

GENERAL ARTICLE

Why Mosquitoes Prefer Some People More Than Others: The Sensory Biology of Differential Host Attraction

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Abstract

Differential attractiveness of humans to mosquitoes is a major factor in individual exposure to diseases spread by vectors. In India alone, this burden includes hundreds of thousands of cases of dengue, malaria, and chikungunya each year. This article summarizes the current understanding of the sensory and chemical basis of mosquito host selection. It starts with the peripheral olfactory system, which allows female mosquitoes to detect signals from potential hosts. Carbon dioxide, sensed by receptors on the maxillary palps, serves as a long-range cue and seems to enhance responses to visual and olfactory signals at closer distances. At landing distance, volatile organic compounds from the skin influence host choice. People who are very attractive to mosquitoes often have higher levels of sebaceous carboxylic acids on their skin, which work with sweat-derived lactic acid and ammonia. ABO blood group, the makeup of the skin microbiome, and genetic factors also affect attractiveness, although the extent varies, and the mechanisms are not fully understood. We also look at species-specific differences in host-seeking behaviour among the mosquito genera most relevant to public health in India: *Aedes*, *Anopheles*, and *Culex*. These differences impact the timing and targeting of vector control efforts. Recent research on modifying the skin microbiome to reduce lactic acid production provides early evidence for microbiome-based alternatives to traditional topical repellents that last longer.

Introduction

Both laboratory and semi-field studies have shown significant differences in how attractive people are to mosquitoes. Some individuals are consistently more attractive to mosquitoes than others, even in the same experimental conditions (Verhulst et al., 2011; Fernandez-Grandon et al., 2015; De Obaldia et al., 2022). This variation matters; since mosquitoes spread some of the most serious infectious diseases, knowing who gets bitten and why can impact disease transmission and control.

The diseases in question vary by vector.

Aedes aegypti and *Aedes albopictus* carry dengue, chikungunya, Zika, and yellow fever. *Anopheles* species are the only vectors for human malaria. *Culex* species transmit lymphatic filariasis and Japanese encephalitis. These genera not only differ in the pathogens they carry but also in when and how they look for hosts. This distinction will be discussed later in this article, where species-specific attraction is examined along with its importance for vector control in India, where all three genera are common.

This article describes the sensory biology behind how mosquitoes seek and are attracted to



Figure 1. A female mosquito probing human skin during blood-feeding. Only females take blood meals, which supply the protein required for egg development; males feed exclusively on nectar and other sugar sources.

hosts. It covers the peripheral olfactory system, the detection of carbon dioxide and body Odour, as well as blood type, skin microbiome, and genetic influences. After that, it addresses species-specific behaviour, the disease burden in India, and current and upcoming protection strategies.

Mosquito Olfaction: The Sensory Basis of Host Detection

Host-seeking in mosquitoes relies on their sense of smell. The biological mechanisms involved show why the cues described later in this article are detected. The main olfactory organs are the antennae, each made up of thirteen segments covered in hair-like structures called sensilla. Three types of sensilla stand out: sensilla trichodea, which are the most common, sensilla basiconica, known as “grooved pegs,” and the less common pitted sensilla coeloconica. These structures contain most of the olfactory sensory neurons, typically two or three in each sensillum. The maxillary palp is another important organ, especially for detecting carbon dioxide.

Two main gene families give this system its ability to be sensitive and specific. Odourant receptors (ORs) pair with a co-receptor, Orco, to create ion channels that respond to certain classes of smelling compounds. Ionotropic receptors

(IRs) create a separate system that includes co-receptors IR8a, IR25a, and IR76b. The pathways relying on IR8a are crucial for detecting carboxylic acids and amines, which are prominent in human sweat. Disruption of this pathway significantly reduces attraction to human Odour. Carbon dioxide detection occurs separately through a receptor complex located on the maxillary palps, not on the antennae (McMeniman et al. 2014). Odourant-binding proteins transport these mostly water-insoluble molecules through the fluid in the sensilla to the receptor membrane. Signals from the receptors converge in the antennal lobe of the brain. Neurons that express the same type of receptor project to the same glomerulus, creating a spatial map of odour identity. Downstream circuits then translate this information into flight and landing behaviour.

Only female mosquitoes seek a blood host because blood provides the protein necessary for developing eggs. Their antennae also have a different structure compared to the bushier, more plumose antennae of males. The male antennae are designed to pick up the wingbeat frequency of females during mating swarms rather than cues from hosts. This highlights that the sensory biology discussed here is specific to host-seeking females, not mosquitoes in general.

Carbon Dioxide: The Long-Distance Host Cue

Within this sensory system, carbon dioxide (CO₂) is the main signal mosquitoes use to find a potential host from afar. Female mosquitoes detect CO₂ through the maxillary-palp receptor complex mentioned earlier. They can track a rising CO₂ plume from a considerable distance. Estimates usually place the effective range at several tens of meters under favourable wind conditions.

Table 1. How CO₂ modulates mosquito sensory responses

Effect	Description
Enhanced visual tracking	CO ₂ improves the precision with which mosquitoes track moving visual targets
Sharper low-contrast tracking	CO ₂ exposure improves tracking of dim or low-contrast objects in flight
Context-dependent odour response	CO ₂ strengthens both attractions to host odours and avoidance of repellents, depending on the odour's behavioural value

Humans exhale air that contains roughly 4% CO₂, while the ambient background is about 0.04%. This difference helps mosquitoes follow a trail. Besides attracting them from afar, CO₂ seems to make mosquitoes more responsive to other signals. Experiments in a virtual-reality flight arena revealed that *Aedes albopictus* reacted more accurately to moving visual targets. They adjusted their response to odours, showing increased attraction to host odours and stronger repulsion from unpleasant ones when CO₂ was present (Kato-Namba et al. 2025). Additional research on *Aedes aegypti* has shown that CO₂ detection, through the Gr3 receptor subunit, works together with heat and skin odours to guide their attraction to live hosts. This combination of signals, rather than any single signal alone, helps them effectively seek out hosts (McMeniman et al. 2014).

People who exhale more CO₂, such as pregnant women who exhale about 21% more, larger individuals, and those doing physical activities, tend to attract more mosquitoes. This may explain the common increase in bites during and after exercise or later in pregnancy (Lindsay et al., 2000).

Body Odour Chemistry: Volatile Compounds and Host Discrimination

While CO₂ attracts mosquitoes from a distance, body odour decides if a mosquito lands and seeks a blood meal. Human skin releases hundreds of volatile organic compounds (VOCs). The chemical profile that results is what the IR8a-dependent pathway recognizes.

Carboxylic Acids and Skin Emissions

A 2022 study from the Voss hall laboratory at Rockefeller University, led by Maria Elena De Obaldia, found that carboxylic acids play a major role in how attractive humans are to mosquitoes. Sixty-four volunteers wore nylon sleeves on their forearms for six hours. When tested against *Aedes aegypti*, the main carrier of dengue, Zika, and yellow fever, the scent of the most attractive volunteer was about 100 times more appealing than that of the least attractive (De Obaldia et al. 2022). Chemical analysis indicated that highly attractive individuals produced significantly higher levels of sebaceous carboxylic acids. These fatty-acid compounds come from the skin's sebaceous glands. This difference remained consistent when the same individuals were retested over several years.

Lactic Acid and Ammonia

Lactic acid, released in sweat during exercise, has long been known to attract mosquitoes. A systematic review of the dengue vector *Aedes* spp. found it works with other skin-derived compounds to increase attraction (Mubarak et al. 2021). Ammonia, also found in sweat, seems to require this combination. Early behavioural studies on *Aedes aegypti* showed that ammonia alone had little effect, but when combined with lactic acid, it significantly boosted attractiveness (Geier et al. 1999). This combined effect helps explain why exercise, which raises sweating and lactic-acid

levels, usually makes a person more appealing to mosquitoes.

Blood Type and Mosquito Preference

A popular belief suggests that mosquitoes prefer certain blood types, and the evidence backs this up to some extent. A 2004 study of *Aedes albopictus* landing behaviour found that mosquitoes landed on people with Type O blood almost twice as often as those with Type A, with Type B in between (Shirai et al. 2004). Another laboratory study of *Aedes aegypti* allowed mosquitoes access to all four blood types through membrane feeders, also showing a clear preference for Type O (Prasadini et al. 2019).

Table 2. Reported mosquito landing preference by ABO blood type

Blood type	Relative attraction	Notes
Type O	Highest	Nearly twice as attractive as Type A in landing assays
Type B	Moderate	Intermediate attraction level
Type AB	Moderate	Broadly similar to Type B
Type A	Lowest	Significantly less attractive than Type O

However, these findings should be approached with caution. Texas A&M University entomologist Sonja Swiger noted that comparative trials like these always show a statistical “winner,” but this doesn’t guarantee blood type is a reliable predictor of any individual’s risk (Vargo 2026). Secretor status might matter as much as blood type. About 85% of people secrete a chemical marker of their blood type through the skin, and mosquitoes tend to prefer these “secretors” over

“non-secretors,” regardless of blood group (Shirai et al. 2004).

The Skin Microbiome Connection

Skin bacteria add another important layer to host attractiveness. A 2011 study on the African malaria vector *Anopheles gambiae* found that the makeup of skin bacteria, not just their presence, influenced appeal. Skin with high numbers of a few bacterial species was more attractive to this mosquito than skin with a diverse mix of bacteria (Verhulst et al. 2011). This pattern may explain why feet and ankles, rich in odour-producing bacteria, are particularly appealing. Some of these bacteria are related to those that create the smell of Limburger cheese, which has sometimes been used in mosquito traps.

Engineered Microbiomes: Toward “Living Repellents”

Since much of this attraction depends on bacteria-produced L- (+)-lactic acid, researchers have started to re-engineer the skin microbiome. In 2024, a team at the University of California, San Diego, led by Omar Akbari, deleted the lactic-acid-producing gene in two common skin bacteria, *Staphylococcus epidermidis* and *Corynebacterium amycolatum*. Mice with the engineered *S. epidermidis* attracted up to 64% fewer mosquitoes than those with the unmodified strain. This reduced attraction lasted for up to eleven days, much longer than the four-to-eight-hour effectiveness of topical DEET (Liu et al. 2024). If similar engineered strains can colonize and thrive on human skin, which remains unresolved, this approach could provide a long-lasting, self-replicating alternative to traditional repellents.

Species-Specific Host-Seeking and Relevance to Vector-Borne Disease Control in India

Much of the biology discussed mainly involves *Aedes aegypti* and *Anopheles gambiae*. However, the mosquito genera responsible for human disease vary greatly in their host-seeking behaviour, and these differences are crucial for applying attraction research to control strategies. *Aedes* species are aggressive daytime feeders, most active in the early morning and late afternoon, and often take multiple blood meals in one reproductive cycle. In contrast, *Anopheles* species primarily feed at night or during twilight, typically seeking hosts that are asleep after dark. *Culex* species are generally active in the early evening and night. A protection strategy focused on one genus, like bed nets for nocturnal *Anopheles*, is ineffective against daytime-biting *Aedes* and vice versa.

Table 3. Major mosquito vectors of human disease in India

Genus / species	Disease(s) transmitted	Peak biting activity
<i>Aedes aegypti</i> , <i>Ae. albopictus</i>	Dengue, chikungunya, Zika	Daytime (early morning, late afternoon)
<i>Anopheles culicifacies</i> , <i>An. stephensi</i>	Malaria	Night / crepuscular
<i>Culex quinquefasciatus</i>	Lymphatic filariasis	Dusk / night
<i>Culex tritaeniorhynchus</i> and allied spp.	Japanese encephalitis	Dusk / night

This distinction is particularly relevant in India, which faces a significant share of the global burden of mosquito-borne disease. *Aedes aegypti* is the main vector of dengue in India, with *Aedes albopictus* as a secondary vector. Malaria is mainly spread by *Anopheles culicifacies* in rural areas and by the increasingly urban-adapted *Anopheles stephensi*. *Culex quinquefasciatus* is the key vector for lymphatic filariasis, while *Culex tritaeniorhynchus*

and similar species transmit Japanese encephalitis (Naik et al. 2023). According to the National Centre for Vector Borne Diseases Control, India reported over 233,000 dengue cases and around 255,500 malaria cases in 2024, along with more than 17,800 confirmed chikungunya cases. The country accounts for nearly 40% of the global burden of lymphatic filariasis (NCVBDC 2025).

Given this variety, the attraction biology discussed here is practically important: understanding why certain individuals attract *Aedes* more strongly could help in more targeted use of repellents or spatial control measures in urban areas facing dengue outbreaks. The daytime feeding behaviour of *Aedes* limits the effectiveness of bed nets, which work well against nocturnal *Anopheles* and *Culex*.

Other Factors Influencing Attraction

Several other factors affect mosquito attraction. Pregnancy can double a person's appeal, mainly due to increased CO₂ output (about 21% higher) and raised body temperature (Lindsay et al., 2000). Drinking beer has also been shown to increase attraction to *Anopheles gambiae*, through a mechanism that does not seem to involve changes in exhaled CO₂ or body temperature (Lefèvre et al. 2010). Exercise boosts both lactic-acid production and body heat, which further enhances attraction. Additionally, mosquitoes are drawn to red, orange, and black, which overlap with human skin tones, while blue, green, and white are less noticeable.

Genetics plays a role too. A genome-wide association study of self-reported mosquito bite size, itchiness, and attractiveness, using 23andMe survey data, identified fifteen independent genetic markers linked to these traits. Most of these are related to immune function rather than olfactory biology directly (Jones et al. 2017). This suggests

Table 4. Additional factors affecting mosquito attraction

Factor	Effect on mosquito attraction
Pregnancy	Attracts roughly twice as many mosquitoes, linked to increased CO ₂ output (~21%) and body temperature (~0.7°C)
Beer consumption	Increases attraction to <i>An. gambiae</i> ; mechanism unclear but not attributable to CO ₂ or temperature changes
Exercise	Increases lactic-acid output and body heat, raising detectability
Clothing colour	Red, orange, and black attract more strongly; lighter colours (blue, green, white) are less readily detected

that part of an individual's apparent attractiveness may come from their immune and inflammatory

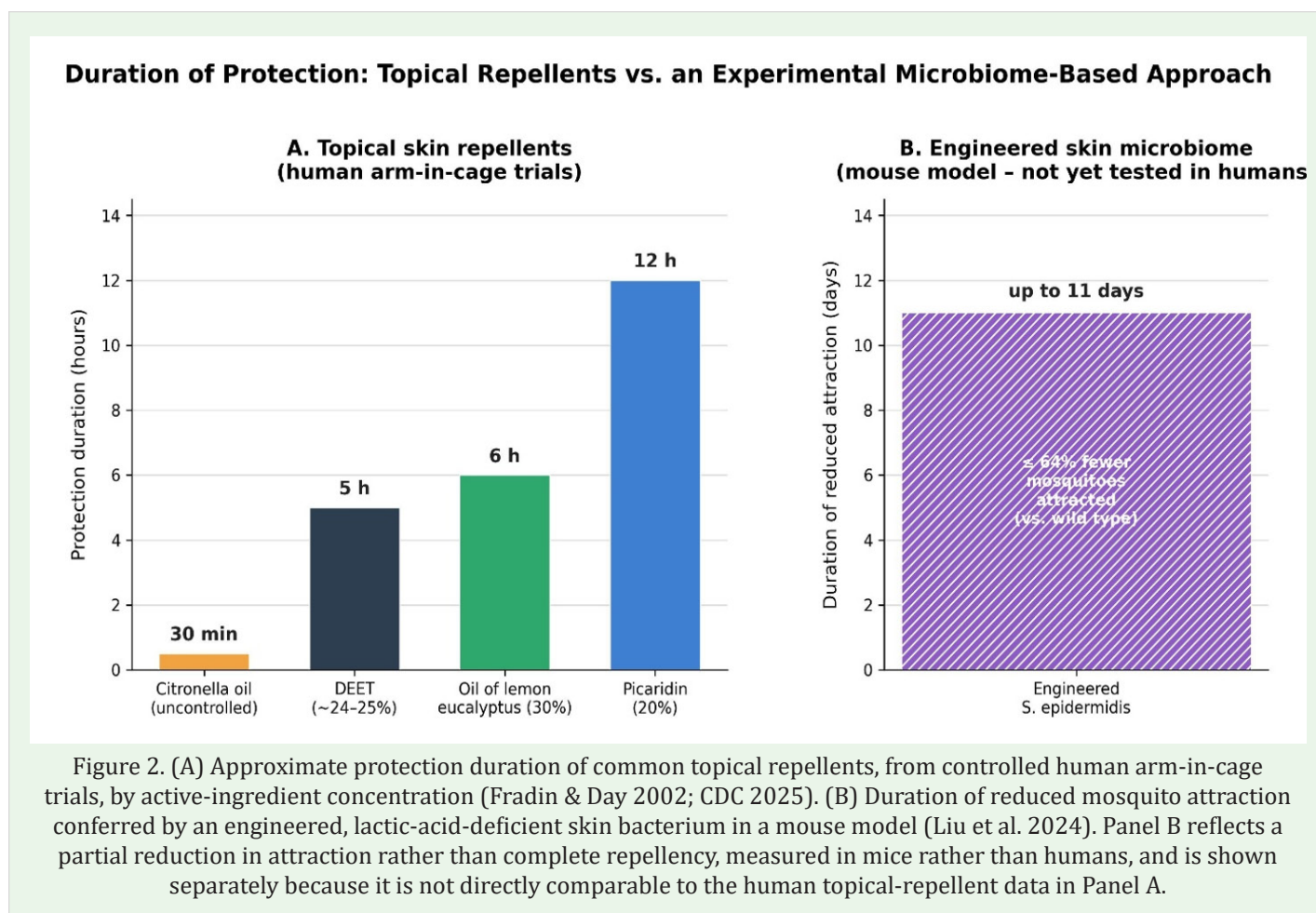
response to bites, rather than the odour they emit. This distinction is important when family members report different experiences with mosquito bites.

Protection Strategies

Understanding why mosquitoes prefer certain people is only part of the picture. The sections above also point toward practical, evidence-based ways to reduce individual risk.

Chemical Repellents

DEET (N, N-diethyl-meta-toluamide) remains the most studied repellent. In controlled human trials, a 23.8% DEET formulation provided a mean complete protection time of about five hours (Fradin & Day 2002). Picaridin, a synthetic compound modeled on piperine (a compound found in pepper plants), offers somewhat longer protection at similar concentrations. It lasts up to around 8 to 12 hours at 20%. It also has less odour



and does not break down certain plastics like DEET does (CDC 2025). Oil of lemon eucalyptus provides a plant-based alternative that is effective for about six hours at a concentration of 30 to 40% (CDC 2025).

Behavioural Modifications

Regular bathing reduces the buildup of skin compounds discussed throughout this article. Light-coloured clothing is less detectable than dark clothing, consistent with the visual cues discussed earlier. *Aedes* species bite mostly during the day, while *Anopheles* and *Culex* bite mainly from dusk onward. Therefore, the timing of protective measures should match the locally dominant mosquito species instead of being applied uniformly around dawn and dusk.

Conclusion

Over two decades of chemical, genetic, and microbiome research have clarified why some people attract more mosquitoes than others. Carbon dioxide draws mosquitoes in from a distance, while skin compounds particularly carboxylic acids and lactic acid determine whether they land and bite. Blood type and skin microbiome composition also influence attractiveness, but none of these factors operate alone. The importance of each one can vary across studies and mosquito species.

These mechanisms are not just of academic interest. The mosquito genera responsible for dengue, malaria, and filariasis differ in when and how they seek hosts. Translating attraction biology into practical protection whether through standard repellents, better-timed behavioural precautions, or new microbiome-based approaches requires focus on which mosquito species and diseases are most relevant locally. In a country like India, where *Aedes*, *Anopheles*, and *Culex* all circulate widely, understanding this species-specific detail is key to

reducing the burden of mosquito-borne diseases.

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