
Vector alert: *Anopheles stephensi* invasion and spread in Africa and Sri Lanka

IDENTIFIED THREAT

Anopheles stephensi, a highly competent vector of *Plasmodium falciparum* and *P. vivax*, is considered to be an efficient vector of urban malaria. There are three biological forms of *An. stephensi*, of which “type” and “intermediate” are efficient vectors in rural and peri-urban areas, notably in India. The third form – “mysorensis” – is considered to be a less efficient vector, although it has been involved in malaria transmission in certain rural areas of Afghanistan and Iran. Until 2011, the reported distribution of *An. stephensi* was confined to certain countries of South Asia and parts of the Arabian Peninsula. Since then, the vector has been collected in Djibouti (2012), Ethiopia (2016), Sudan (2016), Sri Lanka (2017), Somalia (2019), and most recently Nigeria (2020) and Yemen (2021). *Anopheles stephensi* larvae are found in domestic and other artificial water containers, and may also exploit a wide variety of larval habitats in the local environment (including cryptic habitats such as deep wells). The vector also survives extremely high temperatures during the dry season, when malaria transmission usually declines. In addition, *An. stephensi* has been shown to be resistant to multiple insecticide classes in many locations, including Africa, posing challenges to its control.

The World Health Organization (WHO) considers the spread of *An. stephensi* to be a major potential threat to malaria control and elimination in Africa and southern Asia, and has recently launched an initiative against the spread of *An. stephensi* in Africa (1). Prior to the launch of the initiative, a vector alert was developed to urge WHO Member States and their implementing partners – especially those in sub-Saharan Africa – to take immediate action, as outlined below (2). The current update includes new data on the presence of the vector and lessons learned in recent years, particularly regarding surveillance. With reports of the invasive vector in additional countries, the urgency to determine the extent of the invasion and respond to it has increased significantly, as has the need to build an evidence base to inform surveillance and control of this vector and to contribute to assessing the feasibility of eliminating *An. stephensi* from invaded areas.

WHAT SHOULD COUNTRIES THREATENED BY THE SPREAD OF *AN. STEPHENSI* DO NOW?

Countries should take the following actions:

- Update existing national vector surveillance strategies and guidelines to integrate *An. stephensi*. Given the overlap between the larval sites of *An. stephensi* and those of *Aedes* spp., national malaria control programmes are encouraged to explore the potential integration of surveillance and control activities with those of arboviral vectors, as envisaged in the *Global Vector Control Response 2017–2030* (3), and implement these where feasible. Countries are encouraged to report on the successes and challenges experienced when integrating *Aedes* spp. and *An. stephensi* surveillance and control, with a view to informing similar attempts by other WHO Member States.
- Train relevant personnel on the morphological identification, typical larval sites and typical resting sites of *An. stephensi*.
- Actively conduct surveillance/spot checks for *An. stephensi* in urban areas, peri-urban areas and areas identified to be at risk of introduction, in addition to routine surveillance in rural areas. Sampling should initially focus on the species' aquatic stages, because methods for collecting adults may be labour-intensive and yield low numbers. However, in some settings, good success has been had in collecting adults by aspiration from animal shelters. Programmes may want to explore different collection methods to identify those that work best in a given setting. Typical larval sites to survey are human-made containers, particularly water storage containers inside and outside the home, rainwater collections, rooftop water storage, wells, large cisterns and even clean water ponds.
- Rear larvae or pupae to adults and identify *An. stephensi* based on the morphological characteristics of the adult female as described in Coetzee (4). If possible, eggs should be collected from adult females to identify the form of *An. stephensi* (type, mysorensis or intermediate).
- Preserve specimens in Eppendorf tubes with silica gel for molecular analysis, both to confirm the initial morphological identification and to study population dynamics across a recently invaded area. Pinned voucher specimens should also be kept in national entomology reference laboratories. If sequencing facilities are not available, researchers may contact vectorsurveillance@who.int to request assistance in identifying molecular forms of the species and for resistance mechanism profiling.
- Describe the bionomics (biting times and locations, resting sites, larval sites, etc.) of *An. stephensi* to help guide control measures.
- Report outcomes of any surveillance activities that include efforts to detect *An. stephensi* to WHO by completing the "WHO form to report detection of invasive *Anopheles* vector species" (5) and emailing it to vectorsurveillance@who.int. The detection will then be displayed on the Malaria Threats Map (<https://apps.who.int/malaria/maps/threats/>). If targeted searches for *An. stephensi* fail to detect the vector, these "negative" findings should also be reported. WHO also encourages countries to report any practical lessons learned from their surveillance activities so as to inform an update of this vector alert, as well as surveillance activities elsewhere.
- If sufficient larvae or pupae are found, these should be reared to adult stage, so that insecticide resistance can be evaluated using WHO susceptibility test procedures (6). Test results should be reported to WHO alongside data on the occurrence of the vector.

- If specimens are tested using ELISA for the presence of sporozoites, the homogenate of any positive specimens should be heated to 100°C for 10 minutes and retested. This will avoid false positives due to the presence of animal blood, which is common in *An. stephensi*.
- International Health Regulations (2005) (7) should be enforced to ensure that any points of entry are free of vectors in order to minimize the risk of any further spread of *An. stephensi*.

WHAT SHOULD COUNTRIES DO IN AREAS WHERE THE VECTOR HAS BEEN DETECTED?

Where the vector has been detected, countries should do the following:

- Undertake interventions directed against *An. stephensi* with the aim of controlling this species. Part of this effort should consist of validating the effectiveness of vector control interventions with respect to their impact against the vector and the prevention of malaria cases. This will require an intense effort towards enhancing and expanding surveillance and control activities.
- Ensure that the immediate focus for the control of *An. stephensi* is on managing vector larval sites in urban and peri-urban environments. Recommended activities include:
 - removal of larval sites, where feasible, including by filling in or covering disused wells;
 - modification of larval sites to prevent mosquito access, including the installation of hermetically sealed lids to water storage containers; and
 - where larval site removal or modification is not feasible, treatment with WHO-prequalified chemical or biological larvicides, following WHO guidelines (8).
- Direct local authorities to regularly conduct surveillance, map remaining and new larval sites, and inspect the sites for larvae once a week, where feasible.
- Introduce and enforce by-laws to regulate water storage practices and construction work in order to avoid the creation of potential breeding sites.
- Consider the feasibility of introducing or reinforcing the use of insecticide-treated nets or indoor residual spraying in areas where *An. stephensi* is found.
- Make housing improvements (e.g. window and door screening) to prevent mosquitoes from entering human dwellings, with the aim of reducing mosquito entry and human exposure.
- Raise public awareness of this mosquito species, including by integrating messages on *An. stephensi* into existing information education and communication and social and behaviour change materials and programmes for dengue vectors, where these exist. The aim of social and behaviour change activities is to contribute to the reduction of larval sites and to prevent vector proliferation.
- Engage local communities and schools in *An. stephensi* surveillance and control activities.

- Enforce International Health Regulations (2005) to ensure that airports, sea ports, ground crossings, and other points of entry and exit are free of vectors. Treat departing and landing aircraft and ships to kill insects, following WHO guidance (9).
- Monitor malaria cases, particularly in urban and peri-urban areas, for potential increases, as this may be indicative of the presence of *An. stephensi* and its contribution to transmission. In these settings, it is particularly important to ascertain the travel history of cases.
- Prioritize the evaluation of existing and new vector control interventions for their effectiveness against *An. stephensi* with a view to expanding the armamentarium against this vector. This focus should be in addition to existing evaluation needs for new tools against native malaria vectors.

References

1. WHO initiative to stop the spread of *Anopheles stephensi* in Africa. Geneva: World Health Organization; 2022 (<https://apps.who.int/iris/handle/10665/363318>, accessed 7 December 2022).
2. Vector alert: *Anopheles stephensi* invasion and spread: Horn of Africa, the Republic of the Sudan and surrounding geographical areas, and Sri Lanka: information note. Geneva: World Health Organization; 2019 (<https://apps.who.int/iris/handle/10665/326595>, accessed 7 December 2022).
3. Global vector control response 2017–2030. Geneva: World Health Organization; 2017 (<https://apps.who.int/iris/handle/10665/259002>, accessed 7 December 2022).
4. Coetzee M. Key to the females of Afrotropical *Anopheles* mosquitoes (Diptera: Culicidae). *Malar J.* 2020;19:70. doi:10.1186/s12936-020-3144-9.
5. WHO form to report detection of invasive *Anopheles* vector species. Geneva: World Health Organization; 2019 (<https://www.who.int/teams/global-malaria-programme/prevention/vector-control/global-databases-on-invasive-mosquito-vector-species>, accessed 7 December 2022).
6. Manual for monitoring insecticide resistance in mosquito vectors and selecting appropriate interventions. Geneva: World Health Organization; 2022 (<https://apps.who.int/iris/handle/10665/356964>, accessed 7 December 2022).
7. International Health Regulations (2005), third edition. Geneva: World Health Organization; 2016 (<https://apps.who.int/iris/handle/10665/246107>, accessed 7 December 2022).
8. Larval source management: a supplementary malaria vector control measure: an operational manual. Geneva: World Health Organization; 2013 (<https://apps.who.int/iris/handle/10665/85379>, accessed 7 December 2022).
9. WHO aircraft disinfection methods and procedures. Geneva: World Health Organization; 2016 (<https://apps.who.int/iris/handle/10665/339863>, accessed 7 December 2022).

Vector alert: *Anopheles stephensi* invasion and spread in Africa and Sri Lanka

ISBN 978-92-4-006771-4 (electronic version)

ISBN 978-92-4-006772-1 (print version)

© World Health Organization 2022. Some rights reserved. This work is available under the CC BY-NC-SA 3.0 IGO licence.

