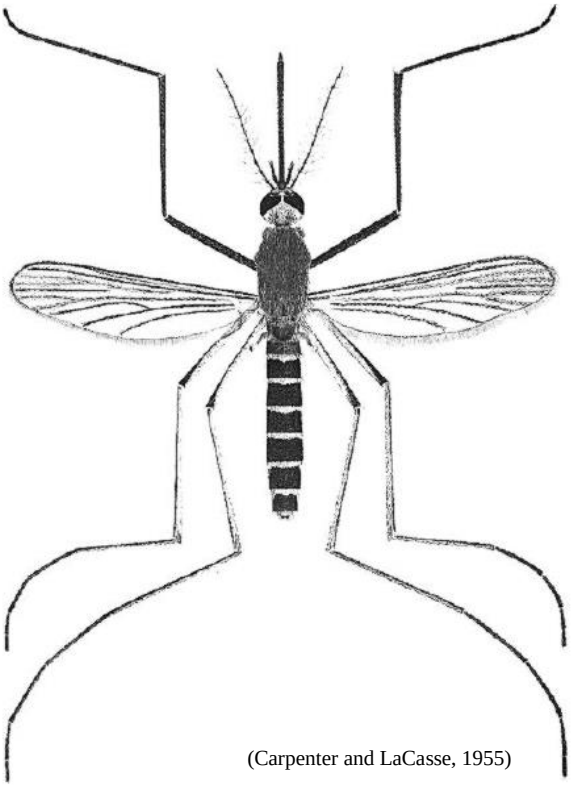
New Zealand BioSecure
A division of Southern Monitoring Services Limited

Culex pipiens Complex

NZ Status: Not present – *Culex pipiens* (the *molestus* form and *Cx. pipiens pallens* are Unwanted Organisms), *Culex australicus*, and *Culex globocoxitus*. Introduced – *Culex quinquefasciatus*

Please also see profile for *Culex quinquefasciatus* for more information on this species



(Carpenter and LaCasse, 1955)

Vector and Pest Status

Mosquitoes in the *Culex pipiens* complex are important disease vectors with global distribution. They are vectors of St. Louis encephalitis virus in eastern and south central North America (Tsai and Mitchell, 1989), West Nile virus in northeastern United States (Lanciotti *et al*., 2000) and Europe (Hubalek and Halouzka 1999), Rift Valley fever virus (Meegan, 1979), *Wuchereria bancrofti* (Farid *et al*., 2001), *Dirofilaria immitis* (dog heartworm) (Lai *et al*. 2000), and bird malarias such as *Plasmodium relictum* (Atkinson *et al*., 1995 in Cornel *et al*. 2002).

Culex pipiens f. *molestus* is known to carry Murray Valley encephalitis in the laboratory but its potential as a vector is unknown (Russell, 1993). Like the other variants of *Cx. pipiens*, *Cx. pipiens* f. *molestus* is a competent vector of West Nile Virus, with the effectiveness increasing when it hybridises with *Cx. pipiens* f. *pipiens* as this mixture will readily bite both birds and humans (Mavridis *et al*, 2018).

In northern China *Cx. pipiens pallens* was identified as the main vector of bancroftian filariasis, a filariasis (Huang *et al.*, 2020; Lui *et al*., 2019) and Japanese encephalitis (Lui *et al*., 2019).

Cx. *australicus* and *Cx. globocoxitus* are not considered to be of concern as vector species, however Murry Valley encephalitis, Kunjin virus and Ross River virus have been isolated from field collections of *Cx*. *australicus,* and Ross River virus and Burmah Forest virus has been isolated from field collections of *Cx*. *globocoxitus* (Russell, 2012).

Taxonomy

At present the *Culex pipiens* complex includes four recognised species. These are: *Cx.* (*Cx*.) *pipiens* Linnaeus, *Cx*. (*Cx*.) *quinquefasciatus* Say, *Cx*. (*Cx*.) *australicus* Dobrotworsky and Drummond, and *Cx.* (*Cx*.) *globocoxitus* (Aardema *et al*., 2022). The species *Cx. pipiens* has two forms: *Cx. pipiens* f. *molestus* and *Cx. pipiens* f. *pipiens*, and one subspecies *Cx*. (*Cx*.) *pipiens pallens* Coquillett (Aardema *et al*., 2022). In Australia, *Cx. pipiens* f *molestus* is referred to *Cx. molestus*, which may be a result of simplifying the name in absence of the other types of *Cx. pipiens* (Russell, 2012).

Morphologically members of this species complex are very hard to distinguish between, and there are several other species of *Culex* mosquito outside the complex (e.g. *Cx. torrentium* and *Cx. pervigilans*) that also share very similar features making it difficult to tell them apart, especially if the specimen is damaged (Farajollahi *et al*, 2011). This is particularly true for the two forms of *Cx. pipiens* as large amounts of variation in features creates no distinct morphological differences between *Cx. pipiens* f. *molestus* and *Cx. pipiens* f. *pipiens* (Harbach, 2012). Hybridisation also makes morphological characteristics unreliable (Farajollahi *et al*, 2011).

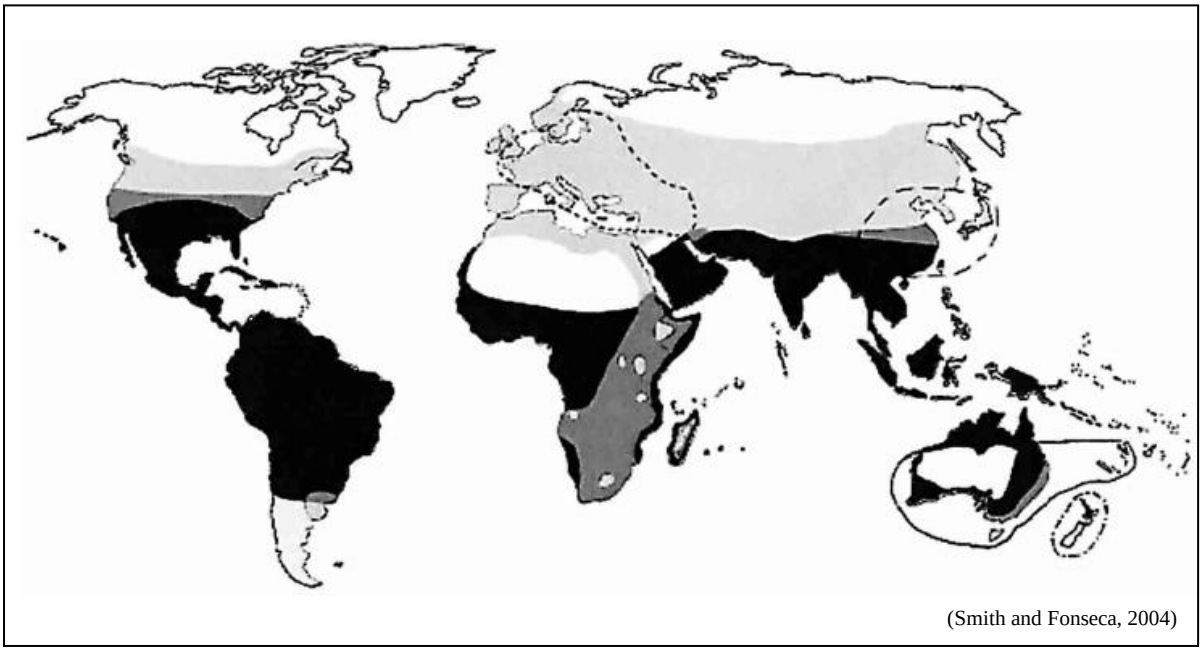
Smith and Fonseca (2004) have developed molecular assays that identify the members of the *Cx. pipiens* complex and other sibling species across several geographic regions worldwide. This study also detected introgression (process by which new genes are introduced into a wild population by backcrossing of hybrids between two populations) between *Cx. pipiens* and *Cx. quinquefasciatus* (Smith and Fonseca, 2004). Bahnck and Fonseca (2006) have also developed a rapid assay to identify the two genetic forms of *Cx. pipiens*, form *pipiens* and form *molestus*. This allows the identification of pure and hybrid populations of the two *Cx. pipiens* forms as well as those including *Cx. quinquefasciatus* (Bahnck and Fonseca, 2006).

According to a genetic grouping study by Fonseca *et al*. (2004), which included 33 populations of species in the complex, specimens designated *Cx. molestus* (*Cx. pipiens* f. *molestus*) from Pt. Willunga in South Australia were placed in the European underground *Cx. pipiens* group which is also present in North Africa, the Middle East and Japan.

Culex torrentium (a European species) and *Culex pervigilans* (a New Zealand species) are mentioned in the geographic distribution as they are morphologically similar to, but no longer part of the *Cx. pipiens* complex (Smith and Fonseca, 2004).

Geographic Distribution

The distribution of the *Culex pipiens* complex and its sibling species are displayed on the map below ex Smith and Fonseca (2004).



(Smith and Fonseca, 2004)

Light grey = *Cx. pipiens* (both forms); black = *Cx. quinquefasciatus*; dark grey = overlapping ranges of *Cx. pipiens* and *Cx. quinquefasciatus*; region marked by dotted line = *Cx. torrentium*; region marked by solid line = *Cx. australicus*; region marked by dashed line = *Cx. pipiens pallens*; New Zealand marked by dotted and dashed line = *Cx. pervigilans.*

Cx. pipiens (both forms) is an Old-World taxa that was originally distributed from Northern Europe to South Africa, and has since been introduced to the Americas, Asia and Australia (with only the *molestus* form in Australia) (Farajollahi *et al*, 2011).

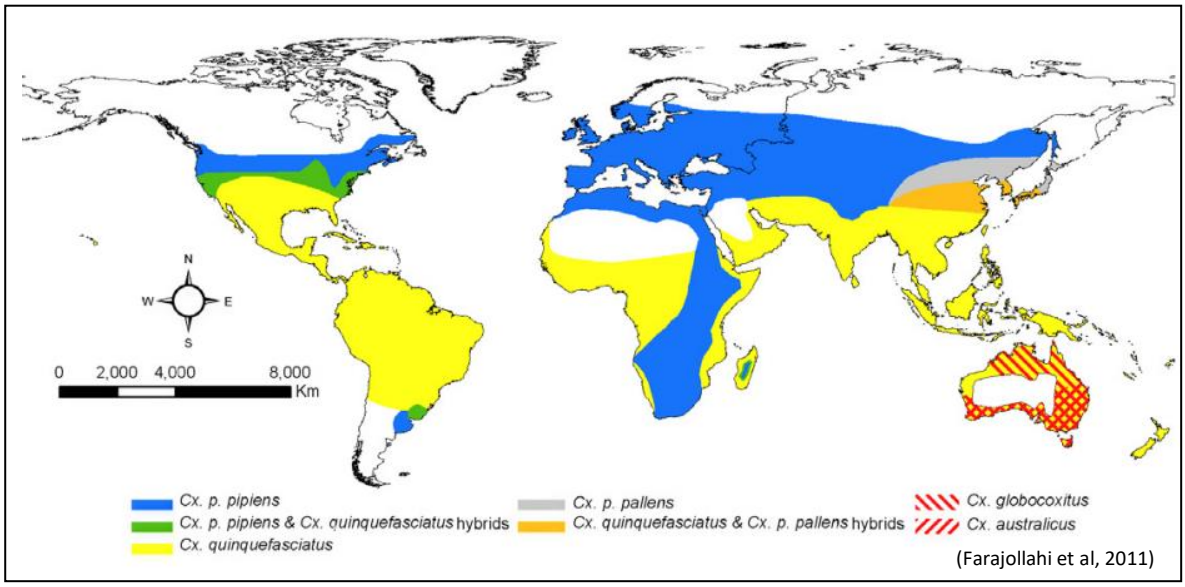
The *Cx. pipiens* complex in Japan consists of three taxa, *Cx. quinquefasciatus*, *Cx. pipiens pallens* and *Cx. pipiens molestus. Culex quinquefasciatus* is distributed throughout the Ryukyu Islands and Ogasawara Islands. The other two are found throughout the main Kyushu Islands and northwards, but not in the southern parts such as Okinawa (Oda *et al*., 1999).

Culex quinquefasciatus is widespread throughout the tropics, subtropics and warm temperate regions of the world (Lee *et al*., 1989). This species is present in both Australia and New Zealand.

Culex australicus is indigenous to Australia (Lee *et al*., 1989; Russell, 2012) and is also found in New Caledonia (Russell and Burkot, 2023). It has also been recorded in Vanuatu, however this has not been confirmed (Lee *et al*., 1989).

Culex globocoxitus is indigenous to Australia (NSW, Victoria, South Australia, Tasmania, southwest Queensland and southwest Western Australia) (Russell, 1993). This species is primarily found in rural areas (Russell, 2012)

Hybridisation is common and area's that this occurs is shown below on a map from Farajollahi *et al* (2011). Please note that the blue area represents both the *pipiens* and *molestus* forms of *Cx. pipiens*.



(Farajollahi et al, 2011)

Hybridisation occurs in locations where overlap between *Cx. quinquefasciatus* and *Cx. pipiens* occurs, and where overlap between *Cx. quinquefasciatus* and *Cx. pipiens pallens* occurs (Farajollahi *et al*, 2011). Hybridisation also occurs between the two forms *Cx. pipiens* f. *pipiens* and *Cx. pipiens* f. *molestus* with Mavridis *et al*, (2018) finding that in a routine monitoring survey in Southern Greece 37% of the *Cx. pipiens* collected were a *pipiens*/*molestus* hybrid.

Incursions and Interceptions

Culex pipiens has been intercepted in New Zealand on several occasions, including dead from a transitional facility in Lower Hutt, from a routine surveillance trap and, in 2024, a large number being collected both alive and dead from air cans from Shanghai over a period of several months. Genetic analysis conducted on a selection of samples from 2024 showed that a mixture of the two forms *molestus* and *pipiens*, and the subspecies *pallens* were collected, along with various hybrid combinations which included hybrids with *Cx quinquefasciatus*.

The subspecies *Cx. pipiens pallens* was also intercepted at the Ports of Auckland when an adult male was collected from a 44-gallon drum on the deck of a ship on the 20th September 2001. The ship originated from Japan and arrived in New Zealand via Hong Kong.

Culex australicus specimens have been intercepted on five occasions in New Zealand. A live female adult was collected on the 5th December 2005 at Christchurch Airport, in a plane originating from Melbourne, Australia. A live female adult was also collected in Dunedin inside a shipping container also from Melbourne on the 25th May 2006. On the 11th January 2012, a dead female was collected during a ship inspection at Tauranga Port, and then on two occasions in November 2014 (8th and 11th) dead females were collected from containers of melons from a transitional facility in Auckland.

Culex quinquefasciatus has been intercepted at air and shipping ports on a number of occasions. As this species is already present in New Zealand it is unknown whether adults and larvae collected have a New Zealand or overseas origin, however there are many interceptions of this species that are of overseas origin, which was determined

by analysing the factors related to their collection. Molecular testing of all intercepted specimens is not currently carried out and would help identify if the specimens were of New Zealand or exotic origin.

Culex globocoxitus has not been intercepted in New Zealand to date.

Habits and Habitats of each of the *Culex pipiens* complex

***Culex pipiens* – northern house mosquito**

(*Culex pipiens* f. *pipiens and Culex pipiens* f. *molestus*)

There are several behavioural/ecological differences between the two forms of *Culex pipiens, Cx. pipiens* f. *pipiens* diapauses, requires a blood meal to lay eggs (anautogeny), and is unable to mate in confined spaces. Whereas *Cx. pipiens* f. *molestus* does not diapause, is able to lay its first batch of eggs without a blood meal (autogeny), and mates in confined spaces (Mattingly *et al*., 1951; Bahnck and Fonseca, 2006).

Cx. pipiens f. *molestus* is highly domestic and thrives in highly polluted sewers, will often enter houses and feeds on mammals, including humans (Farajollahi *et al*, 2011). This form is also found in sylvan areas (Russell, 1993). In Japan, *Cx. pipiens* f. *molestus* occurs most frequently in underground water pools and occasionally in open water (Oda *et al*., 1999). Larvae of *Cx. molestus* in Australia are found in sewerage ponds, septic tanks and other polluted ground and container water, drainage pits (Russell, 1993). This form will attack humans and birds readily at night and can be a serious domestic pest indoors in certain areas (Russell, 1993). The development rate of larvae of the *molestus* form increases with temperature with one study from Greece finding that development took an average of 10.9 days at 32.5^{o}C to 52.7 days at 15^{o}C (Spanoudis *et al*., 2018) and a study from Australia finding that the shortest development time was between 12 and 30 days with development taking longer at lower temperatures (Kassim *et al.,* 2012).

Cx. pipiens f. *pipiens* larvae are often found in semi-permanent waters, rice fields and other pools with vegetation, along the edges of rivers in still water, and inundation areas (Becker *et al.* 2010). They will also occasionally be found in tree-holes and are frequently found in man-made bodies of water such as water barrels, construction sites, flooded cellars, ponds, tanks, and garden containers (Becker *et al.* 2010). Larvae of the *pipiens* form will complete their development from hatching to adults in one week in warmer conditions to a few weeks in cooler temperatures (Becker *et al.* 2010).

A temperature study found that the survival of *Cx. pipiens* f. *molestus* was adversely affected by temperatures of 28°C and higher (Oda *et al*., 1999). A study by Spanoudis *et al*. (2018) of *Cx. pipiens* f. *molestus* from Greece found that the longevity of adults ranged between 1.4 days at 32.5°C to 73.5 days at 15 °C.

A similar study by Andreadis *et al.* (2014) found that the average lifespan of adults of *Cx. pipiens* f. *pipiens* decreased as temperature increased. At 30°C the lifespan averaged at 8.2 days for males and 11.3 days for females, while at 15°C the average lifespan was 65.9 days for males and 92.3 days for females. Some adults of both sexes in this study had a lifespan exceeding 120 days at 15°C.

In the United States, blood meal analysis revealed that *Cx. pipiens* f. *pipiens* bites both humans and birds, suggesting they may serve as bridge vectors of the West Nile Virus from birds to humans (Spielman, 2001 in Fonseca *et al*., 2004). This is likely because they are often the most common mosquitoes in urban areas and the *Cx. pipiens* found in the USA have a large proportion of hybrids of the *pipiens* form (bird biters) and *molestus* form (man biters) (Fonseca *et al*., 2004).

Culex pipiens pallens
(Subspecies of *Culex pipiens*)

http://www.city.funabashi.chiba.jp/kankyohozen/envmp/photogallery/insect/28-2138.html

This species is a primarily domestic species occurring in urban areas, close to human habitation (Tanaka *et al*., 1979). Larvae occur in a very wide variety of artificial containers, subterranean habitats, ditches, gutters and ground pools with polluted water and containing abundant organic matter (Oda *et al*., 1999).

Cx. pipiens pallens females lay eggs after taking a bloodmeal (Oda *et al*., 1999). They are primarily avian feeders, but will also feed on humans and mammals, and will readily feed on reptiles (Tanaka *et al*., 1979).

Females of this subspecies can exhibit diapause (Oda *et al*., 1999).

It has been hypothesised that *Cx. pipiens pallens* resulted from ongoing hybridisation between *Cx. quinquefasciatus* and *Cx. pipiens* in Asia. However, there is some question surrounding this as *Cx. pipiens* has a limited distribution in East Asia and *Cx. pipiens pallens* will diapause while the other two species do not (Aardema *et al*., 2020).

Culex australicus

Larvae have been found in a number of habitats including ground pools, hoofprints, rock pools in creeks, larger artificial containers, drains, irrigation ditches and rice fields; effluent ponds and sewage treatment works, normally in freshwater but occasionally in brackish situations (Lee *et al*., 1989; Russell, 1993; Russell, 2012), and is generally found in more rural environments (Russell, 2012). This species does not normally bite humans and appears to feed predominantly on rabbits and birds (Dobrotworsky, 1965). Phylogenetic analysis by Aardema *et al* (2020) suggests that *Cx australicus* may have diverged from *Cx quinquefasciatus*.

This species is anautogenous and eurygamous and can overwinter as adults or slow-developing larvae (Russell, 2012).

Culex globocoxitus

Larvae are usually found in freshwater, in open swamps, grassy ground pools, drainage pits, waterholes and artificial containers such as tanks, troughs and wells. This species can tolerate brackish and polluted water (Lee *et al*., 1989). *Cx globocoxitus* will reproduce throughout the year (Lee *et al*., 1989). Adult females do not normally bite humans but may feed on birds and rabbits (Lee *et al*., 1989; Russell, 1993). This species is capable of carrying Murray Valley encephalitis under laboratory conditions (Lee *et al*., 1989). As with *Cx australicus* above, phylogenetic analysis by Aardema *et al*

(2020) suggests that *Cx globocoxitus* may have also diverged from *Cx quinquefasciatus*.

***Culex quinquefasciatus* – southern house mosquito**

This species is a domestic container breeding species which breeds in all kinds of artificial habitats containing polluted water such as wells, tanks, fountains, drains, septic tanks (Lee *et al*., 1989). *Culex quinquefasciatus* is generally prefers more nutrient dense waters than *Cx. pipiens* (Savage and Miller, 1995). This species is a nocturnal biter and usually attacks indoors and outdoors from 10 pm onwards and is a pest species in many locations it is found (Lee *et al*., 1989). More information about *Cx. quinquefasciatus* can be found in the profile for this species.

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