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Original article

Trends in insect catch at historic properties

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ABSTRACT

Warmer climate has the potential to increase the number of insect pests in historic properties. This possibility has been explored using the catch from some thirty thousand insect traps laid out in English Heritage properties over more than a decade. The trapping programme resulted from an increasing focus on integrated pest management (IPM). Trapping has been more frequent in London and the Southeast. Quarterly inspection and replacement has led to a detailed record of catch. Although these data were collected for management purposes, they offer the potential to assess the impact of environmental change. Variation in the number of traps placed out requires data to be expressed as *catch rate* (insects caught per trap). The record suggests an increase in the average catch of booklice (*Liposcelis bostrychophila*) summed across all the properties examined over the period 2000–2012. There was a striking increase in the prevalence of the webbing clothes moth (*Tinea pellionella*) even when accounting for the increasing use of attractant pheromones in traps. In addition, infestations (i.e. > 10 insects per trap) also seemed to increase. However, these increases over time are not likely to be attributable to increasing temperatures. Nevertheless, the catch rate for woolly bear larvae (*Anthrenus* spp.) at the London properties showed a weak correlation with temperature in the warmer seasons. If temperature were to increase across the 21st century, a dramatic increase in catch rate would be expected. However, it is hardly likely as the abundance of insects is not driven by temperature alone. Other factors such as: food, habitat, access points, housekeeping and indoor climate can all have an impact on insect numbers and on infestations within a property.

1. Research aims

The aim of the research was to evaluate trends in insect catch in historic properties, and the impact of climate and environmental change on insect numbers. The study made use of insect trapping data collected over a period of more than ten years in properties managed by English Heritage. It follows earlier work using observations derived from the same data set, and which focused on broad observations of insect catch and its geographical distribution. In the current study, data was assessed against temperature records to determine correlation with temperature, and against expected future temperatures to predict changes in insect numbers. The results can be used to help guide pest management policies in historic properties.

2. Introduction

Climate change may alter the distribution of insects. This has the potential for example to alter the prevalence of mosquitoes, and thus affect the distribution of malaria [1]. It can also be relevant to the management of historic properties [2,3] as there is much concern about increasing insect populations in historic houses [4,5]; insects attack the structure of wooden buildings, furniture, and textiles. As early as classical times, there was discussion of the damage to clothes by moths and the potential solutions to this nuisance.

Although there have been a number of recent studies of the role climate change, in particular how increasing temperatures might affect the number of insects in the heritage environment, these have been theoretical studies [3] or based on a small number of observations [2]. Support for the idea of an increasing threat comes from observations of the move of more temperature-sensitive species northward. An example of this has been the discovery of barkfly (*Atlantopsocus adustus*) characteristic of Madeira and the Canary Islands, in Cornwall [6]. In the heritage context, brown carpet or

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vodka beetle, (*Attagenus smirnovi*) has shown a widening distribution. Found in Russia in 1961, it has been seen as a threat in many European countries in more recent times [2].

Insects are sensitive to the effects of climate throughout their life cycles; their activity can be sluggish below 15 °C [7,8]. The number of eggs laid by clothes moths depends on temperature with few eggs laid at 15 °C, 80 at 25 °C, but perhaps 100 at 30 °C [8,9]. Multiple life cycles each year are increasingly common [4,8]. Low humidity can also harm insects as they lose water despite their waxy external cuticle. Dehydration can be particularly significant for eggs and larvae; the furniture beetle (*Anobium punctatum*) requiring the relative humidity to be about 65% or above [8]. Nevertheless, some insects have developed mechanisms for preventing desiccation, and the webbing clothes moth can survive dry conditions by metabolizing food to provide water [8–10]. The long-term changes in temperature are much discussed, but changes in ambient humidity over time is less frequently addressed [11], and historic interiors may show only slight variation in the future [12,13]. Studies of the combined impact of temperature and relative humidity are not common for museum pests, but are available for the biscuit beetle (*Stegobium paniceum*) from the laboratory studies of Lefkovitch [14].

Concern over increasing insect populations in historic houses has occurred at a time when integrated pest management (IPM) has been widely adopted at historic properties in the UK. It is difficult to unravel the effects of changing management practice from those of the environment. Integrated pest management has been welcomed as an important step forward [15,16], but it is not always easy to determine the criteria for judging success. This is especially true if insect populations are on the increase across a period when it is being more widely implemented.

The work presented here explores the insect trapping data and climate from properties managed by English Heritage (EH). It follows earlier work using observations derived from the same data set [18]. This initial study focused on the broad observations of insect catch and its geographical distribution, but made only brief comments on changes in catch with time or climate.

3. Method

The data used in this work is taken from the quarterly inspection of more than thirty thousand traps laid out in a set of EH properties, as part of the increasing focus on monitoring which is seen as integral to IPM. The traps were typically sticky museum traps [17] sometimes termed blunder traps, although occasionally pheromone traps were also used [18]. Pheromone traps were set to catch either the webbing clothes moth or the case bearing clothes moth. The traps were collected and examined at the end of each quarter to count and identify trapped insects.

The insects found in the traps were typically adults of the brown house moth (*Hofmannophila pseudospretella*), case bearing clothes moth (*Tinea pellionella*), webbing clothes moth (*Tineola bisselliella*), white shouldered house moth (*Endrosis sarcitrella*), deathwatch beetle (*Xestobium rufovillosum*), furniture beetle (*Anobium punctatum*), Guernsey carpet beetle (*Anthrenus sarnicus*), two spot carpet or fur beetle (*Attagenus pellio*), biscuit beetle (*Stegobium paniceum*), hide or leather beetle (*Dermestes* spp.), plaster beetle (*Lathridiidae*), wood weevil (*Pentarthrum and Euophryum*), Australian spider beetle (*Ptinus tectus*), golden spider beetle (*Niptus hololeucus*), white marked spider beetle (*Ptinus fur*), booklouse (*Liposcelis bostrychophila*) and silverfish (*Lepisma saccharina*). Two insects in particular were frequently trapped as larvae: the woolly bear, which is the larval form of the carpet beetles (*Anthrenus* spp.), and mealworms, which are the larval form of the mealworm beetle (*Tenebrio molitor*). In addition, the crustacean woodlouse (*Porcellio spinicornis*) was also trapped and counted at a relatively high abundance. Spiders, ants etc were also noted on occasions, but not counted.

Table 1
Data from the seven key London properties. The number is that assigned to the property by EH. The table also lists the total number of traps available for this analysis, the start year, the number of quarters where data is available and the maximum number of traps placed out in any quarter.

No.	Property	Traps	Start	Quarters	Maximum
42	Apsley House	1079	2004	32	35
149	Chiswick House	885	2001	39	52
200	Down House	1663	1998	47	43
217	Eltham Palace	1444	2001	44	35
361	Kenwood House	1330	1998	45	36
434	Marble Hill House	1258	1998	52	26
532	Ranger's House	1444	1998	43	37

The insect counts were entered onto individual Excel spreadsheets, later transformed to ASCII files to facilitate statistical analysis of the entire dataset. The data come from traps set out in properties managed by EH across London and the other EH territories. The number of blunder trap counts available for this study were: London (9150), Southeast (8457), East (3126), West (2176) and North (6539) territories in addition to some 1500 pheromone traps. Trapping is far from even across the territories and in general began later in the West. Some properties have relatively limited records, although a number have fairly continuous data for more than a decade. The London properties are more constant in terms of the number of traps laid over the years, and are rather similar (i.e. they are houses rather than store rooms or tunnels), so the work here will tend to focus on these seven properties (Table 1). The London record becomes coherent in the 21st century, so analysis here typically begins with the year 2000.

The trap monitoring program was not designed for research, so caution is needed when using the data to evaluate the assumptions that lie at the heart of this project. In particular, time trends could be sensitive to variation in the deployment of traps that can arise as a part of a management response to monitor an infestation, impact of maintenance and building works, an exhibition, etc. It is also important to be cautious about interpreting the number of insects trapped as being directly proportional to the population present in a property.

In this study, we attempt to handle the varying number of traps laid by expressing the data in terms of a *catch rate*. This has been common in fisheries research, as it allows the number of fish caught to be expressed in terms of given effort, by expressing the catch in terms of the number of hooks, nets or traps [19]. In the current work, catch rate is simply the number of insects caught divided by the number of traps set out.

Temperature measurements are not available for all the trap locations, so the analysis of the relationship between insect catch and climate uses the monthly temperature data from London's Heathrow Airport, which is continuous from the 1940s. As shown in earlier work [13,14], the temperature in unheated areas of historic rooms correlates well with the temperature of nearby sites, although the interiors are usually warmer. It seems likely that insects might seek quiet and optimal climates within the building structure, but little is known of the temperature difference of their specific habitats, so here we explore the relationship with outdoor temperatures. While it may seem unreasonable to correlate the temperatures of insect habitats in a set of historic houses with outdoor temperatures, any agreement between insect catch and outdoor temperatures would be useful for management purposes given the lack of climate measurements for their habitats.

This monthly *historic station data* is available from a UK Meteorological Office website [20]. The predictions for future temperature at Heathrow are taken from the UKCP09 weather