# Distribution and breeding sites of potential dengue vectors in Kandy and Nuwara Eliya districts of Sri Lanka

P. H. D. Kusumawathie[1], R. R. M. L. R. Siyambalagoda[2]

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## Abstract

Entomological investigations were conducted in 26 urban and semi urban areas in Kandy and Nuwara Eliya districts to determine the distribution and breeding sites of potential vectors of dengue, *viz., Aedes aegypti* Linnaeus and *Aedes albopictus* Skuse in these areas. *Aedes* larval surveys were carried out around suspected/ serologically positive dengue fever (DF)/ dengue haemorrhagic fever (DHF) cases in dengue transmission areas, and, in bus depots, government institutions and tyre shops (high risk places for *Aedes* breeding) in DF/ DHF non transmission areas.

*Aedes aegypti* and *Ae. albopictus* were not encountered in the Nuwara Eliya town (altitude 1900 m). But, either *Ae. albopictus* or *Ae. aegypti* and *Ae. albopictus* were encountered in all the other localities (elevation 100 - 1300 m). The majority (96%) of breeding sites of *Ae. aegypti* and *Ae. albopictus* comprised of water storage containers, discarded receptacles and tyres. Breeding sites of *Ae. aegypti* and *Ae. albopictus* differed from one locality to another as well as from one time period to another.

This study shows that the areas situated below 1300 m elevation in Kandy and Nuwara Eliya districts are receptive for dengue transmission. Strengthening of DF/ DHF surveillance and control measures in these areas is an urgent need to reduce morbidity and mortality, and the spatial distribution of DF/DHF in the two districts. Since, the breeding sites differed from one period of time to another and from one locality to another, dengue control measures should be planned based on local and current entomological information.

**Key words:** *Ae. aegypti, Ae. albopictus,* Kandy, Nuwara Eliya.

## Introduction

*Aedes aegypti* Linnaeus is important as the primary vector of dengue fever (DF) and dengue haemorrhagic fever (DHF) in tropical countries of the world. *Aedes albopictus* Skuse is considered as a secondary vector of DF in South East Asia and the Western Pacific (1).

In Sri Lanka, DF was first reported in early 1960s (2). Since then, sporadic, progressively large and more frequent DF/DHF outbreaks occurred in the country. Over the past 10 years, the morbidity, mortality and the spatial distribution of the disease increased considerably with 15,434 suspected and serologically positive DF/DHF cases and 88 deaths for the year 2004. At present, DF/DHF is endemic in many urban and semi urban areas, and has invaded new areas, making the disease an important public health problem in the country (3).

1. *Regional Office, Anti Malaria Campaign, No. 43/50, Talwatta, Kandy.*
2. *Director, Anti Malaria Campaign Directorate, Narahenpita, Colombo 5.*

Occurrence of seasonal/periodic peaks of DF/DHF in dengue endemic areas and emergence of new foci of transmission in hitherto DF/DHF transmission free areas are important problems faced by the dengue control programme in the country. Information on the distribution of *Ae. aegypti* and *Ae. albopictus* and their breeding sites in a particular area would definitely help to take timely and appropriate preventive and control measures to reduce the morbidity, mortality and the spatial distribution of the disease. This study was carried out to determine the distribution and breeding sites of *Ae. aegypti* and *Ae. albopictus* in Kandy and Nuwara Eliya districts of Sri Lanka.

## Methods

### Study area

This study was carried out from January 2003 to December 2004 in the Kandy and Nuwara Eliya districts of Sri Lanka. The study area comprises of plain and hilly areas with a land area of 3,681 km$^2$ and an estimated mid year population of 2.04 million, for the year 2004 (Chief Secretariat, Planning and Monitoring Division, Kandy). According to the Regional Epidemiologists in the Kandy and Nuwara Eliya districts, the Kandy Municipality and the adjoining urbanized areas in the Divisional Director of Health Services (DDHS) areas, namely, Gangawatakorale, Harispattuwa, Kundasale, Pathadumbara, Udunuwara and Yatinuwara are endemic for DF/DHF. The Nuwara Eliya district has reported a few mini outbreaks during the past few years.

### Entomological investigations carried out in the area

Twenty six urban and semi urban areas located at different altitudes in 24 DDHS areas in the Kandy and Nuwara Eliya districts were randomly selected for *Aedes* larval surveys. In DF/DHF transmission areas in the districts, *Aedes* larval surveys were carried out around the suspected and serologically positive DF/DHF cases that were notified mainly by the government hospitals. In hitherto DF/DHF non transmission areas, the surveys were carried out in and around bus depots, government institutions and tyre shops (high risk plaies for *Aedes* breeding) as these institutions reported frequent *Ae. aegypti* and *Ae. albopictus* breeding. During each survey, a minimum of 100 houses within a 200 m radius around the DF/DHF case or the high risk institution were visited, all possible *Aedes* breeding sites were examined and 20 larvae from each positive container were collected randomly by pipetting or dipping, depending on the nature of the breeding habitat. If a particular container had less than 20 larvae, all larvae were collected. The larvae were placed in separate containers (one container per one habitat), staged and identified as 3$^{rd}$ and 4$^{th}$ stages using standard keys (4, 5). The 1$^{st}$ and 2$^{nd}$ stage larvae were allowed to develop to 3$^{rd}$ and 4$^{th}$ stages, and the pupae to become adults prior to identification. If, *Ae. aegypti* and/or *Ae. albopictus* were not encountered in a particular area at the first survey, two more surveys at more than 3 month intervals were carried out in the same area. *Aedes* mosquito density was determined by the Container Index (CI = percentage of containers positive for *Ae. aegypti* and *Ae. albopictus*) for *Ae. aegypti* and/or *Ae. albopictus*.

Breeding sites of *Ae. aegypti* and *Ae. albopictus* were categorized into 5 groups, *viz.*, (1) water storage containers (water storage cemented tanks and iron and plastic barrels), (2) discarded receptacles in the domestic and peridomestic environment (discarded plastic containers, pots, bottles, coconut shells, polythene, metal ware and tins), (3) tyres,

(4) domestic appliances (refrigerator trays, flower vases and ant traps) and (5) others (eg., bamboo stump, leaf axils, concrete slabs and roof gutters). The relative importance of each category of containers for *Ae. aegypti* and *Ae. albopictus* breeding was determined based on the percentage positivity of each type of container for *Ae. aegypti* and *Ae. albopictus* breeding.

## Results

Of the 26 study sites, neither *Ae. aegypti* nor *Ae. albopictus* was encountered in the Nuwara Eliya town. *Ae. albopictus* was encountered in Kalapitiya, Kurunduwatta, Hataraliyadda, Madugoda and Panwila. Both *Ae. aegypti* and *Ae. albopictus* were reported from the rest of the localities (Fig 1).

*Ae. aegypti* and *Ae. albopictus* were encountered primarily in water storage containers in Ambagamuwa, Bulugohotenna, Galagedera, Galaha, Gampola, Hijjapura, Kandy, Madawala, Poojapitiya, Rikillagaskada and Talatuoya; in discarded receptacles in Daulagala, Hataraliyadda and Kalapitiya; and in tyres in Hanguranketha, Hasalaka, Hatton, Madugoda, Pundaluoya and Walapane (Table 1).

In a particular area, the types of breeding sites of *Ae. aegypti* and *Ae. albopictus* differ from one period of time to another (Table 2).

Water storage tanks are the most preferred breeding site of *Ae. aegypti* and *Ae. albopictus* while discarded receptacles and tyres serve as important breeding sites of the two vector mosquito species (Table 3).

In the study sites that were positive for *Ae. aegypti* and *Ae. albopictus* breeding, the CI for *Ae. aegypti* varied from 1 to 75%, with high CI values for Hasalaka (38%), Hatton (11%), Madawala (11%), Pundaluoya (18%) and Walapane (75%). High CI for *Ae. albopictus*, were observed in Hasalaka (25%), Madugoda (15%), Rikillagaskada (12%) and Walapane (100%) (Table 4).

## Discussion

Dengue and DHF is a disease complex caused by four serotypes of the dengue virus, namely, Dengue 1, 2, 3 and 4. The disease is transmitted by *Ae. aegypti* and *Ae.albopictus* (1, 6, 7). Thus, natural transmission of DF/DHF depends on the presence of the dengue virus, *Aedes* vector mosquitoes and a susceptible population.

According to serological studies carried out in Sri Lanka, the World Health Organisation (1985) reported DF in towns that are situated below an altitude of 1200 m (2). Vitarana (1986) too, reported that dengue was prevalent in areas below the altitude of 1000 m (8). However, these studies have not sufficiently dealt with the entomological aspects of DF/DHF in these areas. In the present study, *Ae. aegypti* and *Ae. albopictus* were encountered even at elevations of 1300 m, making the areas that are situated below 1300 m receptive for DF/DHF transmission. Also, the density of *Ae. aegypti* and *Ae. albopictus* remains high in some areas, especially, Hasalaka, Hatton, Madugoda, Pundaluoya, Rikillagaskada and Walapane, making these areas highly receptive for DF/DHF transmission. Thus, strengthening of DF/DHF surveillance and control measures, specially in urbanized areas situated below 1300 m elevation is of importance in reducing morbidity, mortality and the spatial distribution of DF/DHF.

In the absence of a specific treatment or a vaccine for DF/DHF, vector control is of

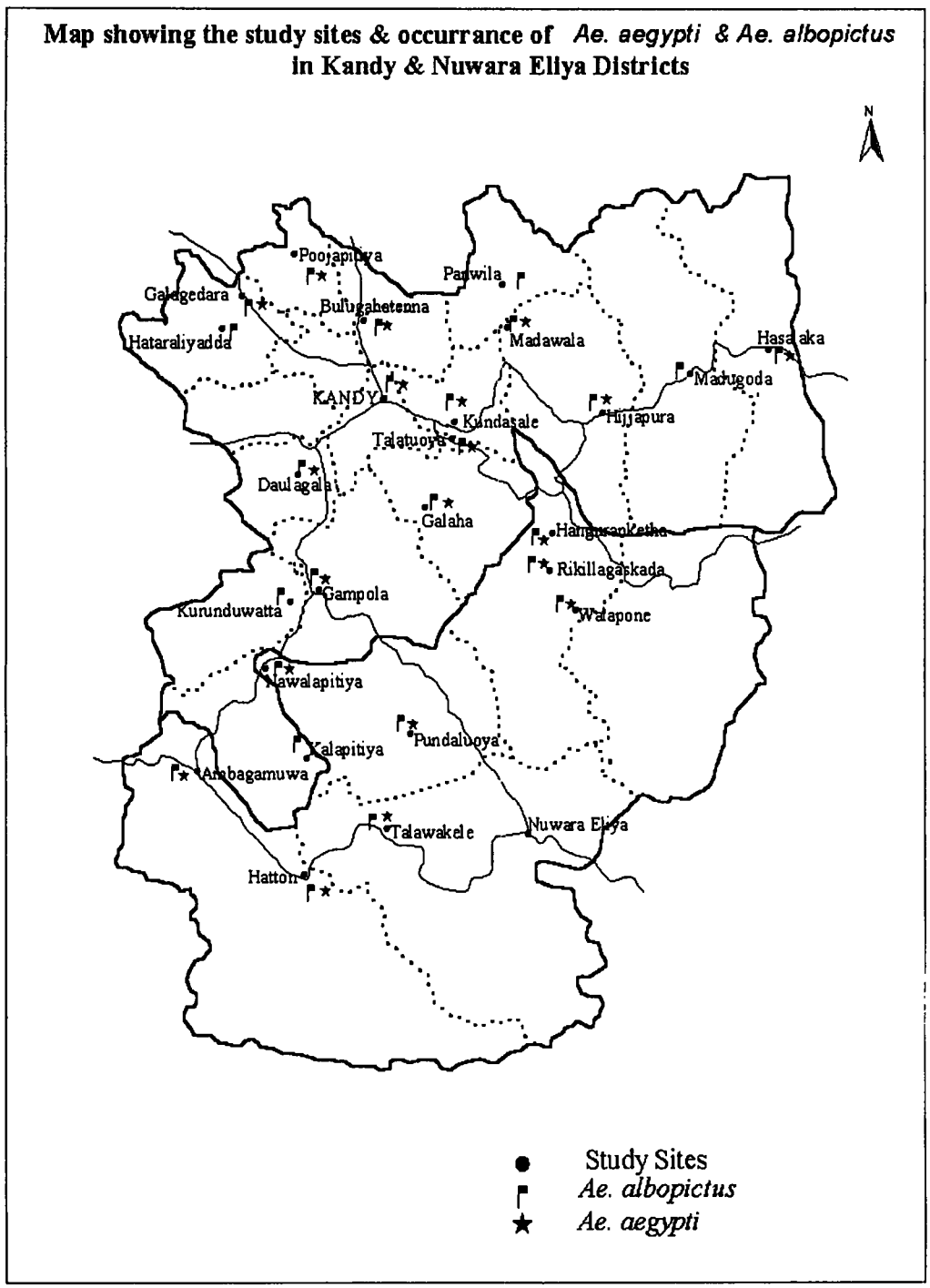
Map showing the study sites & occurrance of Ae. aegypti & Ae. albopictus in Kandy & Nuwara Eliya Districts
N
Poojapitiya
Panwila
Galagedara
Bulugahetenna
Hataraliyadda
Madawala
Hasalaka
Madugoda
KANDY
Kundasale
Hijapura
Talatuoya
Daulagala
Galaha
Hanguranketha
Rikillagaskada
Gampola
Kurunduwatta
Walapone
Nawalapitiya
Pundaluoya
Kalapitiya
Ambagamuwa
Talawakele
Nuwara Eliya
Hatton
Study Sites
Ae. albopictus
Ae. aegypti

Figure 1

Table 1. Number and % (given in parentheses) of different types of containers positive for *Ae. aegypti* and *Ae. albopicus* in the study sites in Kandy and Nuwara Eliya districts: January 2003 – December 2004.

| DDHS area | Locality | Number (%) of containers positive for *Ae. aegypti* and *Ae. albopictus* in 5 different container types | | | | | |
|---|---|---|---|---|---|---|---|
| | | WSC | DR | T | DA | O | Total |
| Akurana | Bulugohotenna | 24 (83) | 4 (14) | 0 (0) | 1 (3) | 0 (0) | 29 (100) |
| Ambagamuwa | Ambagamuwa | 7 (78) | 2 (22) | 0 (0) | 0 (0) | 0 (0) | 9 (100) |
| Galaha | Galaha | 5 (83) | 1 (17) | 0 (0) | 0 (0) | 0 (0) | 6 (100) |
| Hanguranketha | Hanguranketha | 0 (0) | 0 (0) | 4 (100) | 0 (0) | 0 (0) | 4 (100) |
| Hanguranketha | Rikillagaskada | 23 (55) | 10 (24) | 8 (19) | 0 (0) | 1 (2) | 42 (100) |
| Hasalaka | Hasalaka | 0 (0) | 0 (0) | 6 (100) | 0 (0) | 0 (0) | 6 (100) |
| Hataraliyadda | Hataraliyadda | 2 (29) | 5 (71) | 0 (0) | 0 (0) | 0 (0) | 7 (100) |
| Kotmale | Kalapitiya | 1 (25) | 2 (50) | 1 (25) | 0 (0) | 0 (0) | 4 (100) |
| Kotmale | Pundaluoya | 0 (0) | 0 (0) | 10 (100) | 0 (0) | 0 (0) | 10 (100) |
| Kundasale | Kundasale | 6 (35) | 3 (18) | 8 (47) | 0 (0) | 0 (0) | 17 (100) |
| Kurunduwatta | Kurunduwatta | 0 (0) | 1 (33) | 2 (67) | 0 (0) | 0 (0) | 3 (100) |
| Maskeliya | Hatton | 0 (0) | 3 (17) | 14 (78) | 1 (5) | 0 (0) | 18 (100) |
| MC Kandy | Kandy | 12 (53) | 9 (39) | 1 (4) | 0 (0) | 1 (4) | 23 (100) |
| Medadumbara | Hijjapura | 27 (96) | 1 (4) | 0 (0) | 0 (0) | 0 (0) | 28 (100) |

*WSC = water storage containers, DR = discarded receptacles, T = tyres, DA = domestic appliance, O = other

*(Contd. on next page)*

Table 1. *(Contd.)*

| DDHS area | Locality | Number (%) of containers positive for *Ae. aegypti* and *Ae. albopictus* in 5 different container types | | | | | |
|---|---|---|---|---|---|---|---|
| | | WSC | DR | T | DA | O | Total |
| Nuwara Eliya | Nuwara Eliya | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Panwila | Panwila | 1 (33) | 0 (0) | 0 (0) | 1 (33) | 1 (33) | 3 (99) |
| Pasbage | Nawalapitiya | 7 (30) | 7 (30) | 8 (35) | 0 (0) | 1 (5) | 23 (100) |
| Pathadumbara | Madawala | 23 (85) | 3 (11) | 1 (4) | 0 (0) | 0 (0) | 27 (100) |
| Pathahewaheta | Talatuoya | 36 (80) | 5 (11) | 0 (0) | 1 (2) | 3 (7) | 45 (100) |
| Poojapitiya | Poojapitiya | 11 (74) | 2 (13) | 0 (0) | 2 (13) | 0 (0) | 15 (100) |
| Talawakele | Talawakele | 2 (40) | 2 (40) | 1 (20) | 0 (0) | 0 (0) | 5 (100) |
| Tumpane | Galagedera | 8 (67) | 4 (33) | 0 (0) | 0 (0) | 0 (0) | 12 (100) |
| Udadumbara | Madugoda | 1 (4) | 0 (0) | 27 (96) | 0 (0) | 0 (0) | 28 (100) |
| Udapalatha | Gampola | 14 (54) | 7 (27) | 2 (8) | 1 (4) | 2 (7) | 26 (100) |
| Udunuwara | Daulagala | 2 (33) | 4 (67) | 0 (0) | 0 (0) | 0 (0) | 6 (100) |
| Walapane | Walapane | 0 (0) | 0 (0) | 3 (100) | 0 (0) | 0 (0) | 3 (100) |

*WSC = water storage containers, DR = discarded receptacles, T = tyres, DA = domestic appliance, O = other

Table 2. Number and % (given in parentheses) of different types of containers positive for *Ae. aegypti* and *Ae. albopictus* at different periods of time in three localities in Kandy and Nuwara Eliya districts: January 2003 – December 2004.

| Study site and date | Number (%) of containers positive for *Ae. aegypti* and *Ae. albopictus* | | | | |
|---|---|---|---|---|---|
| | WSC | DR | T | Other | Total |
| Bulugohotenna | | | | | |
| 2.1.2004 | 5 (71) | 2 (29) | 0 (0) | 0 (0) | 7 (100) |
| 8.11.2004 | 9 (82) | 2 (18) | 0 (0) | 0 (0) | 11 (100) |
| 10.12.2004 | 8 (100) | 0 (0) | 0 (0) | 0 (0) | 8 (100) |
| Hijjapura | | | | | |
| 26.1.2004 | 38 (100) | 0 (0) | 0 (0) | 0 (0) | 38 (100) |
| 21.2.2004 | 3 (100) | 0 (0) | 0 (0) | 0 (0) | 3 (100) |
| 22.4.2004 | 5 (83) | 1 (17) | 0 (0) | 0 (0) | 6 (100) |
| 22.10.2004 | 6 (100) | 0 (0) | 0 (0) | 0 (0) | 6 (100) |
| Selambridge | | | | | |
| 7.1.2004 | 4 (36) | 2 (18) | 5 (46) | 0 (0) | 11 (100) |
| 4.2.2004 | 0 (0) | 3 (100) | 0 (0) | 0 (0) | 3 (100) |
| 11.5.2004 | 3 (50) | 2 (33) | 0 (0) | 1 (17) | 6 (100) |

*WSC = water storage containers, DR = discarded receptacles, T = tyres, O = other

Table 3. Positivity of different types of breeding sites for *Ae. aegypti* and *Ae. albopictus* in Kandy and Nuwara Eliya districts: January 2003 – December 2004.

| Habitat | Number (%) of habitats positive for | | |
|---|---|---|---|
| | *Ae. aegypti* | *Ae. albopictus* | Total* |
| Water storage containers | 126 (62) | 108 (48) | 214 (54) |
| Discarded receptacles | 25 (12) | 53 (23) | 75 (19) |
| Tyres | 48 (24) | 52 (23) | 94 (23) |
| Domestic appliances | 4 (1) | 5 (2) | 7 (2) |
| Other | 1 (1) | 8 (4) | 9 (2) |
| Total | 204 (100) | 226 (100) | 399 (100) |

*Total number of containers positive for both *Ae. aegypti* and *Ae. albopictus* breeding does not equal to the sum of positive containers for *Ae. aegypti* and *Ae. albopictus* due to mixed breeding of the two species in 31containers.

Table 4. Container index (CI) of *Ae. aegypti* and *Ae. albopictus* in different study sites in Kandy and Nuwara Eliya districts: January 2003 – December 2004.

| DDHS area | Locality | No.of containers encountered | No (%) of containers positive for | |
|---|---|---|---|---|
| | | | *Ae. aegypti* | *Ae. albopictus* |
| Akurana | Bulugohotenna | 349 | 22 (6) | 9 (3) |
| Ambagamuwa | Ambagamuwa | 75 | 5 (7) | 4 (5) |
| Galaha | Galaha | 88 | 3 (3) | 3 (3) |
| Hanguranketha | Hanguranketha | 95 | 1 (1) | 3 (3) |
| Hanguranketha | Rikillagaskada | 279 | 8 (3) | 34 (12) |
| Hasalaka | Hasalaka | 8 | 3 (38) | 2 (25) |
| Hataraliyadda | Hataraliyadda | 129 | 0 (0) | 7 (5) |
| Kotmale | Kalapitiya | 56 | 0 (0) | 4 (7) |
| Kotmale | Pundaluoya | 39 | 7 (18) | 3 (8) |
| Kundasale | Kundasale | 234 | 12 (5) | 5 (2) |
| Kurunduwatta | Kurunduwatta | 96 | 0 (0) | 3 (3) |
| Maskeliya | Hatton | 126 | 14 (11) | 3 (2) |
| MC Kandy | Kandy | 376 | 18 (5) | 7 (2) |
| Medadumbara | Hijjapura | 441 | 40 (9) | 15 (3) |
| Nuwara Eliya | Nuwara Eliya | 186 | 0 (0) | 0 (0) |
| Panwila | Panwila | 70 | 0 (0) | 3 (4) |
| Pasbage | Nawalapitiya | 466 | 10 (2) | 13 (3) |
| Pathadumbara | Madawala | 149 | 17 (11) | 10 (7) |
| Pathahewaheta | Talatuoya | 272 | 18 (7) | 25 (9) |
| Poojapitiya | Poojapitiya | 133 | 4 (3) | 11 (8) |
| Talawakele | Talawakele | 100 | 4 (4) | 1 (1) |
| Tumpane | Galagedera | 191 | 4 (2) | 8 (4) |
| Udadumbara | Madugoda | 175 | 0 (0) | 27 (15) |
| Udapalath | Gampola | 393 | 8 (2) | 19 (5) |
| Udunuwara | Daulagala | 166 | 3 (2) | 3 (2) |
| Walapane | Walapane | 4 | 3 (75) | 4 (100) |
| Total | | 4696 | 204 (4) | 226 (5) |

importance in DF/DHF prevention and control where elimination of breeding sites of *Ae. aegypti* and *Ae. albopictus* is a priority. Although *Ae. aegypti* and *Ae. albopictus* breed in a wide variety of containers, the most preferred breeding sites of these vectors in the study sites were the water storage containers (cemented tanks and iron and plastic barrels), tyres and discarded receptacles. Water storage is a common household practice in the study sites, even in the sites that are situated in the wet zone. Water storage tanks were reported as important breeding sites of *Ae. aegypti* and *Ae. albopictus* in other localities of Sri Lanka (9, 10), in other South East Asian countries (11, 12) and in the Western Pacific (5). Thus, suitable measures have to be taken for elimination of vector breeding in these containers, if DF is to be controlled.

In the study area, the types of vector breeding sites differ from one time period to another and from one locality to another. Hence, DF/DHF control measures should be planned based on local and current entomological information, targeting the potential breeding sites of *Ae. aegypti* and *Ae. albopictus* in the particular areas, in order to achieve effective and efficient DF/DHF control.

*Ae. aegypti* and *Ae. albopictus* were not encountered in the Nuwara Eliya town (elevation 1900 m) in the present study. With the global warming, increase in temperature and less rainfall is expected at high elevations in the Nuwara Eliya district (13). This may create suitable habitats for *Ae. aegypti* and *Ae. albopictus* breeding at elevations higher than 1300 m. Thus, regular and long term entomological investigations in these areas would help to detect such areas early and to take timely remedial measures in order to prevent DF/DHF transmission in these areas.

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