoe Bat (0% / 79.2%), Intermediate Horseshoe Bat (100% / 0%), and Least Horseshoe Bat (0% / 18.1%)

* Percentage of individuals of the species out of the total number of bat in the tunnel.

Discussion

The roost censuses provide baseline information on the abundance and distribution of 11 species of cave dwelling bats in Hong Kong. Six bats species are ranked either very common or common in this study, including the ones which were thought to be either rare or uncommon in Hong Kong, such as the Rickett's Big-footed Bat (*Myotis ricketti* 大足鼠耳蝠) and Greater Bent-winged Bat. Most roosts are either water tunnels or abandoned mines. These man-made structures provide excellent roosting habitats for many cave-dwelling bats in Hong Kong.

Among the species recorded, only the Horsfield's Bat is ranked as "Rare", worthy for further conservation enhancement. The water tunnels in Sai Kung (SK01 & SK02) and Kau To Shan (KTS01-KTS02) are the key sites of cave dwelling bats in Hong Kong.

Species Account

Himalayan Roundleaf Bat (大蹄蝠) – Very Common

Hipposideros armiger (Hodgson, 1835) (Fig. 3)

Colony size ranges from several individuals to a thousand or more, and individuals usually maintain a small distance between each other. The species can be found in various types of caves, such as abandoned mines, water tunnels and sea caves (Lamma Island). Large colonies were recorded in Silvermine Bay, Shek Kong, Nam Chung, Kau To Shan and Sai Kung (>1,300 individuals in January 2005) (Fig. 4).

Fig 3. Himalayan Roundleaf Bat (*Hipposideros armiger* 大蹄蝠)

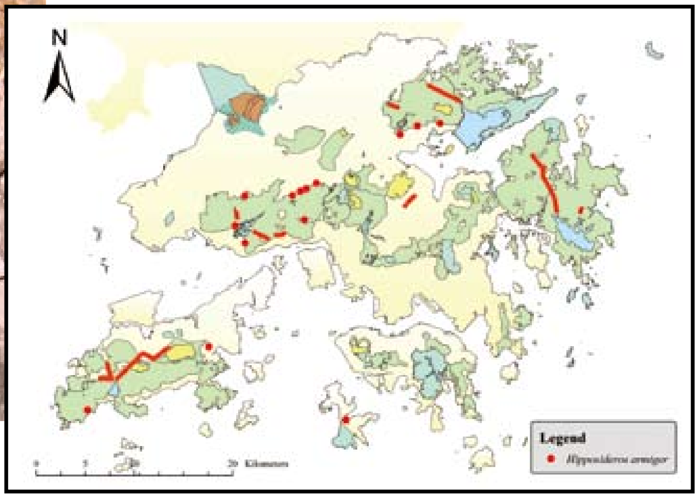

Fig 4. Distribution of the Himalayan Roundleaf Bat in Hong Kong (2004-05).

Pomona Roundleaf Bat (小蹄蝠) – Very Common

Hipposideros pomona Andersen, 1918 (Fig. 5)

Colony size ranges from 50 individuals to more than 1,000, and individuals usually maintain a small distance between each other. The species roosts in various types of caves, and aggregates in small chambers or enclosures, like drainage pipes and air raid shelters. Large colonies were found in Shek Pik, Lau Shui Heung, Shan Liu, and Lin Fa Shan (>1,100 individuals in March 2005) (Fig. 6).

Fig 5. Pomona Roundleaf Bat (*Hipposideros pomona* 小蹄蝠)

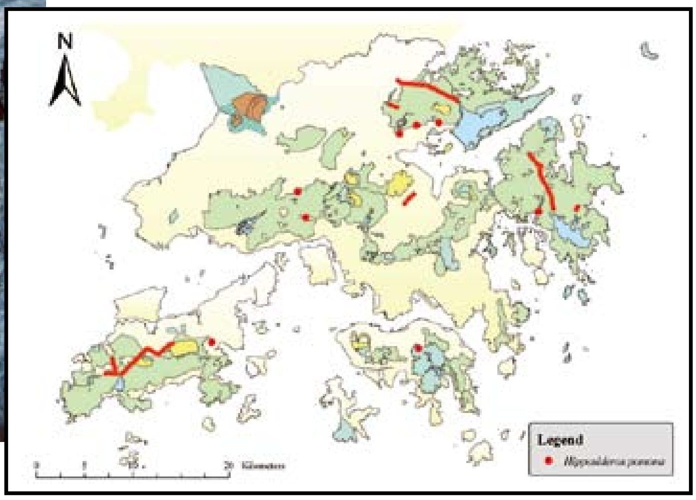

Fig 6. Distribution of the Pomona Roundleaf Bat in Hong Kong (2004-05).

Chinese Horseshoe Bat (中華菊頭蝠) – Very Common

Rhinolophus sinicus Andersen, 1905 (Fig. 7)

This species forms tightly packed aggregation during winter, and sometimes, mixes with Intermediate Horseshoe Bat in their roosts. Colony size ranges from a few individuals to several hundreds. Strong sexual segregation was observed, at least during the breeding season. Females tend to form large aggregations during parturition and lactation and males usually roost alone or in small groups. Large colonies were found in Shek Kong, Lin Fa Shan and Sai Kung (over >1,000 individuals in May 2005) (Fig. 8). This species was once being considered as a subspecies of *R. rouxi*. However, based on the differences in the chromosome numbers (2*n* =36) of the *R. rouxi sinicus*, it is now upgraded as a separate species.

Fig 7. Chinese Horseshoe Bat (*Rhinolophus sinicus* 栗黃菊頭蝠)

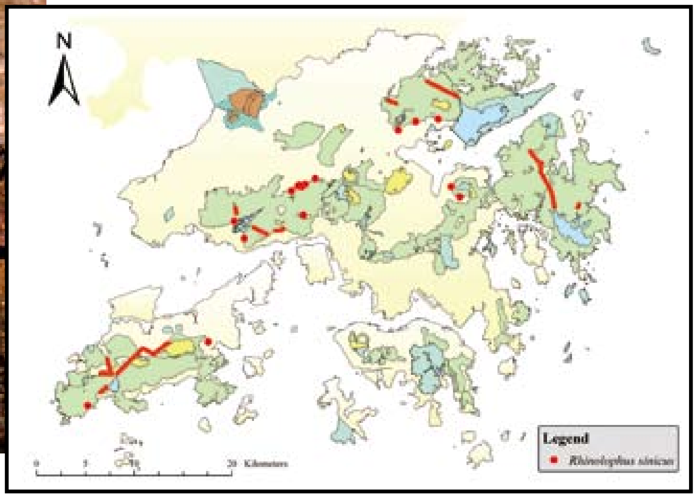

Fig 8. Distribution of the Chinese Horseshoe Bat in Hong Kong (2004-05).

Leschenaulti's Rousette (棕果蝠) – Common

Rousettus leschenaulti (Desmarest, 1820) (Fig. 9)

In Hong Kong, this fruit bat always roosts in twilight zone or near the entrance of water tunnels, or even in sea caves. Colony size ranges from a few individuals to more than several thousands. Upon disturbance, the whole colony may take flight and swoop out of the cave. Large colonies were recorded in Shek Kong, Kat O and Kau To Shan (>6,000 individuals in October 2004) (Fig. 10).

Fig 9. Leschenaulti's Rousette (*Rousettus leschenaulti* 棕果蝠)

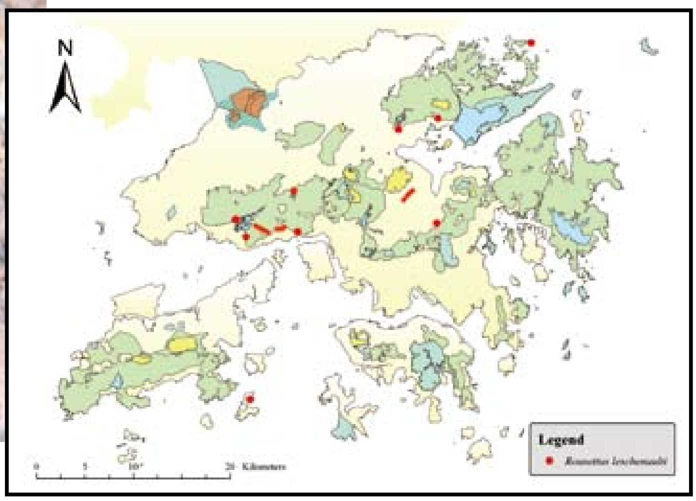

Fig 10. Distribution of the Leschenaulti's Rousette in Hong Kong (2004-05).

Rickett's Big-footed Bat (大足鼠耳蝠) – Common

Myotis ricketti (Thomas, 1894) (Fig. 11)

This Asian fishing bat tends to roost in abandoned mines and water tunnels. Colony size ranges from a few individuals to 1,000. In winter, it forms small groups in small rock crevices. In summer, this species forms large aggregations with other species, e.g. the Greater Bent-winged Bat and Chinese Myotis. Large colonies were observed in Tung Tze and Sai Kung in summer (>750 individuals in August 2004) (Fig. 12).

Fig 11. Rickett's Big-footed Bat (*Myotis ricketti* 大足鼠耳蝠)

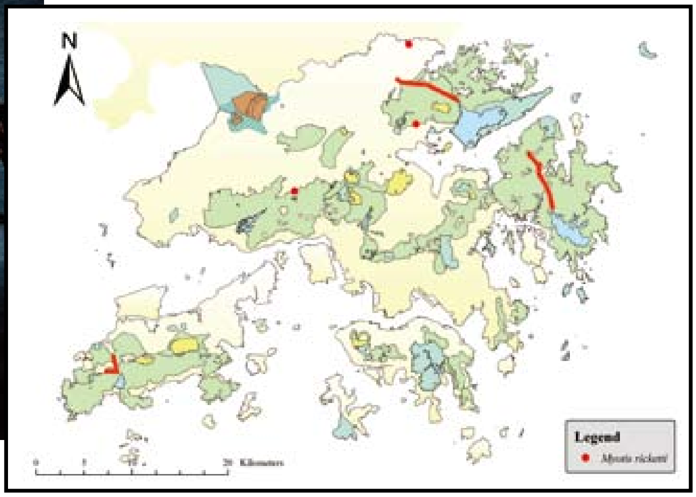

Fig 12. Distribution of the Rickett's Big-footed Bat in Hong Kong (2004-05).

Greater Bent-winged Bat (大長翼蝠) – Common

Miniopterus magnater Sanborn, 1931 (Fig. 13)

This species forms tightly packed aggregations in winter with individuals stacking on each other. The largest over-wintering population of this species was located in an abandoned mine at Lin Ma Hang, which was designated as a Site of Special Scientific Interest in 1994. Colony size ranges from a few individuals to several hundreds. Aggregations sometimes mix with the Lesser Bent-winged Bat and Rickett's Big-footed Bat. Some individuals could be found in rock crevices or weep hole of water tunnels during winter. Large colonies were found in Tung Tze (summer only) and Lin Ma Hang (>900 individuals in August 2004) (Fig. 14).

Fig 13. Greater Bent-winged Bat (*Miniopterus magnater* 大長翼蝠)

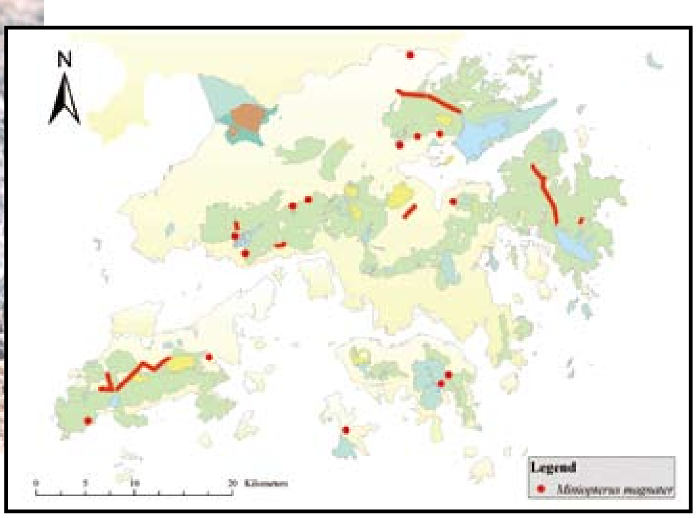

Fig 14. Distribution of the Greater Bent-winged Bat in Hong Kong (2004-05).

Lesser Bent-winged Bat (南長翼蝠) – Uncommon

Miniopterus pusillus Dobson, 1876 (Fig. 15)

Similar to Greater Bent-winged Bat but colony size ranges from a few individuals to several dozens only. It always forms aggregations with the Greater Bent-winged Bat during winter. Colonies were found in Tung Chung and Lin Ma Hang (>250 individuals in August 2004) (Fig. 16).

Fig 15. Lesser Bent-winged Bat (*Miniopterus pusillus* 南長翼蝠)

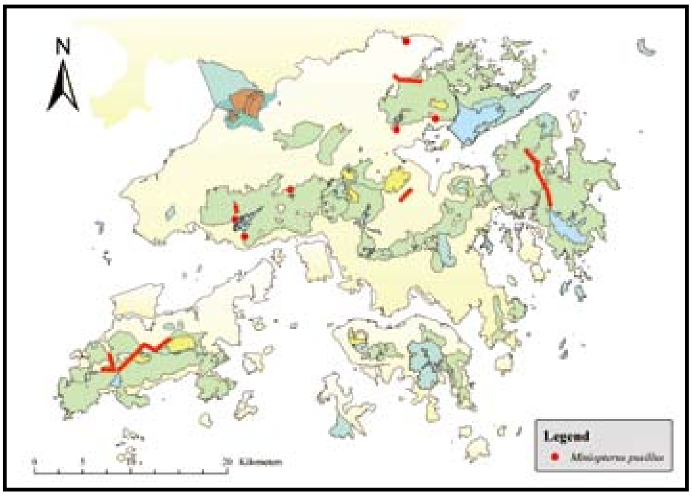

Fig 16. Distribution of the Lesser Bent-winged Bat in Hong Kong (2004-05).

Intermediate Horseshoe Bat (中菊頭蝠) – Uncommon

Rhinolophus affinus Horsfield, 1823 (Fig. 17)

Colony size ranges from few individuals to several dozens. This species preferentially hangs from ceilings or upper walls and maintains individual spacing, but individuals were also found roosting beside the colony of Chinese Horseshoe Bat. Sometimes, a few individuals may be found in the colonies of Chinese horseshoe Bat during winter. Colonies were recorded in Shek Kong, Fung Yuen and Shek Pik (91 individuals in February 2004) (Fig. 18).

Fig 17. Intermediate Horseshoe Bat (*Rhinolophus affinus* 中菊頭蝠)

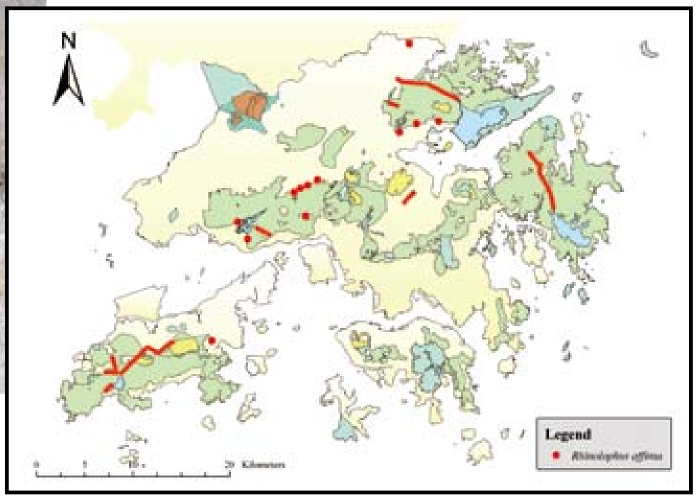

Fig 18. Distribution of the Intermediate Horseshoe Bat in Hong Kong (2004-05).

Least Horseshoe Bat (小菊頭蝠) – Uncommon

Rhinolophus pusillus Temminck, 1834 (Fig. 19)

Solitary individuals roost in scattered assemblages in caves. This species was also recorded in small chambers or drainage pipes. Usually, less than 10 individuals were recorded in each cave. Aggregations were recorded in Silvermine Bay, Tung Chung, and Shek Pik (46 individuals in February 2004) (Fig. 20).

Fig 19. Least Horseshoe Bat (*Rhinolophus pusillus* 小菊頭蝠)

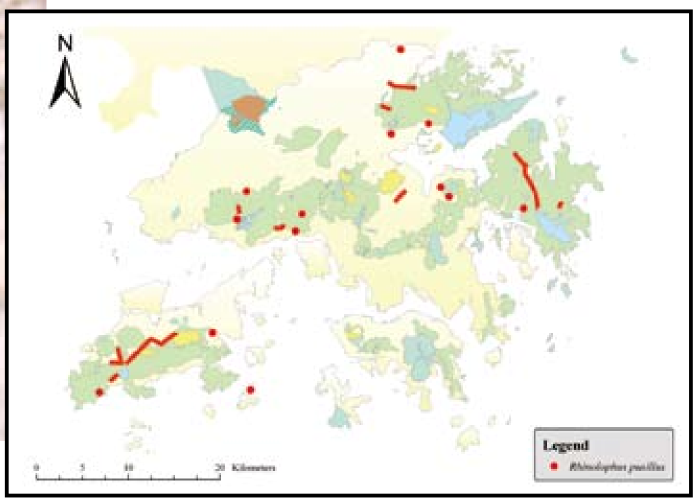

Fig 20. Distribution of the Least Horseshoe Bat in Hong Kong (2004-05).

Chinese Myotis (中華鼠耳蝠) – Uncommon

Myotis chinensis (Tomes, 1857) (Fig. 21)

This species usually roosts alone or in pairs, but sometimes forms colonies of a few individuals to a dozen. In winter, it forms small groups in small rock crevices, but in summer, this species forms large colonies with other species, e.g. the Greater Bent-winged Bat and Rickett's Big-footed Bat. Aggregations were recorded in Shek Kong, Lin Ma Hang and Sai Kung (35 individuals in August 2004) (Fig. 22).

Fig 21. Chinese Myotis (*Myotis chinensis* 中華鼠耳蝠)

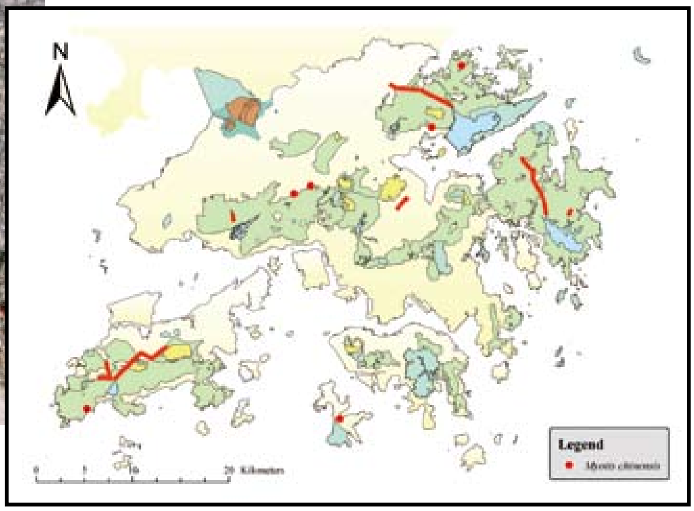

Fig 22. Distribution of the Chinese Myotis in Hong Kong (2004-05).

Horsfield's Bat (霍氏鼠耳蝠) – Rare (Species of Conservation Concern)

Myotis horsfieldi (Temminck, 1840) (Fig. 23)

It roosts in water tunnels, and spends the day secretly in weepholes alone or in small groups of 2 to 3 individuals. Records were found in Nam Chung and Shek Kong (6 individuals in December 2004) (Fig. 24). This *Myotis* species is so-called a sibling species of some other big-footed myotis, in which, species are physically similar to each other. The taxonomy of an individual captured was further confirmed by an mtDNA analysis (Lin and Chou, personal communication) and it is further confirmed by Dr. Gabor Csorba from the Hungarian Natural Museum.

Fig 23. Horsfield's Bat (*Myotis horsfieldi* 霍氏鼠耳蝠)

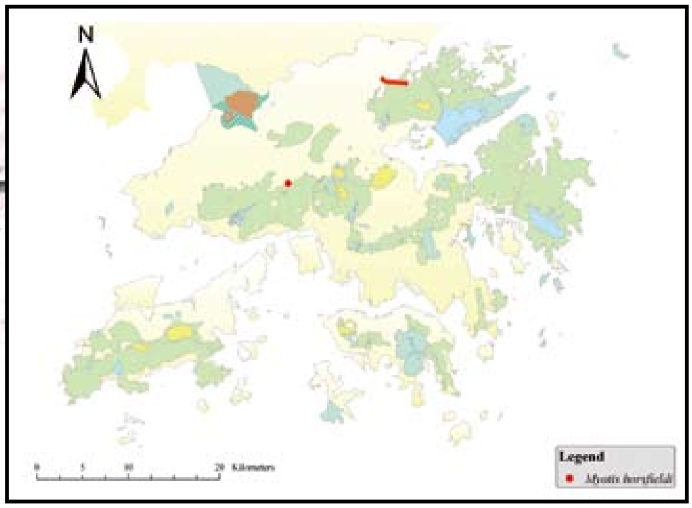

Fig 24. Distribution of the Horsfield's Bat in Hong Kong (2004-05).

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An Introduction to Two Exotic Mangrove Species in Hong Kong: *Sonneratia caseolaris* and *S. apetala*

Winnie P. W. Kwok, Wing-Sze Tang and Barry L.H. Kwok

Introduction

In early 2000, AFCD staff found some extra-ordinary mangrove plants on the exposed mudflat close to the mouth of Shenzhen River in the Deep Bay area. They were later identified as an exotic mangrove species belonging to the genus Sonneratia.

In 2001, Sonneratia individuals were also found among the native mangrove species including *Aegiceras corniculatum*, *Kandelia obovata* and *Acanthus ilicifolius* along the embankment of the downstream section of the Kam Tin Main Drainage Channel (MDC) (Fig. 25). The 13 ha mangroves along the MDC were planted in 1998 as a mitigation measure for the mangrove lost due to the MDC project. Being faster growing, Sonneratia could be easily recognized among other planted mangroves by their height. As Sonneratia usually grow in the outermost region of the seashore, their occurrence among native mangrove suggests that they were planted mistakenly with the native species. In April 2002, the then Territory Development Department (now renamed as Civil Engineering and Development Department) which commissioned the original planting cleared Sonneratia found along the MDC.

The two subcommittees of the Wetland Advisory Committee discussed the occurrence of Sonneratia in Hong Kong in May 2001. Although the potential impact of this exotic species on the native mangrove communities was still unknown, both subcommittees agreed to the precautionary measure to remove the exotic mangrove from the Ramsar site. Since then, AFCD has conducted Sonneratia removal exercises regularly.

Classification of Sonneratia

Sonneratia are evergreen trees with open spreading crown which can grow up to 20 m high. Although they do not have buttress or prop roots, they have thick, cone-shaped and upright densely congregated pneumatophores which originate from the underground cable roots similar to the native *Avicennia marina*. Flowers are solitary with numerous stamens and vestigial (or no) petals. Fruits are fleshy and globule (Hogarth, 1999). *Sonneratia* spp. mainly distribute in the tropical and subtropical area, from East Africa through Indo-Malaya to tropical Australia, Micronesia and Melanesia including the Hainan Island of Mainland China.

The Sonneratia specimens found in the Deep Bay area in 2000 were formerly misidentified as *Sonneratia alba* (杯萼海桑). Based on the key published by Hogarth (1999), AFCD suggests that there are two species of Sonneratia in Hong Kong – *Sonneratia caseolaris* (海桑) (L.) Engl and *Sonneratia apetala* (無瓣海桑) Buch.-Ham (Table 4). In 2005, the Royal Botanic Gardens of Kew in Britain confirmed the specimens sent to them as *Sonneratia caseolaris*.

Both *S. caseolaris* and *S. apetala* belong to the Family Sonneratiaceae (海桑科) which consists of two genera: Sonneratia L. f. (海桑屬) and Duabanga (八寶樹屬) which accounts to 12 species (Wang and Chen, 2002). The genus Sonneratia can be divided into two Sections: Section Sonneratia with capitate stigmas and Section Pseudosonneratia with peltate stigmas. There are six species and three varieties in the genus.

Fig 25. Sonneratia in Kam Tin Main Drainage Channel.

Table 4. The morphological characteristics of *S.caseolaris* and *S. apetala*.

Species	*Sonneratia caseolaris* (L.) Engl	*Sonneratia apetala* Buch. -Ham
Chinese Name	海桑 	無瓣海桑 
Section	*Sonneratia*	*Pseudosonneratia*
Height	up to 15 m	up to 20 m
Natural Distribution	South East Asia to the northern Australia. Native to China where they are naturally found on Hainan Island.	South Asia such as India, Bangladesh and Malaysia.
Leaves	Broad, ovate, opposite leaf, incompletely unrolled to show venation. Apex acute in young plants which becomes round at later stage. Length to width ratio is less than two. Petiole short (0.5 cm) and red. 	Narrow, elliptical, opposite, gradually taper toward the apex. Petiole is longer (~1 cm). 
Flowers	Relatively larger (~5 cm). Bisexual. Stamens red and white distally, standing erect. Style greenish and long, twice the length of stamens, topped with capitate stigma. Usually have 6 sepals. Petals red and oblong. Flowers appear all year round. 	Flower small (1.5-2 cm) and stalked, single or clustered at branch ends. 4 green calyx lobes. Bisexual. Stamens white, standing erect. Style yellow topped with mushroom-shaped or peltate stigma. Flowers appear from May to December. 
Fruits	Compressed and edible fleshy. Large (up to 8.5 cm). Green when young and turns yellowish green and aromatic when mature. Produces 800-1,300 seeds per fruit. Fruits appear all year round. 	Oval berry. Distinctively smaller (1.5-2.5 cm) than *S. caseolaris*. 4-5 calyx lobes. Green when young and becomes grayish when mature. Each fruit produces 100-130 seeds. Fruits appear from August to early Spring. 

Sonneratia in Afforestation

Because of their fast growing nature and the occurrence in the low intertidal level, Sonneratia are often used to stabilize coastline or mudflat (Zan *et al*., 2003). In the ninety centuries, Sonneratia have been widely adopted for afforestation in South China including eastern and western Guangdong Province and Fujian Province (Chen *et al*., 2003).

In 1993, *S. caseolaris* and *S. apetala* were introduced to the Futian Mangrove Nature Reserve (福田紅樹林自然保護區) from Dongzhaigang Mangrove Nature Reserve (東寨港紅樹林區) of Hainan Island as part of a national key project to afforest Shenzhen Bay. While *S. caseolaris* is native to Hainan Island, *S. apetala* was originally introduced from Sundarban in the southwest of Bangladesh to Hainan Island in 1985 (Liao *et al*., 2004; Zan *et al*., 2003).

In Futian, *S. apetala* and *S. caseolaris* started producing flowers and fruits successfully in 1996 and 1997 respectively (Zan *et al*., 2003; Li *et al*., 1998). Similar to those on Hainan Island, the tallest *S. apetala* reached 12.5 m. As at 2003, there was more than 0.6 ha of artificial forest of these two species in Futian.

Sonneratia are renowned for the ease to proliferate. The buoyancy nature of the seeds allows them to be drifted by the water current and travel a long distance. Germination requirements are not specific and seeds tolerate a relatively wide fluctuation of temperature, pH and salinity (Liao *et al*., 1997). In view of these characteristics, the close proximity of the Deep Bay area in Hong Kong to the Futian Nature Reserve (Fig. 26), it is likely that the Sonneratia in Hong Kong was originated from Futian.

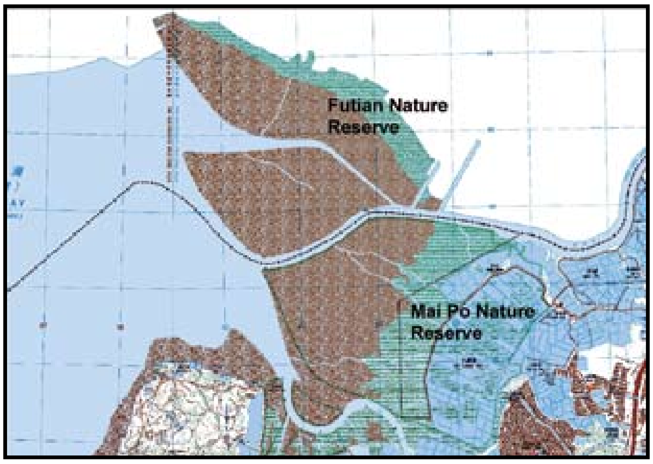

Fig 26. Map showing Mai Po Nature Reserve and Futian Nature Reserve.

Potential "Impact" of Sonneratia on Native Mangrove

Field surveys carried out by AFCD in 2005 found that Sonneratia are distributed in the intertidal area and channels of the Deep Bay area, Tsim Bei Tsui, Hong Kong Wetland Park, Nam Sang Wai, Sheung Pak Nai and Ha Pak Nai (Fig. 27). There were about 1,600 Sonneratia plants in the Deep Bay area (70% *S. caseolaris* and 30% of *S. apetala*). They are mainly distributed in the outlets of stream and channels where salinity is relatively lower. They were also found in the outermost region of the mangrove forests or in isolated 'gaps' within the mangrove forests where light penetrates.

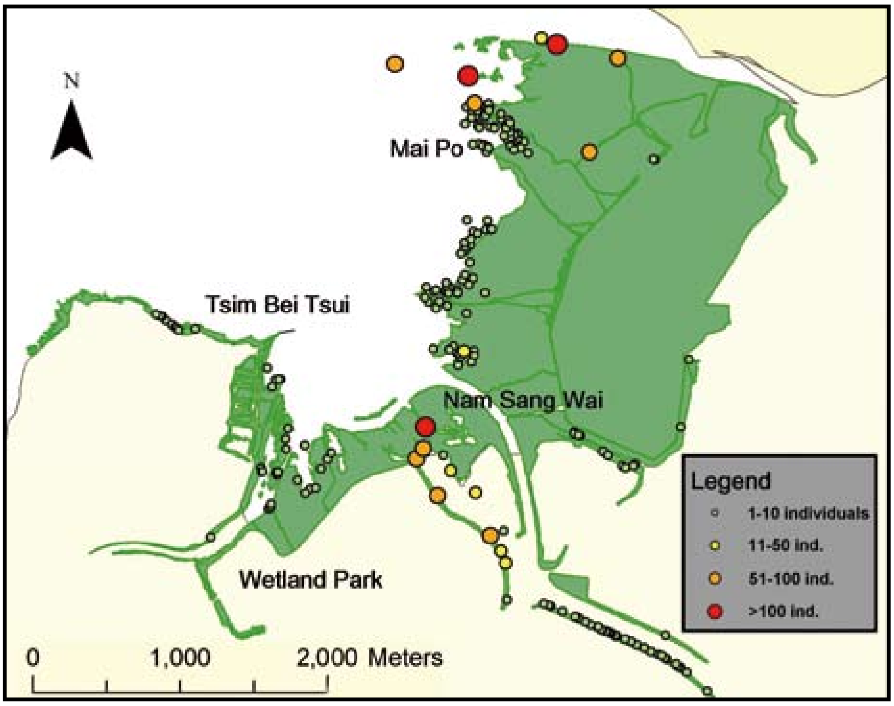

Fig 27. Map showing the distribution of Sonneratia in the Ramsar Site.

There are some discussions on the potential impact of Sonneratia on the native mangrove flora community. When compared with other terrestrial and riparian habitats, mangrove is relatively resistant to invasion as the instable substratum and saline conditions prevent invasion of most exotic plant species (Teo *et al*., 2003). Zan *et al*. (2003) suggested that the niche of *Sonneratia* spp. does not overlap with the native mangroves and therefore it was unlikely that the indigenous mangrove species would be replaced. Moreover, Li *et al*. (2003) showed that *Sonneratia* spp. improve soil quality in the mudflat by increasing salinity, organic materials as well as nitrogen, phosphate and potassium concentration and reducing pH, which could promote the growth of native species. In fact, although *Sonneratia* spp. have colonized the Deep Bay area for several years, there is no sign that they have out grown the well established native mangrove species.

Information Gaps and Way Forward

Information on the basic biology and ecology and the roles played by Sonneratia in Hong Kong is limited but at least it has been observed that some waterbirds like grey herons or egrets made use of Sonneratia for resting. Sonneratia have been reported to serve a number of ecological functions. In Singapore, the fragrant flowers of Sonneratia are pollinated mainly by the Dawn Bat (*Eonycteris spelaea*), the Common Long-tailed Bat (*Macroglossus minimus*), and the Lesser Short-nosed Fruit Bat (*Cynopterus brachyotis*). These bats feed on nectar and pollen of flowers and rely mainly on Sonneratia for sustenance (Tan, 2001). Similar to other native mangrove trees, many mangrove creatures and plants also depend on Sonneratia. Being a pioneer species that grow low on the tidal mudflats, Sonneratia stabilize riverbanks and coasts and provide a more favourable ground for other types of trees and plants (Chen *et al*., 2000). However, as Sonneratia are exotic to Hong Kong and they grow faster than indigenous mangrove species, there are concerns on their possible impacts on the native mangrove species.

The existing 'control' method is on-site mechanical removal which may not be very cost effective because *Sonneratia* spp. regenerate branches easily and quickly from cut trunks. Complete eradication could only be done by either removal of the young seedling when the roots are not well established or dredging out the roots together with their extensive pneumatophores after cutting. In view of the vast area of mangrove and mudflat in the Deep Bay area and that complete root removal would inevitably affect the native mangrove trees nearby, eradication of this exotic species seems impossible by using simple mechanical removal methods.

In view of the above, AFCD initiated a study on the basic biology and potential impact with a view to preparing a management plan for these two species in collaboration with Prof. Nora Tam Fung-Yee of the City University of Hong Kong in summer 2005. The study is expected to last for two years and covers the following topics:

- Coverage and growth rate to determine the spread of these species.
- Germination requirements through experiments in the greenhouse to quantify the habitat requirement of these species.
- Quantifying the flowering and fruiting season and evaluation of the seedling vigor in different fruiting seasons for formulation of the best season for mechanical removal.
- Field competitiveness of seedlings with native mangrove species including *Kandelia obovata*, *Aegiceras corniculatum* and *Avicennia marina* to determine their potential threat to the native mangroves.
- Evaluation of the different physical and chemical control methods to find out the most effective way to clear these species.

Hopefully, more information would be available to help formulating an effective way to control these species after the study. Meanwhile, the precautionary measures to clear these exotic species would be carried out in the Ramsar site.

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Working Group Column

Butterfly Garden in the Shing Mun Country Park

Eric Y.H. Wong, Vinci P.K. Li, Phoebe W.C. Sze and Alfred K.C. Wong
Butterfly Working Group

Introduction

The Butterfly Working Group commenced this trial project, to establish an open butterfly garden in August 2003. The garden forms part of the Working Group's conservation action plan, which aims to carry out *in situ* conservation of butterflies, particularly the species of conservation concern identified in our territory-wide ecological survey. The butterfly garden project also aims to enhance the public awareness of butterfly conservation by providing a place for the public to see and experience encounters with live butterflies.

In contrast to traditional butterfly houses, in which physical environment and biological components are controlled to keep butterflies for public enjoyment, open style butterfly gardens are usually constructed for butterfly conservation as well as nature education. The principle of an open style butterfly garden is to support wild populations of local butterflies by providing plant species having specific relations to their life cycles. Overseas examples of open style butterfly gardens include the Smithsonian Butterfly Habitat Garden in the United States, and the Ecological Education Garden of the Taiwan Endemic Species Research Institute in Taiwan.

The Site

Site selection determines the success of an open style butterfly garden, in terms of both butterfly conservation and public education. The selection was guided by various criteria, where a suitable site should (i) be located within the protected areas which facilitate the protection and management of the garden; (ii) comprise habitats for the growth of nectar plants / larval foodplants and for the colonization of butterflies; (iii) have a good reserve of butterflies; and (iv) be easily accessible to the public. The Shing Mun Country Park is without doubt a good candidate, given its rich records of butterflies and strong popularity among country park visitors.

Among several potential sites in the Shing Mun Country Park, a terrace of about 2,560 m^2 was selected for the trial project (Fig. 28). The public can easily reach the site with a 20-minute walk from public transport. The site, lying on a slight slope facing east, consists of four land patches comprising various microhabitats which fit the needs of different butterfly groups. The dense natural woodland surrounding the site and the scrub plantings bounding the terraced zones form windbreaks, which are required by many butterflies, and which also protect the garden from disturbance.

Planting Materials

Baseline surveys were conducted at the site and its adjacent areas to provide inventories of the existing plants and butterflies in the area. Such information is important to avoid haphazard garden planning. For instance, the presence of a nearby larval foodplants may make it unnecessary to add the plant to the garden, and the butterfly inventory together with knowledge of their larval foodplants and habitat preferences also form the basis of the plant selection.

Apart from the plant species which have proven ability to attract certain butterflies, plants used by the butterfly species of conservation concern were also selected. For instance, India Birthwort (*Aristolochia tagala*, 印度馬兜鈴) and Illigera (*Illigera celebica*, 寬藥青藤), which are the larval foodplants of the Birdwings (*Troides* spp., 裳鳳蝶屬) and White Dragontail (*Lamproptera curius*, 燕鳳蝶) respectively, were planted at the garden.

In addition to larval foodplants, nectar sources can also entice butterflies. Various factors, namely flowering period, nectar production and flower shape, were considered in choosing the appropriate plantings at the garden in order to ensure good nectar sources in terms of both quantity and quality throughout the year.

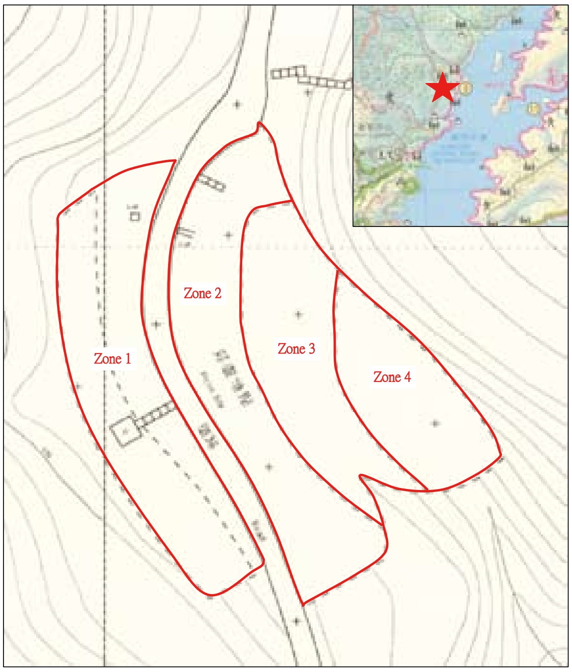

Fig 28. Location map of the Butterfly Garden

A total of 6,700 butterfly larval foodplants and nectar plants of 31 species have been planted at the garden since 2003. Table 5 lists the butterfly larval foodplants and nectar plants at the garden.

Planting Arrangement

While maintaining a mosaic structure of habitats through applying low levels of disturbance has been proven effective in promoting species diversity at butterfly gardens (Kocher and Williams, 2000), proper planting arrangement at the garden links closely with the level of future maintenance required.

Plantings at the butterfly garden were arranged to form clusters of blooms of a species, and different clusters were planted close together to made maintenance easier, and the garden more attractive to butterflies both visually and fragrantly. Furthermore, the herbaceous plants were placed in front of the shrubs in accordance with the rule of thumb in gardening, that is, shorter in front, taller at the back (Fig. 29).

Fig 29. Plantings at the Butterfly Garden, Zone 1.

The plantings, together with the physical characteristics in different parts of the garden, create microhabitats for a variety of butterflies. Trees including a number of citrus (柑橘屬) were planted along the woodland edge of Zones 1 and 4 for butterflies of the families Papilionidae (Swallowtails and Birdwings, 鳳蝶科), Nymphalidae (Nymphs, 蛺蝶科) and Danaidae (Crows and Tigers, 斑蝶科). The shaded edges of these zones are welcomed by Satyridae (Browns, 眼蝶科) and Amathusiidae (Duffer and Faun, 環蝶科). A slope in Zone 4 is left untouched and remains as an open grassy area, which is attractive to Hesperiidae (Skippers, 弄蝶科). Two bamboo scaffolds were also erected in this zone for the climbers – India Birthwort and Illigera (Fig. 30). Being more exposed, Zone 3 is planted with shrubs to attract Lycaenidae (Blues, 灰蝶科) and Pieridae (Whites and Yellows, 粉蝶科). Zone 2 was a picnic area, within which the piece of open grassland allows butterflies to soak up the sunshine during the day.

Fig 30. A bamboo scaffold at the Butterfly Garden, Zone 4.

Visitor Facilities

To enhance the role as a place for nature education, visitor facilities in the garden include a pavilion and two picnic tables in Zones 1 and 2 respectively. The areas of interest in the garden are linked by a well aligned footpath, along which a total of 17 interpretative plates have been installed to introduce butterfly ecology and conservation, and also the local butterflies which may be seen in the garden (Fig. 31 and 32).

Fig 31. Pavilion at the Butterfly Garden, Zone 1.

Fig 32. Interpretative plates at the Butterfly Garden, Zone 2.

Butterfly Uses at the Garden

Compared to the 31 butterfly species representing eight families recorded in the baseline surveys, the number of species recorded in the garden since September 2003 has increased more than twofold to 79 species of nine families. They include species of conservation concern such as Golden Birdwing (*Troides aeacus*, 金裳鳳蝶), Common Rose and White Dragontail. Rare species Common Spotted Flat (*Celaenorrhinus hinus*, 白觸星弄蝶) and the rare vagrant Comma (*Polygonia c-aureum*, 黃鈎蛺蝶) were also recorded.

Larval foodplants in the garden have been used by various butterfly species. Common Rose was found laying eggs on the India Birthwort in Zone 4. Winged Cassia (*Cassia alata*, 翅莢決明) in Zones 1 and 3 are highly effective in attracting the Whites and Yellows including Lemon Emigrant (*Catopsilia Pomona*, 遷粉蝶) and Mottled Emigrant (*C. pyranthe*, 梨花遷粉蝶). Immature Swallowtails, namely Great Mormon (*Papilio memnon*, 美鳳蝶), Common Mormon (*P. polytes*, 玉帶鳳蝶) and Red Helen (*P. helenus*, 玉斑鳳蝶), have been found on the Chinese Lemon (*Citrus limonia*, 黎檬), Pummelo (*C. maxima*, 柚) and Mandarine (*C. reticulate*, 柑橘) in Zones 1 and 4.

Nectar plants in the garden are also used by many butterflies. Distinguished nectar sources include Lantana (*Lantana camara*, 馬纓丹), Blood-flower (*Asclepias curassavica*, 馬利筋) and Pentas (*Pentas lanceolata*, 五星花), where butterflies can feed on their clustered flowers with less time and energy spent. Billygoat-weed (*Ageratum conyzoides*, 藿香薊), Ivy Tree *(Schefflera hetaphylla*, 鵝掌柴) and Prickly Ash (*Zanthoxylum avicennae*, 勒欓花椒) were highly attractive to the Crows during their flowering period in the fall and winter.

Maintenance of the Garden

Plantings in the garden include various flowering shrubs, herbs and climbers providing nectar and larval food sources to butterflies. Field observations, however, revealed that keeping these plants in good condition, particularly in the dry season, needs intensive maintenance. In order to make the butterfly garden a long-term and manageable project, fine-tuning maintenance work is essential. In fact, enrichment and replacement plantings of more self-sustaining species with similar ecological functions have been carried out, and the effects are so far satisfactory. Frequent weeding is also required, as weeds including Mile-a-minute Weed (*Mikania micrantha*, 薇甘菊) otherwise would overwhelm the plantings, in particular the herbs.

Unexpected management problems were recognized after the planting work commenced. Some plantings in the garden were damaged by stray cattle, or by feral monkeys. Some of the branches of young trees were broken by feral monkeys, and the garden was particularly vulnerable to stray cattle that fed on the plantings and stayed in the garden at night. To prevent stray cattle from damaging plants in the garden, fence and uni-directional gates have been erected along the boundary of the garden.

Overall, an adaptive management approach has been adopted to plan the future maintenance work, which is to keep the diverse habitats at the site suitable for *in-situ* butterfly conservation and, at the same time, to meet the visitors' expectation of a garden in bloom for human appreciation as well as nature education.

Ways Forward

Overseas experiences suggest that a successful butterfly garden may necessitate at least three years of observation, trial and error planning and planting (New, 1997). The Butterfly Working Group will closely monitor the butterfly uses in the garden and its conditions and carry out maintenance work where appropriate.

Given the experience gained from this butterfly garden project and that more than 98% of the local butterfly species that are represented in the protected areas, which cover about 40% of the total land area of Hong Kong, there is great potential for establishing more such appropriate sites in our protected areas for *in-situ* butterfly conservation.

Table 5. List of butterfly larval foodplants and nectar plants at the Butterfly Garden.

	Nectar Plants and Larval Foodplants	
Asclepias curassavica, 馬利筋	*Michelia x alba*, 白蘭	*Zanthoxylum avicennae*, 勒欓花椒
Oxalis corniculata, 酢漿草	*Mussaenda erosa*, 楠藤	*Duranta erecta*, 假連翹
Cassia alata, 翅莢決明	*Citrus limonia*, 黎檬	*Osmanthus fragans*, 桂花
Maesa perlarius, 鯽魚膽	*Citrus maxima*, 柚	*Perilla frutescens*, 紫蘇
Crateva unilocularis, 樹頭菜	*Citrus reticulata*, 柑橘	*Hedychium coronarium*, 薑花
Viburnum odoratissimum, 珊瑚樹	*Litsea glutinosa*, 潺槁樹	*Barleria cristata*, 假杜鵑
Ligustrum sinense, 山指甲	*Clerodendrum japonicum*, 赬桐	*Schefflera hetaphylla*, 鵝掌柴
Pentas lanceolata, 五星花	*Microcos paniculata*, 破布葉	
	Nectar Plants	
Lantana camara, 馬纓丹	*Spilanthes grandiflora*, 大花金鈕扣	*Ageratum conyzoides*, 藿香薊
Lantana montevidensis, 小葉馬纓丹	*Salvia splendens*, 一串紅	*Lagerstroemia indica*, 紫薇
Gomphrena globosa, 千日紅	*Melia azedarach*, 楝	*Bidens alba*, 白花鬼針草
Raphiolepis indica, 石斑木 (車梅輪)	*Vitex negundo*, 黃荊	
Ixora chinensis, 龍船花	*Murraya paniculata*, 九里香	
	Larval Foodplants	
Aristolochia tagala, 印度馬兜鈴	*Bambusa multiplex* var. *riviereorum*, 觀音竹	*Boehmeria nivea*, 苧麻
Ovate Tylophora, 娃兒藤	*Toddalia asiatica*, 飛龍掌血	*Illigera celebica*, 寬藥青藤

Acknowledgements

The Butterfly Working Group cordially thanks the Hong Kong Lepidopterists' Society for their advice on the selection of site and plantings, and for the permission to use their photographs on the interpretative plates. We also wish to thank the Kadoorie Farm and Botanic Garden for providing the Blood-flower and the Field Investigation Unit of the Hong Kong Herbarium for the India Birthwort and Illigera. Assistance of the Shing Mun Country Park Management Office in managing the vegetation and constructing the facilities in the butterfly garden is also very much appreciated.

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Discovery of the Fifth Seagrass Species in Hong Kong – *Halophila minor*

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Coastal Community Working Group and the Hong Kong Herbarium

本署職員最近在西貢土瓜坪發現香港第五個海草品種 — 小喜鹽草。及後在蠔涌、斬竹灣及小灘亦發現此品種。

During our territory-wide seagrass monitoring in 2002 and a re-visit on 30 March 2005 to To Kwa Peng, the first and second authors noticed a patch of seagrass with spoon-shaped leaves growing on the mudflats adjacent to the mangrove (Fig. 33). The seagrass looked like *Halophila ovalis* (喜鹽草) but with a different leaf-vein pattern. A subsequent examination of previously collected samples revealed that it was *Halophila minor* (小喜鹽草). Re-examinations of specimens previously deposited in the Hong Kong Herbarium also confirmed the presence of *H. minor*. This species was previously unknown to Hong Kong (Hong Kong Herbarium, 2004).

Fig 33. *Halophila minor*

Both *H. minor* and *H. ovalis* process elliptical spoon-shaped leaves with cross veins. Since they are similar morphologically, they are quite difficult to differentiate in the field. A possible way to identify them is by carefully examining their leaf-vein pattern. In general, the leaf of *H. minor* possesses 3 - 10 pairs of cross veins at an angle of 70 to 90° to the main vein (Fig. 34) while that of *H. ovalis* possesses more than 12 pairs of cross veins with a sharper angle of 45 to 60° (Fig. 35).

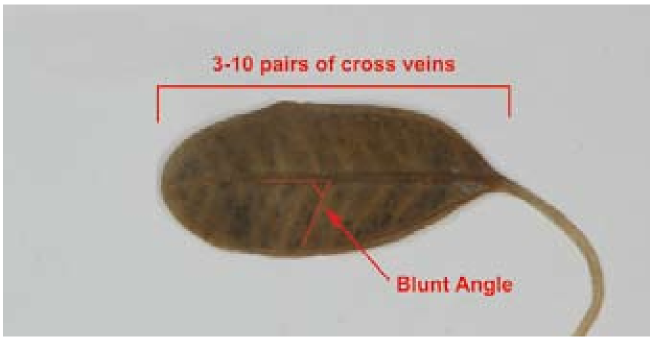

Fig 34. Leaf of *Halophila minor*

Fig 35. Leaf of *Halophila ovalis*

The *Halophila ovalis* recorded in To Kwa Peng as reported in Table 2 of Issue No. 8 should therefore be recognized as *H. minor*. After the discovery of *H. minor* in To Kwa Peng, the species was later recorded in three other localities namely Ho Chung, Tsam Chuk Wan and Siu Tan. A taxonomic treatment of the *Halophila* species in the Hong Kong will be published elsewhere in the near future.

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