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The domestic mosquitoes of the Neston area of Cheshire, UK

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Abstract

A survey of adult mosquitoes was carried out in gardens, homes and schools of residents of the Neston area of Cheshire, UK over 4 years from 2007 to 2010. The western border of this area consists of the tidal estuary of the River Dee. Mosquitoes were caught either in traps, mainly MosquitoMagnet traps, or individually by residents, when the mosquitoes were biting or resting. A total of 3213 mosquitoes were caught, 2787 in traps and 426 by residents. The most numerous mosquito species was *Ochlerotatus detritus*, the salt marsh mosquito, with 1966 (61.2%), *Culex pipiens s.l.* (which may include *Cx. torrentium*) numbered 1130 (35.2%) with small numbers of *Culiseta annulata* (35, 1.1%), *Anopheles claviger* (30, 0.9%), *Oc. rusticus* (7, 0.2%) and *An. plumbeus* (4, 0.1%). *Ochlerotatus detritus* was found in every month of the year except January with peak prevalence in September. *Ochlerotatus detritus, Cx. pipiens s.l* and *Cs. annulata* were found throughout the whole area and up to 2 km from the estuary. Complaints of biting nuisance by mosquitoes were received by the Local Authority in every year from 2004 to 2010 with annual numbers varying from as few as 4 to a maximum of 67. This survey suggests that *Oc. detritus* was responsible for virtually all the complaints since *Cx. pipiens* biotype *pipiens* (and *Cx. torrentium*) are ornithophilic and the other species which bite humans are uncommon. Control measures are restricted due to the conservation status of the estuary but the Local Authority regularly sprayed a restricted area of the extensive marsh with *Bacillus thuringiensis israelensis*. Further studies on the ecology of *Oc. detritus* in its breeding sites are in progress.

Keywords

Mosquito, Neston, Dee estuary, biting nuisance

Introduction

Neston is a civil parish in the county of Cheshire and consists of Neston, Little Neston, Parkgate and Ness. Neston formed part of the Borough of Ellesmere Port and Neston until 2009 and since local government reorganisation is part of the unitary authority of Cheshire West and Chester. The tidal estuary of the River Dee forms the western boundary and is a United Kingdom Site of Special Scientific Interest and a European Union Special Area of Conservation, largely due to its flora and fauna and especially the enormous populations of birds. The major part of this area is owned or managed by the Royal Society for the Protection of Birds as part of their Dee Estuary Nature Reserve. The Local Authority (LA) has no responsibility to manage the marsh. Figure 1 shows a map of the area.

The history of biting nuisance by mosquitoes in the Neston area is described by Davies (1995). This account states that problems were first seen in 1983 due to the downstream development of marsh and rapidly worsened due to the large number of pools resulting from the silting up of the channels. Two-hundred and thirty complaints were received from the public by the Environmental Health Department of the LA in September and October, 1985. The mosquito responsible was identified as *Aedes (Ochlerotatus) detritus* and control by spraying of the marsh with *Bacillus thuringiensis israelensis (Bti)* was commenced in 1986 and continued every year except 2007 when consent from Natural England and the Environment Agency was delayed.

In 2005 and 2006, 67 and 46 complaints, respectively, were received by the LA from residents about the biting nuisance of mosquitoes, the complaints occurring over a wide area (Fig 1). In September 2006, the numbers of complaints increased but 10 of 14 mosquitoes received along with the complaints were *Culex pipiens s.l.* It was decided that a more detailed and extensive survey would be valuable to shed light on the biting nuisance of the local mosquitoes since it was 20 years since the previous study and only involved *Oc. detritus*.

In addition, the presence of West Nile virus (WNV) infection in Europe has stimulated interest in the species of mosquito which might transmit infection if it was ever imported into Britain (Medlock *et al.,* 2005). This interest was stimulated when Buckley *et al*. (2003) produced serological evidence which indicated that birds in UK had been infected with WNV though a more recent study has not found evidence of WNV in a wide range of birds in the UK (Phipps *et al*., 2008).

Recently, two surveys of mosquito species have been carried out in the United Kingdom. Hutchinson *et al.* (2007) compared the efficacy of two carbon dioxide-baited traps, the CDC light trap and the MosquitoMagnet trap, in four sites in central and southern England. They concluded that both traps were efficient at catching mosquitoes though the MosquitoMagnet trap caught more mosquitoes with a wider range of species. They suggested that MosquitoMagnet traps were suitable for longitudinal studies over the summer months whilst CDC traps were to be preferred for rapid assessments of the presence or absence of mosquitoes. They collected over 5000 mosquitoes from June to September in 8 traps and identified 16 different species. *Coquillettidia richiardii* and *Anopheles claviger* were the most abundant species, accounting for 45% of the total mosquitoes caught. *Culex pipiens s.l.* and *Cx. torrentium* made up 11.8 % and a total of only 14 (0.25%) were *Oc. detritus* from a single salt-marsh site.

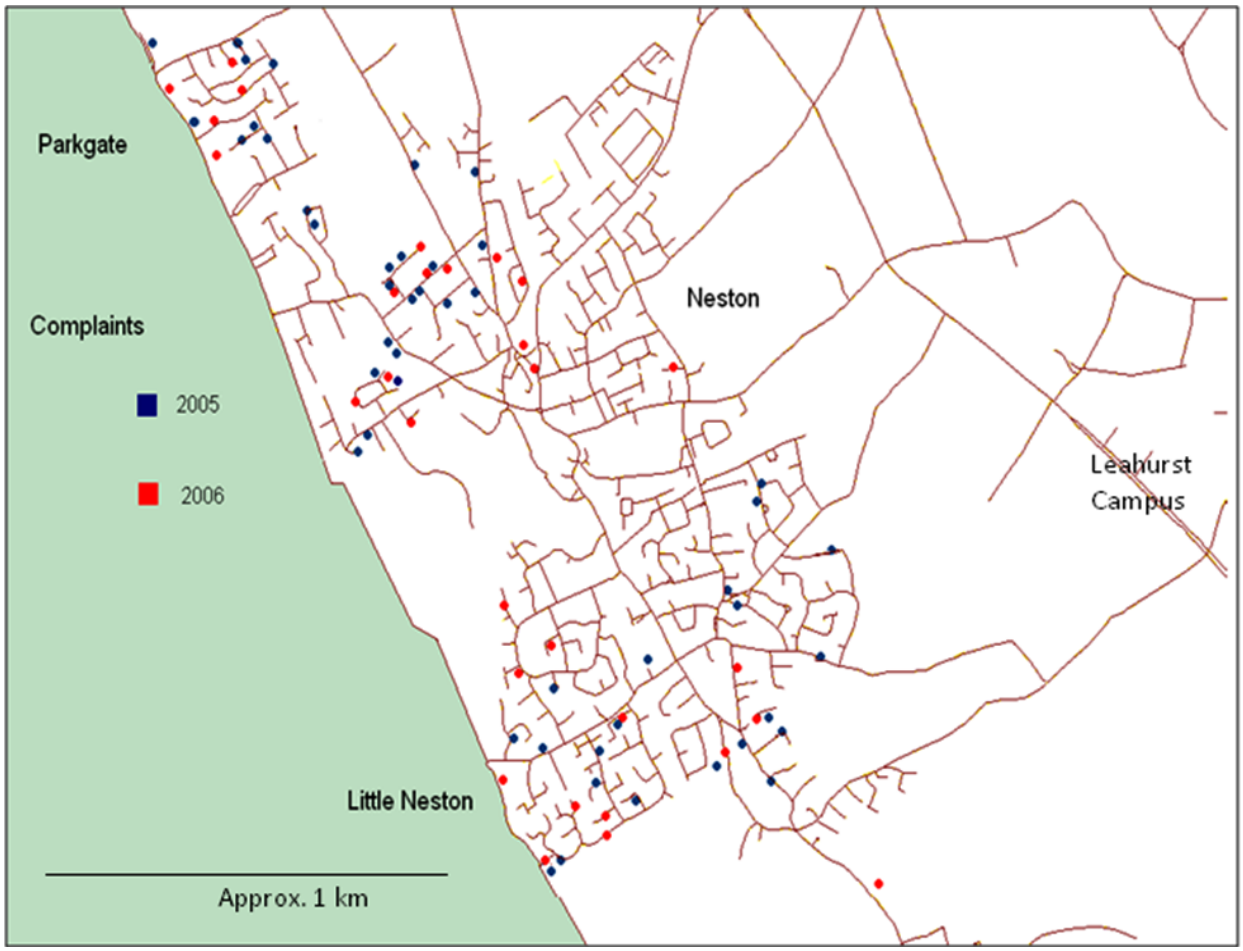

Figure 1. Map of the Neston area of Cheshire, UK, showing the distribution of complaints of biting nuisance by mosquitoes in 2005 and 2006.

The other collection was by Snow & Medlock (2008) which was a survey of 11 sites in Epping Forest and the adjoining urban area by the collection of larvae and pupae by netting and dipping and of adults by several methods including carbon dioxide suction traps. Seventeen species were recorded, the woodland species *Oc. cantans* and *Oc. punctor* were present in the greatest numbers but *Cx. pipiens* was found at all 11 sites. No salt-water sites were present and *Oc. detritus* was not seen.

The surveys described in this paper were designed to provide information on the species of mosquito associated with the residential area of Neston.

Materials and Methods

Mosquitoes were collected either by means of traps or by residents.

The Local Authority used CDC light traps without carbon dioxide for the months of May to October in 2006 and 2007 to collect mosquitoes in gardens of residents who had indicated a problem with mosquitoes. A small number of BG- Sentinel UV-light traps without carbon dioxide were used towards the end of 2007 but neither of these traps attracted many mosquitoes. In 2008, Midg-it Midgeater traps (Texol Ltd.) with propane cylinders to generate carbon dioxide along with an octenol attractant were used. Constraints in 2008 resulted in only a few traps being used for some weeks over the July – October period and deployed in a

number of different sites in the Neston area. Funding became available in 2009 and four MosquitoMagnet traps (American Biophysics Corp) were used continuously from May to December in 2009 and 2010.

In 2009 and 2010, traps were placed in two gardens in Parkgate near the marsh and in the grounds of two schools, one in Parkgate and the other in a school in Neston about one km from the marsh. The schools are located in residential areas. The traps were run continuously and emptied weekly. The propane gas cylinder and the octenol attractant were changed every three weeks. The nets from the traps were placed in a freezer at -20^{0}C to kill any live insects and the contents delivered to the laboratory. Since the mosquitoes had been in the trap for up to 7 days and had been subjected to considerable movement, they were sometimes in poor condition for identification.

Mosquitoes were also collected by staff of the University of Liverpool based at the Leahurst Campus (Fig. 1) following requests and instructions which was distributed on the communal e-mail list. They were asked to collect insects which they thought were mosquitoes in their homes and gardens and at Leahurst campus and to indicate where the flies were caught and if they were attempting to bite humans or pets or were resting. The staff lives over a wide area of the Wirral peninsula and Cheshire. Only those specimens collected within the Neston area were included in the present survey. The insects were collected in 90 x 25 mm Universal tubes and killed in a freezer at -20^{0}C. The dead insects were kept in the V of the tube by gently pushing tissue paper down the tube which held them in position during transportation to the laboratory and preserved them in good condition for identification.

The mosquitoes were identified on morphological grounds with a key produced from Marshall (1938) and Cranston *et al.* (1987). Mosquitoes identified as *Cx. pipiens s.l* may have included both *pipiens* and *molestus* biotypes and *Cx. torrentium* since the latter species was not identified separately. In this paper *Cx. pipiens s.l* may denote one or more of these.

The distribution of the mosquitoes within the Neston area was mapped by means of an interactive database.

Results

Complaints by residents

Figure 2 shows the number of complaints received by the LA over the years 2004 to 2010. The annual number of complaints varied from a minimum of four complaints in 2008 to a maximum of 67 in 2005.

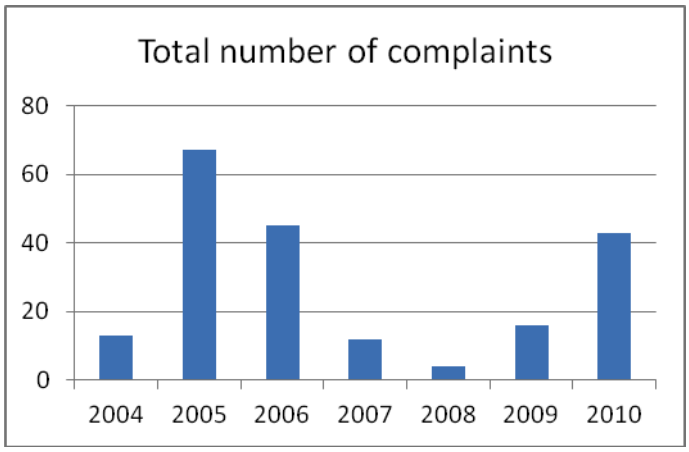

Figure 2. The number of complaints of mosquito nuisance from residents of Neston.

Most complaints were received in September and October, accounting for 63% of all complaints though in some years, notably in 2005, some complaints were received in April and May. Surprisingly, few complaints were received in July and early August in any year.

Mosquitoes caught in traps and by residents

Table 1 shows the total mosquitoes caught each year by the two methods. A total of 3213 mosquitoes were collected, 2787 in traps and 426 by residents.

Table 1. The numbers of mosquitoes caught in each year in traps and by residents.

Year	Mosquitoes in traps	Mosquitoes caught by residents	Total mosquitoes caught
2007	168	250	418
2008	161	76	237
2009	993	55	1048
2010	1465	45	1510
Total	**2787**	**426**	**3213**

Table 2. The species and sex of the mosquitoes caught each year in traps or by residents.

Year & method	*Oc. detritus*		*Cx. pipiens s.l.*		*Cs. annulata*		*Oc. rusticus*	*An. claviger*	*An. plumbeus*	Un-identifiable	Total
	♀	♂	♀	♂	♀	♂	♀	♀	♀		
2007t	38	10	97	11	7	0	0	0	0	5	168
2007i	79	1	155	7	4	2	0	0	0	2	250
2008t	107	3	34	1	4	0	0	0	0	12	161
2008i	24	0	47	0	4	1	0	0	0	0	76
2009t	501	29	387	36	1	4	6	25	0	4	993
2009i	30	1	19	0	2	1	1	1	0	0	55
2010t	1078	24	309	23	4	1	0	4	4	18	1465
2010i	38	3	4	0	0	0	0	0	0	0	45
Total	1895	71	1052	78	26	9	7	30	4	41	3213
Total	**1966**		**1130**		**35**		**7**	**30**	**4**	**41**	**3213**
Percent	59.0	2.2	32.8	2.4	0.8	0.3	0.2	0.9	0.1	1.3	100
t = traps, i = captured by residents											

Table 2 summarises the results of the identification of the mosquitoes collected. The two most common species of mosquitoes collected both in the traps and by residents were *Oc. detritus* and *Culex pipiens s.l* with small numbers of *Culiseta annulata, Oc. rusticus, Anopheles claviger* and *An. plumbeus. Ochlerotatus detritus* and *Cx. pipiens s.l* accounted for around 96 % of the total mosquitoes collected. The small numbers of the other species did not allow further analysis. Around 95% of the mosquitoes of the two main species were female but small numbers of males of both species were collected both in the traps and by residents. Female mosquitoes of both species were collected by residents every month from February to November inclusive and in traps every month from May, when they were first used, to December. Large populations of hibernating *Cx. pipiens s.l* could be found on the walls of boiler houses and cellars at the Leahurst Campus from September to March inclusive but these are not included in the table.

The seasonal distribution of *Oc. detritus* and *Cx. pipiens s.l.* caught in the traps in 2009 and 2010 is shown in Figs 3 and 4, respectively.

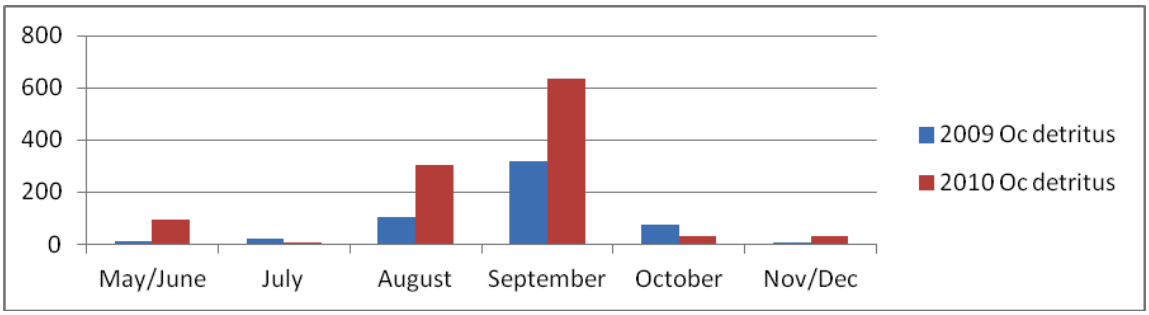

Figure 3. The number of *Oc. detritus* found in traps in 2009 and 2010.

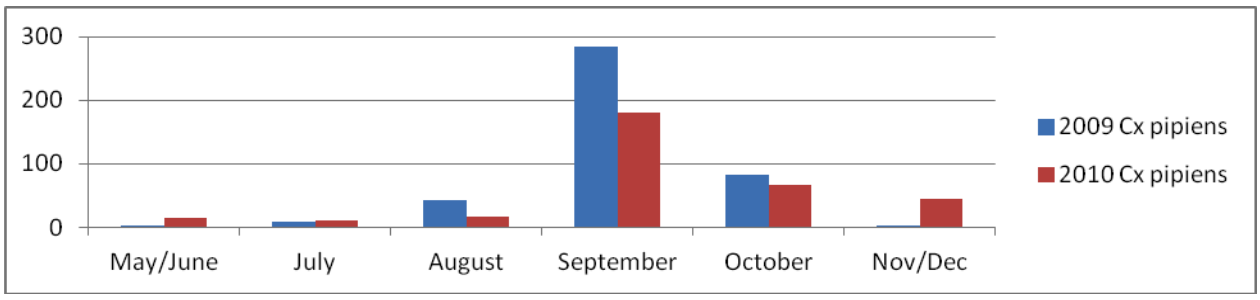

Figure 4. The number of *Cx. pipiens s.l.* found in traps in 2009 and 2010.

In both years, numbers of mosquitoes were low until August and the peak of both species occurred in September though it can be seen that the number of *Oc. detritus* was higher in September 2010 than in 2009 whereas the opposite was true for *Cx. pipiens s.l.*

Geographical distribution

Figure 5 shows a sample map derived from the database. For details, including the colour codes for the different species see the dynamic map of mosquito distribution at http://www.zoonosis.ac.uk/zoonosis/mosquitoes/mos1.aspx with the cursor arrow held on a coloured spot.

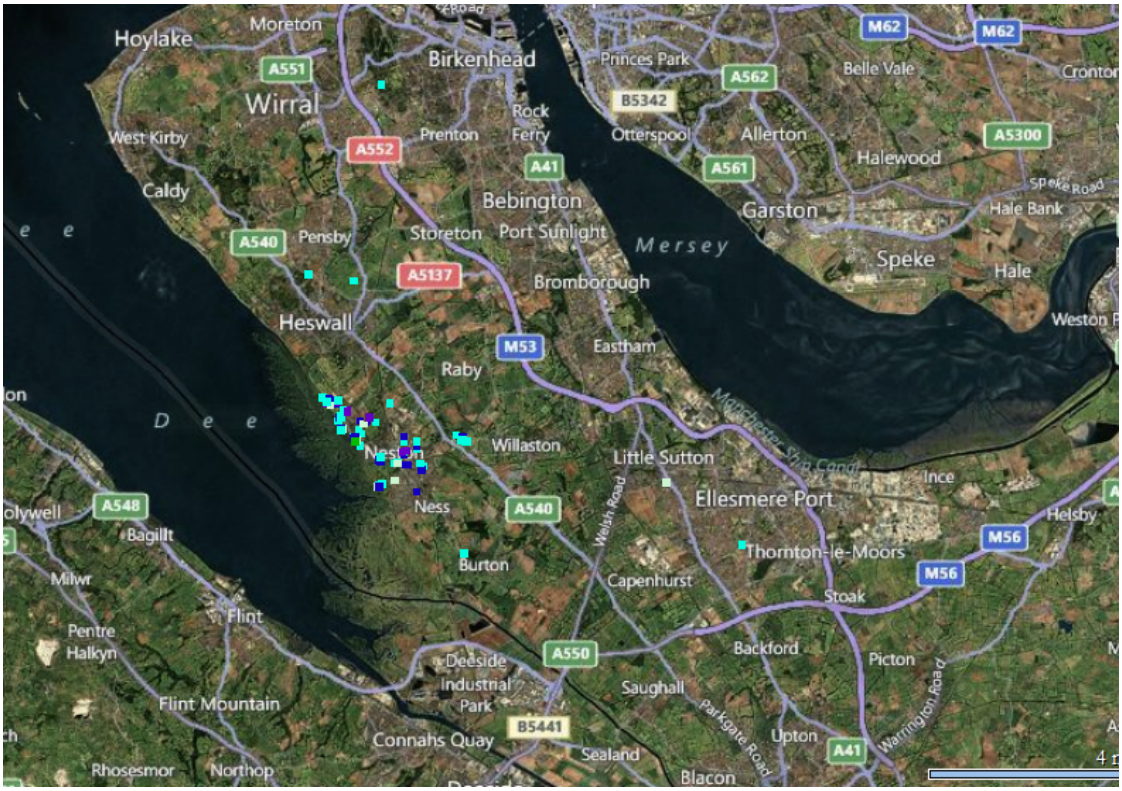

Figure 5. Geographical distribution of mosquitoes in Neston area.

Ochlerotatus detritus, Cx. pipiens s.l and *Cs. annulata* occur throughout the Neston area. The other species were found in such small numbers that it was not possible to draw conclusions about their distribution. *Ochlerotatus detritus* was found in significant numbers, especially in September 2010, at the Leahurst Campus which is situated about 2 km from the nearest marsh but no specimens were received from Willaston, a further 0.5 km from the marsh, despite requests to staff living in this area to submit mosquitoes.

Control

The LA has undertaken a spraying programme of the marsh pools with *Bti* every year since 1986 except 2007. Consent must be obtained from Natural England and the Environment Agency prior to spraying due to the protected nature of the site and this has occasionally delayed annual treatment and prevented it in 2007. Ten treatments were carried out in 2010. A decision to treat pools

with *Bti* ('Vectobac 12AS, Valent Biosciences') using back-pack sprayers was made after finding mosquito larvae in pools. Spraying was from the Little Neston to Parkgate area on Fig. 1 from the shore to a distance of about 400 m out at an application rate of 1 l per hectare. The area was split into three and each section was sprayed approximately 3 times at monthly intervals from May to September, 2010.

Discussion

This survey was not designed to determine the total number of mosquito species found in the Neston area but was restricted to those species which occurred in close proximity to the general population, being the species found in the gardens, homes and schools of the residents. Other studies have found additional species of mosquito in woods and fields and we are aware that at least 14 species of mosquito have been found in the Wirral area, of which Neston is a part (MW Service, *pers. comm.*). The mosquitoes found in this survey are almost entirely accounted for by *Oc. detritus* and *Cx. pipiens s.l.* (which may include *Cx. torrentium*).

The species of *Culex* were determined solely on morphological grounds and *Cx. torrentium* was not distinguished from *Cx. pipiens s.s.* since many of the mosquitoes from the traps were damaged and the distinguishing features difficult to see. The mosquitoes identified as *Cx. pipiens s.l* could therefore possibly be *Cx. pipiens* biotypes *pipiens* or *molestus* or *Cx. torrentium.* This is clearly of importance since *Cx. pipiens* biotype *pipiens* and *Cx. torrentium* are ornithophilic, feeding on birds, whereas *Cx. pipiens* biotype *molestus* feeds on mammals as well as birds. *Culex* species are vectors of West Nile virus which is found in birds and is capable of transmission to horses and humans, in which it may produce disease. *Culex pipiens* biotype *molestus* would have to be present to transmit the virus from birds to mammals whereas *Cx. pipiens* biotype *pipiens* and *Cx. torrentium* could only maintain the virus in birds. Whilst *Cx. pipiens* biotype *molestus* is included in the 14 species of mosquito found in Wirral, it seems that it is uncommon and may not even be present amongst the mosquitoes found in this survey. This conclusion is based on the fact that in no case did any of the residents sending in mosquitoes identified as *Cx. pipiens s.l* report that they were being bitten despite clear instructions to report this and no subterranean breeding sites have been found, essential for the larval stages of *Cx. pipiens* biotype *molestus*. In addition, examination of the DNA of 30 mosquitoes identified morphologically as *Cx. pipiens s.l* were shown by the technique of Bahnck & Fonseca (2006) to be *Cx. pipiens s.s.* The virus of West Nile disease has never been found in UK though Buckley *et al.* (2003) found serological evidence of WNV in birds.

This study shows clearly that *Oc. detritus* is by far the most important mosquito biting humans in the Neston area. The large numbers of this species in September and to a lesser extent in August and October coincided with the number of complaints received by the LA in both 2009 and 2010. The number of complaints received by the local authority varied significantly from year to year and the numbers of mosquitoes caught in 4 traps kept in the same sites was much higher in 2010 than 2009. J.P.C. Davies, the Head of the Environmental Health Department of the LA, contributed a section on the control of *Oc. detritus* on the Dee Estuary (Davies, 1995) in the publication on mosquito control in Britain by Ramsdale & Snow. He believed that the reduction in complaints by residents from 230 in autumn, 1985 to only 4 in autumn, 1986, was due to spraying with *Bti* which commenced in summer, 1986. He describes some of the practical problems of spraying the extensive marsh with heavy back-packs including the safety of staff who were fearful of being sucked into the bog. One area was particularly difficult where aerial spraying was used on a single occasion in 1989 but abandoned due to logistic problems. It is to the credit of the staff of the LA who have continued to spray a significant area of the marsh by hand almost every year since then and it seems likely that their efforts have played a part in reducing the complaints to the present numbers. However, it is clear that the conditions on the marsh can allow the rapid development of adults in September despite spraying, as happened in 2010. The area of the estuary sprayed, though extensive and involving the marsh alongside the main residential areas of Little Neston, Neston and Parkgate, was of necessity a small proportion of the whole tidal estuary. Although the large number of pools on the marsh of at least 6000 hectares has not been surveyed for mosquitoes, it seems reasonable to conclude that many will be infected. Since mosquitoes were found over a wide area of Neston up to 2 km from the marsh, the residential area may be receiving mosquitoes which have bred over the part of the estuary which has not been sprayed.

Further studies on the ecology of the larval stages in relation to high tides and rainfall are being done to attempt to explain the differences in mosquito numbers and complaints in different years. In general, tides which are high enough to completely cover the marsh and replenish the thousands of pools occur only in the spring, notably February, March and April and occasionally in September and October but this also depends on wind direction and speed and on barometric pressure. For the remainder of the year, rainfall determines whether the pools dry out or remain with standing water which influences the hatching and development of the eggs and larval stages of *Oc. detritus* (Service, 1968).

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This study would not have been possible without the diligent work of staff of Ellesmere Port and Neston Borough Council and Cheshire West and Chester Council including especially Carl Murphy, Angela Chambers, Emma Smith, Michael Cronley, Dennis Pitchford, Conrad Jaundrill, Jim Bilsland and Chris Humpreheys.

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References

Bahnck, C. M. & Fonseca, D. M. (2006) Rapid assay to identify the two genetic forms of *Culex (Culex) pipiens* L. (Diptera: Culicidae) and hybrid populations. *American Journal of tropical Medicine and Hygiene* **75**, 251-255.

Buckley, A., Dawson, A., Moss, S.R., Hinsley, S.A., Bellamy, P.E. & Gould, E.A. (2003) Serological evidence of *West Nile virus, Usutu virus* and *Sindbis virus* infection of birds in the UK. *Journal of General Virology* **84**, 2807-2817.

Cranston, P.S., Ramsdale, C.D., Snow, K.R. & White, G.B. (1987) Adults, larvae and pupae of British Mosquitoes (Culicidae). Freshwater Biological Association Scientific Publication No. 48. pp. 152.

Davies, J.P.C. (1995) Control of *Aedes detritus* on the Dee Estuary, Cheshire. *In* Ramsdale and Snow (1995) Mosquito control in Britain. University of East London pp. 46-50.

Hutchinson, R.A., West, P.A. & Lindsay, S.W. (2007) Suitability of two carbon dioxide-baited traps for mosquito surveillance in the United Kingdom. *Bulletin of Entomological Research* **97**, 591-597.

Marshall, J.F. (1938) The British Mosquitoes. The British Museum, London. pp. 341.

Medlock, J.M., Snow, K.R. & Leach, S. (2005) Potential transmission of West Nile virus in the British Isles; an ecological view of candidate mosquito bridge vectors. *Medical and Veterinary Entomology* **19**, 2-21.

Phipps, L.P., Holmes, J.P., Gough, R.E., McCracken, F., McElhinney, L.M., Johnson, N., Hughes, L., Chantrey, J., Pennycott, T., Murray, K.O., Brown, I.H. & Fooks, A.R. (2008) Surveillance for West Nile virus in British birds (2001 to 2006). *Veterinary Record* **162**, 413-415.

Service, M.W. (1968) The ecology of the immature stages of *Aedes detritus* (Diptera: Culicidae). *Journal of Applied Ecology* **5**, 613-630.

Snow, K. & Medlock, J.M. (2008) The mosquitoes of Epping Forest, UK. *European Mosquito Bulletin* **26**, 9-17.