Report on survey and control of Oak Processionary Moth *Thaumetopoea processionea* (Linnaeus) (Lepidoptera: Thaumetopoeidae) (OPM) in London in 2008

Client: Forestry Commission

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EXECUTIVE SUMMARY

This report collates and summarises work in London in 2008 to control and eradicate oak processionary moth (OPM), a well-known pest in continental Europe. It is a forest pest, sometimes occurring in vast numbers causing extensive, occasionally lethal defoliation of deciduous oaks. Minute, easily detached hairs on the backs of larvae cause skin irritation and other allergic reactions, occasionally severe, in people and animals and pose a significant public health hazard. The distribution is mainly central and southern Europe. Since the 1980s it has spread north, with major outbreaks in Belgium, Holland, Germany and France.

In 2006, two OPM infestations were found in London, in Richmond and Ealing/Brent. Evidence strongly suggested they were the result of accidental importation of eggs on planted semi-mature trees, in both cases a form of pedunculate oak known as Cypress oak, imported from mainland Europe 2-4 years previously, from OPM infested areas. Large populations had developed at both sites prior to their discovery, with dispersal having occurred into the local area to a distance of at least 1km. OPM readily colonises urban habitats and thrives in a warm, sunny microclimate.

Consultations took place in 2006-7 between the Forestry Commission, DEFRA (PHSI), Royal Botanic Gardens Kew (RBGK), Richmond and Ealing Borough Councils and Health Protection Agency (HPA) and included a Tree Health Forum at RBGK focussed on OPM. Larvae were found in early May 2007, the Forestry Commission's Plant Health Contingency Plan was initiated and an Outbreak Management Team was formed. An Action Plan was agreed and implemented and included imposition of specific phytosanitary import controls against OPM. The UK sought Protected Zone status for OPM in December 2007 and the Pest Risk Analysis prepared by Forest Research has been submitted to the European Food Standards Agency for an Opinion on the quarantine pest status of OPM. This is still awaited.

Actions in 2007 and 2008 included tree inspections from ground level and aerial inspections by tree climbers, use of insecticidal sprays against larvae or manual removal of nests. Monitoring using pheromone traps and light traps, and research into OPM life history and optimisation of control methods using field observation and desk study were also carried out. Plant Health Inspectors have been appointed and have issued Notices under Article 31 (4) of the Plant Health (Forestry) Order 2005 to owners or occupiers of premises where appropriate. Advice has been given along with Forestry Commission OPM Control Guidelines, including advice on PPE. In 2008, one control

operative presented with a severe rash despite using PPE. In 2008, the work was extended to include searches for egg plaques and old nests prior to the larval season.

Local authorities initiated publicity to increase the likelihood of locating infestations which could be brought to the attention of the OMT. Neighbouring boroughs were informed by borough emergency planning staff and Forestry Commission inspectors. The Health Protection Agency continued public awareness.

The level of infestation has been measured principally by the number of larval nests found in each year of survey and management. In 2008, the figures were as follows (2007 numbers in parentheses): Overall 506 (708), comprising 424 (171) in Richmond, 13 (3) in Hounslow, 51 (458) in Ealing and 18 (76) in Brent. No egg plaques were found until after larvae had hatched. One additional nest was found in pre-season surveys at a new location, leading to the discovery of larvae and nests in 2008. A large number of oaks were logged, and the data used in later surveys.

In both years, a network of pheromone traps (which attract only male moths) was deployed by the Forestry Commission over a wide area of London. In 2008, 16 moths were trapped, 10 outside the known infestation areas. None were trapped in 2007, as lures supplied were ineffective. Pheromone traps were used in RBGK using the same source of lures in 2008, with 165 moths caught (31 were caught in 2007 using a different, effective, source of lures to those employed by the FC).

Control measures in 2007 impacted significantly on populations, with an estimated 25-50,000 larvae or pupae destroyed. However, the data on nests located and destroyed indicated that measures had been more effective in some locations than in others (e.g. a large decline in Hounslow but an increase in Richmond). Moth behaviour such as pupation by a proportion of larvae away from the main nest, and delayed development of the early stages may also be important factors governing the numbers observed, although this has not been investigated in detail.

The area affected has not changed greatly, although additional outliers were found in Richmond and Hounslow, close to those already established in 2007. The discrepancy between the decline in numbers and smaller spread in Ealing/Brent and the increase and greater spread in Richmond is a reflection of the difficulty of carrying out control measures in the denser oak coverage in the latter. to the greater numbers of OPM and larger, more inaccessible trees makes spotting and dealing with nests more difficult, resulting in less effective control in the core area in Richmond, namely RBGK,

Royal Mid Surrey Golf Course and Old Deer. Oak is abundant here and it therefore has the highest potential for OPM population survival and growth to damaging levels.

It is recommended that work should continue in 2009 using the same methodologies, which it is concluded are effective in removing large numbers of OPM. In a minority of cases it was not possible to destroy the larval and pupal stages of the moth before adult emergence and flight of the moth, and ways to avoid this situation in 2009 should be examined. Efforts should concentrate on improving nest detection methods and more rigorous removal, focussing on larger trees. Trees close to the positive captures in the outlying pheromone traps should be investigated to determine whether larval populations have been established in these areas.

1. INTRODUCTION

1.1 Background

Oak processionary moth (OPM) is a major oak pest in mainland Europe. The larvae, which form a communal silk nest on the tree, sometimes occur in vast numbers, causing complete defoliation of trees in some cases. Repeated infestation can weaken the tree and allow other pests and pathogens (such as buprestid beetles and fungi) to infest the tree and lead to its death. The urticating hairs of the larvae cause allergic reactions, sometimes severe, posing a health risk to both humans and animals. OPM has shown a marked northerly range expansion since the 1980s and problems have at times been large-scale, especially in areas recently colonised, necessitating the use of significant public resources to protect both trees and the public. Establishment of OPM as a widespread breeding species in Britain would have major implications for forestry, horticulture and public health.

Two infestations of OPM were discovered in London in 2006, one in Ealing close to the boundary with Brent, and one in Richmond (Townsend, 2008). Although adults male moths have been recorded previously in light traps, these finds represented the first recorded instances of OPM breeding in mainland Britain. The Ealing infestation was centred on roadside plantings of oak, and was found and treated by landscape gardening contractors and reported to Defra. It was subsequently discovered that the moth had spread to nearby railway embankments. The Richmond infestation occurred on a privately-run residential estate beside the River Thames on trees planted to screen off a Thames Water plc waste treatment plant. Nearby residents and workers at the plant reported suffering rashes as a result of what they described as “insect bites”. The causal agent was at first suspected to have emanated from the plant. An estimated 10,000 larvae and considerable defoliation were found at the site. Richmond BC commissioned a survey of the wider local area, and further nests were found in North Sheen cemetery and Royal Botanic Gardens Kew (RBGK) (Townsend, 2007).

Evidence strongly suggested recent accidental importation in the egg stage as the origin of the outbreaks, since both were centred on amenity plantings of cypress (fastigiate) oaks (*Quercus robur* f. *fastigiata*) recently imported into Britain as semi-mature trees. No pattern of occurrence suggesting natural immigration was found. The male is a strong flier, is highly dispersive and has occurred in Britain as a natural immigrant (Waring et al, 2003), but the female is considered unlikely to be able to cross the English Channel unaided. Discussion with growers revealed that in

recent years, cypress oaks have been imported regularly from parts of Europe where the moth occurs. A label on an infested Richmond tree confirmed that the trees originated in one such area, in southern Holland.

1.2 Action

Discussions took place in winter 2006-7 between Forestry Commission, (FC), Forest Research (FR), RBGK, Defra, the Health Protection Agency (HPA), and Richmond and Ealing BCs. A Tree Health Forum was held at Kew Gardens in May 2007, focussing on OPM and other insect tree pests. As a result of these initiatives, and the results of surveys carried out in May 2007, immediately after the Tree Forum, the FC's Plant Health Service initiated its **Plant Health Contingency Plan** and formed an **Outbreak Management Team**. An **Action Plan** was put in place in June 2007, with a view to developing a strategy to reduce or eliminate the larvae soon after egg hatch in spring 2008 before OPM could spread out of London which would increase the likelihood of its becoming established permanently in Britain.

Surveys consisting of tree inspections from the ground by an appointed FC Plant Health Inspector were commissioned by borough councils and the FC in a coordinated programme of action in 2007 (Townsend, 2008). Some major landowners commissioned their own surveys and provided data. Notice was served under the Plant Health (Forestry) Order 2005 to ensure the eradication of OPM from specific sites, where appropriate, by the landowner, occupier or managing agent. Eradication was carried out by qualified contract tree climbers. The work was continued and extended in 2008 with the cooperation of borough councils and landowners. A further 3 FC Plant Health Inspectors were appointed. Moth emergence was monitored by FR using pheromone trapping, and independently by RBGK using pheromone trapping, light trapping and captive rearing.

1.3 Summary of pre-2008 findings

In July 2006, it is estimated that 100 nests were present in Richmond as a whole, but the borough was not surveyed thoroughly at this stage. A similar outline survey was carried out in Ealing/Brent, where 15 nests were found. The total present in that year is likely is to have been considerably higher in both areas.

In 2007, more accurate data were gathered, and an estimated 708 nests were found and destroyed. Of these, 458 were in Ealing, 76 in Brent, 171 in Richmond and 3 in Hounslow. At the Ealing/Brent site, nests were concentrated in an area roughly 1km² with few outliers beyond this core area. The scatter was greater in Richmond and Hounslow, due most likely to the greater abundance and

continuity of suitable host trees and habitat. Landowners were cooperative and distribution of leaflets by boroughs led to additional discoveries. Pheromone traps for adult males were deployed by the FC but caught no moths. The commercial lures supplied proved to be ineffective, even though chemical analysis suggested that the key constituents were present; however, the lure is known to be very sensitive to precise ratios of chemicals rather than to total amounts of constituents. Traps using pheromone lures from a different source caught 31 males in RBGK.

1.4 Survey Remit in 2008

- Survey for egg plaques before larval hatch, in order to guide larval/nest surveys and treatment. Extend the nest survey area before larval hatch in order to detect further geographical outliers from 2007 and thereby gain an improved picture of the extent of infestations. Also to record trees for future reference. Carry out larval/nest surveys in as great an area of the affected boroughs as possible, liaising with Borough Councils and other landowners.

- Work with landowners and contractors to locate and remove nests, overseeing removal and destruction, providing advice on methods and safety including PPE.

- When nests or evidence of OPM is found, serve Notice under Article 31(4) of the Plant Health (Forestry) Order 2005 to landowners or their agents or managers, for removal of the pest.

- Provide advice and disseminate information to interested parties.
- Liaise with the OPM Outbreak Management Team on progress and report findings.

- Prepare and submit a report on the survey results and actions taken.

1.5 Aims

- Guide the timing of searches for larvae and treatment (egg surveys). Establish the extent of the spread of infestations from previous years.

- Estimate geographical extent and overall numbers of infestations in 2008, and assess the status of the moth in outbreak areas, in order to inform the OMT with regard to planning future control and eradication measures and strategies.

- Facilitate eradication, ensuring that all reasonable efforts are made to survey and remove nests without endangering the health of pest control operatives and the public.

- Assist in co-ordinating the response to the arrival of OPM in Great Britain.

2. SUMMARISED INFORMATION ON OPM

2.1 Life history

2.1.1 Host range

The larvae of oak processionary moth feed on the leaves of a variety of deciduous oaks *Quercus* species, including the native British species pedunculate oak *Q. robur* and sessile oak *Q. petraea*. Colonisation of the evergreen *Q. ilex* (holm, or holly oak) has not been confirmed, but larvae have been found in London on a hybrid Q. *robur*/*ilex*. Evidence from RBGK, where a great variety of oak species from many parts of the world are present, suggests that European species are suitable hosts. However, North American and Asiatic species have also been infested at this site (section 4.6.2), and *Q. rubra* (North American red oak) is also a known host. Other tree species can be affected by OPM, including beech, birch, hawthorn and *Robinia*. However, this has only been known to occur where outbreaks are severe, and is therefore thought to be the result of extreme competition for food. The larvae have only been known to develop into adults on oaks and beech (Roskams, 2008).

2.1.2 Life cycle

Eggs are laid in batches (egg plaques) on twigs, usually in the crown. Trees in open, sunny habitats are favoured, often at the edges of woodlands or isolated trees in open places, frequently in urban situations and including trees as small as only 3-4m high. The larvae hatch in late April or early May and stay at first in groups among the leaves. In the 3rd instar (larval feeding stage) they move to a trunk, bough or main stem where a communal silken nest is constructed, from which they move *en masse* in 'processions' back to the foliage to feed. The larvae pupate in the nest. In some cases, the initial nest is subsequently abandoned and a further nest is formed in which pupation occurs. The first nest is often noticed from the presence of cast larval skins and a small amount of webbing, although in some cases this may be more substantial and difficult to distinguish from a nest produced by larger larvae that has been damaged.

The nests are often conspicuous and persist on trees for up to a year following infestation. They retain large numbers of the toxic hairs and, as an added protective adaptation, the unusually robust larval exuviae (cast skins) remain adhering to the nest, also retaining toxic hairs. The height of the nest from the ground varies considerably and tends to be in the upper canopy, especially on larger trees. On large trees nests are often 20m or more from the ground, but may be as low as 1-2m, and

(usually on smaller specimens) may actually be touching the ground. Nests are very often in a sheltered position, i.e. under a bough or branch usually in a southerly aspect, or orientated towards the warmer, less shaded side of the tree. The nest is rounded and sometimes somewhat elongated, and strongly attached to the tree by thick threads of silk extending outwards, which act as guy ropes. Strands of whitish silk are made along limbs towards the feeding areas and may be a useful visual indicator of the presence of OPM larvae.

Feeding by larger larvae is characterised by stripping of each leaf to the mid-vein, which usually remains at least partly intact. Since the larvae feed in groups, patches of stripped leaves are often seen, but when infestation levels are relatively low, this can often only be seen when the larvae are well grown. While they are still active, the nest is whitish, but it becomes duller and browner with age. When seen in silhouette it may appear as a bulge. Pupation occurs in June or July, the adults emerging from late July to mid September.

The moths have forewing length 14-17mm, and are rather thickset. The antennae are feathered, strongly in the male. Forewing pale brownish-grey, with a small, faint dark central crescent mark, and smooth, rather wavy blackish cross-lines. The basal area is whitish, which helps to distinguish it from pine processionary moth (*Thaumetopoea pityocampa*), which is generally larger and the basal area is not paler than the ground colour of the remainder of the forewing. They are nocturnal and both sexes are attracted to artificial light, sometimes occurring in light traps in very large numbers. The male disperses widely, and is regarded as migratory although the female appears to disperse much less widely. The adults do not feed and are short-lived, surviving roughly 3-4 days.

2.2 European distribution

Leraut (2006) lists five species of processionary moth (genus *Thaumetopoea*, family Thaumetopoeidae) in Europe. Of these, two are widespread and common in Western Europe and regularly become a nuisance, namely oak processionary moth (OPM) *T. processionea* and pine processionary moth *T. pityocampa* (Denis & Schiffermüller). Historically, the distribution of OPM has been southern and central Europe but, since the 1980s, it has been expanding northwards and has colonised areas of Holland, Germany, Belgium and France in which it was previously rare or absent. This expansion is considered to be most likely a result of climate warming.

OPM has a history of northward expansions and southward retreats, and it seems likely that these were climate related. Plagues occurred in Flanders in 1800 and 1927 and there are many 19th

century records from Holland, where it was not recorded for several decades in the 20th century and was considered extinct in 1976, but by 1978 further outbreaks had occurred (Roskams, 2008). There is one reliable early record of *T. pityocampa*in Great Britain, a single male at a light trap in Buckinghamshire in July 1966 (Waring *et al*, 2003). It is not known whether this was a natural immigration or an introduction and its status can be described as "absent: intercepted only".

In the late 20th century (1990s), OPM once again became a pest in Holland. It was recorded in Denmark for the first time in 1996 when 26 (all males) were caught in light traps (Skule and Vilhelmsen, 1997) and recently in southern Sweden, but there appears as yet to be no evidence of breeding in these countries. OPM was first seen in the Channel Islands in 1983, where it is now resident in Jersey (Waring *et al*, 2003) and was first recorded as a natural immigrant in mainland Britain in 1983 (1 in Cornwall), with 30 up to 2008 almost exclusively from the south or southeast coast of England, always as adult males in light traps, and none from the London area. The highest number (12) occurred in 1995, when its abundance in Holland was rapidly increasing, as measured by incidences of tree damage (Moraal *et al*, 2002), which declined rapidly from 1997. This was thought to be due to a combination of control measures and colder weather. Arrivals of immigrant male adults in Great Britain also showed a parallel decline (1996 =1, 1997 =0, 1998 =2, 1999 to 2003 =0). There were 7 recorded in 2004, 0 in 2005, 4 in 2006 (Clancy, 2008), 1 in 2007 and 1 reported in 2008 so far (other than those resulting from the London outbreaks) (Sean Clancy, immigrant lepidoptera records co-ordinator, pers. comm.).

2.3 Outbreak pattern

In mainland Europe, 5 phases are recognised in OPM outbreaks (table 1). The London infestations are currently at stages 1-3.

Table 1. Stages of OPM plagues (after Roskams, 2008).

Phase	**Behaviour and signs**
1	Exploration: only males (e.g. captures in pheromone or light traps), flight distance 50-100 km.
2	First infestation: dispersing females in new sites, nests often unnoticed.
3	Colonisation: starts often within 2 years of first infestation. End: small nests on almost every oak tree, but no mass defoliation, not in forests.
4	Outbreak stage: thousands of caterpillars on most trees, hardly any nests, mass defoliation, other trees attacked, nuisance at peak level.
	Collapse: large numbers of larvae hatch, but population soon collapses due to lack of food.

2.4 Defoliation

The spectacular numbers of OPM larvae that can occur in extensive oak woodland during severe outbreaks cause defoliation of entire trees, sometimes over a wide area. Large trees are normally able to recover from defoliation by lepidopterous larvae but, if this is repeated over several years the tree may suffer and the effects of the larvae can be a factor in weakening the tree defences against attack by other organism such as insects, fungi and environmental stresses such as drought. In these circumstances the death of the tree may result. Where this happens on a large scale in an environment drastically altered by human activity (especially where there is a high degree of habitat fragmentation) there may be detrimental ecological and economic impacts. The potential for this sequence of events to happen in Britain is arguably greater than elsewhere, due to the lack of natural control (see below, section 2.6).

2.5 Deleterious effects on human and animal health

Processionary moths have evolved a potent defence strategy against predators. The adults are harmless, but from the 3rd instar the larvae, in addition to being clothed in long, silvery hairs, also possess an estimated 60,000 minute hairs (setae) 0.1-0.2 mm in length, arising from red spots on the back. These contain toxic proteins (thaumetopoeins), which cause the release of histamines in humans and animals (i.e. an allergic reaction). In some individuals, reactions are severe and include dermatitis, conjunctivitis and pulmonary affection (known collectively as lepidopterism). There are a small number of recorded cases of anaphylactic shock in humans in cases of high exposure to OPM.

Extreme reactions seem to only occur in a small percentage of the human population, but sensitivity can increase quite rapidly with repeated exposure events. People who on first contact are either unaffected or only slightly so, may develop more severe symptoms after only a small number of encounters with the larval hairs. Populations of OPM larvae can build up to extremely high numbers and, in some recently colonised areas of Europe, thousands of people have been affected, as have domestic animals, in which the symptoms are very similar.

The propensity of the female to lay egg batches on isolated trees and those at the edges of woodlands i.e. in sunny situations, increases the risk of human exposure. Recorded instances of large numbers of people being affected include an incident at a recreation area in Germany

(Gottschling and Meyer, 2006) and along roadsides where maintenance work was being carried out, also in Germany (B. Ismay, pers. comm.). In 2006, the BBC reported that thousands of people had reported symptoms in a single town in Belgium, and horses had to be confined to stables. The hairs are easily dislodged and drift on local air currents, so that symptoms often occur in individuals who have had no direct contact with larvae and were several metres from infested trees.

2.6 Control by natural predators

Biocontrol of OPM in Britain is not currently a viable option. The toxicity of the larvae means these have relatively few specialised natural predators, and that OPM is likely to be generally avoided by birds and mammals. Moreover, since OPM is not an endemic species in Britain, any specialised natural enemies will be absent. However, parasitoid wasps were found to be present in samples collected in London. The species involved, *Pimpla rufipes* (Miller), is a generalist parasitoid of lepidopteran larvae (Mark Shaw, pers. comm.). The closely related *Pimpla processioneae* (Ratzeburg), not found in Great Britain, is considered to be a specialist parasitoid of OPM and other processionary larvae. The latter might therefore seem a possible candidate for introduction. However, introduction of bio-control agents is a matter that needs extreme care. Effects on other, native, species are difficult to predict and consequently the process of gaining approval for releases takes many years.

Other possible natural predatory agents, such as arboreal carabid beetles and other predatory insects, birds, mammals and diseases, are probably unlikely to be able to prevent outbreaks, but may together act to help reduce populations in stage 4. However, it is thought that birds generally avoid them. Evidence on this from London is limited and anecdotal, but a great tit was observed in a small tree in 2007, infested with active larvae. The bird seemed aware of the larvae, but also seemed cautious. After several minutes it appeared to attempt a predation, but then flew off rapidly, suggesting that it may have experienced an unpleasant reaction. A small number of nests have been found with holes, their cause unknown. Other small songbirds, Jays, woodpeckers, Ring-necked Parakeets or Grey Squirrel are all present in infestation areas and may attempt to predate OPM larvae or pupae. The toxicity of OPM on these species is unknown, but it seems reasonable to assume that they probably experience a toxic reaction that deters them from further attacks.

3. METHODS

3.1 Work schedule

The work was carried out in three phases according to the life cycle of the moth (as detailed in the guide produced by Forest Research *Survey and intervention in relation to different phases of the oak processionary moth life cycle* (link at http://www.forestresearch.gov.uk/fr/INFD-6URJCF).

- Tree inspections targeted at egg plaques, particularly at known sites, and targeted at old nests in areas geographically peripheral to the outbreak epicentres (February, March and April) and not or partially surveyed in 2007. Record all oaks for future reference.

- Tree inspections for larvae/nests (May-August). Make contact with owner, occupier or site manager and facilitate control by working with them and their appointed contractors.

- Monitoring of adult moth emergence (July-September) using pheromone trapping,

3.1.1 Tree inspections

Trees were inspected from the ground for nests, feeding damage and egg plaques. At one site a Mobile Elevated Work Platform (MEWP) was provided by the site managers, and a stepladder was used to search for eggs at RBGK. Good quality binoculars and/or a telescope were used to inspect higher branches and confirm identity. Trees were inspected from all possible angles to ensure the best coverage. Inspections were only carried out in favourable light and were not carried out in rain. For larger trees, it was sometimes found that due to the angle of the sun it was not possible to carry out an adequate inspection. In these cases, a further inspection was made at a different time of day (i.e. one was made in the morning and one in the afternoon).

Numbers of nests, their size, height and positions in the tree, and any larval activity were recorded. Size was recorded very roughly, since it is difficult to gauge the size of nests when high in the tree. The convention that nests were roughly 10, 20, etc. cm in width was used. In some cases, especially where there were large numbers of nests, many of which were only seen by contractors, sizes of nests were not obtained. Location of infested trees (10-figure OS grid reference) was recorded using

GPS. All surveys on private land were carried out with the permission of the landowner or occupier and it was not necessary to resort to use of statutory powers of entry.

3.1.2 Monitoring of adults

Pheromone trapping was carried out by FR and at RBGK. Forest Research deployed 84 traps on 14th July, in a grid, 2 per 2 km OS grid square and covering both infestation areas extending 4-6 km from the epicentres and the intervening area. Cardboard Delta traps were used, hanging on oak trees at 3 m height. Trap contents were collected on 13th August and 11th September.

Monitoring of adult moths and research was also carried out independently by RBGK. 20 Delta traps were deployed. Two traps were deployed on 22nd July and were inspected daily until 6th August. A further 18 traps were deployed on 1st August. From 7th August, 19 traps were checked weekly, and one intermittently. Light trapping was carried out on 4 nights between 21st August and 11th September. Nests were transferred to an insectary and kept at ambient temperature. Moth emergence was recorded.

3.2 Tree inspection team

Four highly experienced ecologists carried out surveys, two working as a team. They were (abbreviations as used in the appendices): the report author (MT), Ralph and Nittaya Parks (R&NP) and Steve Gregory (SG). Surveys, mainly of street trees, were also carried out by staff from Ealing and Richmond Borough Councils. Metronet and Tubelines carried out surveys of railway embankments under their control. Advice and training on search methods was provided by inspectors as required, who worked closely with organisations and individuals.

3.3 Use of the Plant Health (Forestry) Order 2005

On land with evidence of OPM infestation, landowners, their site managers, occupiers or other appropriate representatives, were served with a Notice under Article 31(4) of the Plant Health (Forestry) Order 2005 requiring them to have nests removed and destroyed using appropriate methods and within a prescribed timeframe. A copy of the **OPM Control Guidelines** produced by the FR was provided, including advice on PPE, it being the responsibility of the individual companies to carry out a Risk Assessment. Information was provided as soon as possible to councils and landowners in order to facilitate rapid nest removal and ensure that, as far as possible, removal took place before the flight period of the moth. Leaflets and other information were also

provided freely to landowners and managers where OPM was not found, for possible future reference and as part of dissemination of information.

3.4 Collaborations, requests for information, and publicity and information in affected areas

The request for records of OPM and brief summary of the situation published in the entomological journal *The Entomologists Record and Journal of Variation* in 2006 and 2007 were updated with a further note in 2008 (Townsend, 2008). Reported sightings received via local contacts and from FR were followed up by site visits. Unconfirmed reports received by FR following publicity and website information were followed up by site visits where appropriate. Borough Council staff, including Emergency Planning, Tree Services, Environmental Health, and RBGK disseminated information through local media.

Inspectors distributed FC information leaflets to site managers and interested members of the public. Local authorities were encouraged to initiate publicity, in order that infestations could be more readily brought to the attention of inspectors. Extensive information, including the 2007 report (Townsend, 2008) is posted on the Plant Health pages of the Forestry Commission website and FR staff fielded reports of OPM, passing the information to inspectors.

The HPA worked in close liaison with local authorities (for example the London boroughs of Richmond and Ealing) and other agencies focussing on public and professional awareness, to ensure that residents and visitors were supplied with consistent accurate information. The HPA also wrote to local GPs and dermatologists in affected areas. To reach a wider audience of health professionals, articles, presentations and web-based information on TOXBASE have been used. An HPA public information leaflet for local residents is planned for use in 2009.

3.5 Legislation

In 2007, FR prepared a Pest Risk Analysis (PRA) for OPM, which formed the supporting evidence for emergency action by the FC under the EU Plant Health Directive. In March 2008, the FC, with Ministerial agreement, put in place temporary emergency measures by amending the Plant Health (Forestry) Order 2005 to the effect that all imported oak trees originating in the EU must be accompanied by documentation confirming that the trees have been grown in a nursery where it and the immediate vicinity have been free of symptoms of OPM since the beginning of the last growing season. In addition, the UK has applied to the EU Standing Committee on Plant Health for Protected Zone (PZ) status to apply import controls against OPM. If agreed by the European

Commission and the Member States this will enable the temporary measures to be made permanent protecting the UK from further arrivals of the pest. A decision is awaited.

4. RESULTS

4.1 Overview

- A total of 506 nests were found, 51 in Ealing, 18 in Brent, 424 in Richmond (including 295 in RBGK) and 13 in Hounslow. In many cases tree climbers, while destroying nests, often found additional nests not visible from the ground. Some totals may include a small number of nests from 2007.
- An estimated 100 nests were located but not destroyed before adult emergence had begun (as evidenced by pheromone trapping at RBGK). Whether any adults had emerged from individual nests removed after the start of emergence is not known. No egg plaques were found before larval hatch. Several plaques of hatched eggs were seen at a site in Richmond after larvae had been discovered. These were at heights of roughly 5-8 m, on trees roughly 10-12m tall.
- One additional infestation site was found during early season egg and nest surveys, in Twickenham.

4.2 Feeding damage

In all cases feeding damage was localised to particular branches or twigs. At this level of infestation, the tree was often too large to survey effectively for damage, so in many cases none was observed. No large-scale damage was observed, i.e. involving whole trees or major parts of trees. At one site in Richmond feeding damage would have been significant had treatment not taken place. The trees at this site are relatively small (10-12 m in height) and the infestation in 2006 caused considerable damage, possibly resulting in loss or severe weakening of some trees.

4.3 Host range and infestation patterns

Q. robur and *Q. cerris* are the most frequent hosts in London, roughly reflecting the relative abundances of these tree species in the affected areas. A wide range of oak species was infested at RBGK, as in 2007, including European, Asiatic and North American species.

Nests, especially outliers, were often found on tall, particularly prominent trees, which were usually *Q. cerris* (pers. obs. and R. Parks, pers. comm.) This may indicate that females undertaking longer dispersal flights do so at or above canopy level and may not an indication of preference for this

species as a host. However, as in 2007, the height range of infested trees was large, and varied from 3.5m to 30m or more, with nests from crown to almost ground level, the majority at c.5-20m.

4.4 Survey and infestation areas

The survey area and infestation sites are shown on figure 1. In the Ealing/Brent infestations, the nests were concentrated in a relatively small area. An increase in the known range southwards was noted along the Piccadilly Line south of Hangar Lane station and, although control measures were carried out by Tubelines in this area in 2007, details of nest locations were not provided. As it was not possible for inspectors to access this section of track in 2007, it is possible that first infestations may have already occurred to the same extent in that year. In Richmond/Hounslow the spread was greater than in Ealing/Brent and nests were found further south (Petersham area) than in 2007. However, inspectors noted several old nests in Petersham, indicating that first infestations had already occurred and were undetected in the previous year.

4.5 Pheromone trapping, light trapping and captive breeding

4.5.1 Forest Research

Figure 1. shows the results from the FR pheromone trapping grid. 16 males were trapped, 10 outside the known infestation areas. With the exception of two, all were found closer to the Richmond/Hounslow infestation than to that in Ealing/Brent. One was found within the Ealing/Brent infestation area, and 7 within the Richmond/Hounslow infestation area.

4.5.2 RBGK.

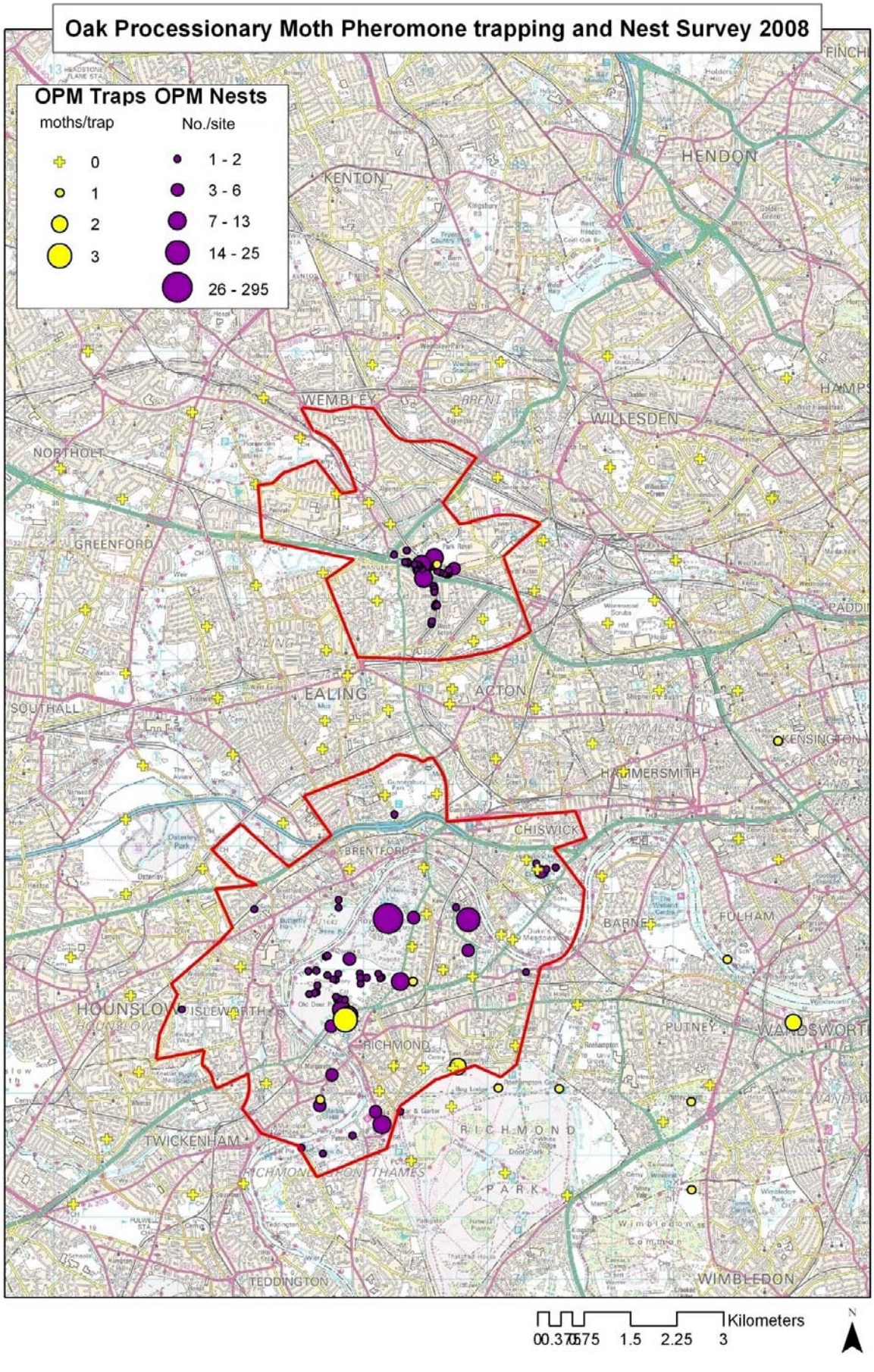
Table 2. Weekly pheromone trap results from RBGK.

Date	24-Jul	31-Jul	07-Aug	14-Aug	21-Aug	28-Aug	04-Sep	11-Sep	18-Sep	Total
Number	0	0	3	65	50	40	7	1	0	166

Table 3. Summary of light trapping results from RBGK (traps were run overnight. Dates are when trap switched on)**.**

Date	21-Aug	28-Aug	02-Sep	11-Sep	Total
Males	2	0	0	0	2
Females	0	7	9	1	17

Figure 1. Map showing results of nest surveys and Forest Research pheromone trapping. Survey area boundaries are shown in red.



4.6 Individual sites – infestation, control measures and feedback
(NB: in line with general policy of non-disclosure of the identity of infested sites, those not already in the public domain have been assigned site codes only)

4.6.1 Richmond – Kew Riverside Development

A row of 80 10-15m high *Q. robur* f. *fastigiata* planted as screening on a residential estate, heavily infested in 2006 and 2007. Small *Q. robur* bushes in shrubberies nearby also slightly affected in 2007. On 13th May, 14 trees had larval clusters and/or feeding damage. Statutory Notice was served. Treatment with *Bacillus thuringiensis* (Bt) took place on 21st May and again a week later. This appeared to be successful. Site visits were made by MT (21st, 27th May) and SC and no live larvae were found, with none also in a further search on 7th July (with SC) including use of a Mobile Elevated Work Platform (MEWP). From these visits an estimate was made of 25 nests before treatment. On 7th July, contractors cutting back vegetation from around trees, having been shown OPM nests, discovered 2 hidden low down among bamboo at the northern end of the site.

As in previous years, residents reported symptoms associated with OPM, and in one case these were severe. It is noteworthy that during the period when the larvae were reaching the toxic stage, quite strong easterly winds occurred regularly. This would increase the likelihood of hairs being blown towards the block of flats in which residents presented symptoms.

Comments:

- The 2008 infestation was at a significant level, and followed control measures in 2007 when several checks were made for survivors. High priority for egg search in 2009 using a MEWP if possible.
- The old nests hidden among bamboo are the probable source of the 2008 larvae, but survival of scattered individuals and dispersal from other sites cannot be ruled out. Therefore, although this is a relatively isolated site with relatively small trees, constant vigilance will be necessary to detect and manage further infestations.
- Site managers were co-operative (although communication could be improved), but additional pressure was required from SC before all measures were implemented, in particular cutting back of bamboo and bushes from around the bases of trees.

4.6.2 Richmond – Royal Botanic Gardens Kew

Monitoring began in late April and continued until late July. Early instar larvae seen mid-May while still in clusters and mobile in the canopy. These were not found easily, but a cluster was

photographed high on a sessile oak near the Palm House Pond. Nests were found by staff in a concerted daily effort using a core team of 9 people and staff surveying outside normal hours, most intensively from late May-early July. Nests were removed from late June into July.

Table 4. List of oak species, forms and varieties infested by OPM in RBGK in 2008.

***Quercus* species, hybrid or form**	**Natural geographical range**
acutissima Carruth.	S. and C. China
alba L.	SE Canada/ Eastern USA
brantii Lindl.	E and SE Anatolia, Syria, N Iraq and Iran
castaneifolia C.A.Mey.	Caucasus/Iran
cerris L.	S Europe/ Asia Minor
cerris L. 'Laciniata'	S Europe/ Asia Minor
ellipsoidalis E.J.Hill	NE USA
frainetto Ten.	S. Italy, Turkey, Balkans
hartwissiana Steven	Turkey, N & E Anatolia, Bulgaria, W Transcaucasia
macranthera Fisch.& C.A.Mey	Caucasus/ N Iran
mongolica Fisch. ex. Turcz.	Japan, Sakhalin, Kuriles
petraea (Matt.) Liebl.	W,C, SE Europe/ Asia Minor
prinus L.	E. USA
pubescens Willd.	W, C and S Europe
robur L.	Eur/Cauc/Asia Minor/N Africa
robur f. *purpurascens*	Eur/Cauc/Asia Minor/N Africa
robur 'Fastigiata'	Eur/Cauc/Asia Minor/N Africa
robur 'Fastigiata Grangei'	garden origin
variabilis Blume	China, Japan, Korea
x haynaldiana hybrid *frainetto* x *robur*	origin not known
x hispanica Lam. 'Fulhamensis' hybrid of *cerris* and *suber*	garden origin
x hispanica Lam. 'Lucombeana' hybrid of *cerris* and *suber*	garden origin
x turneri Wild. hybrid of *ilex* and *robur*	garden origin

295 nests were found during the summer and 6 more as part of routine winter tree health checks. 111 trees were infested. There were problems with access to the tops of some of the exceptionally large specimens, with many nests beyond the reach of MEWPs in use and in many cases it was not considered safe for climbers to attempt access. As a result an estimated 30 – 50 nests were found but not removed. However, some may have been old nests from previous years.

Comments:

- In 2007, 100 nests were found on 45 trees, of which 31 were infested in 2008. Reasons for the 3-fold increase in nests and trees infested are unclear. Considerable control effort was made in 2007, but in such a large area of suitable habitat it is always likely to be difficult.
- A continued (perhaps increased) concerted effort will be needed to control numbers. The site lies adjacent to the Royal Mid Surrey Golf Course, with Old Deer Park further to the south, and across the river from Syon Park, all with abundant oak in open parkland. These sites

together hold the potential to host a major outbreak and be a source of re-infestation in the wider area. Eradication is likely to prove extremely difficult, but control appears feasible.

4.6.3 Richmond – The Old Ryde House

Three semi-mature *Q. cerris* in a sheltered situation surrounded by tall buildings in grounds of commercial premises beside main thoroughfare with shops and other commercial premises. Old nest from 2007 found in April on tree in front of building to right. A larval cluster was seen on 13th May feeding high on same tree, then 1 nest on this tree and 1 larval cluster on the tree to the rear of the building on 21 May. Notice was issued and control measures implemented. On the next follow-up visit on 19 June 2 nests were found on the same trees.

Comments:

- The trees are typical *Q. cerris*, with a fairly open canopy making inspection relatively easy both from the ground and from within the tree. Aerial inspections evidently missed some larvae, which probably hatched later and were too small for detection at the time of inspection.

- Staff were cooperative and polite, but firm views were expressed concerning the emphasis on the site to pay for treatment when the source of the pest is elsewhere, out of their control and very likely to recur in spite of the measures taken. It was felt by them that this was unfair and that alternative funding should be sought.

4.6.4 Richmond –London Welsh Rugby Club, Kew Road

Semi-mature *Q. robur* beside parking bays next to cricket pitch and mature *Q. cerris* and *Q. robur* in car park behind main buildings, some overhanging Kew Road. 9 nests. Those next to the bays were probably surveyed well and few if any nests will have been missed, but the mature specimens around the main carpark could hold further nests. Statutory Notice was served and removal of nests was organised by the club manager, who was co-operative although clearly unhappy about the cost.

Comments:

- The response was slow, but removal was achieved before the flight period.

4.6.5 Richmond - Royal Mid Surrey Golf Course

Abundant oak widely distributed across golf course, mainly *Q. robur*, also *Q. cerris*. 29 nests. Trees from large mature and over-mature to small bushes. Many are isolated and easily accessed but a significant number are in small blocks of woodland, where access and effective survey is more

difficult. Site inspections were made by MT and SG. Groups of large larvae were seen away from nests under branches (see also section 4.6.16 at a site in Ealing).

- Good survey coverage was achieved, but given the abundance of the foodplant it is effectively impossible to assess the proportion removed.
- 4 nests were found in 2007 with similar survey effort, so the increase appears to be real.
- Continued or even increased effort is needed here and the increase in numbers from 2007 is a source of concern but not surprising. The majority of trees are easily accessible for survey.

- In one case, only a single larva was found on a relatively small tree, with its own small nest.

  Whether it was the sole survivor of predation, or a stray from a group is not known.

4.6.6 Richmond – North Sheen Cemetery (Hammersmith & Fulham BC).

Line of semi-mature *Q. robur* in public cemetery. Trees near northern end affected, as in previous years. 6 nests (4 in 2007, 1 in 2006). As in 2007, nest removal was organised by H&FBC. An inspection was scheduled, but action was prompted by an email from Mike Long (Contingency Planning Officer, Richmond BC) to Gavin Simmons (Principal Arboricultural Officer, H&FBC), who provided data post-removal. No further nests were found in the follow-up inspection (MT).

Comments:

- In spite of the small number found, likely to be infested in 2009.

4.6.7 Richmond – Old Deer Park

Mature and semi-mature *Q. robur* in parkland and public car park. 23 nests. Delays in nest removal occurred due to an operator developing OPM skin rash. Single larvae were seen on the ground.

Comments:

- Together with RBGK and Royal Mid Surrey Golf Course this forms a large suitable OPM breeding area. High priority for control.

4.6.8 Richmond – site A

Mature *Q. robur* in a rear private garden. The tree is a large, spreading specimen and dominates the garden and the neighbouring garden. A child at the house whose bedroom overlooks the tree, had presented with an unexplained rash. In June, the householder photographed a final instar OPM larva on the ground beneath the tree and sent the photograph to Richmond BC by email. This was passed to MT (via RBGK) who confirmed the identification. Richmond BC staff visited the site but could

find no sign of OPM. MT inspected on 16th July. One nest was present, but was very difficult to see, being partly hidden by other limbs and foliage. Silk strands and feeding damage were also visible nearby.

Comments:

- Richmond BC offered to remove nests, but for reasons presently unclear this was not carried out, as indicated by the householder in September 2008. The tree has many major overlapping branches, making ground inspection difficult, and the neighbouring garden was not accessible. The tree is highly likely to yield several nests and should be climbed.

- The tree is protected by a Tree Preservation Order. The householder has applied to Richmond BC to have it removed. Such action cannot be justified on phytosanitary grounds.

4.6.9 Petersham (south Richmond) – sites B, C, D and E

22 nests in this outlying area, large parts of which are open ground with oaks representing suitable habitat. A member of RBGK staff reported nests at Petersham Nurseries on 4th August. Inspections were made from 13th August, when full details were provided. Removal was carried out in mid August by contractors working for Richmond BC.

Comments:

- Since this area was visited late in the survey period, it is very likely that some adult emergence will have occurred before removal of nests (as indicated by pheromone trapping, section 4.5). It is also likely that other nests were present but not found, as is usually the case. Therefore re-infestation in 2009 is almost certain.
- The discoveries included old nests. Therefore the area was clearly infested in 2007 (when it was not surveyed) and this does not represent geographical spread in 2008.
- High priority for survey in 2009, along with adjacent parts of Richmond Park, where there is abundant oak. Also high priority to establish if oaks are sold by the nursery.

4.6.10 Hounslow – Syon Park

Thorough inspection of the public and private areas (including the Butterfly House) was carried out by RP&NL. 4 nests (3 in 2007). Nest removal was carried out by Syon Park staff.

Comments:

- Results indicate that the population remains small. However, there are many large trees so the likelihood of there being additional nests that were not located is high.

4.6.11 Hounslow - Chiswick House

A total of 6 nests in public park and gardens (RP&NL) with numerous mature and semi-mature oak. Inspected by MT in 2007 when no nests were found. Removal was organised by Hounslow BC.

Comments:

- An outlier. The number found suggests that a small population was present in 2007 but was undetected, rather than this representing geographical spread in 2008. Oak is relatively scarce in the area between this site and the epicentre.

4.6.12 Hounslow – Gunnersbury Park

Public park with numerous mature and semi-mature oaks. One nest near the southwest boundary (RP&NL). Inspected by MT in 2007 (0 nests). Removal was organised by Hounslow BC.

Comments:

- An outlier. May have been colonised in 2008 but presence in 2007, or elsewhere in the immediate area, cannot be ruled out.

4.6.13 Hounslow – Worton Hall Industrial Estate

Group of 3 large *Q. cerris*. 1 or 2 nests (one may or may not be an abandoned temporary nest). An outlier on a tree inspected in early spring 2008 when no nests were found. The site was not inspected in 2007. Removal was organised by Hounslow BC.

Comments:

- Oak is quite numerous between this site and the epicentre, especially in Mogden Water Treatment Works immediately east, with scattered trees in residential areas. The low number and size of the nest(s) suggests that Worton Hall Ind. Est. was colonised in 2008.

4.6.14 Hounslow – Marlborough School

Single very small nest on large semi-mature *Q. robur*, on horizontal limb at c4m height. Tree near play area in northeast corner of school grounds. Found by MT on 8th August.

- Information was apparently not successfully passed to Hounslow BC. Currently being investigated (December 2008) by MT and Hounslow BC with a view to carry out further inspection and removal.

4.6.15 Ealing – Network Rail-controlled rail embankment

A 1.5 km stretch of railway embankment, much of it wooded. Dominated by *Q. robur* with some *Q. Q. cerris*. The embankment was surveyed from roughly 100m west of the disused branch line that passes under Coronation Road, to roughly 200 m west of Hangar Lane. Also, the disused branch line including wide sections on either side of Coronation Road. The greatest concentration of oaks is in the wide section east of Hangar Lane. This section is nearly 0.5km in length and up to 50m wide, including a fenced, level strip of land behind gardens with large tree specimens, some of which overhang gardens. Further wooded stretches are either side of the Piccadily Line intersection, and the North Acton exit from the A40, along the disused section, and at Hangar Lane.
An initial inspection was made by MT on 10th June, when 4 nests were found. This was far from being a complete survey and since a large number (183) were found on this section in 2007, a thorough survey of the whole area was requested. 12 nests were found on day one (SG). The inspector was unable to attend on day 2 and no further details have been supplied by the contractors despite reminders. It seems unlikely that no further nests were present.

4.6.16 Ealing – Metronet-controlled railway embankment (LU Central Line)

1.5km stretch of railway embankment east of Hangar Lane, much of it wooded and dominated by semi-mature *Q. robur*. Inspections were made by RP&NL (on contract to Metronet) on 26 April, 7th and 14th June and 2nd July and detailed reports were provided to the client. 17 nests. On 7th June, groups of larvae 40 mm in length were seen in clusters under branches. Nests and clusters of larvae were treated with Deltamethrin on 14th June. One group of larvae found on the 7th could not be accounted for, although it is possible they had moved to an adjacent tree. Single larvae were noted in two trees, on the undersides of branches. Only two nests were seen. In other cases, either groups of shed skins and/or clusters of larvae were present.

Tree work was undertaken in the infestation area in winter 2007-8, including felling of 18 trees infested in 2007. The work was aimed mainly at improving access (including for OPM inspections) and clearing potentially infested trees close to public areas. 17 nests were noted in April, from 2007. These were the remains of nests treated with PVA glue in 2007 in order to prevent adult emergence.

Comments:

- 139 nests were recorded on this site in 2007, so a definite decline is indicated, suggesting that control measures have been effective.
- Large larvae observed away from any nest were most likely on a feeding expedition from an unseen nest, or had recently abandoned a temporary nest after moulting and were about to form the final nest. This behaviour was also seen at a site in Richmond (section 4.6.5)

- Single larvae observed away from nests may indicate that a small proportion become separated from the main group and may even pupate singly, making them virtually impossible to find. This is one possible explanation for persistence at some sites after nest removal or other control measures. Single larvae were also seen at two sites in Richmond (sections 4.6.5 and 4.6.7)

4.6.17 Ealing – Tubelines-controlled railway embankment (London Underground Piccadilly Line)

A 1.5 km stretch of railway embankment, much of it wooded with abundant mature and semi-mature *Q. robur*. Southerly limit is just south of North Ealing station. Northerly limit is a wide section, roughly triangular in shape just north of Park Royal station. North of this, there is no oak for almost 1km until the A406 North Circular trunk road, north of which oak is numerous.

MT inspected after attending LU H&S courses run by Tubelines. Access was not permitted in 2007 and statutory powers of entry were not used as this would have necessitated line closure. Site visit was made on 14th July. 10 nests were found, the northerly limit of which was Park Royal station (trees on embankment behind) and the southerly limit was North Ealing station .

Comments:

- The triangular piece of land north of the A40 had many nests in 2007, but none were seen here in 2008. Visibility is reasonable, and it seems likely that OPM was either drastically reduced or eliminated in this section. However, no tree climbing took place here.

4.6.18 Land surrounding compound at Hangar Lane.

Site discovered in 2007 during inspections along Network Rail embankment adjacent to south. Single nest on small scrubby *Q. robur*. First visit on 10th June. Information on ownership obtained from contractors working on-site. Site due to be developed and trees destroyed.

Comment:

- Should be checked in 2009 in case trees still stand.

4.6.19 Ealing–islands between slip roads from Hangar Lane junction at A40 North Acton junction

Lines of semi-mature *Q. robur* f. *fastigiata* planted as part of landscaping. 1 cluster of larvae on 15th May (MT). The trees and other landscaping are maintained by Enterprise Plants Ltd, who sprayed all trees with Decis (deltamethrin) on 31st May.

Comments:

- These trees were the likely source of infestation having been imported since 2003. They were also sprayed in 2006 when larvae were first found, and were clear in 2007. The evidence therefore suggests that they were re-infested in 2007 from a nearby site.

4.6.20 Ealing – Mercury House

Mature *Q. robur* in secure carpark behind blocks of privately managed block of flats, south of the A40 and within a few 100 m of the outbreak epicentre. 8 nests and 1 nest from 2007. Inspection by MT on Aug 7th. Nest removal was organised by management company responsible for flats. Discovered in 2007 after leafleting by Ealing BC to local residents. Several nests were found, including one very large “the size of a human head”, and removal was organised by Ealing BC Tree Service.

Comments:

- The presence of an old nest is significant. It was not difficult to see and it is surprising that it was not seen and removed in 2007. However, removal in 2007 was carried out late in the inspection period, and the number of nests in 2008 suggests that some emergence had already occurred.
- Removal in 2008 was also carried out late in the inspection period and after emergence of moths was recorded at RBGK (section 4.5) so infestation in 2009 is likely.

4.6.21 Ealing - Twyford Abbey Road close to railway bridge (Piccadilly Line)

Mature *Q. robur* on street. 2 nests (4 in 2007).

Comments:

- Re-infestation or result of nests not found in 2007 due to size of trees.

4.6.22 Brent - landscaped garden to rear of Diageo building, Lakeside Drive

A single mature *Q. cerris* and numerous 3-5 m *Q. robur*. 9 nests (8 in 2007). Inspection on 11th May and 25th June (MT). Site workers also found nests and reported back. Some nests were destroyed in situ by burning, others were removed.

Comments:

- Although the landscaped garden around the pond was infested again, a *Q. robur* and *Q. cerris* close to Lakeside Drive were subject to aerial inspections and declared clear. Probably subject to re-infestation from neighbouring sites.

4.6.23 Brent – site of old Guiness building (now demolished), Coronation Road

Two large semi-mature *Q. hispanica* on the eastern edge of a large, levelled building site. Large semi-mature *Q. robur* on the western side of a building site. 9 nests.

Comments:

- One of the *Q. robur* is due to be moved as part of the building work. The intended new location has not yet been obtained from the developers, but it is understood to be elsewhere on the site.
- A large number of young *Q. robur* f. *fastigiata* were planted in winter 2007-8 on this site and along a new spur road (Rainsford Road) alongside it. All were inspected and found to be free of OPM.

5. DISCUSSION

5.1 Overall numbers and distribution pattern

The overall number of nests is significantly reduced from 2007 (506 against 708). In terms of the two infestation areas, the pattern is reversed, with more in Richmond/Hounslow and fewer in Ealing/Brent in 2008. The difference is largely explained by the large number of nests in RBGK (with a much smaller, but increased, number on the adjacent Royal Mid Surrey Golf Course, Old Deer Park and London Welsh Rugby Club area adding to the effect). As described in section 4.6.2, the infestation in RBGK was extensive, and in many cases removal of nests proved impractical in both years. It is therefore most likely that control was less effective here and this is the main cause of the discrepancy between the two outbreak areas.

Overall, survey effort was greater in 2008, although the positive effects of an increased number of Plant Health Inspectors were lessened by illness and prior, unavoidable commitments. Therefore, the decline from 2007 in Ealing and overall would appear to be real, but the large, apparently real, increase in Richmond is a concern, especially following a cool, wet summer in 2007, when numbers of moths generally were low. Under these conditions, OPM, a species more used to a southern, more continental climate, might be expected to struggle, even taking into account the control difficulties particular to that infestation area. However, since the adults are short-lived, only brief periods of favourable weather are needed for successful breeding. Therefore, cool summers may merely delay emergence, although there is no firm evidence to associate population fluctuations with weather conditions at this early stage in the London infestation. Research from mainland Europe suggests that a more important climatic factor in reducing OPM is the occurrence of late frosts in April and May, which kill the newly hatched larvae. It seems highly likely that in warmer seasons, and in the absence of a lethal late frost, OPM could increase rapidly. The degree to which climate will impose restrictions on the ability of OPM to spread in Great Britain is difficult to assess, but the climate in areas recently colonised in mainland Europe is very similar to that across a

wide area of southern Britain. This would suggest that the only factor preventing OPM from colonising GB naturally has been its physical separation as an island.

Spread into Brent is slight, with nests only found in a small portion of the borough protruding into Ealing close to the infestation epicentre. Spread into Hounslow also remains slight, but new outliers indicate that colonisation on a greater scale could be imminent. It is surprising that more outliers were not found in Ealing/Brent. Clearly, at lower densities the nests are more difficult to detect, but this applies everywhere. Therefore, the lesser degree of spread in Ealing/Brent appears real, although it is very unlikely that there are no outliers. The reasons for this more localised distribution are unclear, but compared to Richmond, less continuity of foodplant and greater levels of light pollution (which may affect the nocturnal adults) seem likely factors. The climate might be cooler in Ealing as it is on slightly higher ground. The effect may be slight, but perhaps more important in sub-optimal conditions. It may be significant that nests were again highly concentrated along railway embankments, which are lower and more sheltered than surrounding land. The prevailing wind at the time of female flight may also have an effect on dispersal and egg-laying patterns, but this has not been investigated in the London area.

Although the survey area was larger in Richmond/Hounslow, a high percentage of nests was concentrated in the RBGK, Royal Mid Surrey Golf Course and Old Deer Park area. Therefore overall, the areas affected have not changed greatly. The high concentration of foodplants here, while providing for a larger population, also makes thorough inspection and control much more difficult. As mentioned previously, this effect may have carried through from 2007. The concentration in Petersham, south Richmond, appears to have originated from 2007, since old nests were seen here, rather than representing spread in 2008.

5.2 Assessment of the 2008 campaign

A large number of nests and larvae were destroyed. Nests typically contain at least 50 larvae and often 100 or more. Therefore, the total is roughly 25,000 to 50,000. However, an even greater number were destroyed in 2007 and yet sufficient survived to produce a large number in 2008. Possible factors could include:

A - Significant numbers of nests are being missed in survey and control work.
B - Pupation is occurring away from the nests at a significant level.
C - Eggs remain dormant over two winters and/or pupae are overwintering.

D - Nests were missed in private residential gardens, which were not surveyed extensively, and from which re-colonisation might have occurred.

A - while many nests are obvious, others are well hidden. At St. James (Richmond), old nests, most likely constructed in 2007, were revealed after dense bamboo was cut back from around trees. Several inspections were made at this site in 2007, by different people after larvae were sprayed, but none were found. Others were missed by contractors in 2007, e.g. at Mercury House (Ealing). On the Central Line (Metronet, Ealing) a group of larvae could not be re-located a week after their initial discovery, and may have constructed a well-hidden nest. It is inevitable, given the size of the area and its urban nature, that not all nests will be found, nor all trees located.

There is some indirect evidence for **B**. Solitary final instar larvae were seen at several sites, either on the ground or on an oak trunk. These could have been parasitised and would therefore have died anyway, as lepidopteran larvae attacked by parasitoids are known to show atypical behaviour. However, any that pupated singly would be impossible to detect. Delayed development, including diapause over two winters, is known to occur in other Lepidoptera, especially in sub-optimal conditions. Therefore **C** is also a possibility. **D** may be a factor in some areas, but is impossible to assess at present.

In a number of cases in 2008, nest removal was undertaken after moth emergence had begun, so an unknown number of moths would have emerged from the nests affected, as these were not inspected to ascertain their emergence status. It was not always possible for inspectors to attend removal, and accurate information from contractors and sites was not always forthcoming (despite requests and reminders) especially with regard to dates, making assessment of late removal of nests even more difficult. Illness and prior or unavoidable commitments of contract inspectors delayed nest discovery in some cases. Nest removal contractors were slow to carry out control work at some sites, again no doubt mainly due to prior commitments to existing customers. In addition, some were new to the OPM problem and needed time to make risk assessments and obtain the necessary PPE. However, in one case a contractor developed a severe rash so could not continue, despite using recommended PPE. Reluctance by owners and occupiers to carry out the work due to concerns about escalating costs was also a factor in at least one case, and seems likely to be an ongoing problem.

Although the pre-larval season egg search was unsuccessful, the data were very helpful later, in terms of tree locations recorded using GPS.

In general the methodology is effective. To thoroughly survey all potential host trees in and around the infestation areas would require unrealistically high resources. Live nests are only apparent for approximately 4-5 weeks, a short window of opportunity, so that survey effort needs to be intensive during this period. Larvae can be dealt with from May, but at that stage are difficult to locate. This is exemplified by the experience of the author at The Old Ryde House, Twickenham (Richmond), where 3 large semi-mature *Q. cerris* were infested. It seemed very likely that larvae would be found here, after the discovery in April of an old nest. A group of larvae were located on 13th May after over an hour of scanning the trees in good light with good quality binoculars. They were only seen for a few minutes high in the tree whilst feeding, after which they went back out of sight. Larvae were seen here forming nests on 21st May and were dealt with, but two further nests were located on the same trees by MT on 19th June, highlighting the importance of follow-up visits when infestations are found and treated early. Larvae located in RBGK early in the period were also highly mobile and difficult or impossible to re-locate.

A major problem in co-ordinating the work and monitoring progress is the large number of individuals and organisations involved. Owners and occupiers were generally cooperative, but it was evident in 2008 that, in spite of the general good will, delays occurred that undoubtedly resulted in emergence of a considerable number of moths from known nests.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

6.1.1 Assessment of the current situation.

The population in Ealing/Brent has declined but remains significant. The Richmond/Hounslow population has increased. This discrepancy is most likely due to less effective control in that area, caused by the much higher concentration and extent of habitat and suitable host trees in Richmond. This makes effective survey and control much more difficult. Climatic factors may be impacting on population levels and it is likely that overall, conditions for a southern, thermophilic species such as OPM have been sub-optimal, which could have adversely affected OPM populations. However, this was not apparent from the survey and management effort especially taking into account the resources deployed in 2007. It had been hoped that the control effort and weather combined would have reduced numbers more than was the case but, nevertheless, there is an encouraging overall downward trend, especially in the Ealing/Brent area.

Large numbers of nests were destroyed in 2008. However, this was also the case in 2007 and therefore the control measures will undoubtedly have impacted significantly on populations in both years. It is therefore clear that the moth is able to breed and increase successfully and that, without control, numbers would have been higher in 2008. Without continued control, and given a succession of favourable seasons, the core populations in London could move from the current colonisation phase into a further growth phase leading to major infestations (phase 4 - outbreak, see table 1). This would lead to spread across a much wider area, the climatic limit of which is unknown but seems likely to cover much of southern England.

6.2 Recommendations

6.2.1 Survey and eradication should be increased in 2009 with the training and appointment of additional Plant Health Inspectors. A minimum of 5 inspectors is recommended for adequate survey, one of whom should be responsible for overall co-ordination.

6.2.2 Recording of infestations should be standardised by the use of recording forms. A simple recording form for site managers and contractors for control measures should be a statutory requirement, incorporated into the Notices served under the Plant Health (Forestry) Order 2005, to better facilitate collation of the relevant information after the event.

6.2.3 Given the short window of opportunity, the consequent need for a rapid response to infestations and problems achieving eradication before moth emergence (described in section 5.3), the current arrangement of using contractors for control should be reviewed. The most effective process would be the use of a dedicated team of control operatives, available full-time during the larval and pupal periods, with emphasis on nest removal before adult emergence.

6.2.4 In winter-spring 2009, data collected in 2008 on oak tree locations should be collated into a single database. Where control measures are suspected to have been ineffective, follow-up surveys should be carried out before April, in order to assess any possible effects of late removal and to target these areas in 2009. Information should be gathered on tree movements and sales within the infested areas (affecting at least 2 sites). The possibility that pheromone trap records from outside the known infestation area originate from previously unknown infestations should be investigated by tree inspections in those areas.

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Appendix I. Details of infestations found in 2008 (* MT – Martin Townsend, SC – Shaun Case (Richmond BC), RP&NL – Ralph Parks and Nittaya Lawrence).

Borough	**Site/Area**	**Nests**	**Date seen; observer***	**Description and other notes**
Richmond	The Old Ryde House	4	13 May; MT. 21 May; MT. 19 Jun: MT	3 semi-mature *Q. cerris* in grounds of commercial premises. A) Old nest from 2007 found on tree in front of building to right. Larval cluster seen 13 May feeding high on same tree. 1 nest on 21 May. 1 nest on 19 June. B) 1 larval cluster on 21 May, 1 nest on 19 June.
Richmond	Kew Riverside Development	25	13 May; MT. 21, 27 May; MT. 19 Jun: MT. 7 July: MT, SC	Clusters of larvae 15-20 mm long, some forming nests, on row of 80 *robur* f. *fastigiata.* Nests/clusters at <1 to roughly 3m from ground. 1 nest on small (1-2m) *robur* nearby on shrubberies between flats and river, with larvae 8-10 mm. 14 trees showing feeding damage. Most on west facing side of plant. Estimated total 25 nests/clusters after follow-up visit on 7th July using a MEWP. 2 old nests from 2007 found on this date among bamboo.
Richmond	Kew Gardens	295	RBGK staff, MT. Late April to 17th July.	See section 4.6.2 for details including species affected.
Richmond	Royal Mid Surrey Golf Course	29	13 Jun; MT. 19, 26 Jun; SG	Abundant oak widely distributed across golf course, mainly *robur* with small number of *Q. cerris*. Trees infested ranged from large mature and over-mature specimens to small scrubby bushes.
Richmond	Old Deer Park	8	12 Jun: MT	Mature *robur* in open park near tennis courts.
Richmond	Old Deer Park	6	12 Jun; MT, Richmond BC staff	Mature *robur* in parkland S of A316.
Richmond	Old Deer Park carpark off A316.	9	12 Jun; MT, Richmond BC staff	A) Nest 15cm at 1.5m on 3.5m high *robur* in carpark between parking bays near W end. B) Large mature *robur* near central toilet block with 8+ nests high on tree. Single larvae were seen on the ground.
Richmond	London Welsh Rugby Club	9	Jun-Jul MT,SC	Row of semi-mature *robur* beside parking bays along access road beside cricket pitch; mature *Q. cerris* between club carpark and road.
Richmond	Mortlake High Street	1	June/July; (Richmond BC staff)	1 nest reported independently Mature *robur* on roadside close to *Charlie Butler* pub.

Richmond	North Sheen Cemetery (Hammersmith & Fulham BC)	6	26 JunMT	Long line of semi-mature robur in public cemetery. Trees near northern end affected. Not seen - data obtained after removal. 6 nests, up to 20cm, 1.7-3 m high.
Richmond	Kew Road, opposite Victoria Gate, RBGK	4	26 Jun: MT. Early July; SC	Large mature *Q. cerris* on path beside main road.
Richmond		5	15 Aug; MT	Large mature *Q. cerris* in open parkland. 2 nests found on initial visit, 3 more during nest removal
Richmond	Site A	1	16 Jul; MT	1 nest in large mature *robur* in rear garden. Nest centrally placed on a main limb at 8-10m. Not fully visible due to foliage and other limbs. Feeding damage and silk trails visible. Photo of final instar larva on ground taken by householder.
Richmond	Site B	13	13 Aug; RP&NL	Semi-mature *robur*. Details listed separately.
Richmond	Site D	2	18 Aug; RP&NL	In mature *robur* in formal garden.
Richmond	Site C	5	13 Aug; RP&NL	trees in carpark and on roadside. 3 in *Q. cerris* to south of road.
Richmond	Site E	1	22 Aug; SC	Semi-mature *Q. cerris* on roadside near hotel
Richmond	Trees near Sea Scouts hut, in grounds of The German School	1	8 Aug; RP&NL	nest on main limb at 15m height.
Richmond	Close to river west of site C.	1	8 Aug; RP&NL	Shed skins 8 m high on semi-mature *robur* near towpath. Nest not found.
Hounslow	Syon Park	4	24 Jun; RP&NL	Mature *canariensis* in gardens of stately home A) nests at 12 and 14 m. B) nests at 8 and 13 m.
Hounslow	Worton Hall Industrial Estate	1	8 Jul; RP&NL	Nest at 15m height in mature *Q. cerris* in industrial estate.
Hounslow	Marlborough School	1	8 Aug; MT	One small nest at 5m under bough of large spreading tree near play area.
Hounslow	Chiswick House grounds	6	2 Aug; RP&NL	A) mature *Q. cerris* and *robur* in gardens of house
Hounslow	Gunnersbury Park	1	26 Jul; RP&NL	At 16m height in mature *Q. cerris*.
Ealing	slip road island A40 to North Acton	1	15 May; MT	Line of 8-10m high f. *fastigiata*. 1 larval cluster 1.5m high. Larvae c20mm long. Tree 2.5m high.

Ealing	Metronet -Central Line embankment Hangar Lane to North Acton	17	22 Apr; 7, 14 June, 2 Jul; RP&NL.	Semi-mature and mature robur along railway embankment. 13 trees with larval clusters, nests or coalescing areas.
Ealing	Network Rail embankment Hangar Lane to North Acton	12	10-Jun; MT. 17 Jul; SG.	Railway embankment (c.1km long, 30-50+ m wide) on north side of multi-track rail line. Extensively wooded with abundant mature oak (*robur*+*Q. cerris*).
Ealing	Hangar Lane Compound	1	10 Jun; MT	Scrub oak in previously overgrown grassy clearing (now levelled and tree probably destroyed). Nest 20cm. 0.5m high. Live larvae visible inside nest.
Ealing	Tubelines rail embankment	10	May-June; (Tubelines). 14 July; MT	Wooded railway embankments (both sides of track) from just north of Park Royal station south to North Ealing station (nest details listed separately). Mainly *robur*.
Ealing	Mercury House, Heathcroft (S of A40)	8	7 Aug; MT	One of 2 over-mature *robur* in secure carpark beside small recreation area, the tree furthest from building. Also one old nest.
Ealing	Twyford Abbey Road	2	8 Jul; SG	A) Mature *robur* beside main road opposite house No. 36. Nest 10cm at 8 m high under side branch. B) Mature *robur* beside main road opposite house no. 37. Nest 5 cm at 12 m high on side branch in crown.
Brent	Brixton Est. land N Coronation Rd	9	26 Jun; MT. 8 Jul; SG	A) Large semi-mature *robur* near edge of building site - 5 nests. B) Large semi-mature *Q.* x *hispanica* on building site, 4 nests.
Brent	Landscaped area rear of Diageo, Lakeside Drive	9	15 May; MT	Mature pruned *Q. cerris* and 3-5 m high *robur* in landscaped garden area.

Appendix II. Details of individual sites and control measures 2008 ((* MT – Martin Townsend, SC – Shaun Case (Richmond BC), RP&NL – Ralph Parks and Nittaya Lawrence)

Borough	Site/Area	Nests	Date first seen; observer*	Notice served (date)	Date(s) of control	Method
Richmond	The Old Ryde House	4	13, 21 May; 19 Jun; MT	15-May	29 May larvae; 28 Jun (nests)	Manual removal of nests and larvae
Richmond	Kew Riverside Development	25	13 May; MT	15-May	21, 27 May	Larvae sprayed with Bt
Richmond	Kew Gardens	295	RBGK staff, MT; late Apr	15-May	Jun-July	Manual removal of nests
Richmond	Royal Mid Surrey Golf Course	29	13 Jun; MT	25-Jun	late July/early August	Manual removal of nests
Richmond	Old Deer Park	8	12 Jun; MT, Richmond BC staff	N/A	late July/early August	Manual removal of nests
Richmond	London Welsh Rugby Club	9	Jun-Jul; MT, SC	25-Jun	late July/early August	Manual removal of nests
Richmond	Mortlake High Street	1	June/July; (Richmond BC staff)	-	0	Manual removal of nests
Richmond	North Sheen cemetery (Hammersmith & Fulham BC)	6	26-Jun; MT	N/A	16-Jun	Manual removal of nests
Richmond	Kew Road, opposite Victoria Gate to RBGK	4	26 Jun; MT	N/A	late July/early August	Manual removal of nests
Richmond	Marble Hill Park	5	15 Aug; MT	N/A	mid-August	Manual removal of nests
Richmond	Site A	1	16 Jul; MT	-	-	-
Richmond	Site B	13	13 Aug; RP&NL	-	20-Aug	Manual removal of nests
Richmond	Site D	2	18 Aug; RP&NL	-	20-Aug	Manual removal of nests
Richmond	Site C	5	13 Aug; RP&NL	N/A	20-Aug	Manual removal of nests
Richmond	Site E	1	22 Aug; SC	N/A	20-Aug	Manual removal of nests
Richmond	Near Sea Scouts hut, in grounds of German School, Petersham	1	8 Aug; RP&NL	-	20-Aug	Manual removal of nests
Richmond	Close to river west of site C	1	8 Aug; RP&NL	-	20-Aug	Manual removal of nests
Hounslow	Syon Park	4	24 Jun; RP&NL	-	-	Nests burnt off in situ
Hounslow	Worton Hall Industrial Estate	1	8 Jul; RP&NL	N/A	2 Oct 2008	Manual removal of nests
Hounslow	Marlborough School	1	8 Aug; MT	N/A	-	N/A

Appendix II (continued). Details of individual sites and control measures 2008 (* MT – Martin Townsend, SC – Shaun Case (Richmond BC), RP&NL – Ralph Parks and Nittaya Lawrence).

Borough	**Site/Area**	**Nests**	**Date first seen; observer***	**Notice served (date)**	**Date(s) of control**	**Method**
Hounslow	Chiswick House grounds	6	2 Aug; RP&NL	N/A	August	Manual removal of nests
Hounslow	Gunnersbury Park	1	26 Jul; RP&NL	N/A	August	Manual removal of nests
Ealing	slip road island A40 to North Acton	1	15 May; MT	20-May	31-May	sprayed with Deltamethrin (Decis)
Ealing	Metronet -Central Line embankment Hangar Lane to North Acton	17	7 June; RP&NL	-	14-Jun	sprayed with Deltamethrin
Ealing	Network Rail embankment Hangar Lane to North Acton	12	10-Jun; MT	25-Jun	17-18 July	Manual removal of nests
Ealing	Hangar Lane Compound	1	10 Jun; MT	25-Jun	June/early July	crushed into ground
Ealing	Tubelines rail embankment	10	14 July; MT	-	late July	Manual removal of nests
Ealing	Mercury House, Heathcroft (S of A40, east of Hangar Lane	8	7 Aug; MT	07-Aug	August	Manual removal of nests
Ealing	Twyford Abbey Road	2	8 Jul; SG	N/A	July	Manual removal of nests
Brent	Brixton Est. land N Coronation Rd	9	26 Jun; MT	07-Aug	06-Aug	Manual removal of nests
Brent	Landscaped garden to rear of Diageo building, Lakeside Drive	9	15 May; MT	20-May	Jun-July	burnt in situ or on-site

Appendix III. Summary of areas/sites surveyed in early season egg/old nest surveys and results.

Site/area	Date	Hours	Comments
RBGK	21-Feb	2.5	Surveyed smaller trees and lower branches of larger trees. A stepladder was used, with the assistance of RBGK staff.
Alperton	25-Mar	4	Street and park trees. Mainly large specimens found.
Alperton	27-Mar	4	Street and park trees. Mainly large specimens found.
Alperton	29-Mar	5	Street and park trees. Mainly large specimens found.
Royal Mid-Surrey Golf Course, Richmond	31-Mar	7.5	Many small specimens, 3-6m high inspected in addition to larger trees.
Ealing (Perivale)	01-Apr	4	Street and park trees. Mainly large specimens found.
Brentford, Isleworth	04-Apr	10	Street and park trees.
Richmond, Twickenham	08-Apr	9.5	Street and park trees. **10cm nest on large semi-mature Turkey Oak on Richmond Road, Twickenham. TQ 17555 74363**
Richmond, Twickenham	10-Apr	8.5	Street and park trees.
Hounslow (Brentford, etc.)	12-Apr	8.5	Street and park trees.