

The distribution and status of *Ochlerotatus geniculatus* (Olivier) in Fennoscandia

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Abstract

The distribution of the European tree-hole mosquito, *Ochlerotatus geniculatus*, in Fennoscandia is reviewed. Based on the examination of museum specimens from Denmark, and published and unpublished collection data from Sweden, the range of this species is revised and extended. Distributional data from Norway and Finland are scarce and no recent records are available from either country. Factors limiting the northern distribution of *Oc. geniculatus* in Sweden, and the possibility that loss of tree-hole habitats threatens the survival of this species in central Fennoscandia, are also discussed.

Introduction

Could certain specialised mosquitoes be in danger of extinction, especially at their distributional borders? It is suggested that the tree-hole species *Oc. geniculatus*, because of progressive loss of habitat, may be an endangered species in Fennoscandia.

In North America there are several tree-hole mosquitoes, including vectors such as *Oc. triseriatus*, *Oc. sierrensis* and, recently, *Aedes albopictus*. All of these have proven resistant to eradication efforts, in part because it seems virtually impossible to eliminate their larval habitats (Garry & DeFoliart, 1975). In Fennoscandia, however, the situation is quite different. Tree-hole habitats are becoming rare because of modern forestry practice, with clear-cuts of whole areas. Sahlén (1999) has shown a decrease in paravoltine species of Odonata in the Swedish boreal forest because of these factors. The dependence of *Oc. geniculatus* on rainwater to fill cavities provides an additional, unpredictable factor, limiting the size of populations of this mosquito.

The purpose in this communication is to review the status of *Oc. geniculatus* in Fennoscandia and update distributional data.

Identification

Although the type specimen no longer exists, the description by Olivier (1791) of an adult mosquito "*aux environs de Paris, dans les endroits humides*" is undoubtedly that of *Oc. geniculatus*. The characteristic conspicuous black and white scale pattern on the scutum, white lateral patches on the abdominal segments, and the presence of more or less white knee-spots are diagnostic for this species in Fennoscandia. Apart from *Oc. diantaeus* Howard, Dyar & Knab, *Oc. geniculatus* is the only Scandinavian species to have such a prominent scutal scale pattern. The former species, however, has less white on the scutum and lacks white knee-spots. *Ochlerotatus rusticus* Rossi, the other Fennoscandian species with white knee-spots, has a less pronounced, quite different scutal pattern. In southern Europe, the closely related species *Oc. echinus* (Edwards) has a scutal pattern of chestnut coloured stripes bordered by white scales and the scutellum carries many more white scales than that of *Oc. geniculatus*. In central and southern Europe *Aedes aegypti* (L.), *Orthopodomyia pulcricarpis* Rondani and the recently introduced *Ae. albopictus* (Skuse) also have black and white scaling, but quite different scale patterns on the scutum.

Oc. geniculatus females have an unusually broad sternum VIII. Male genitalia are characterised by a gonostylus with apicodorsal lobe absent and basal dorsomesal lobe weak, and by sparsely setate, elongated tergum IX lobes. The larvae of *Oc. geniculatus* and *Oc. echinus* have characteristic stellate abdominal setae, shorter in the former and markedly longer in the latter species. The larvae of *Oc. geniculatus* also have short antennae and short lateral palatal brushes well adapted to their small larval sites and their brushing feeding mode (Dahl, 2000).

Systematics

Edwards (1921) regarded *Culex fuscus* Zetterstedt, from Sweden as a doubtful synonym under *Oc. geniculatus*, and Natvig (1948) later synonymized *Cx. fuscus* with *Oc. punctor* (Kirby). For other synonyms, see Knight & Stone (1977). The species exhibits limited morphological variability and intra-specific enzyme variability in populations from England and Italy is also low (Munsterman, 1980). The use of the generic name *Ochlerotatus* follows Reinert (2000), who recently elevated the subgenus *Ochlerotatus* to generic rank.

Biology

Kitching (1971) recognised two categories of tree-holes: pans and rot-holes. In northern Europe, eggs, larvae and pupae of *Oc. geniculatus* are found only in deciduous trees sufficiently old to develop pans or rot-holes capable of retaining rainwater for periods of at least 4 weeks. Because the formation of such tree-holes in a northern climate is a slow process, only relatively mature trees can provide suitable habitats. Marshall (1938) reported "ash, beech, chestnut, elm, lime, oak and sycamore" as habitats of *Oc. geniculatus* in England. Yates (1979) added ash, and Cranston *et al.* (1987) added birch. For Denmark, Wesenberg-Lund (1920-21) mentions oak and beech. Andersson (1999) collected *Oc. geniculatus* from elms in southern Sweden and Natvig (1948) provides a summary of trees mentioned in older literature as being habitats of this mosquito. In nemoral situations in southern Sweden, deciduous trees like birch, beech and elm provide the most common *Oc. geniculatus* habitats. These trees were abundant in this region before the advent of modern forest management practices. Today, only relict stands with trees old enough to provide mosquito habitats remain (Diekmann, 1999), mostly in parks and some marginal or protected habitats. Mature trees are rarely left in managed forests. In central and southern Europe, oak (Ramos, 1983), walnut, beech, poplar, ash (Gutsevitch *et al.*, 1974) and maple (Domashenko & Sheremet, 1988) provide larval habitats.

The so-called "Limes norrlandicus", which is partly characterised by the northern distribution limit of pedunculate oak (*Quercus robur*), marks the northern border of the boreo-nemoral zone (Sjörs, 1999) of central Sweden. Within this zone beech (*Fagus sylvatica*), in which good tree-holes form, also occurs. This zone also seems to limit the occurrence of *Oc. geniculatus*. In the boreal mixed forest, only the southern birch (*Betula pubescens*) could potentially form tree-holes that might retain water. The question remains open as to whether the more northern birch (*B. pubescens* ssp. *czerepanovii*) develops cavities that hold water and whether *Oc. geniculatus* could be found where birches occur north of the Limes norrlandicus.

A most comprehensive study of egg, larval and adult biology was made in southern England by Yates (1979). He found that *Oc. geniculatus* overwinters primarily in the egg stage, that first and second instar larvae reach their peak densities in March and April, that third instar larvae are abundant from April to late July and fourth instars are present from May to September, with pupation mostly in May to August.

Studies as extensive as those of Yates (1979) have not been repeated elsewhere, but Wesenberg-Lund (1920-21) expressed the view that probably only one summer generation develops in Scandinavia; Natvig (1948) reached the same conclusion. Mohrig (1969) reported that in Germany asynchrony of hatching could create the illusion that there are several generations per season. Our observations, and the material presented below, suggest that both early and late hatching occurs, because newly emerged adults have been found in the same area in May and in July. In this respect, eggs have been observed to hatch in late autumn in Ukraine, though most were in hibernation by this time (Domshenko & Sheremet, 1982). Hatching depends on the water level in the cavities and, in some years, water might not reach the eggs until well into spring or even as late as August. In the latter case, it is conceivable that overwintering may be as larvae or pupae. In southeastern Europe, adult *Oc. geniculatus* have been observed in winter.

The larvae of *Oc. geniculatus* live in rather acid (Ramos, 1983) and tannin rich water enriched by micro-organisms and dissolved organic matter. Martini (1931) observed a special feeding behaviour in *Oc. geniculatus*, which left circular traces in the microbial film at the water meniscus. There is a record of *Oc. geniculatus* in a ground pool in England together with *Anopheles plumbeus* (Harold, 1926) and also in southeastern Europe together with *Oc. pulchritarsis* and *Orthopodomyia* sp. (Gutsevich *et al.*, 1974). In Sweden, *Oc. geniculatus* is usually the only species inhabiting tree-holes, although on one

occasion *An. plumbeus* larvae and two Chironomidae sp. larvae also were found in the same cavity (C. Dahl, personal observation). The eggs are laid along the dry walls and hatch when rainwater fills the holes. The species is prone to parasitic attack by *Ascogregarina* spp. (Munsterman & Levin, 1983).

Both the threat of a warmer climate with diminished rainfall and the non-preservation of older deciduous trees in sufficient numbers will affect tree-hole mosquitoes, and care should be taken to preserve their habitats, particularly in marginal zones such as southern Fennoscandia. Drought is probably a greater threat in central Europe and the Mediterranean than habitat loss.

An old laboratory record indicating that the yellow fever virus can survive in *Oc. geniculatus* (Roubaud *et al.*, 1937) has never been verified (Gutsevich *et al.*, 1974). However, although Yates (1979) cites several instances of its vectorial capacity, the species should not pose a threat as a vector species in Fennoscandia.

The Asian tiger mosquito, *Ae. albopictus*, imported in tyres, has established itself in western Europe (Schaffner, 2000). In Asia it is known as a container and tree-hole species (Hawley, 1988), and one of the vector species for dengue virus (Sulaiman *et al.*, 1999). If this species also colonises tree-holes in Europe it might compete with *Oc. geniculatus*. In an established tree-hole community in southern England, Bradshaw & Holzapfel (1992), studied habitat segregation and possible competition between the tree-hole mosquito species *Oc. geniculatus*, *Cx. torrentium* Martini and *An. plumbeus* Stephens, and the benthic fauna *Metriocnemus martinii* Thien (Chironomidae), *Prionocyphon serricornis* Müller (Coleoptera) and *Dasyhelia difouri* Laboulbène (Syrphidae). Segregation within and between habitats was found which was assumed to be more the result of inherent behavioural traits than prevailing competition within the tree-hole community.

Should this species, at least in the central Fennoscandian region, be classified as a rare, vulnerable species according to the IUCN code? Clearly, addressing this question will require collection of additional data throughout Europe to allow comparison between different regions.

Distribution in Fennoscandia

Sweden

The species is newly recorded from Halland, Uppland and Gästrikland. If not otherwise indicated, the collector is C. Dahl. Gästrikland: Österfärnebo, Bay of Fängsjön (collector M.S. Blackmore, C. Dahl), carbon dioxide suction traps: 29 July 1999, 1 female; 2 August 1999, 2 females and 3 August 1999, 2 females (new to Gästrikland).

Uppland: Kungsham-Morga Nature Reserve (collector T.G. Jaenson), on human bait: 19 July 1982, 1 female, chicken-baited suction trap; 2-3 July 1983, 1 male; 29-30 July 1983, 1 female; in rabbit-baited suction trap: 12-13 July 1983 1 female (see also Jaenson (1990)).

Halland: Dagsås, Öströö (collector T.G. Jaenson) engorging on the collector 19 July 1984, 1 female (unpublished, new to Halland).

Scania: Scania (collector C.H. Boheman), 2 males, 2 females without locality, probably near Ringsjön (Boheman, 1863), identified by Edwards (1921), material checked by C. Dahl; Lund, city park in elm 6 June 1997 numerous larvae; 8-11 June 1997, 11 males, 1 female (Andersson, 1999); Revinge, Stensoffa, Hägerdungen in beech holes 6 June 1976, 2 instar III larvae, two pupal exuviae; 11 May 1978, 3 males, 2 females; 18 May 1978 1 instar II, 2 instar III and 3 instar IV larvae; 18 July 1978, 19 instar IV larvae, 20 pupal exuviae; Revinge, Stensoffa, forest in beech hole, 5 June 1976, 3 instar III larvae together with *An. plumbeus*, *Asellus aquaticus* and chironomid larvae; Sövde, Navröd, Björkemossen in birch: 15 April 1974, 5 instar II larvae; 24 April 1974, 2 instar III larvae; Sövde, Navrödsvägen in beech: 28 May 1976, 1 instar III larva (all these Scanian records unpublished); Kristianstad, Egde sjö (collectors M. Schäfer, J. Lundström), carbon dioxide suction trap: 8 December 1998, 1 female (unpublished); Mölle, Kullaberg, (collector H. Andersson) 27 July 1978, 1 instar II larva and 1 instar III larva (unpublished); Mölle, Kullaberg, north side in birch, 16 May 1986 numerous instar IV larvae (material for analysis to USA); Mölle, Kullaberg, Josefinelust (habitat h) in beech 24 May 2000, 1 instar I larva.

Finland

Not found (Snow & Ramsdale 1999). The species should occur in a narrow zone of southern Finland where deciduous mixed forests are present.

Norway

West-Agder: Mandal, tree not stated 21 May 1929, 1 larva (Natvig, 1948); no further records (Mehl *et al.*, 1983).

Denmark

Without locality or date (collector H.J. Hansen), 1 female.

NEZ: Sjælland: (collector R.C. Staeger) - no date, 3 females; Tisvilde Hegn (collector I.P. Kryger) 7 June 1922, 2 males. Published; 3 females years 1969 and 1971 at Furesø lake and Lungby lake (Arevad *et al.*, 1973), material not in Museum in Copenhagen.

NFZ: Nordsjælland: (collector J.P. Kryger) June 24 two females; Uggeløse Skov (collector H. Anthon) 14 August 1938 one female; Lillerød (collector H. Anthon) May 1939, 1 male; Jaegerspris (collector S. Gisle Larsen), 15 August 1941, 1 male.

LFM: Lolland: Maribo, bøgeskoven (collector B.V. Petersen) 17 May 1964, 13 females, 8 males; and 14 June 1964, 1 female.

B: Bornholm: Paradisbakkerne (collector B.V. Petersen) 25 June 1964, 1 male; Rutsker, Holyng 4 August 1966, 1 female, 1 male.

All of the material in the Zoological Museum, Copenhagen was seen by one of us (C. Dahl); no tree sources were mentioned on labels but most or all were probably beech.

For the distribution of *Oc. geniculatus* in the remainder of Europe, see Snow & Ramsdale (1999).

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