CONTROL OF MOSQUITO NUISANCE IN BRITAIN

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ABSTRACT. The situation regarding mosquito nuisance and control in Britain is presented together with data resulting from a questionnaire circulated to Local Authorities throughout England, Scotland, Wales and Northern Ireland. Details of several recent control programs are given.

INTRODUCTION AND HISTORICAL BACKGROUND

Mosquitoes are no longer of great importance in the transmission of disease in Britain although some native species are disease vectors in other parts of the world. Up to around 90 years ago malaria was a naturally occurring disease in Britain, being transmitted in the valleys and marshlands where suitable mosquito vectors were found. The most efficient vector was *Anopheles atroparvus* van Thiel and this was the chief transmitter of the benign tertian form of malaria (*Plasmodium vivax*) which occurred in Britain. The disease was commonly called 'ague' and was especially rife in the marshlands and estuaries of East Anglia, Essex, Kent and counties of southern England (Dobson 1980). Housing improvements, which separated people from livestock and so made *An. atroparvus* more zoophilic as it overwintered in animal shelters, had a major effect on the decline of malaria and was aided by the drainage of marshlands, climatic changes and the availability of quinine (MacArthur 1951). The last records of endemic malaria in Britain date from around the turn of this century (James 1929, Shute and Maryon 1974).

During World War I (1914–18), transmission of malaria occurred once again as large numbers of troops returned to Britain with malaria (Shute and Maryon 1974) and infected passengers and crews of merchant ships arrived from African ports (MacNalty 1943). By 1921 the number of reports of transmission had declined to only a few per year (Shute 1949). Between the wars only a small number of cases were seen each year but a second influx of imported malaria took place during and soon after World War II (1939–45) (Shute 1949).

Nowadays approximately 2,000 cases of imported malaria are detected annually, all having been contracted abroad (Curtis and White 1984). However, during exceptionally hot summers, cases of locally transmitted malaria may occur. In 1983, for example, two cases of malaria were contracted in the vicinity of Gatwick Airport by people who had not travelled to malarious areas and were, almost certainly, bitten by infective tropical *Anopheles* mosquitoes which had entered Britain aboard aircraft (Curtis and White 1984).

Yellow fever outbreaks occurred on ships arriving at British ports in the last century. It would appear that some of these ships also imported the tropical mosquito, *Aedes aegypti* (Linn.), developing in water tanks on the decks. After feeding on sailors infected with yellow fever the mosquitoes subsequently bit people in these port towns so transmitting the virus (Buchanan 1866). It is unlikely that these conditions could be duplicated now and hence it is doubtful whether yellow fever could occur in Britain again.

Many other viral diseases are transmitted by mosquitoes in Europe. Examples are Inkoo and Tahyna in the California Group transmitted by *Aedes* species and, in the case of the latter virus, additionally by *Culiseta annulata* (Schrank) and *Culex pipiens* Linn. Although most of these mosquito species are present in Britain none of the viruses has been detected in serological surveys of potential host mammals and birds.

Despite the lack of disease considerations, control measures may be necessary when local populations of mosquitoes constitute an intolerable biting nuisance. Decisions have then to be made as to the most appropriate means of control. The method, or combination of methods, selected will depend upon the magnitude of the problem, the species of mosquito involved, environmental acceptability and efficiency of the method, safety of application and financial and support facilities available.

RECENT AND PRESENT-DAY PROBLEMS AND CONTROL

In order to ascertain the nuisance caused by mosquitoes in Britain, methods used for their control and the level of control activities, a questionnaire was designed and copies were circulated to Environmental Health Officers within the 482 Local Authorities throughout England, Wales, Scotland and Northern Ireland. Of the 328 replies received, 81 (25%) indicated that they had received complaints of mosquito nuisance during the last 25 years and 40 (12%)

reported incidences of mosquito biting during 1985 (Fig. 1). The number of cases reported to these 40 Local Authorities within that year ranged from one to over a hundred with a mean of seven.

In 21 administrative areas the mosquitoes were identified to species. In almost all cases the identifications were made by expert entomologists. Seven species were implicated and are listed below together with the number of areas from which they were reported:

Culex pipiens Linnaeus, 1758 (including form *molestus*)—10
Aedes detritus (Haliday, 1833)—9
Culiseta annulata (Schrank, 1776)—4
Aedes cantans (Meigen, 1818)—3
Anopheles claviger (Meigen, 1804)—2
Aedes caspius (Pallas, 1771)—1
Aedes rusticus (Rossi, 1790)—1.

Forty-seven Local Authorities stated that they had implemented control programs against mosquitoes within the last 25 years and 22 indicated

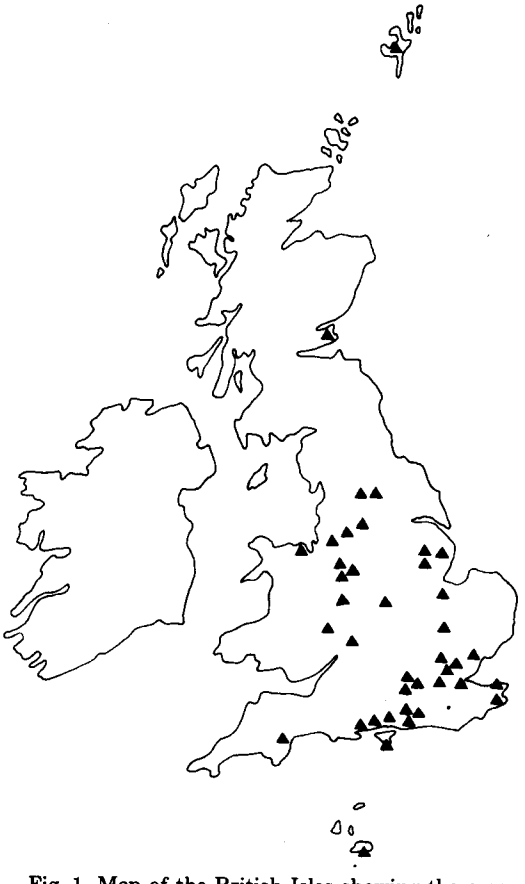

Fig. 1. Map of the British Isles showing the areas reporting mosquito nuisance in 1985.

control measures in 1985. Of the 22, 8 gave the number of control attempts in 1985 which ranged from 2 to 6.

Of the 38 responses as to whether control was judged to be successful or not, 35 indicated that it was successful and 3 gave negative replies. Two criteria for judging success were given: (i) no further complaints from the public or the complainant satisfied that control had been achieved (32 responses), (ii) no further mosquitoes apparent to council staff or that survey evidence showed a decline in the density of mosquito populations (11 responses). Both criteria were given jointly in several returns. The survey evidence given for the second criterion ranged from casual observations to systematic dip testing and the conducting of human bite counts. It was apparent that in many cases accurate assessments of the population density before treatment were not attempted and hence the degree of success or otherwise of the control programs were not quantifiable.

Recurrence of mosquito problems, often within 1–2 months, but almost always within a year, was reported in 19 of the 38 responses to this question. Of the remaining responses, recurrence was often prevented by annual treatments in advance of the onset of mosquito problems. Often recurrence was considered due to insufficient control measures or because of lack of follow-up. There were several where *Bacillus thuringiensis* var. *israelensis* (*B.t.i*) was used but it was not recognised that this killed larvae only and did not affect unhatched eggs or pupae. In the control of univoltine species there was evidence of good control when an application was made early in the season before the appearance of pupae followed by further applications at planned intervals during the larval season. Many Local Authorities reported that they were unable to carry out full treatments because of financial reasons, staffing constraints or because the breeding areas were too extensive and/or too abundant.

Local Authorities directed their control measures against both immature (aquatic) stages of mosquitoes and against adults. However, the predominant control efforts reported (for the last 25 years and 1985 in parentheses) were against aquatic stages with 66% (67%) electing to control immatures alone. Only 19% (19%) attacked adults alone in their control programs and a further 15% (14%) directed control efforts against both aquatic and adult stages.

A wide range of control methods have been practiced over the last 25 years. These are categorized below, the first figure in parentheses indicating the number of times in the last 25 years that the particular method was used and the second figure the number during 1985. In

the case of both immature and adult control the number of individual techniques used is greater than the number of control attempts, as more than one method was used on occasions.

1. *Measures directed against adults* (16, 7)
   (a) Residual spraying of surfaces in buildings (10, 3)
   Chemicals used: bendiocarb (2, 1); chlorpyriphos-methyl + synergized pyrethroids (2, 0); permethrin (2, 1); phenothrin + tetramethrin (pyrethroids) (2, 0); diazinon (1, 1).
   (b) Direct spraying of resting or flying adults in buildings (7, 4)
   Chemicals used: unspecified pyrethroids (5, 1); hexachlorohexane (HCH) = lindane (1, 1); phenothrin + tetramethrin (1, 2).
2. *Measures directed against immature stages* (34, 17)
   (a) Environmental modification/physical control (17, 4)
      (i) Land drainage/site reclamation/infilling (13, 2)
      (ii) Straightening and clearing of water course (1, 1)
      (iii) Flooding areas of marshland with sea water (1, 0)
      (iv) Enclosing cooling tower with lid (1, 0)
      (v) Removal of water in containers (1, 1)
   (b) Chemical application to larval habitats (30, 15)
   Chemicals used: lecithins (10, 7); oil/paraffin (6, 2); unspecified insecticide/"mosquito capsules" (6, 0); *B.t.i* (3, 3); pirimiphos-methyl (2, 1); chlorpyriphos-methyl + synergized pyrethroids (1, 1); DDT (1, 0); hexachlorohexane (HCH) = lindane (1, 0); malathion (1, 0); oil + unspecified insecticide (1, 0).

The reasons for selecting the methods employed were given as follows (in order of popularity of response):

(a) Ease of use
(b) Effectiveness (as judged by advice from others including manufacturers and previous experience)
(c) Low environmental impact, specifically low toxicity to non-target organisms
(d) Cost
(e) Availability (especially being in stock)
(f) Known to be an approved larvicide.

Details of dilutions used and/or application rates were given in only 3 returns; *B.t.i* was reported as being applied at rates of 0.5 and 2.0 liters/hectare while a pyrimiphos-methyl preparation was diluted 10 g/liter for application to the surface of a pond.

It should be noted that in 1985 no conventional chemical insecticide had clearance for application to water for the control of mosquitoes in Britain although clearly several were used by Local Authorities in contravention of the guidelines. Only *B.t.i.* and lecithins were cleared by the Pesticides Safety Precautions Scheme (1985) for use in Britain as mosquito larvicides. However, on October 6, 1986 the non-statutory Pesticides Safety Precautions Scheme was replaced by the statutory Control of Pesticides Regulations 1986. A comprehensive list of approved pesticide products and chemical compounds is now contained in the publication "Pesticides 1986" (Reference Book 500) published by her Majesty's Stationery Office. It is planned to update this publication annually.

The cost of individual treatments in 1985 was declared in 5 returns and ranged from £11 to £40 with an average cost of about £26[1]. The annual cost of mosquito control to Local Authorities also varied widely in 6 declarations from £10 to £4000 (average cost approximately £790). Only 3 local authorities said that they had an annual financial allocation for mosquito control.

Several of the general comments made on the returns are of interest. Many Environmental Health Officers were surprised at the lack of complaints considering the sometimes high densities of mosquitoes in their areas. Several noted that people seem to accept the presence of mosquitoes as part of the rural ecology. The general view was that in the absence of complaints by members of the public, no control measures were initiated.

The financial implications of control were commented upon in several returns and one Local Authority was concerned that in the present financial climate it might not be possible to fund further control measures. Another stated that it was unable to undertake mosquito control as the work is too labor intensive and costly for existing resources. Although it was usually the case that mosquito control was performed in response to individual complaints, it was also declared to be necessary for political and economic reasons where mosquitoes posed a problem in holiday resorts.

The last survey of mosquito nuisance and control methods conducted in Britain was by Service (1970). A comparison of the major findings of the present survey with the 1970 survey is given in Table 1.

From a comparison of the findings of the 2 surveys it appears that there is a great similarity between the percentages of replies indicating mosquito nuisance. However far less control ac-

[1] During 1985, £1 was equivalent to U.S. $1.40.

Table 1. Comparison of levels of mosquito nuisance and control and preferred insecticides in 1970 and 1985.

	Service (1970)	Present survey (data for 1985)
% replies indicating no nuisance	84.8	87.8
% replies indicating some nuisance but no-control attempted	4.8	5.5
% replies indicating nuisance and control attempted	11.2	6.7
Two most popular insecticides employed	DDT BHC (=HCH)	lecithins *B.t.i.*

tivity was revealed in the present survey. The change in the selection of insecticides is to be expected as *B.t.i.*, lecithins, and many of the pyrethroid, organophosphate and carbamate insecticides were not available 15 years before. Also the withdrawal and restrictions of clearance of certain chemicals for use as pesticides, e.g., DDT, has had a marked effect on the availability and usage of these persistent and environmentally detrimental insecticides.

No attempt was made to compare the figures for cost of treatments and annual financial burdens of mosquito control as this would be meaningless over such a long period of time.

SOME RECENT CASE HISTORIES

Since the inception of the British Mosquito Group[2] in 1980, many Local Authorities have sought advice regarding mosquito problems. Surprisingly few of the complaints have proved to be due to mosquitoes; rather they were initiated by the presence of chironomids. A recent example of this was in South-East England on the Thames Estuary (Snow, unpublished) where dredging operations have created brackish water lagoons. Examination of these lagoons revealed chironomid larvae but no mosquito larvae. However numerous swarms of the chironomids *Halocladius varians* (Staeger) and *Chironomus lugubris* Zetterstedt were present along the banks of the lagoons. The local Environmental Health Department had been treating these lagoons and adjacent fresh-water pools with lecithins with no impact upon the number of complaints. This was a clear case of the association of high insect densities, albeit non-biting midges, with mosquito nuisance.

In the Sandwich area of Kent, South-East England, a biting density of 200 per person per hour was recorded in September 1981: the majority of mosquitoes being *Ae. detritus* (Hargreaves 1986). Control trials using methoprene delivered in sand with added silicon dioxide were conducted in 1982. Two treatments were made in spring with a delivery rate of approximately 200 g AI/ha on each occasion. A high measure of control was achieved using this method. Further trials, this time using *B.t.i.*, were carried out in 1982 and 1983 at a rate of between 2.5–5.0 liters concentrate/ha in highly vegetated areas and less in pools devoid of vegetation. Spraying was carried out in March and an estimated 90% kill was achieved. Exceptionally high tides at the end of March flooded the area and a further hatch of *Ae. detritus* occurred. A further application of *B.t.i.*, using the same dosage and method, gave similarly effective control.

In the Dee Estuary and on Thorney Island in England *B.t.i.* has also been used successfully against *Ae. detritus*. Application to the salt-marsh breeding sites was as a flowable concentrate through a compression sprayer at a dose-rate of 1 liter of concentrate per hectare (Burgess 1986).

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[2] The British Mosquito Group was established in 1980 to promote discussion and interest in British mosquitoes and to organize a Recording Scheme in collaboration with the Biological Records Centre of the Institute of Terrestrial Ecology. Meetings of the Group are held biannually and topics discussed include aspects of the distribution, ecology and control of British mosquitoes.

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