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Kaliyamoorthy Dass, Srinivasan Prabhu, Rangarajan Murugesan

DOI: http://dx.doi.org/10.31584/jhsmr.20261505

Received: 11 February 2026

Revised: 11 May 2026

Accepted: 21 May 2026

Published online: 11 November 2026

Please cite this article as: Dass K, Prabhu S, Murugesan R. Assessment of the larvicidal activity of plant extracts, with special reference to *Aedes aegypti* and *Aedes albopictus* in India: a review. J Health Sci Med Res 2026. doi: http://dx.doi.org/10.31584/jhsmr.20261505

Early Version — Uncorrected: This accepted manuscript has not been typeset or proofread. Content and formatting may change prior to final publication and should not be regarded as the final Version of Record.

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Review Article

Assessment of the Larvicidal Activity of Plant Extracts, with Special Reference to *Aedes aegypti* and *Aedes albopictus* in India: A Review

Kaliyamoorthy Dass[1], Srinivasan Prabhu[2], Rangarajan Murugesan[3]

[1]Department of Pharmacology, Saveetha Medical College and Hospital, Saveetha Institute of Medical and Technical Sciences (Deemed to be University), Chennai 602 105, Tamil Nadu, India.
ORCiD: https://orcid.org/0000-0002-4564-3275
[2]Division of Phytochemistry and Drug Design, Department of Bioscience, Rajagiri College of Social Sciences (Autonomous), Kalamaserry, Kochi 683 104, India.
ORCiD: https://orcid.org/0000-0001-5839-0345
[3]Division of Entomology, Department of Bioscience, Rajagiri College of Social Sciences (Autonomous), Kalamaserry, Kochi 683 104, India.
ORCiD: https://orcid.org/0000-0002-0755-3658

***Corresponding author**:
Contact: Kaliyamoorthy Dass
Department of Pharmacology, Saveetha Medical College and Hospital, Saveetha Institute of Medical and Technical Sciences (Deemed to be University), Chennai 602 105, Tamil Nadu, India.
E-mail address: dass@avasctnj.edu.in : kdassrsgc1987@gmail.com

Running Title: Larvicidal Activity of Plant Extracts Against Aedes spp. in India

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Abstract

Mosquitoes are vectors for various deadly diseases, such as chikungunya, dengue fever, filariasis, haemorrhagic fever, Japanese encephalitis, malaria, yellow fever, the West Nile virus, and Zika fever. Mosquito-borne diseases affect millions of people every year. Consequently, mosquito control is essential for public health, particularly in tropical areas. Various synthetic chemicals, such as pyrethrum, picaridin, dimethyl phthalate, dimethyl carbonate, organophosphates, and carbamates, are widely used in mosquito control. These compounds can be broadly classified into insecticides (e.g., pyrethrum, organophosphates, and carbamates) and insect repellents (e.g., picaridin and dimethyl phthalate) based on their mode of action. However, their extensive use is associated with adverse effects, including biomagnification, environmental pollution, persistence (non-biodegradability), and toxicity to non-target organisms. To overcome these effects, we must seek alternatives. Conversely, plant-based phytochemicals are predominantly active in mosquito control initiatives due to their efficiency, environmental safety, and suitability as a viable alternative to synthetic larvicides. This review provides evidence that various plant extracts can control Ae. aegypti and Ae. albopictus mosquito populations. This control is crucial for reducing the incidence of mosquito-borne diseases. By exploring various locally available plant extracts, this study highlights research gaps, guides future studies, and promotes eco-friendly vector management.

Keywords: *Aedes*, Good Health, Larvicidal activity, plant extract, vector control

Introduction

Mosquitoes are important insect vectors, responsible for several serious human diseases, such as malaria, chikungunya, dengue, yellow fever, encephalitis, the West Nile virus, filariasis, and Zika, all of which are transmitted by the genera *Aedes*, *Anopheles*, and *Culex* [1]. Dengue incidence varies from year to year. The World Health Organization estimates that there are 100-400 million infections globally each year. The WHO reported more than 14.3 million cases worldwide by 30 April 2024, highlighting an exceptionally high global burden [2–4]. In contrast, millions of mosquito-borne deaths have been reported in India[5,6], including chikungunya, dengue fever, brain fever, Japanese encephalitis, haemorrhagic fever, malaria, filariasis, yellow fever, and Zika fever [7,8.]

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In this state, control of mosquito vectors occurs at various stages, such as egg, larvae, pupa, and adults, using synthetic chemicals such as pyrethrum, picardin, di-methyl phthalate, di-methyl carbonate, organophosphates, carbamates; however, synthetic chemical agents create a number of humans health risks (respiratory, neurological, dermatological, and cancer), as well as environmental contamination and toxicity to co-habitat species [9–11]. As a result, the development of chemical alternatives to control mosquito vectors, using natural resources like bacteria, fungi, plant extracts, and green nanoparticles, is required[12]. Greens-based mosquito controls are highly active biological compounds, offering an alternative that is safer than chemical insecticides. They are low-cost, biodegradable, and less toxic to other organisms[13,14]. In this review, we focused on the various plant extracts used in mosquito control strategies, with special reference to *Aedes aegypti* and *Aedes albopictus*.

Current status of dengue in India

Dengue is currently the most prevalent and rapidly escalating vector-borne disease globally, with India accounting for one-third of the global infections due to the climate, poor hygiene, and population [5,15]. In India, approximately 393 mosquito species have been documented in tropical and subtropical areas [16–18]. Among the most well-known and recognized *Aedes* vectors are *Ae. aegypti*, *Ae. albopictus*, *Ae. niveus*, and *Ae. vittatus*, all of which spread a number of fatal diseases, including dengue, chikungunya, filariasis, Zika, and yellow fever [17]. Data on dengue fever and mortality in India over the last five years (2020-2025) were analysed (Figure 1 and Table 3). Among all the states, a limited number reported comparatively higher dengue cases associated with mortality and due to hygiene status [5,19]. The spatial distribution of dengue, chikungunya, and Japanese encephalitis prevalence across Indian states is illustrated in Figures 2–4. Overall, the data suggest a significant burden of dengue infection in India [6].

Geographic distribution of dengue in India

Dengue affects all ages and genders, including pregnant women and children [20,21]. Stagnant rainwater, which provides favorable breeding conditions for *the Aedes* mosquito species, is the primary factor for dengue transmission [22,23]. Dengue in India has spread beyond conventional tropical regions, with notable outbreaks across the country, including the north, south, east, west, and northeast. Among them, Maharashtra, Rajasthan, Uttar Pradesh, West Bengal, and Punjab are high-burden states, both in the urban and rural environments. The

spread of disease is affected by temperature, precipitation, and humidity, which determine the prevalence of *Aedes* mosquitoes. Tribal and marginalized communities exhibit a limited understanding of dengue management and prevention [24,25]. Pesticide toxicity should be considered an important environmental and public health concern in mosquito control strategies due to its potential to cause pollution, biomagnification, and harm to non-target organisms.

Methods

The present review was conducted on the larvicidal activity of plant extracts using various online research databases. Sources included the World Health Organisation (WHO) and indexed scientific publications such as the Web of Science, Scopus, PubMed, and the National Centre for Vector Borne Disease Control (NCVBDC) in India. The key terms encompass mosquito-borne diseases, mosquito species such as *Culex, Anopheles*, and *Aedes*, plant extracts, larvicidal activity, LC_{50} values, and relevant peer-reviewed publications from 2020 to 2025. This study focused exclusively on the application of plant products for mosquito control and management.

Larvicidal activity of plant extracts

Plants are natural biological resources used for various purposes, including food, cosmetics, pest control, and traditional medicine. They have also been systematically compiled to highlight the major active compounds of larvicidal plants and their pharmacological activities, along with representative images (presented in Tables 1 and 2). Acetone extract of *Avicennia marina* exhibited larval mortality against *Ae. aegypti*, with LC_{50} of 164 ppm. The results indicate that *A. marina* extracts act as a natural larvicidal agent, supporting an environmentally sustainable mosquito management strategy [26].

The larvicidal efficacy of *Andrographis paniculata* and *Tinospora cordifolia* was evaluated against the third instar of *Ae. aegypti*. The methanolic extract of *A. paniculata* showed higher activity than the methanolic extract of *T. cordifolia*, with LC_{50} values of 15.75 ppm and 349.60 ppm, respectively. The results express that the crude extracts of *A. paniculat*a and *T. cordifolia* may serve as potential biocontrol agents against *Ae. aegypti* mosquitoes [27].

The insecticide activity of both the methanol and ethyl acetate extracts of *Plectranthus amboinicus* demonstrated significant efficacy against the fourth instar of *Ae. aegypti*, with LC_{50} values of 53.36 ppm. *P. amboinicus* exhibits mosquitocidal activity and may serve as a viable

alternative source for the formulation of larvicidal agents [26]. The study examined the ovicidal and larvicidal effects of the ethanolic leaf extracts of *Cyathocline purpurea, Blumea lacera, Neanotis lancifolia*, and *Neanotis montholonii* on *Ae. aegypti* larvae. Among these, *C. purpurea* extracts had the highest larvicidal activity (LC_{50} = 88 ppm), followed by *B. lacera* (LC_{50} = 758 ppm), *N. lancifolia,* and *N. montholonii,* with no significant activity. These findings show *C. purpurea* has the highest larvicidal activity against *Ae. aegypti* [28].

Priya *et al*. (2021) investigated and evaluated the efficiency of *Piper longum* L. leaf extract tested against *Ae. aegypti*. The LC_{50} values were 38.96 ppm for *Ae. aegypti*, indicating that the extract from *P. longum* leaves had significant activity on *Ae. aegypti*. The research emphasises the value of exploring plant-based alternatives for vector management, especially in light of rising insecticide resistance. Further research could investigate the mechanisms of action and the potential for synergistic effects with other natural compounds [29]. Ethanol extracts from different parts of *Asparagus setaceus* have shown effective larvicidal activity against *Ae. aegypti*. *A. setaceus* possesses significant larvicidal efficacy against *Ae. aegypti* and may serve as an environmentally sustainable insecticide in the near future. This potential not only highlights the importance of *A. setaceus* in pest management strategies but also encourages further research into its active compounds. Understanding the mechanisms behind its effectiveness could lead to the development of new, eco-friendly alternatives to synthetic insecticides [30].

Methanolic extracts of *Aegle marmelos* and *Coleus aromaticus* exhibit potential larvicidal activity against *Ae. aegypti* larvae and pupae. The 24 h LC_{50} values for the II, III, and IV instars and the pupa of methanolic solvent leaf extracts of *A. marmelos* were 124.27 ppm, 145.07 ppm, 178.87 ppm, and 225.99 ppm, respectively. The LC_{50} values for the extract of *C. aromaticus* were 62.46 ppm in the second instar, 81.94 ppm in the third instar, 101.19 ppm in the fourth instar, and 124.34 ppm in the pupal stage. These findings indicate a notable difference in the effectiveness of the two plant extracts against the different life stages of *Ae. aegypti*. The lower LC_{50} values for *C. aromaticus* suggest it may be a more potent larvicidal agent compared *to A. marmelos,* highlighting its potential for use in integrated pest management strategies [31].

Various solvent (water, ethanol, hexane, and acetone) extracts of *Calotropis procera* were evaluated against the late third instar of the *Ae. aegypti*. Specifically, the ethanolic extract of *C. procera* leaves exhibited significant larvicidal efficacy among the three solvents, with an

LC_{50} of 1.923 ppm, to *Ae. aegypti larvae*. These findings suggest that the plant-derived larvicides could be a viable alternative to synthetic insecticides [32].

Yagoo *et al*. (2023) examined the larvicidal effects of successive n-hexane, chloroform, and methanol extracts from the leaves of *Peltophorum pterocarpum* tested against *Ae. aegypti*. The LC_{50} values for these extracts were 111.77 ppm (methanol extract), 170.74 and 169.18 ppm (chloroform extract), and 219.14 ppm (n-hexane), respectively. The methanol extract had superior larvicidal efficacy against *Ae. aegypti.* These findings suggest that the methanol extract of *P. pterocarpum* could be a promising natural alternative for mosquito control. Further research is warranted to explore the active compounds responsible for this enhanced larvicidal activity [33].

The study assessed the insecticide efficacy of petroleum ether, chloroform, methanol, and aqueous extracts of *Annona squamosa* leaves against *Ae. aegypti*. Of those, the methanol leaf extracts of *A. squamosa* revealed significant larvicidal efficacy against the 3rd instar larvae of *Ae. aegypti*, with a lethal concentration of LC_{50} value of 51.45 ppm. Further analysis indicated that the chloroform extracts also exhibited promising results, although their efficacy was slightly lower than that of the methanol extracts. These findings suggest that *A. squamosa* could be a valuable natural resource in the development of eco-friendly insecticides for the control of mosquito populations [34].

The larvicidal efficacy of *Commiphora wightii* was evaluated against the fourth instar of *Ae. aegypti*. The larvae were exposed to different concentrations of *C. wightii*. The LC_{50} was determined to be 197.38 ppm. *C. wightii* possessed significant larvicidal activity, indicating its potential as a natural insecticide [35]. The study evaluated the larvicidal efficacy of extracts from the leaves of *Parthenium hysterophorus*, formulated in acetone, methanol, and hexane, against *Ae. aegypti*. Among those solvents, methanol extracts demonstrated significant larvicidal efficacy (LC_{50}=351.14 ppm). The research shows that the leaves of *P. hysterophorus* exhibit the highest toxicity in methanol, followed by acetone and hexane, against *Ae. aegypti* larvae [36].

The earlier study evaluated the larvicidal potential of *Ziziphus mauritiana* extracts against the second and fourth larvae and pupae of *Ae. aegypti*. The methanolic extract of *Z. mauritiana* exhibited larvicidal activity with LC_{50} values of 208.57 ppm for the second larvae and 252.13 ppm for the fourth larvae of *Ae. aegypti*, underscoring its potential as a natural and environmentally sustainable alternative for controlling insect vectors and enhancing integrated mosquito management programs [37]. The larvicidal efficacy of *Ocimum hadiense, Rosmarinus officinalis*, and *Carissa spinarum* was tested on the third instar of *Ae. aegypti*. The LC_{50} and

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LC_{90} values were calculated for all the extracts. The chloroform extracts of *O. hadiense* showed the highest larvicidal activity (LC_{50} = 24,000 ppm), whereas the chloroform extract of *C. spinarium* exhibited the lowest larvicidal activity (LC_{50} = 73,688 ppm) [38].

Six different extracts from *Artemisia nilagirica* (n-hexane, petroleum ether, methanol, aqueous, and ethanol) were evaluated for their efficacy in mosquito control. Among those extracts, the aqueous extract exhibited the highest toxicity to *Ae. aegypti*, with an LC_{50} of 583.33 ppm. The new initiative will serve as a first step towards replacing synthetic insecticides with plant-derived biopesticides in order to address detrimental vector mosquitoes in the future. This approach not only aims to reduce reliance on chemical insecticides but also promotes sustainable pest management practices. By harnessing the natural properties of *A. nilagirica*, researchers hope to develop effective, environmentally friendly solutions that can significantly lower mosquito populations while mitigating the spread of vector-borne diseases [39].

The larvicidal activity of the ethyl acetate extract of the *Platostoma menthoides* was evaluated against the larvicidal activity of the IV larvae of *Ae. aegypti*. Biological investigations of *P. menthoides* extract have shown significant mosquito larvicidal efficacy against the fourth instar larvae of *Ae. aegypti*, with LC_{50} and LC_{90} values of 81.32 and 161.47 ppm, respectively. These findings indicate that *P. menthoides* is a substantial source of phytoconstituents with diverse medical applications and effective larvicidal properties [40]. The study evaluated *Sargassum wightii* extracts (petroleum ether, chloroform, acetone, and methanol), which were tested against the II and III instars of *Ae. aegypti*, *An. stephensi*, and *Cx. quinquefasciatus*. Among the extracts, the chloroform extract demonstrated the highest larval mortality at the lowest concentration against all three species, with respective LC_{50} values of 158.39, 158.42, and 178.94 ppm. The results show that *S. wightii* could be an alternative to synthetic insecticides [41].

Conclusion and future perspectives

This review exclusively focuses on *Ae. aegypti and Ae. albopictus* species in India by different plant extracts. The larvicidal efficacy and LC_{50} values varied depending on the solvents and plant part extracts, due to factors such as plant species, plant parts, mosquito species, and larval stages. This literature study summarises 34 larvicidal plants belonging to 18 families against the *Aedes* mosquito for larvicidal efficacy (represented in Table 1 and Figure 5). The present review reports on 34 larvicidal plants belonging to 18 families against the *Aedes* mosquito. This review's findings underscore the diverse range of research topics explored

across different states in India. This regional variation underscores the growing emphasis on addressing local issues through academic inquiry. The findings indicate diverse geographical representation in the research output, with Tamil Nadu contributing significantly. This highlighted regional variations in research activity and may reflect local academic priorities or availability. A number of studies have reported the potential for plant-based larvicides to control mosquito populations [42,43.] According to Aravinth (2024), plant bioactive compounds play a key role in larvicidal activity, and the active compounds should be synthesised and commercialised [44].

Plant-derived insecticides are increasingly recognized as effective alternatives to synthetic insecticides for managing a range of pests and vectors. Globally, plants serve as a crucial source of medicinal resources. Plant biochemicals have demonstrated insecticidal potential. Mosquito activity is observed in numerous prominent plants across diverse families: Fabaceae, Lamiaceae, Menispermaceae, Piperaceae, Rhamnaceae, Rutaceae, Solanaceae, and Verbenaceae. All research constructs have been evaluated under laboratory conditions, which differ from field settings; therefore, field studies are essential in order to obtain more reliable and applicable results. Such studies would enhance the validity of the findings and offer valuable insights into real-world applications, ultimately enabling the development of more effective solutions tailored to specific environmental conditions.

The present literature review found that the larvicidal plant extract of *Asparagus setaceus* was non-toxic to non-target organisms, such as *Chironomus circumdatus* larvae and Daphnia [30]. Similarly, the extract from the *Clitoria ternatea* plant was tested on a non-target organism, the *Poecilia reticulata* (guppy fish), and the results indicated no mortality with plant extracts at 2,500 ppm [45]. These findings suggest a promising avenue for using plant extracts in pest control, as they can effectively target harmful larvae while preserving beneficial aquatic species. Further research could examine the mechanisms underlying this selectivity and assess the long-term ecological impacts of these treatments.

According to Dey (2023), *Annona squamosa* has toxic effects on several parts of the larval body, including the thorax, midgut, and anal gills, and damages internal cells. These toxic effects can hinder larval growth and development, potentially leading to lower survival rates in populations exposed to the plant. Further research is necessary to fully understand the extent of these impacts on aquatic ecosystems [34].

The toxicity of pesticides will be regarded as a critical environmental safety measure in mosquito control efforts. Plant-derived insecticides are relatively safe, economical, and widely

available in many parts of the world. These natural alternatives are not only minimally toxic to non-target organisms but also foster sustainable agriculture practices. As research progresses, the incorporation of these environmentally sustainable methods will likely become standard practice when addressing mosquito-borne diseases [46,47]. The extensive use of synthetic insecticides has led to widespread resistance; however, rotating and minimizing their use could prevent this development in the future [48].

This literature review provides an overview of management strategies for *the Aedes* mosquitoes that utilise plant extracts currently in development. It is essential for public awareness to help protect our natural environment from the spread of diseases. Although dengue vaccines are available, such as Qdenga (TAK-003) and Dengvaxia (CYD-TDV), their use is limited by factors such as the eligibility criteria, safety considerations, and region-specific approvals; therefore, vector control remains the primary strategy for preventing dengue transmission.

Plant-based larvicides are also considered promising substitutes for synthetic chemicals in *Ae. aegypti* and *Ae. albopictus* control, especially in Indian settings, where plant biodiversity and traditional medical knowledge are far-reaching. Nevertheless, in order to convert laboratory results into useful tools for controlling vectors, a number of critical research and development gaps will have to be filled.

In any future research, the standardization of plant extracts, such as the identification, quantification, and validation of bioactive phytochemicals that cause larvicidal activity, should be prioritized. The change in extraction procedures, solvents, plant parts, and seasonality usually results in an inconsistent effect on efficacy, which restricts reproducibility and widespread use. Regulatory approval and commercialization will require setting standard protocols and quality control standards.

The other significant direction is the mechanistic and molecular-level studies. Most plant extracts show high levels of larval death, although their specific mechanisms of action are not well understood. Such sophisticated methods as enzyme inhibition tests, histopathological experiments, transcriptomics, or proteomics can clarify the impact of phytochemicals on larval physiology, development, and survival, helping to prove the rational design of the formulations.

Formulation research will be an essential future direction. The insensitivity and high breakdown of most naturally occurring plant-derived compounds in the field limit their usefulness. Novel delivery systems, such as nano-formulations, microencapsulation, and slow-

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release biodegradable carriers, can be used to improve stability, remaining activity, and targeted delivery, while remaining environmentally safe.

There should also be field-based assessments. Most of the available research is limited to laboratory bioassays, and little has been validated in natural or semi-field breeding environments. Large-scale field trials in various ecological areas in India should be conducted to determine the efficacy, cost-effectiveness, and non-target effects, as well as community acceptance of botanical larvicides. Plant-based larvicides should be actively considered and included in Integrated Vector Management (IVM) programs, in addition to biological control agents and environmental management.

Finally, future research should concentrate on regulatory structures and translational pathways. Strengthening partnerships between academic institutions, public health services, and the phytopharmaceutical industry could be useful in building safe, efficient, and cost-effective botanical larvicides. With continual interdisciplinary research and policy backing, plant-derived larvicidal agents can play a major role in sustainable mosquito control and the reduction of vector-borne diseases in India.

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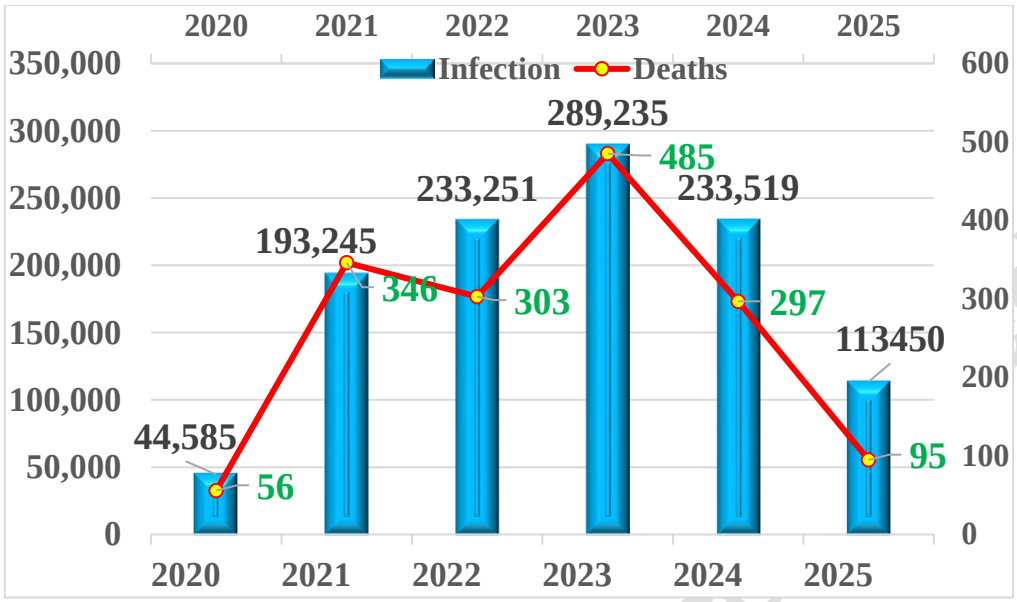


Figure 1 Dengue situation in India from 2020-2025 (NCVBDC)

National Centre for Vector Borne Disease Control (NCVBDC)

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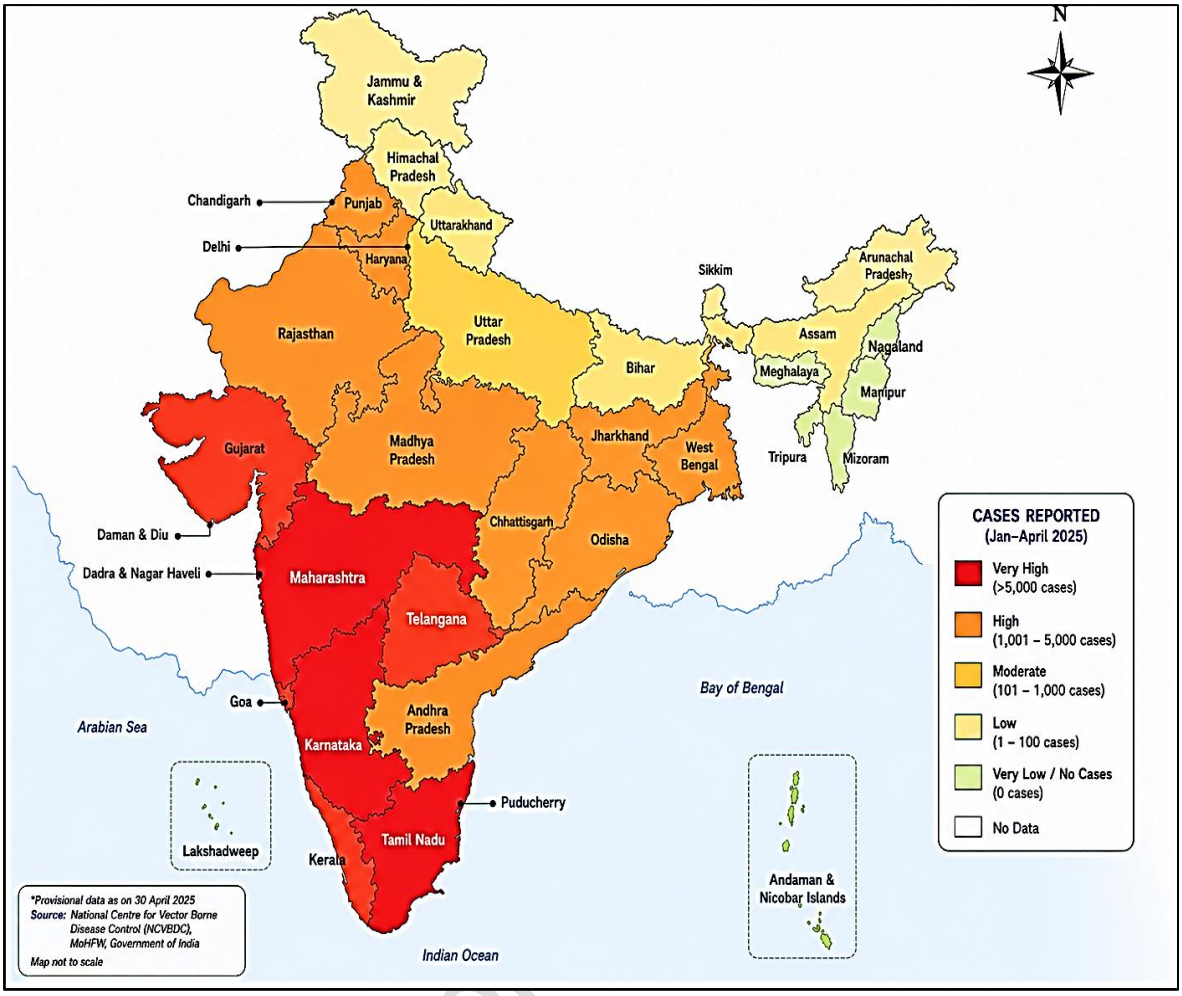


Figure 2 High-risk dengue distribution area in India (NCVBDC)

National Centre for Vector Borne Disease Control (NCVBDC)

Early Version

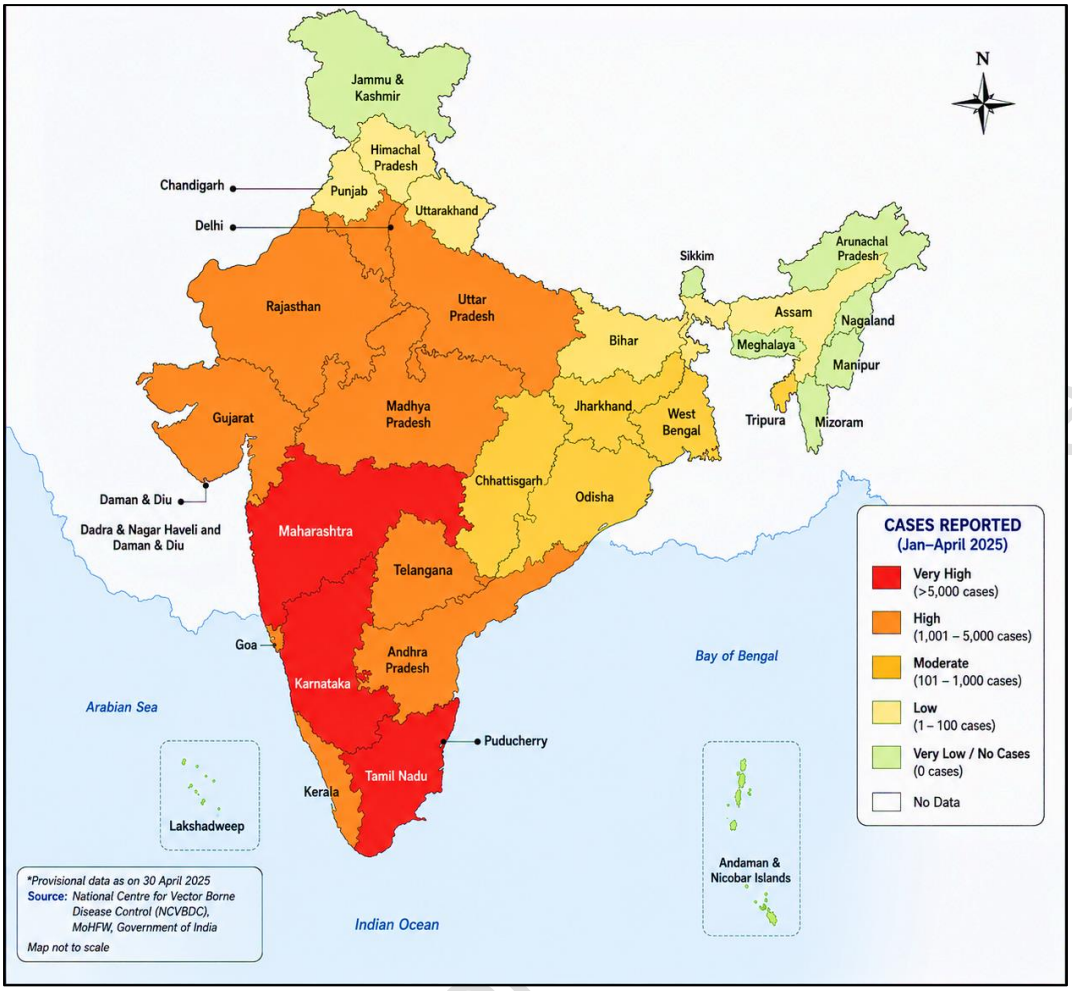


Figure 3 Chikungunya situation in India (NCVBDC)

National Centre for Vector Borne Disease Control (NCVBDC)

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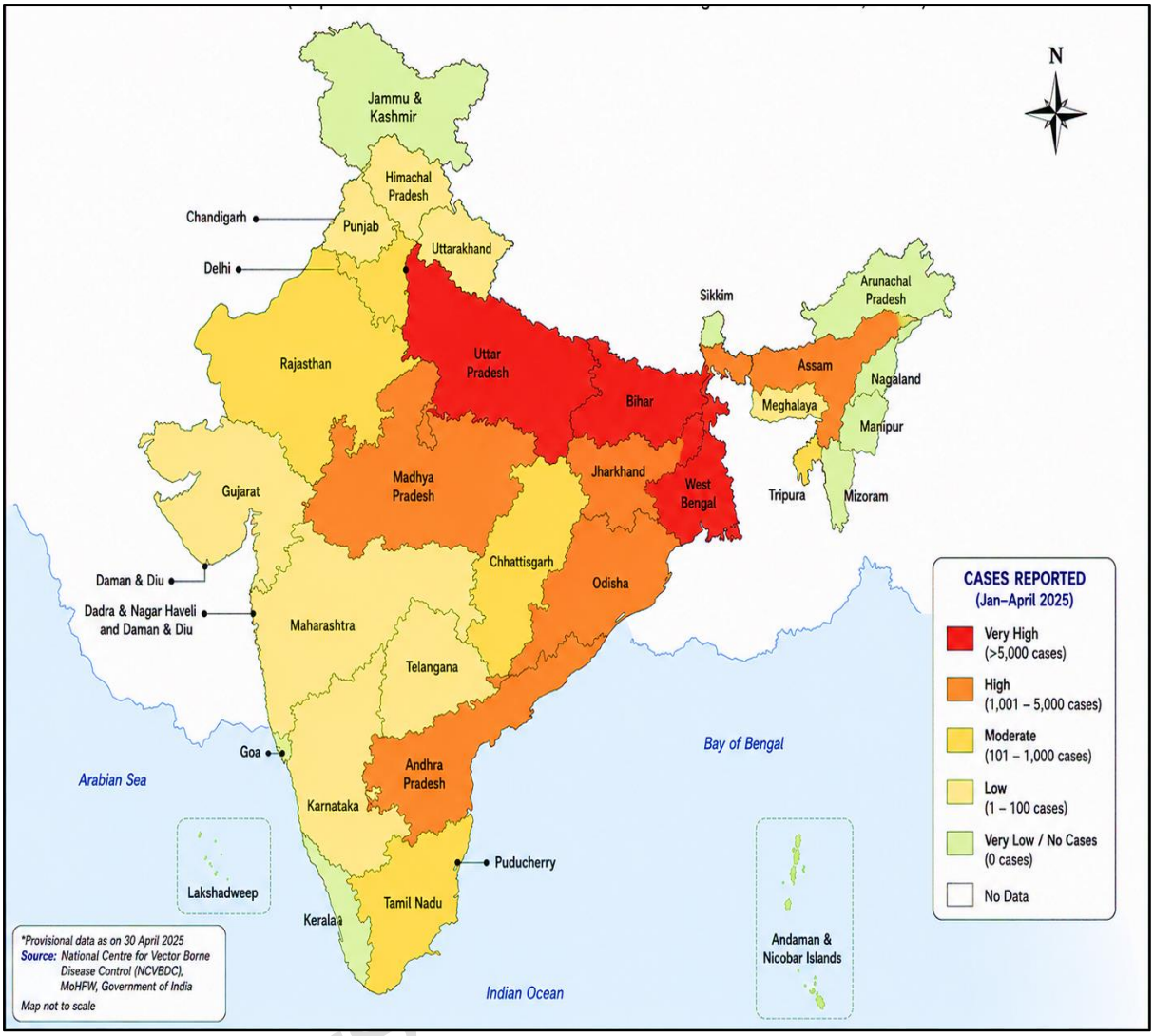


Figure 4 Japanese encephalitis distribution area in India (NCVBDC)

National Centre for Vector Borne Disease Control (NCVBDC)

Early Version

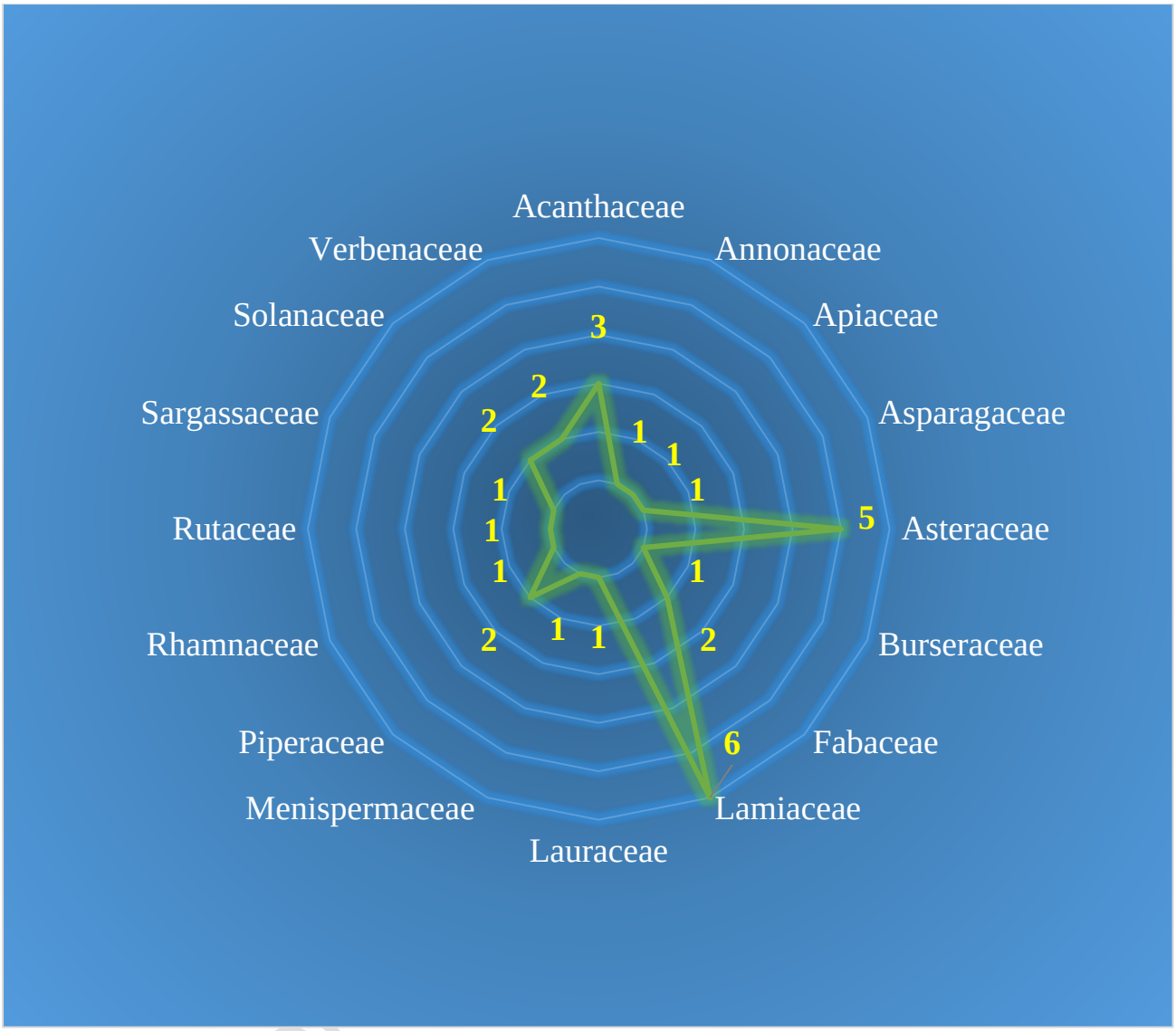


Figure 3 Radar graph of larvicidal plant counts and their families

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Table 1 Larvicidal potential of plant extracts from different families using various solvents

S. no	Plant species	Plant parts	Family	Solvent	Dengue vector	Larval stage	LC_{50} (ppm)	State	References
1.	*Avicennia marina*	Leaves	Acanthaceae	Acetone	*Ae. aegypti*	III	164	Tamil Nadu	[26]
2.	*Andrographis paniculata*	Stem, leaves and root	Acanthaceae	Methanol	*Ae. aegypti*	III	154.94	Haryana	[27]
				Ethanol		III	197.00		
				Aqueous + methanol		III	201.08		
				Aqueous + ethanol		III	231.56		
3.	*Tinospora cordifolia*	Stem and root	Menispermaceae	Methanol	*Ae. aegypti*	III	181.63		
				Ethanol		III	162.82		

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S. no	Plant species	Plant parts	Family	Solvent	Dengue vector	Larval stage	LC_{50} (ppm)	State	References
				Aqueous + methanol		III	211.69		
				Aqueous + ethanol		III	240.18		
4.	*Plectranthus amboinicus*	Leaves	Lamiaceae	Methanol	*Ae. aegypti*	IV	53.36	Tamil Nadu	[49]
				Ethyl acetate		IV	13.63		
				Hexane		IV	68.85		
				Aqueous		IV	135.36		
5.	*Elytraria acaulis*	Whole plant	Acanthaceae	Aqueous	*Ae. aegypti*	III	124.25	Tamil Nadu	[50]
6.	*Piper longum*	Leaves	Piperaceae	Petroleum ether	*Ae. aegypti*	III	213.88	Assam	[34]
				Chloroform		III	389.36		
				Methanol		III	395.51		
				Aqueous		III	50.80		

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S. no	Plant species	Plant parts	Family	Solvent	Dengue vector	Larval stage	LC_{50} (ppm)	State	References
7.	*Cyathocline purpurae*	Leave	Asteraceae	Ethanol	*Ae. aegypti*	III	720	Maharashtra	[28]
8.	*Blumea lacera*	Leave	Asteraceae	Ethanol		III	7,300		
9.	*Piper longum*	Leaves	Piperaceae	Ethanol	*Ae. aegypti*	III	3,896	Tamil Nadu	[29]
10	*Asparagus setaceus*	Leaves	Asparagaceae	Ethanol	*Ae. aegypti*	IV	22.67	West Bengal	[30]
		Root		Ethanol		IV	41.33		
		Bark		Ethanol		IV	38.67		
		Fruit		Ethanol		IV	84.00		
11	*Lantana camara*	Leaves	Verbenaceae	Ethyl alcohol	*Ae. aegypti*	IV	139	West Bengal	[51]
12	*Ocimum americanum*	Leaves	Lamiaceae	Aqueous	*Ae. aegypti*	III	4520	Tamil Nadu	[52]

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S. no	Plant species	Plant parts	Family	Solvent	Dengue vector	Larval stage	LC_{50} (ppm)	State	References
					An. stephensi	III	4050		
13	*Wrightia tinctoria*	Leaves	Apocynaceae	Methanol	*Ae. aegypti*	III	149.90	Tamil Nadu	[53]
						IV	183.97		
						Pupa	228.20		
14	*Colocasia esculenta*	Leaves	Asteraceae	Methanol	*Ae. aegypti*	III	126.02	Tamil Nadu	[53]
						IV	161.60		
						pupa	189.28		
15	*Coleus aromaticus*	Leaves	Lamiaceae	Methanol	*Ae. aegypti*	III	81.94	Tamil Nadu	[54]
						IV	101.19		
						pupa	124.34		
16	*Calotropis procera*	Leaves	Apocynaceae	Aqueous	*Ae. aegypti*	III	2.60	Delhi	[32]
				Ethanol		III	1.93		

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S. no	Plant species	Plant parts	Family	Solvent	Dengue vector	Larval stage	LC_{50} (ppm)	State	References
				Acetone		III	4.1		
				Hexane		III	5.3		
17	*Aegle marmelos*	Leaves	Rutaceae	Methanol	*Ae. aegypti*	III	145.07	Tamil Nadu	[54]
						IV	178.87		
						pupa	225.99		
18	*Peltophorum pterocarpum*	Leaves	Fabaceae	N-hexane	*Ae. aegypti*	III	219.14	Tamil Nadu	[33]
				Chloroform		III	170.74		
				Methanol		III	111.77		
19	*Annona squamosa*	Leaves	Annonaceae	Petroleum ether	*Ae. aegypti*	IV	63.54	Assam	[34]
				Chloroform		IV	61.33		
				Methanol		IV	51.45		
				Aqueous		IV	57.65		

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S. no	Plant species	Plant parts	Family	Solvent	Dengue vector	Larval stage	LC_{50} (ppm)	State	References
20	*Commiphora wightii*	Gum	Burseraceae	Hexane	*Ae. aegypti*	IV	197.38	Chandigarh	[35]
21	*Peltophorum pterocarpum*	Flowers	Fabaceae	Hexane	*Ae. aegypti*	IV	111.81	Tamil Nadu	[33]
				Methanol	*Ae. aegypti*	IV	104.84		
				Chloroform	*Ae. aegypti*	IV	121.92		
22	*Solanum xanthocarpum*	Leaves	Solanaceae	Methanol	*Ae. aegypti*	IV	130.01	Delhi	[55]
23	*Lantana camara*	Leaves	Verbenaceae	Ethanol	*Ae. aegypti*	IV	139.07	West Bengal	[56]
24	*Cinnamomum tamala*	Leaves	Lauraceae	Ethanol		IV	254.83		
25	*Coriandrum sativum*	Root	Apiaceae	Methanol	*Ae. albopictus*	I	103.45	West Bengal	[57]
						II	105.56		
						III	93.63		
						IV	129.41		

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S. no	Plant species	Plant parts	Family	Solvent	Dengue vector	Larval stage	LC_{50} (ppm)	State	References
2(	*Parthenium hysterophorus*	Leaves	Asteraceae	Hexane	*Ae. aegypti*	IV	1,920.05	Uttar Pradesh	[36]
				Acetone			1,539.26		
				Methanol			351.14		
2'	*Ziziphus mauritiana*	Leaves	Rhamnaceae	Methanol	*Ae. aegypti*	II	208.57	Tamil Nadu	[37]
						IV	252.13		
						Pupa	514.99		
2{	*Datura metel L.*	Leaves	Solanaceae	Acetone	*Ae. aegypti*	III	184.70	Tamil Nadu	[58]
				Ethanol		III	135.70		
				Chloroform		III	140.29		
2'	*Rosmarinus officinalis*	Leaves	Lamiaceae	Water		III	87.38	Uttarakhand	[38]
3(	*Carrisa spinarium*	Leaves	Apocynaceae	Water		III	53.45		
3	*Artemisia nilagirica*	Leaves	Asteraceae	Aqueous	*Ae. aegypti*	IV	583.33	Odisha	[39]

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S. no	Plant species	Plant parts	Family	Solvent	Dengue vector	Larval stage	LC_{50} (ppm)	State	References
3	*Platostoma menthoides*	Leaves	Lamiaceae	Ethyl acetate	*Ae. aegypti*	IV	81.32	Tamil Nadu	[40]
3	*Sargassum wightii*	Leaves	Sargassaceae	Chloroform	*Ae. aegypti*	II	158.39	Tamil Nadu	[41]

Larval stages: I- First instar; II - Second instar; III -Third instar; IV - Fourth instar

Table 2 Pharmacological activity and key active compounds of larvicidal plants

S.no	Plant species	Pharmacological activities	Major Phytochemical profile	Plant image	References
1.	*Avicennia marina*	Anti-inflammatory, antimicrobial, antioxidant, anticancer, and antidiabetic activities	2h-pyran-3-ol, tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl)		[59]

Early Version - Uncorrected

S.no	Plant species	Pharmacological activities	Major Phytochemical profile	Plant image	References
2.	*Andrographis paniculata*	Antimicrobial, anti-inflammatory, antioxidant, immuno-stimulant, hepatoprotective (liver-protective), and antidiabetic	Andrographolide, deoxyandrographolide, neoandrographolide, isoandrographolide		60
3.	*Tinospora cordifolia*	Anti-diabetic, anti-inflammatory, antioxidant, anti-cancer, immunomodulatory, and hepatoprotective properties, anti-stress, anti-allergies, and anti-malaria.	Berberine, magnoflorine, diterpenoid, columbin, glycosides, β-sitosterol and ecdysone		61
4.	*Plectranthus amboinicus*	Antimicrobial, anti-inflammatory, antioxidant, and wound-healing, treating skin conditions, respiratory illnesses.	Carvacrol, thymol, β-caryophyllene, α-humulene, and rosmarinic acid		62

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S.no	Plant species	Pharmacological activities	Major Phytochemical profile	Plant image	References
5.	*Elytraria acaulis*	Antibacterial, anticancer, antioxidant, antifungal, anti-inflammatory, hepatoprotective (liver-protective), and larvicidal activities.	Imidazole, imidazolidinone, phytol, phytol acetate, octacosane, thymol 1-thiocarbonylimidazolide, and methoxyacetic acid.		63
6.	*Piper longum*	Anti-inflammatory, antioxidant, anticancer, antimicrobial, immunomodulatory, and neuroprotective effects, treating respiratory issues, digestive disorders, and metabolic conditions like diabetes	Piperlongumine, piperlonguminine, lignans, esters, and esters, caryophyllene and bisabolene		64
7.	*Cyathocline purpurae*	Anti-inflammatory, anticancer, antimicrobial and antihelmintic properties	Methyl oleate, pentadecanoic acid derivatives, α-cadinol, β-selinene, and β-ocimene,thymohydroquinone dimethyl ether, cytoclol.		65

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S.no	Plant species	Pharmacological activities	Major Phytochemical profile	Plant image	References
8.	*Blumea lacera*	Anti-inflammatory, antioxidant, antimicrobial, and anthelmintic, anxiolytic, antidiabetic, and antidiarrheal, hepatoprotective and cytotoxic properties.	B-caryophyllene, Carvotanacetone, Chrysanthenone, 2,6-dimethyl phenol, Thymoquinol dimethyl ether, α-humulene, E-β-farnesene, α-amyrin, β-sitosterol, Stigmasterol, Lupeol and Lupeol acetate		66
9.	*Piper longum*	Anti-inflammatory, antioxidant, anticancer, antimicrobial, immunomodulatory, and neuroprotective effects, treating respiratory issues, digestive disorders, and metabolic conditions like diabetes	Piperine, piperlongumine, pipernonaline, guineesine, esters, and caryophyllene		64
10.	*Asparagus setaceus*	Antiulcer, antioxidant, antidiarrhoeal, antidiabetic and immunomodulatory, santimicrobial, antioxidant, and anti-inflammatory activities	Dimethyl ether, Hexadecanoic acid, Kaempferol Flavanols, Aurones, Anthocyanidins, Xanthones, and Chalcones		67

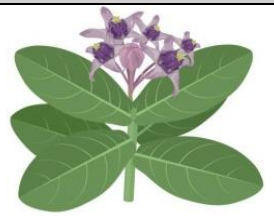
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S.no	Plant species	Pharmacological activities	Major Phytochemical profile	Plant image	References
11.	*Lantana camara*	Antioxidant, antibacterial, anti-inflammatory, and wound healing, anticancer, anthelmintic, anti-hyperglycemic, insecticidal, and antipyretic effects. T	Germacrene D, E-caryophyllene, bicyclogermacrene, and α-humulene, triterpenoids, flavonoids, phenylpropanoids, iridoid glycosides, alkaloids, tannins, saponins, and phenols		68
12.	*Ocimum gratissimum*	Antioxidant, anti-inflammatory, anticancer, antidiabetic, hepatoprotective, and antimicrobial acivity	The major phytocompounds in methyl eugenol, E-caryophyllene, β-ocimene, and germacrene-D, thymol, chavibetol, limonene, and α-pinene, rosmarinic acid, apigenin, rutin, and quercetin.		69
13.	*Ocimum americanum*	Antimicrobial, antioxidant, and anti-inflammatory,antiulcer, insecticidal, and larvicidal effects	Camphor, limonene, and caryophyllene, rosmarinic acid and ferulic acid, chrysin, 1-octanol and octyl acetate		70

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S.no	Plant species	Pharmacological activities	Major Phytochemical profile	Plant image	References
14.	*Wrightia tinctoria*	Anti-inflammatory, anti-ulcer, anti-psoriatic, antibacterial, antifungal, diabetes, viral infections, and wound healing, and possesses antioxidant, analgesic, and hepatoprotective effects	Kaempferol and Quercetin Aglycone, Kaempferol and Quercetin		[13]
15.	*Colocasia esculenta*	Anti-diabetic, anti-inflammatory, antimicrobial, antioxidant, hepatoprotective, anti-cancer. Traditional uses include remedies for bleeding, ear ailments, and skin conditions	Vicenin, isovitexin, vitexin, orientin, leteolin, Apigenin, luteolin, anthocyanin		[71]
16.	*Coleus aromaticus*	Antimicrobial, antioxidant, anti-inflammatory, and anticonvulsant properties	Carvacrol, thymol, eugenol, chavicol, ethyl salicylate.		[72]

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S.no	Plant species	Pharmacological activities	Major Phytochemical profile	Plant image	References
17.	*Calotropis procera*	Anti-inflammatory, antioxidant, antimicrobial, anticancer, anthelmintic, antipyretic, rheumatic pain and diarrhea, anti-ulcer and anti-fertility potential	Glycosides, calotropin, uscharin, calotoxin, calactin, thioacetic acid, 2,3 Dihydro-3,5-dihydroxy-6- mehtyl-4h-pyran-4-one, and 5 Hydroxymethyl-2-urancarboxaldehyde		73
18.	*Aegle marmelos*	Antioxidant, antidiabetic, anti-inflammatory, antimicrobial, and anticancer	Aegelin, auraptene, cineol, citral		74
19.	*Peltophorum pterocarpum*	Antimicrobial, antioxidant, anti-inflammatory, cytotoxic, antiglycemic, and antiulcer properties	Plumbagin, Quercetin, Kaempferol, Leucocyanidin, β-Sitosterol, Stigmasterol, aliphatic alcohols and fatty acids		75

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S.no	Plant species	Pharmacological activities	Major Phytochemical profile	Plant image	References
20.	*Annona squamosa*	Antidiabetic, antioxidant, anticancer, antimicrobial, anti-inflammatory, and hepatoprotective, diabetes, cancer, diarrhea and dysentery.	Acetogenins, anonaine cyclopeptides,		76
21.	*Commiphora wightii*	Anti-inflammatory, anti-arthritic, hypolipidemic, anti-diabetic, antioxidant, cardiovascular, metabolic disorders	Z-guggulsterone and E-guggulsterone, steroids, triterpenoids, diterpenoids, long-chain aliphatic sterols, and lignans.		77
22.	*Peltophorum pterocarpum*	Antimicrobial, antioxidant, anti-inflammatory, cytotoxic, antiglycemic, and antiulcer properties	Plumbagin, Quercetin, Kaempferol, Leucocyanidin, β-Sitosterol, Stigmasterol, aliphatic alcohols and fatty acids		75
23.	*Solanum xanthocarpum*	Antibacterial, antifungal, antioxidant anti-inflammatory, hepatoprotective, anti-asthmatic effects, anticancer and anti-fertility activities	Solasodine, glycoalkaloids campesterol, stigmasterol, and β-sitosterol, quercetin, luteolin, 3-methoxy apigenin, oleanolic acid, lupeol, and carotene.		78

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S.no	Plant species	Pharmacological activities	Major Phytochemical profile	Plant image	References
24.	*Lantana camara*	Antioxidant, antibacterial, anti-inflammatory, and wound healing, anticancer, anthelmintic, anti-hyperglycemic, insecticidal, and antipyretic effects.	Germacrene D, E-caryophyllene, bicyclogermacrene, and α-humulene, triterpenoids, flavonoids, phenylpropanoids, iridoid glycosides, alkaloids, tannins, saponins, and phenols		79
25.	*Cinnamomum tamala*	Antioxidant, anti-inflammatory, antimicrobial, antidiabetic, antidepressant, anxiolytic, diuretic anti-diarrhea, neurological and cardiac ailments, psychological disorders and wound healing.	Sesquiterpenoids furanodienone, curzerenone, furanodiene, and curzerene, eugenol, sabinene, germacrene D, and β-caryophyllene, cinnamaldehyde, camphene, myrcene, limonene, and α-pinene.		80
26.	*Coriandrum sativum*	Antioxidant, anti-inflammatory, antimicrobial, and neuroprotective effects, anti-diabetic, rheumatism and dyspepsia	Linalool, α-pinene, γ-terpinene, camphor, and limonene, as well as various phenolic compounds, flavonoids, and fatty acids.		81

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S.no	Plant species	Pharmacological activities	Major Phytochemical profile	Plant image	References
27.	*Parthenium hysterophorus*	Antimicrobial, anti-inflammatory, antioxidant, and insecticidal properties, skin infections, dermatitis, and muscular rheumatism, anti-cancer and hypoglycemic	Parthenin, coronopilin, and hysterophorin, caffeic, p-coumaric, and gallic acids, germacrene-D		82
28.	*Ziziphus mauritiana*	Antioxidant, anti-inflammatory, antibacterial, anti-diabetic properties, treating diarrhea, gastric disorders, liver damage, anxiety, and insomnia	Berberine, quercetin, and kaempferol, betulinic acid and oleanolic acid, phenolic compounds, lipids, and certain sugars.		83
29.	*Datura metel*	Analgesic, anti-asthmatic, anti-inflammatory, sedative, and antimicrobial properties traditional medicine for conditions like pain, asthma, skin diseases, and infections, which can lead to severe, life-	Scopolamine, hyoscyamine, and atropine, along with flavonoids, terpenoids, glycosides, phenolic compounds, tannins.		84

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S.no	Plant species	Pharmacological activities	Major Phytochemical profile	Plant image	References
		threatening anticholinergic toxicity and poisoning.			
30.	*Rosmarinus officinalis*	Antioxidant, anti-inflammatory, antimicrobial, and anticancer properties, treating muscle pain, indigestion, respiratory problems, and renal colic	Rosmarinic acid, carnosic acid, and carnosol, camphor, eucalyptol (1,8-cineole), and α-pinene, ursolic acid, betulinic acid and borneol.		85
31.	*Carrisa spinarium*	Antioxidant, anti-inflammatory, antimicrobial, anticancer properties, it is treat for gastrointestinal infections, diabetes, jaundice, rheumatism, malaria, and convulsive disorders.	Syringic acid, resveratrol, quercetin, epicatechin, and gentisic acid, and coumarins.		86
32.	*Artemisia nilagirica*	Antimicrobial, antifungal, anti-inflammatory, antioxidant, anticancer, larvicidal, and antiulcer effects	A-thujone, β-thujone, and compounds like borneol, camphene, β-caryophyllene, sesquiterpene lactones and coumarins.		87

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S.no	Plant species	Pharmacological activities	Major Phytochemical profile	Plant image	References
33.	*Platostoma menthoides*	Antibacterial, antioxidant, and anti-inflammatory properties.	B-caryophyllene, limonene, bornyl formate, α-humulene, and caryophyllene oxide.		88
34.	*Sargassum wightii*	Antioxidant, anti-inflammatory, anti-cancer, and anti-microbial, protecting against liver damage	Fucoidan, fucoxanthin.		89

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Table 3 Dengue infected and mortality data in India from 2020 to 2025 (NCVBDC)

S. No.	Affected States/UTs	2020		2021		2022		2023		2024		2025*	
		C	D	C	D	C	D	C	D	C	D	C	D
1	Andhra Pradesh	925	0	4760	0	6391	0	6453	0	5555	2	2386	5
2	Arunachal Pradesh	1	0	7	0	114	0	130	0	20	0	412	0
3	Assam	33	0	103	0	1826	2	8208	7	2271	0	618	0
4	Bihar	493	2	633	2	13972	32	20224	74	10157	16	3774	2
5	Chhattisgarh	57	0	1086	0	2679	10	2412	0	3523	2	454	0
6	Goa	376	0	649	0	443	1	512	3	567	3	101	0
7	Gujarat	1564	2	10983	14	6682	7	7222	7	7891	6	3947	0
8	Haryana	1377	0	11835	13	8996	18	8081	11	6469	9	2554	0
9	Himachal Pradesh	21	0	349	0	3326	1	1989	0	3359	0	229	0
10	Jammu and Kashmir	53	0	1709	4	8269	18	6403	10	6876	1	3343	2
11	Jharkhand	79	0	220	1	290	0	2578	4	1528	0	335	1
12	Karnataka	3823	0	7393	7	9889	9	19300	11	32886	27	6759	0
13	Kerala	4399	5	3251	27	4432	29	17426	153	20674	128	10239	49
14	Lakshadweep	0	0	1	0	67	0	445	0	513	0	109	0
15	Madhya Pradesh	806	0	15592	11	3318	2	6979	0	10224	6	1910	0

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S. No.	Affected States/UTs	2020		2021		2022		2023		2024		2025*	
		C	D	C	D	C	D	C	D	C	D	C	D
16	Meghalaya	4	0	129	0	26	0	114	0	74	0	63	0
17	Maharashtra	3356	10	12720	42	8578	27	19034	55	19385	40	13333	13
18	Manipur	37	0	203	0	503	4	2548	0	2463	5	5457	1
19	Mizoram	67	0	83	0	1868	5	2060	2	744	1	901	0
20	Nagaland	1	0	24	0	154	0	4943	2	42	0	68	0
21	Odisha	496	0	7548	0	7063	0	12845	1	9892	0	2544	0
22	Punjab	8435	22	23389	55	11030	41	13687	39	6260	13	4857	4
23	Rajasthan	2023	7	20749	96	13491	10	13924	14	12514	5	4017	0
24	Sikkim	11	0	243	1	264	0	311	0	374	0	162	0
25	Tamil Nadu	2410	0	6039	8	6430	8	9121	12	27378	13	20866	12
26	Tripura	24	0	349	0	56	0	1447	0	1198	0	699	0
27	Telangana	2173	0	7135	0	8972	0	8016	1	10077	0	8139	0
28	Uttar Pradesh	3715	6	29750	29	19821	33	35402	36	15868	9	8926	3
29	Uttarakhand	76	1	738	2	2337	0	4320	17	494	0	976	0
30	West Bengal*	5166	0	8264	7	67271	30	30683	4	441	0	NR	NR
31	Andaman and Nicobar Islands	98	0	175	0	1014	3	846	0	59	0	351	0
32	Chandigarh	265	0	1596	3	910	1	454	0	349	0	54	0
33	Delhi	1269	0	13089	23	10183	9	16866	19	10585	11	3746	2

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S. No.	Affected States/UTs	2020		2021		2022		2023		2024		2025*	
		C	D	C	D	C	D	C	D	C	D	C	D
34	Dadra and Nagar Haveli	248	0	547	0	685	0	1178	0	403	0	193	0
35	Daman and Diu	71	0	279	0	228	0	284	1	278	0	117	0
36	Puducherry	633	1	1625	1	1673	3	2790	2	2128	0	811	1
	Total	**44585**	**56**	**193245**	**346**	**233251**	**303**	**289235**	**485**	**233519**	**297**	**113450**	**95**

*Provisional till November 2025 (NCVBDC, 2025)

C=Cases | D=Deaths | NR=Not Reported

NCVBDC: National Centre for Vector Borne Disease Control

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