

Research Note

New mosquito species records (Diptera: Culicidae) from Singapore

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Abstract. Nine species of mosquitoes in eight genera are recorded for the first time in Singapore. An additional two species were overlooked in a 1986 checklist for mosquitoes in Singapore, and one was described after 1986. Location and habitat data are provided for the nine new records. With the inclusion of these new records the number of species reported from Singapore is 137.

The Republic of Singapore is an island-city situated 137 kilometres north of the Equator between latitudes 1° 09'N and 1° 29'N and longitudes 103° 36'E and 104° 25'E. It comprises of mainland Singapore and its 62 islets. The total land area is 710.2 square kilometer. Mainland Singapore being the largest of the islands, measures 47.2 kilometres from east to west and 23.2 kilometres from north to south. It has 4.99 million people. The population density is 6814 per square kilometer. Singapore is a highly urbanized city. Approximately 23% of its land area are forest and nature reserves. The highest natural point is Bukit Timah Hill with a height of 166 metres. Due to its proximity to the Equator, Singapore experiences tropical rainforest climate with no distinct seasons. The average daily temperature range between 25°C to 31°C and mean relative humidity is 72%. Rainfall is abundant throughout the year. Average total rainfall per year is 2325 milimetres.

Singapore has an abundance of diverse fauna due to its tropical rainforest and climate. It is also an environment conducive

for the breeding of many species of mosquitoes. Many records and discoveries were reported since the discovery of Singapore, but only until 1980s. The checklist for mosquitoes of Singapore is in need of update.

The last known checklist of mosquitoes of Singapore was prepared by Apiwathnasorn (1986) who listed **126** species in 15 genera. Apiwathnasorn included *Stegomyia aegypti queenslandensis* in the Singapore list of species. However, Lee *et al.* (1987) reduced *queenslandensis* to a synonym of *St. aegypti* in 1987. Hence, the actual number of species in Apiwathnasorn's checklist for Singapore should be 125.

In 2003, the Environmental Health Institute (EHI) of National Environment Agency initiated a study of the mosquito fauna in Singapore that continued through 2005. During that period, collections of mosquito adults and larvae were conducted routinely from vegetated areas on the main island and resulted in many specimens. Also, additional specimens were supplied by the

Singapore Armed Forces from their training areas from 2003 to 2008, and other specimens were provided by the Environmental Health Officers of the National Environmental Agency. The new species records presented below came from these combined specimens.

Collection methods included sweep nets and aspirators for adults, and vials and pipettes for larval specimens. Geographical positioning system (GPS) was used to register the locations of the catches. All survey data were then captured in our vector reference collection system. Adult mosquitoes were identified after collection using a stereozoom microscope (SZ 6, Olympus). Larval specimens were identified using a binocular compound microscope. Species determinations were made using keys by Wharton (1962), Harrison & Scanlon (1975), Huang (1972, 1979), Reid (1968), Reinert (1981), Thurman (1959) and Mattingly (1959). Adult specimens were labeled and stored in boxes while larval specimens were labeled and preserved in vials with 70% ethyl alcohol. Voucher specimens are deposited in the reference collections of the Environmental Health Institute of National Environment Agency.

We have followed Reinert *et al.* (2004), in which subgenera *Paraedes*, *Scutomyia*, and *Stegomyia* were restored to their original status as genera, and subgenus *Lorrainea* was elevated to generic status. Generic and subgeneric abbreviations used are those of Reinert (2009).

This study revealed there were two species, *Anopheles nitidus* Harrison, Scanlon and Reid, and *Armigeres subalbatus* (Coquillett) overlooked by Apiwathnasorn (1986), and *Armigeres kesseli* Ramalingam (1987) was published a year after the checklist. Colless (1959) recorded *Anopheles indiensis* Theobald, in Singapore. However the type for that species was of Indian origin and determined to be a junior synonym of *Anopheles nigerrimus* Giles by Harrison *et al.* (1973), who described the species that occurs in Singapore, Malaysia, and Thailand (but not in India) as a new species, *Anopheles nitidus*. The *Armigeres* species records not

included in Apiwathnasorn (1986) are explained as follows. Colless (1956, 1957) collected *Armigeres obturbans* (Walker) in Singapore. Thurman (1959) restricted the distribution of *Ar. obturbans* to the Celebes and considered *Ar. subalbatus* the correct name for most Southeast Asian specimens previously called *Ar. obturbans*. Lee *et al.* (1988), after discovering the location of the type specimen, determined that *Ar. obturbans* is valid, but likely restricted to the Celebes as Thurman suggested. A year after the checklist was published, Ramalingam (1987) determined that *Armigeres durhami* Edwards, in Malaysia and Singapore, actually included *Ar. durhami*, a high elevation species, and another undescribed species, which he described and named *Armigeres kesseli* Ramalingam.

Anopheles sundaicus (Rodenwaldt) was recorded in the checklist in Singapore by Apiwathnasorn (1986). However, Linton *et al.* (2005) described a new species, *Anopheles epiroticus* Linton and Harbach, for the species previously considered *An. sundaicus* on mainland Southeast Asia and India, and determined that true *An. sundaicus* is restricted to the Island of Borneo. Singapore is between Johore, Malaysia, where *An. epiroticus* occurs, and the Island of Sumatra, Indonesia, where another undescribed species, *An. sundaicus* E, occurs (Dusfour *et al.*, 2007). The true identity of the species in Singapore is being investigated by the Environmental Health Institute using molecular technology.

Beside the three species addressed above that were overlooked by Apiwathnasorn (1986) or described as new species after the checklist, an additional nine species belonging to eight genera were collected during this study and determined to be new records for Singapore. The details of the collection dates, locations and habitats of the new mosquito records are shown in Table 1 and Figure 1.

Twelve species (including nine new species records) are added to the mosquito fauna of Singapore and this brings the total to 137. Currently, the EHI collections have about 80 of those species preserved. Future

Table 1. New mosquito records, collection dates, locations and habitats in Singapore

Species	Collection Date	Number of Specimens	Locations	Habitats
<i>Anopheles (Anopheles) separatus</i> Leicester, 1908	1997, Jan to Dec 2007	6	Pulau Tekong, Pasir Laba, Jurong Island, Pulau Ubin	Forested swamp, Human bait, Pond, Puddle
<i>Armigeres (Arm.) confusus</i> Edwards, 1915	23 Apr 2003, 9 Jun 2004 and 05 Sep 2005	10	Old Holland Rd, MacRitchie Nature Trail, Bukit batok	Black trash bag, Wilton trap with CO ₂ , Puddle
<i>Lorrainea amesii</i> (Ludlow, 1903)	Jan–Jul 2007	113	Pulau Tekong	Human bait, discarded item
<i>Paraedes collessi</i> (Mattingly, 1958)	Jan 2004	14	Turut Track, Pulau Tekong	Open forest, inside car boot, Human bait
<i>Scutomyia albolineata</i> Theobald, 1904	Mar 2004, Jan–Apr 2007	36	Pulau Tekong, Sungei Buloh Wetland Reserve	Water receptacle, container, roadside caps, Discarded item, Wilton trap with CO ₂
<i>Stegomyia (Xye.) desmotes</i> Giles, 1904	08 Sep 2005	1	Mt Faber Park, Nanyang Avenue	Wilton trap with CO ₂
<i>Stegomyia gardnerii</i> ssp. <i>imitator</i> Leicester, 1908	24 Jul 2003	2	SAF Training Area near Nanyang Avenue	Human bait
<i>Coquillettidia (Coq.) nigrosignata</i> (Edwards, 1917)	02 Feb 2007	10	Pulau Tekong	Human bait
<i>Mansonia (Man.) bonnea</i> Edwards, 1930	May 1981, 3 Jan 1994, 2003–2005	69	Sentosa, Pulau Tekong, SAF training area near Chua Chu Kang	Human bait, Training Shed, Light trap

mosquito surveys are envisaged to collect the other 57 species not yet represented in our collections.

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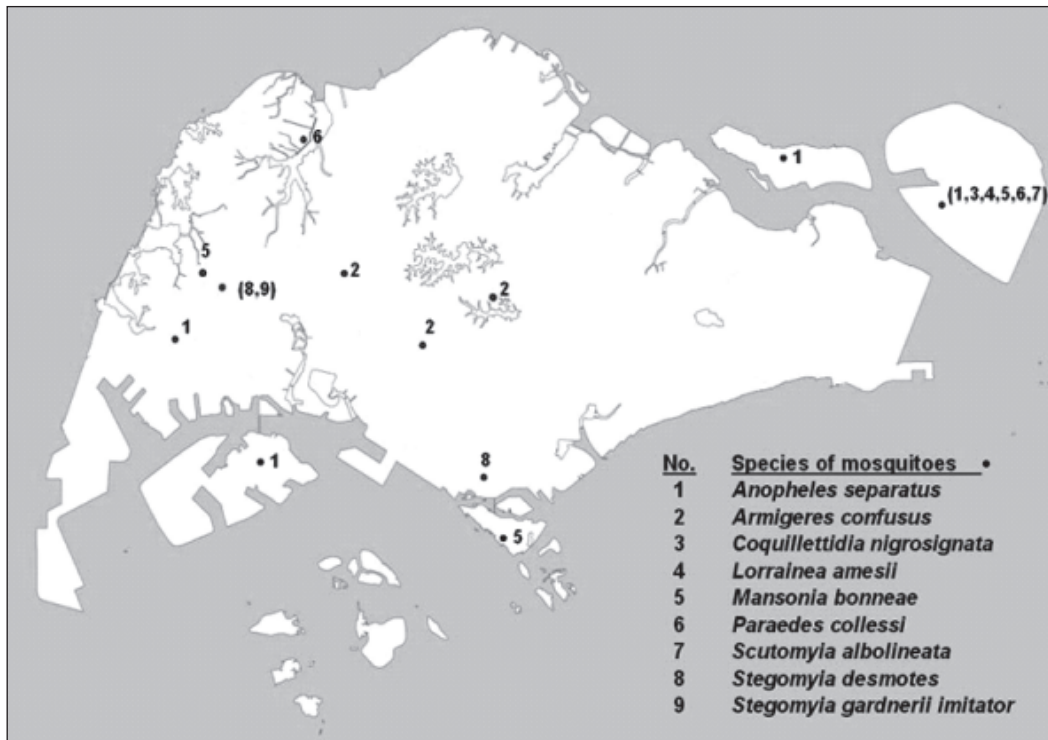


Figure 1. Collection locations of the nine new mosquito records in Singapore.

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