

New data on the bat fauna of Con Dao Islands (Ba Ria – Vung Tau Province, Vietnam)

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ABSTRACT. The composition of the bat fauna of Con Dao Islands (Southern Vietnam) is discussed. The insular fauna apparently comprises only eight species, including one frugivorous pteropodid, one nectarivorous pteropodid, one *Rhinolophus* species, and three species of leaf-nosed bats, false vampire, and one *Kerivoula*. The Fawn leaf-nosed bat, *Hipposideros galeritus*, was recorded on Con Dao for the first time. Some of previously published records should be treated as mistakes. Data of the cox 1 mitochondrial gene sequences support that mainland and insular horseshoe bats are conspecifics. Thus the usage of the name *Rhinolophus chaseni* in connection to the mainland populations is justified. The same genetic data show that the insular *Hipposideros* cf. *larvatus* and mainland *H. grandis* are also probably conspecifics, despite morphological difference of these two forms. In general, it can be supposed that the insular bat populations were derived from their mainland conspecifics at the very beginning of the Holocene, a presumed time of the archipelago origin.

KEY WORDS: Bats, Island fauna, *Rhinolophus*, *Hipposideros*, *Kerivoula*, Vietnam.

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Новые данные по фауне рукокрылых островов Кондао (провинция Бария–Вунгтау, Вьетнам)

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РЕЗЮМЕ. Обсуждается состав фауны рукокрылых островов Кондао (Южный Вьетнам). По-видимому, островная фауна насчитывает всего восемь видов, включая одного фруктоядного крылана, одного нектароядного крылана, один вид подковоносов, три вида листоносов, ложного вампира и воронкоухого гладконоса. Хохлатый листонос, *Hipposideros galeritus*, обнаружен на Кондао впервые. Некоторые из ранее опубликованных находок следует признать ошибочными. Данные по последовательности митохондриального гена сох 1 подтверждают конспецифичность материковых и островных подковоносов, а, соответственно, оправданность использования названия *Rhinolophus chaseni* в отношении материковых популяций. Те же данные показывают вероятную конспецифичность островного *Hipposideros* cf. *larvatus* и материкового *H. grandis*, несмотря на морфологические различия этих форм. В целом, можно предположить, что островные популяции рукокрылых обособились от материковых в самом начале голоцена, что совпадает с предполагаемым временем возникновения архипелага.

КЛЮЧЕВЫЕ СЛОВА: рукокрылые, островная фауна, *Rhinolophus*, *Hipposideros*, *Kerivoula*, Вьетнам.

Introduction

The Con Dao Archipelago and its largest island Con Son, as well as many islands in the Indochinese region, probably separated from the mainland due to the huge sea transgression in the latest Pleistocene – early Holocene, about 12–8 thousand years BP (Hanebuth *et al.*, 2000). Along with other issues, this means that the isolation of the island is not too long for local bat populations to become highly divergent from their mainland conspecifics. It is though only true if the island and mainland forms have originated from the common ancestors. At present Con Son is situated in *ca.* 82 km from the nearest mainland coast. It is thus sufficiently

separated from the mainland to prevent any interchange for, at least, forest species, not capable to move for such a distance without landing. So we may suppose that the bat populations occurring on Con Son today belong to the same species which lived on this territory several thousands years ago. During the period of isolation the local fauna could change only in the way of decline as a result of extinction of selected populations. A limited number of water sources, critically important first of all for the members of Vespertilionidae and Molossidae, could be one of the serious reasons for elimination. According to the published data, the latter family was not found on the archipelago and the former one is represented by a single species (Vu Dinh Thong *et al.*,

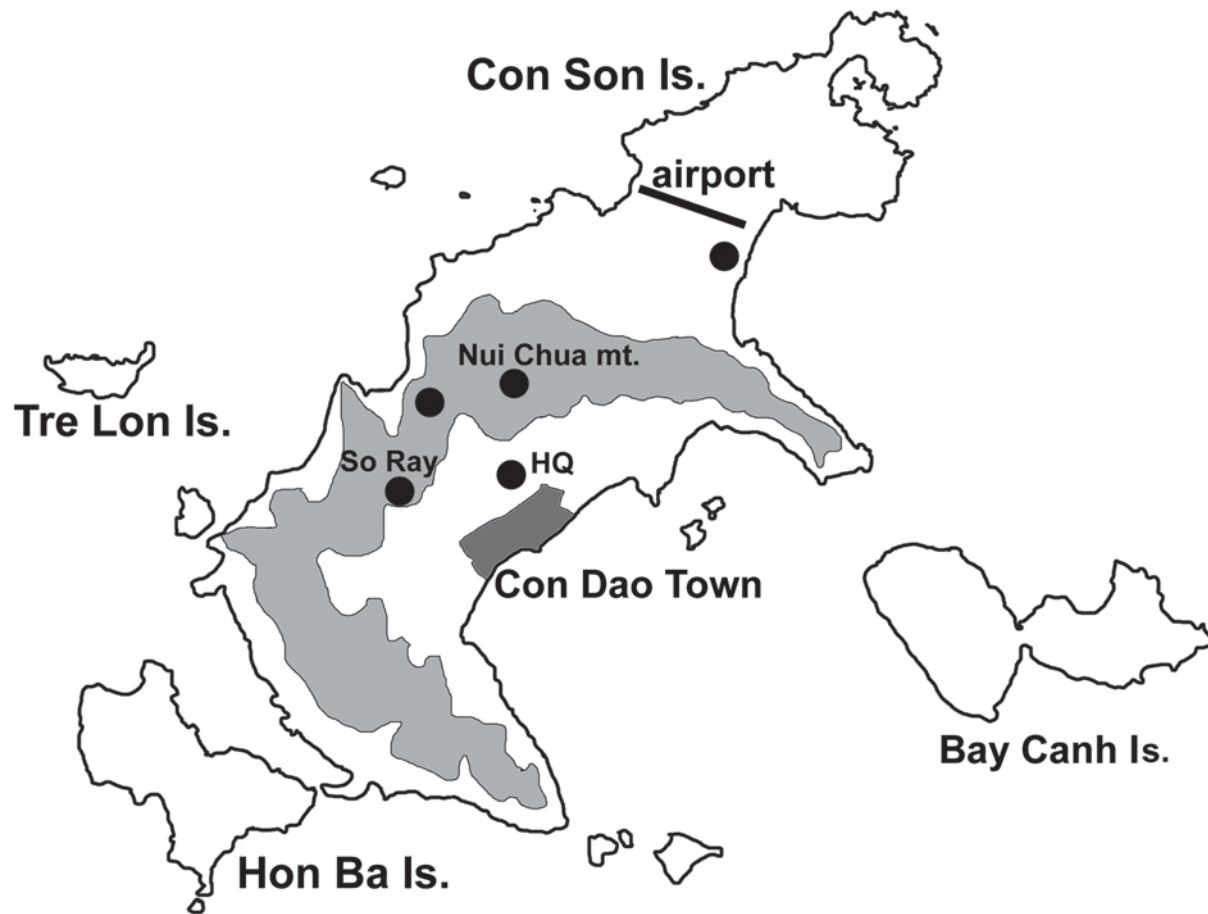


Figure 1. Schematic map of the Con Dao Archipelago. Gray shading shows the main mountain range of the Con Son Island. Black dots mark sites where bats were captured and/or observations were occurred. HQ — Headquarters of the National Park.

2010). Theoretically, the local island fauna could have been enriched through invasions via ships in the last century, though this way is more or less realistic only for synanthropic forms as some pipistrelles.

In the light of these considerations, the Con Son bat fauna should represent a restricted subset of the fauna of coastal areas of the Southern Vietnam. However in the Pleistocene, before its separation, Con Dao represented a part of large terrestrial area, which joined Indochina with the present Great Sunda Islands. The presence on the archipelago of Malayan faunal elements, not found or rare on the mainland, was supposed for some groups of organisms, e.g. some butterflies demonstrate relations with their Bornean congeners (Moulton, 1923). Likewise, some species of pigeons, occurring on the Islands, are not known from Indochina (Robson, 2008). The same may be supposed also for bats. For some extent this idea is supported by the fact that the *Hipposideros* from the *larvatus* group, inhabiting Con Dao, differs morphologically from its relative on the Southern Vietnam mainland (Kruskop, 2003) and supposed to belong to the Bornean subspecies (Van

Peenen *et al.*, 1970; Koopman, 1994; Csorba *et al.*, 2003).

Published data about Con Dao bat fauna look somewhat controversial. The review by Van Peenen (Van Peenen *et al.*, 1970) containing reports about five bat species from four families seems to be most trustable and based on the real collection material. Dang Huy Huynh (Dang Huy Huynh *et al.*, 1994) in his checklist apparently based on Van Peenen publication and reported to Con Dao only one additional species, namely *Hipposideros bicolor* Temminck, 1834. However, later Kuznetsov (2000), discussing the mammalian fauna of the Vietnamese coastal island, enriched Con Dao bat fauna up to twelve species, some of which were mentioned on uncertain grounds. Then, partially due to Kuznetsov's publication, in the recent checklists of the Vietnamese mammals (Borisenko & Kruskop, 2003; Dang Ngoc Can *et al.*, 2008; Kuznetsov, 2006) the summarized local faunal content looks too inflated for such a small isolated territory with some of these records could be based on misidentifications. The same idea was expressed by Vu Dinh Thong *et al.* (2010), who

Table 1. External measurements (in millimeters) of bats from Con Son Island; measurements of *Hipposideros grandis* and *Rhinolophus chaseni* from the Vietnamese mainland are also provided.

			M, grams	L	C	PI	A	FA
<i>Macroglossus minimus</i>	female		15.8	68	–	9.1	16	42
<i>Pteropus hypomelanus</i>	male		267	183	–	37.9	25.4	122.2
<i>Kerivoula hardwickii</i>	n=7	mean	3.7	43	43	6.2	13.4	33.1
		min–max	3.3–4.4	40–45	41.5–45	5.7–6.9	12.1–14.7	31.7–35.0
<i>Megaderma spasma</i>	male		15.5	67	–	12.8	37.2	53.7
	male		15.5	68	–	13.9	36.2	53.6
<i>Hipposideros cineraceus</i>	n=9	mean	4.18	44	27	5.0	16.7	35.1
		min–max	3.4–4.8	42–46	26–31	4.5–5.7	15.2–18.4	34.5–36.0
<i>Hipposideros galeritus</i>	n=5	mean	6.50	52	38	4.8	16.4	47.0
		min–max	6.0–6.8	51–54	36–39	4.4–5.3	14.6–17.8	46.6–47.4
<i>Hipposideros cf. grandis</i> (Con Dao)	n=15	mean	13.94	64	28	7.8	21.2	55.8
		min–max	11.1–18.7	62–67	25–31	7.0–8.6	19.8–22.7	53.8–57.6
<i>Hipposideros grandis</i> (South Vietnam mainland)	n=13	mean	16.88	69	33	9.4	22.3	60.7
		min–max	13.5–22.6	61–75	29–38	9.1–9.6	19.7–24.5	58.1–63.2
<i>Rhinolophus chaseni</i> (Con Dao)	n=24	mean	6.85	51	25	7.3	18.7	42.3
		min–max	5.7–8.0	48–54	21–28	6.4–8.0	15.9–21.2	40.7–44.4
<i>Rhinolophus chaseni</i> (South Vietnam mainland)	n=16	mean	9.25	57	27	8.8	18.6	45.9
		min–max	8.0–10.8	55–60	24.5–32	7.1–10.0	18.0–21.1	43.9–49.0

captured on Con Dao only four species (including previously unreported *Kerivoula cf. hardwickii* Horsfield, 1824) but did not confirmed any of the previous doubtful records. At the same time we could not entirely exclude possibility to find any species not mentioned in previous reviews.

Material and methods

We conducted a short-term investigation of the Con Son bat fauna from May 26 to June 12, 2010, in the course of the complex field investigation, organized by the Joint Vietnamese-Russian Tropical Center with the support of the Con Dao National Park administration. Most of observations and captures were made in the central part of the main range and on the adjacent plain, between range foothills and the Con Dao populated place (Fig. 1).

Bats were observed on the sunset and in the early night, and also early in the morning before sunrise. Observations were held with the use of electric torches and heterodyne ultrasound bat detector D-100 (Petters-

son Elektronik AB). Alive bats were captured by monofilament nylon mist nets (4 by 10 meters) set in the standard way across their flying paths, and mobile flap-trap: nylon or fishing line net 2.5 by 2 meters put on the two carbon five meter fishing rods, using as a large two-handle hand-net (see Kunz & Kurta, 1990; Borisenko, 1999; Borisenko & Kruskop, 2003). However we were obliged to restrict the use of the mist nets because of extremely high density of *H. larvatus* which could badly destroy the mist net before capture of any other species. Thus most of the processed bats were netted by the flap-trap. Captured animals were externally measured with the use of dial calipers; measurement definitions are as follows: M — body mass (in grams), L — head and body length, C — tail length, PI — hind foot length (to the bases of claws), A — ear length, FA — forearm length (see Tab. 1). Selected specimens were photographed with the autofocus digital camera Sigma SD-14. Ectoparasites, mainly parasitic flies from Nycterebiidae and Streblidae families, were collected and fixed in 70% ethanol for further study. Selected specimens from each species (except for *Pteropus*)

Table 2. List of voucher specimens of bats from Con Son Island with associated GenBank numbers.

Species	ZMMU collection number	GenBank number (COI-5)
<i>Hipposideros cineraceus</i>	ZMMU S-186730	JQ365628
<i>Hipposideros cineraceus</i>	ZMMU S-186726	JQ365629
<i>Hipposideros cineraceus</i>	ZMMU S-186727	JQ365630
<i>Hipposideros cineraceus</i>	ZMMU S-186728	JQ365631
<i>Hipposideros cineraceus</i>	ZMMU S-186729	JQ365632
<i>Hipposideros galeritus</i>	ZMMU S-186734	JQ365633
<i>Hipposideros galeritus</i>	ZMMU S-186731	JQ365634
<i>Hipposideros galeritus</i>	ZMMU S-186732	JQ365635
<i>Hipposideros galeritus</i>	ZMMU S-186733	JQ365636
<i>Hipposideros galeritus</i>	ZMMU S-186735	JQ365637
<i>Hipposideros</i> cf. <i>grandis</i>	ZMMU S-186749	JQ365638
<i>Hipposideros</i> cf. <i>grandis</i>	ZMMU S-186747	JQ365639
<i>Hipposideros</i> cf. <i>grandis</i>	ZMMU S-186746	JQ365640
<i>Hipposideros</i> cf. <i>grandis</i>	ZMMU S-186743	JQ365641
<i>Hipposideros</i> cf. <i>grandis</i>	ZMMU S-186742	JQ365642
<i>Hipposideros</i> cf. <i>grandis</i>	ZMMU S-186739	JQ365643
<i>Kerivoula hardwickii</i>	ZMMU S-186757	JQ365644
<i>Kerivoula hardwickii</i>	ZMMU S-186751	JQ365645
<i>Kerivoula hardwickii</i>	ZMMU S-186752	JQ365646
<i>Kerivoula hardwickii</i>	ZMMU S-186753	JQ365647
<i>Kerivoula hardwickii</i>	ZMMU S-186754	JQ365648
<i>Kerivoula hardwickii</i>	ZMMU S-186755	JQ365649
<i>Kerivoula hardwickii</i>	ZMMU S-186756	JQ365650
<i>Macroglossus minimus</i>	ZMMU S-186758	JQ365651
<i>Rhinolophus chaseni</i>	ZMMU S-186783	JQ365656
<i>Rhinolophus chaseni</i>	ZMMU S-186785	JQ365657
<i>Rhinolophus chaseni</i>	ZMMU S-186775	JQ365658
<i>Rhinolophus chaseni</i>	ZMMU S-186784	JQ365659

were collected for further identification, study and comparison with other scientific material (preserved as dry skin and skull or totally in 70% ethanol) and now are housed in the Zoological Museum of Moscow University (ZMMU; Tab. 2); from each of them and also from some released individuals biopsy samples were taken for molecular genetic studies.

Processing of the genetic material was held at the Canadian Centre for DNA Barcoding, Biodiversity In-

stitute of Ontario, in Guelph, Canada. The standard DNA barcode region — 657 base pair 5' segment of the cytochrome oxidase subunit I (COI) gene was analyzed. PCR amplification for the standard DNA barcode region using M13-tailed primer cocktails C_VF1LFt1 and C_VR1LRt1 (Ivanova *et al.*, 2007) was performed as described in Clare *et al.* (2007). For degraded samples we obtained 421 bp the using M13-tailed RonM primer (Pfunder *et al.*, 2004) in combina-

tion with the reverse mammal cocktail C_VR1LRt1 as described in Borisenko *et al.* (2008). PCR products were sequenced using an ABI Prism BigDye Terminator v 3.1 Cycle Sequencing kit and analyzed on ABI 3730XL Genetic Analyzer (Hajibabaei *et al.*, 2005). Bidirectional reads were assembled and manually edited in SEQSCAPE 2.1.1 software (Applied Biosystems). We obtained a DNA barcodes for 29 animals from Con Son as well as for 26 specimens from the mainland Indochina taken as comparative material. Further analysis of molecular COI data was performed using MEGA4 molecular genetic analysis software (Tamura *et al.*, 2007). A distance-based tree was built with the Neighbour-Joining algorithm using the Kimura-2-Parameter method and pairwise deletion of missing data.

Results and discussion

On the whole during the field work more than 70 individuals of eight species were netted and processed. In general our list resembles that of Van Peenen *et al.* (1970). Based on our collecting data, we could critically review some published identifications and reports and came to conclusion that the insular bat fauna in the latest Vietnamese mammalian checklist (Dang Ngoc Can *et al.*, 2008) was mistakably “inflated”. We also did not detect any species for which we could suspect a human-assisted invasion. In addition, we revealed the occurrence of one hipposiderid bat species not previously reported from the archipelago, which extend the known taxonomic diversity of Con Dao chiropterans.

Faunal content and taxonomic remarks

The list of the Con Dao bat species found by us includes two fruit bats: *Pteropus hypomelanus* Temminck, 1853 and *Macroglossus minimus* E. Geoffroy, 1810; one horseshoe bat *Rhinolophus chaseni* Sanborn, 1839; three leaf-nosed bats: *Hipposideros* from *larvatus* group, *H. galeritus* Cantor, 1846 and *H. cineraceus* Blyth, 1853; one false vampire *Megaderma spasma* Linnaeus, 1758; and one woolly bat *Kerivoula hardwickii* Horsfield, 1824. The latter species (and thus the family Vespertilionidae) was reported for Con Dao only recently (Vu Dinh Thong *et al.*, 2010), and our finding confirms that record and specifies the identification. *Hipposideros galeritus* represents the most remarkable finding since was not previously reported for Con Dao.

The conducted molecular study revealed certain affiliations of the Island bat populations; some of them contradict previous opinions.

First of all we entirely prove the idea that the *borneensis*-like *Rhinolophus* from Indochina should be named *R. chaseni*. The latter form was described as a distinct species based on the single specimen in the collection of the British Museum of Natural History (Sanborn, 1939). Mainly specimens of *Rhinolophus malayanus* Bonhote, 1903, the smallest member of the

“*megaphylus*” species group, were used for comparison in that description. Later the form *chaseni* was synonymized with another species of the same group — *R. borneensis* Peters, 1861 from the Sunda Islands (see Csorba *et al.*, 2003), with which it is very similar morphologically. However, according to the recent genetic studies, Indochina is inhabited by different species for which the name *R. chaseni* was suggested as provisional (Francis *et al.*, 2010). In our dataset, four analyzed specimens from Con Dao were nested within the cluster of morphologically similar horseshoe bats from different parts of the mainland Vietnam (Fig. 2). Distances within this cluster vary from 0 to 0.5%. At the same time, the distances from this cluster to both *R. malayanus* from Phu Quoc Island and *R. borneensis* from Borneo are about 13%. Thus the name *chaseni* can be used as valid for the Indochinese species.

Another *Rhinolophus* species reported for Con Dao is *R. lepidus* Blyth, 1844 (Borisenko & Kruskop, 2003; Dang Ngoc Can *et al.*, 2008). Reports of *R. thomasi* Andersen, 1905 and *R. sinicus* Andersen, 1905 are obviously based on misidentified *R. chaseni*, while *R. lepidus* was tentatively confirmed by the specimen in the ZMMU collection. During our survey we captured two other specimens with triangle connecting process which, in combination with external size, is treated as a diagnostic feature of *R. lepidus* (Fig. 3). But further comparison of these specimens and the old one in ZMMU collection with insular and mainland *R. chaseni* revealed no other difference besides the connecting process shape. The penis bone prepared for one of *lepidus*-like specimens looks almost identical to that of *R. chaseni* and well differs from that of *R. cf. lepidus* from Dalat Plateau (Fig. 4), possessing straight and not thickened distal part. Finally we may conclude that the insular population of *R. chaseni* has an uncommon variation in shape of the connecting process, which previously resulted in one more misidentification. It is worth mentioning that *R. chaseni* from the insular population are significantly smaller than their mainland conspecifics (Tab. 1), even not overlapping in body weight. This size difference may explain in part a reason for previous misidentifications.

As it was said above, *Hipposideros larvatus* Horsfield, 1823 was thought to be the most probable Sunda element in the Con Dao bat fauna (in addition to *Pteropus hypomelanus*). Van Peenen *et al.* (1970) mentioned that the insular race is smaller than that from the mainland and allocated it to the Bornean subspecies *H. l. neglectus* Sody, 1936. Worth noting that *H. larvatus* *sensu lato* actually represents a complex of species-level forms (Francis *et al.*, 2010), and the larger bats from Southern Indochina are now treated as a separate species, *H. grandis* G. Allen, 1936 (Thabah *et al.*, 2006; Simmons, 2005). Also according to our data, Con Dao individuals are smaller, has duller coloration and narrower noseleaves than specimens from Southern Vietnam (Kruskop, 2003). Based on our recent material, we even found no overlap in forearm length between South Vietnamese *H. grandis* and insular individuals.

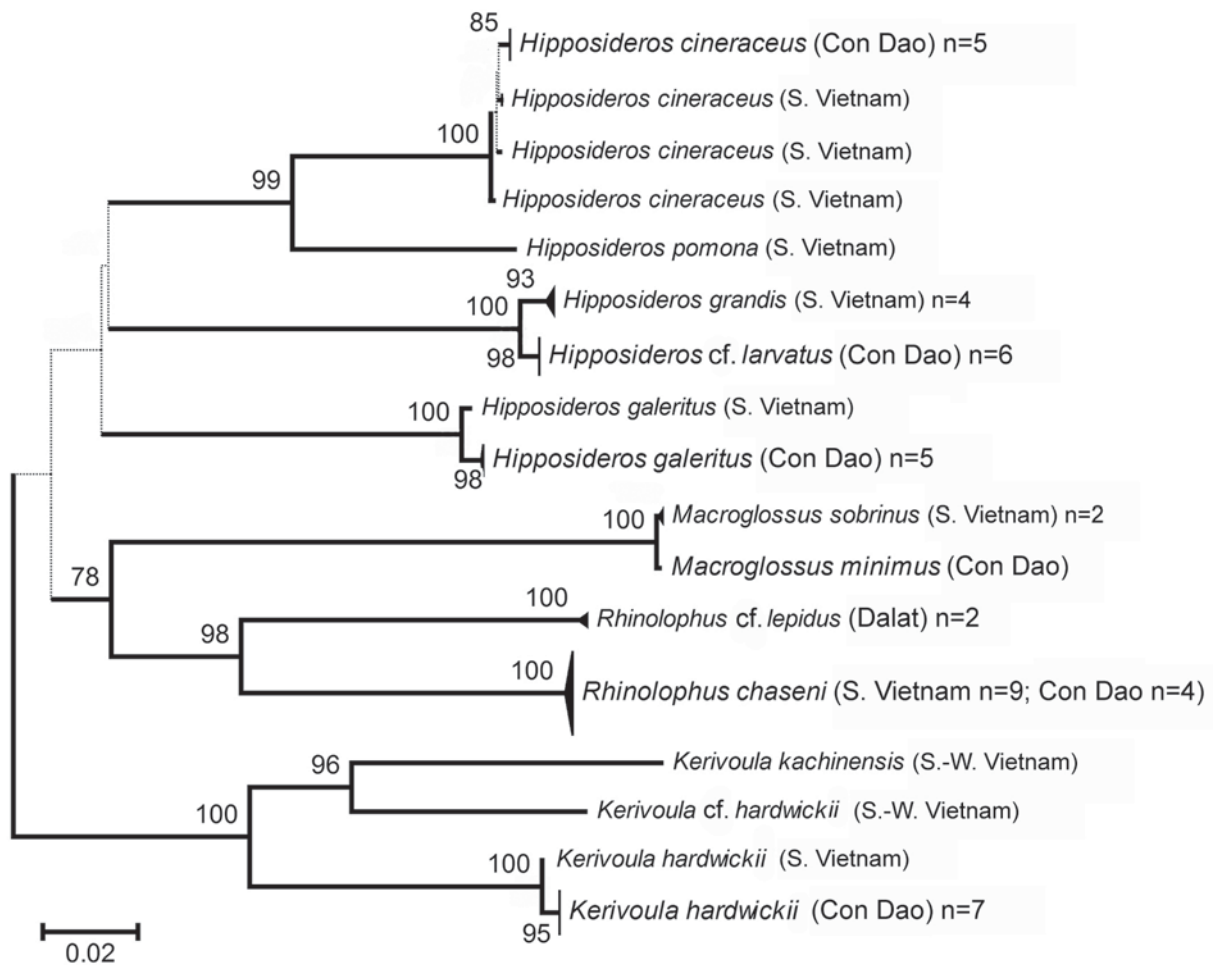


Figure 2. Neighbour-joining tree (Kimura's 2-parametres) built for Con Dao bat specimens and some their mainland congenetics on the basis of cox 1 mt-gene sequences. Bootstrap values (calculated for 1500 replications) only over 70% are shown.

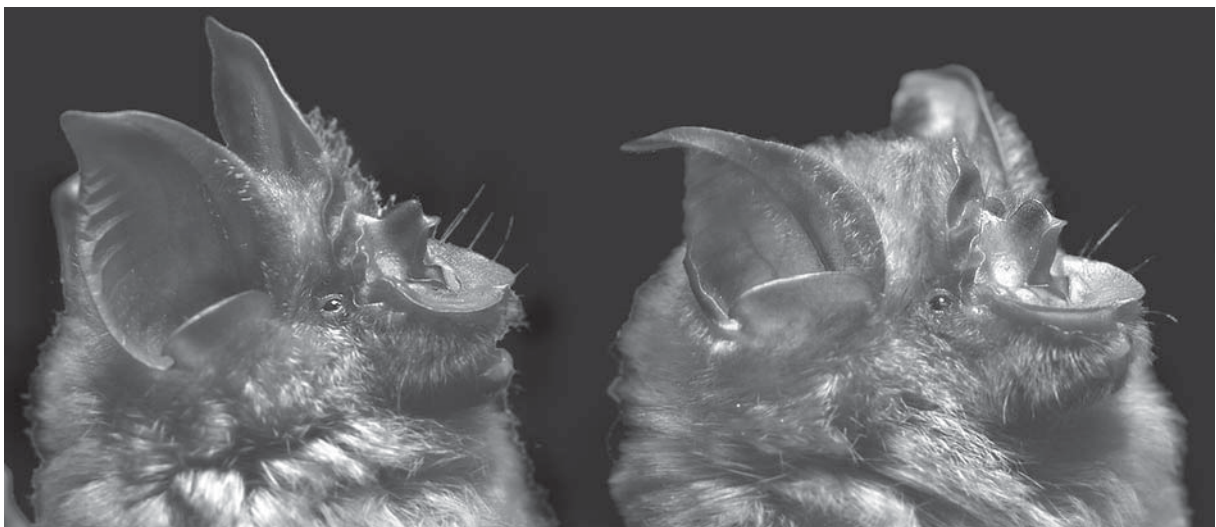


Figure 3. Portraits of the Con Dao horseshoe bat, *Rhinolophus chaseni*: “*lepidus*” (left) and “*borneensis*” (right) morphotypes.

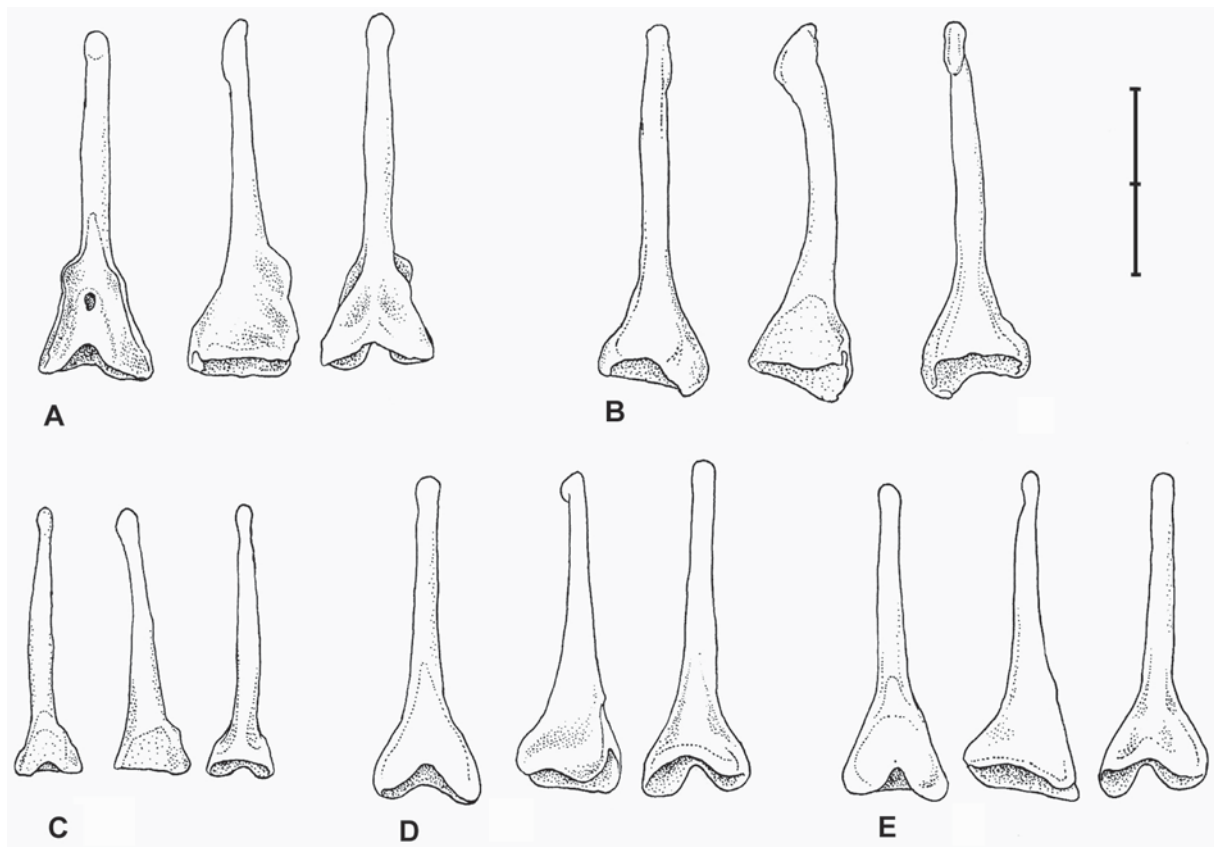


Figure 4. Penis bones (bacula) of some *Rhinolophus* (dorsal, left and ventral views): A, C — *R. chaseni*, Southern Vietnam (A — Cat Tien, Dong Nai Province, $l = 3.4$ mm; C — Vinh Cuu, Dong Nai Province, $l = 2.8$ mm); B — *R. cf. lepidus*, Dalat Plateau, Lam Dong Province, $l = 4.0$ mm; D — *R. chaseni*, “borneensis” morphotype, Con Dao, $l = 3.5$ mm; E — *R. chaseni*, “lepidus” morphotype, Con Dao, $l = 3.4$ mm. Scale bar is 2 mm.

Vu Dinh Thong *et al.* (2010) also reported about higher echolocation frequency in Con Dao *H. “larvatus”*. All these factors support the idea that animals from Con Dao should be assigned to *H. larvatus* and not to *H. grandis*. But contrary to previous suppositions, animals from Con Dao appeared to be very close genetically to the South Vietnamese specimens. Though the insular specimens form a separate cluster on the tree, its distance from *H. grandis* is about 1% (Fig. 2), suggesting an early Holocene divergence. At the same time, the known distances between other populations of *H. larvatus* s. lato, calculated for the same gene, often exceed 5% (Francis *et al.*, 2010). It can be discussed if the Con Dao population belongs to a divergent small insular race of *H. grandis* or represents “real” *H. larvatus* with traces of ancient mt-DNA introgression. Both these theories require an analysis of additional genetic material. But it can be postulated that the insular *Hipposideros* contacted with the mainland *H. grandis* not so long ago and therefore can hardly represent a Sunda faunal component.

As to other bat species, namely *Hipposideros cineraceus*, *H. galeritus*, and *Kerivoula hardwickii*, each of them forms a monophyletic cluster from Con Dao with about 0.3–0.5% distances from the South Vietnamese

conspecifics (Fig. 2). Because *K. hardwickii* most probably represents a complex of morphologically similar species (Francis *et al.*, 2007, 2010), it is necessary to mention that the insular population demonstrates close relations with the specimen from the lowland Southern Vietnam. Though the comparative material from the mainland is limited, we may state that the insular populations undoubtedly belong to the same mainland species and that they were segregated during Holocene time.

Species accounts

Lesser flying fox — *Pteropus hypomelanus*

One subadult male, netted near the Park Headquarters, was seen in hands and measured.

This large fruit bat (forearm length of the mentioned individual was 122 mm; Van Peenen *et al.* (1970) reported about larger specimens) is probably common throughout the Con Son Island. Two or three animals were observed for several days near the Headquarters, feeding on *Terminalia* fruits. Single individuals and pairs were multiply seen near water reservoirs, in forest patches in the sandy landscape and in So Ray gardens; sleeping animals were recorded on Nui Chua Mountain and on Bay Canh Island. It looks like that *P. hypomela-*

mus on Con Dao does not form colonies but lives more or less solitary, as known for the Maldive population (Jones & Kunz, 2000).

Lesser long-tongue bat — *Macroglossus minimus*

One adult female was captured into mist net set for ornithological purposes.

Despite numerous blooming plants in the populated place and close to the Headquarters, we did not observe this fruit bat there. The net, in which the only specimen was captured, was put into a relatively thick growth on the hill slope at *ca.* 80–100 m above sea level.

Chasen's horseshoe bat — *Rhinolophus chaseni*

About 25 individuals of this bat were studied in hands and measured. Horseshoe bats were netted and observed in almost all days of the survey, thus representing the second most abundant bat species on the Islands.

According to our survey, this species use on the islands wide spectrum of foraging biotopes, including primary forest on the main range, arboreal growths on the sandy plains, in secondary growth along roads, on plantations and near street lamps. Animals commonly forage by the air hawking, about 0.5–4 m above the ground. Flight is relatively fast and maneuverable. Detected echolocation calls were CF, at about 102 kHz. Most of observed females were lactating; estimated time for giving births is middle of May.

Intermediate leaf-nosed bat — *Hipposideros cf. grandis*

About 30 individuals of this species were studied in hands and measured.

This bat species is obviously the most numerous and common amongst the insular bat fauna. They were captured or observed in all biotopes covered by this survey, from the Park Headquarters to the forest on the main range. During the maximum activity (after sunset, approximately from 17⁰⁰ to 21⁰⁰; and before sunrise, at 4³⁰–5¹⁰), up to 6–7 foraging individuals could be observed at the moment. This bat is an aerial forager with fast and powerful flight. It looks very probable that on Con Dao, because of absence of pipistrelles, mouse-eared bats and other larger leaf-nosed bats, *H. cf. grandis* occupies ecological niche which otherwise would share with four or five other species. This may explain its local high numbers and density.

Males and females occurred amongst netted animals in almost equal proportion. All the males in the period of survey were reproductively inactive, while amongst females there were non-breeding, pregnant and lactating individuals.

Fawn leaf-nosed bat — *Hipposideros galeritus*

One female and four adult males were captured in So Ray gardens and near the populated place.

According to our observations as well as published data (Bates, Harrison, 1997) this bat is typical “forest edge forager”, more specialized than *R. chaseni*. Ani-

mals were seen foraging along the edge of arboreal growth, about 1.5–4 m above the ground, sometimes very close to vegetation and obviously avoiding open places. All the males were reproductively inactive; female had traces of the finalized lactation.

Least round-leaf bat — *Hipposideros cineraceus*

Six adult females and five males were studied and measured.

This bat seems to be only slightly less numerous on Con Dao than *Rh. chaseni* and was sometimes observed in large amounts. However being more gleaner than aerial forager, this species forages in more cluttered biotopes, has more maneuverable flight and this is the reason why it was captured less frequently. Most studied individuals were netted in the So Ray garden, near the water source. Four of six captured females were lactating.

Malayan false vampire — *Megaderma spasma*

Two males and one female were studied. They were captured on the trail to So Ray gardens and in the dry forest near the airport.

We observed false vampires in three different places on Con Son Island. Small group of about five adults, including one female with yearling were roosting in the cavity under the rock nearby the So Ray trail. The cavity is about two meters deep and from 30 to 50 cm high. Close to this place an adult male was captured soon after sunset; but in later night hours we did not observe false vampires neither inside the cavity nor nearby. Another *Megaderma* day roost, inhabited by two adults, including one female with yearling, was found under the small stony bridge on the pass across the main range. False vampires were also observed hunting over trails and dry stream-beds in the coastal forest in the vicinity of the Con Dao airport.

Hardwicke's wooly bat — *Kerivoula hardwickii*

One subadult and four adult females and two males were studied and measured; all were captured in the So Ray garden.

These bats were observed only in vicinity of a small but permanent artificial water pool that was used as a drinking place by this and other bat species. These bats have a relatively slow but very maneuverable flight. We may suppose that wooly bats forage in highly cluttered places in thick growth and for this reason commonly avoid captures and even observations. Also, due to its maneuverability, the wooly bat can use very small water sources for drinking. Because of this ability the wooly bat is the only vespertilionid species that could survive in the Con Dao isolation. The presence of young, not full-growth individuals indicates April as a birth time for this species.

Conclusions

As shown above, there is no sufficient evidence for Bornean or other Sunda elements in the Con Dao bat

fauna. Most of insular bat populations seem to have been derived from their mainland conspecifics. The age of these separations is more or less concordant with the period of intensive marine transgression (Hanebuth *et al.*, 2000) that disconnected Con Dao from the Indochina.

We have already mentioned that some species earlier reported for Con Dao were not found by our survey. Kuznetsov (2000) reported about the occurrence of *Pteropus vampyrus* Linnaeus, 1758 and *Hipposideros diadema* E. Geoffroy, 1813 on Con Son and Bay Canh, and of *H. armiger* Hodgson, 1835, *Rhinolophus thomasi*, and *R. luctus* Temminck, 1834 on Con Son only, though the grounds of these records are not clear. Only *H. armiger* was mentioned as “captured”, all the others were based on unspecified literature data and visual observations. But we were unable to locate even specimens of *H. armiger* from Con Dao in collections.

Because the Con Dao archipelago is quite small (the largest island Con Son has only 15.6 km in length) and thus is limited in resources, we may suppose that our bat list is close to complete. Though there is a possibility for existing populations of some unrevealed species in the northern part of the Con Son Island and on Bay Canh Island, it is somewhat doubtful. It is especially unlikely for large *Hipposideros* species, such as *H. armiger* and even *H. diadema*. Both are noticeable and versatile bats that could scarcely escape attention of investigators; they also depend on the same resource as *H. cf. grandis*. The huge density of the insular population of the latter species seems to be a good argument for the absence of other large hipposiderids on the archipelago. Likewise, a permanent presence on Con Dao of any other fruit-eating bats except *Pteropus hypomelanus*, and especially of other *Pteropus* species, also seems to be highly improbable since the total area of Con Dao is too small for more than one species of frugivorous bats (Wilson, 1989). It is also likely that it is the absence on the Islands of *Cynopterus sphinx* Vahl, 1797, a very ecologically flexible species occurring almost everywhere on the South Vietnam mainland, that saves enough food resources for sustainable population of flying foxes. It is noteworthy that the distance between mainland and the archipelago is potentially surmountable for large flying foxes. So there is a possibility for records of vagrant *Pteropus vampyrus* in past years, though we did not know about any formal evidences.

It is remarkable that in spite of a not rich local bat fauna, the species that survived on Con Dao after its separation from the mainland form an almost “full-component” community containing nectarivorous, frugivorous and animalivorous bat species with different foraging styles and exploring a wide variety of biotopes.

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