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HOUSEFLIES: REGULATIONS AND UNINTENDED CONSEQUENCES

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Abstract In the United Kingdom (UK), legislation is sometimes used to prevent pest problems or to facilitate pest management. However in recent years, the two pieces of legislation that have had the most significant impact on common housefly, *Musca domestica*, infestations across the UK, were not intended to address fly problems at all. Formerly, most household waste in the UK was tipped in landfill sites. However in order to reduce the loss of potentially useful recyclable materials, a Landfill Tax was introduced in 1996, which placed a charge on all waste going to landfill. Alternative processes and products such as In-Vessel Composting, Mechanical and Biological Treatment, and Refuse Derived Fuel were developed, and were very successful in reducing the volume of waste going to landfill. However several of these new process have been found to be vulnerable to housefly infestations. There have been numbers of cases of fly nuisance to neighbouring properties, and the pest management and waste industries have been working hard to identify solutions. Separately, most poultry eggs were formerly produced by hens kept in small battery cages in deep pit units. These units were vulnerable to infestation, and often generated housefly populations that caused problems for neighbours. The European Welfare of Laying Hens Directive came into force in January 2012, and was intended to improve caged birds' welfare by requiring hens to be kept in larger cages. The design of the manure removal system associated with these new cages resulted in common housefly populations almost disappearing from caged layer units, a cessation of fly nuisance cases, and a dramatic drop in insecticide usage. The unintended impacts of these two regulations have had a dramatic impact on UK fly populations, both positive and negative. These two examples emphasise the importance of proper scrutiny of new legislation by pest management professionals, in order to avoid unintended consequences. They also illustrate the possibility of creating pest management legislation that works in conjunction with industry on a national scale, to remove conditions conducive to urban pests.

Key words Poultry, waste, refuse, compost, recycling, *Musca*, *Fannia*.

INTRODUCTION

The housefly (*Musca domestica,* L.) occurs in temperate and tropical regions throughout the world. Larvae develop preferentially in animal manures or putrescible wastes, so they are usually closely associated with human activity. The adult flies' powers of dispersion, their preference for the indoor environment, their ability to cause a nuisance to residents, and their role as mechanical vectors of human pathogens, make them one of the most important urban insects (Hogsette and Amendt, 2008).

Control of houseflies on a local level often relies on use of insecticides (Chapman and Morgan, 1992) or biological controls (Geden and Axtell, 1988). The flies' dependence on well-defined and often localised larval habitat also makes them sensitive to changes in habitat availability or suitability. Habitat manipulation is a commonly-used approach to the control of these insects in both the waste management (Toyama, 1988) and poultry husbandry (Armitage, 1985) sectors, and has the advantage of sidestepping the important issue of insecticide resistance (Pospischil et al. 1996, Zhu Fang et al. 2016). Legislation has also been created in the UK to deal with problems with insects such as houseflies. For example,

the Clean Neighbourhoods and Environment Act 2005 (UK Government, 2005) gave powers to local authorities to take action against 'insects emanating from…business premises'. Useful though all these interventions have been, their impact on housefly problems as a whole has essentially been local and incremental. Nonetheless, in recent years, there has been a widespread change in the nature of fly problems in the UK, arising not from any planned intervention, but from the unintended impacts of other legislation that was not intended to address fly problems at all. This paper reviews these unintended impacts, and discusses what the pest management industry can learn from them.

HOUSEFLIES, WASTE AND REGULATIONS

Landfill sites are designated areas for tipping and disposal of waste, and are often located in former mineral extraction works. Prior to 1996, around 50 million tonnes/year of mixed household waste was disposed of in landfill sites in the UK. Once tipped, the waste is usually compacted in order to reduce its volume, and then covered with a layer of inert material. This process stabilises the surface, reduces fly emergence, and makes the waste less attractive to other pests. Nonetheless landfill sites are still prone to problems with houseflies, especially if the cover is not well applied (Boase, 1999), so insecticides are often applied in warmer weather. However, because landfill sites are often sited away from urban areas, the impact of infestation at most sites is usually (but not always) relatively low.

There were numbers of concerns about this reliance on landfill sites; for example the loss of potentially useful recyclable materials such as metals, plastics or timber, the subsequent generation of ozone-depleting methane within landfill sites, and the lack of space for the numbers of landfill sites required to take the nation's waste. In 1996 the UK Landfill Tax (UK Government, 2017) was introduced, in order to ensure compliance with the forthcoming European Landfill Directive 1999/31/EC. It placed a charge on every tonne of waste deposited at landfill sites. As intended, the tax reduced the volume of waste going to landfill (Figure 1), and stimulated the development of a wide range of alternative waste processing, recycling and energy generation systems (Figure 2). However, several of these processes have been found to be vulnerable to housefly infestation, and a selection is briefly discussed below.

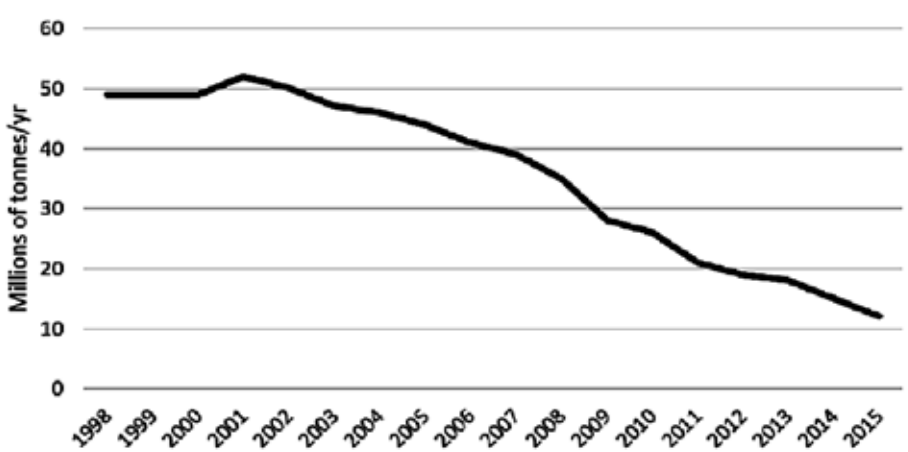

Figure 1. UK biodegradable landfill inputs 1998 – 2015.

At the core of the waste processing industry are now Mechanical and Biological Treatment facilities (MBT). At these sites recyclables are extracted from mixed household waste, and the residual

waste is then composted within a building for 2 – 6 weeks. During the composting process, the waste spontaneously heats up to a temperature of c. 50°C, which results in its moisture content being reduced from c. 50% to 20%, which increases its value as fuel. However, the warm waste is highly attractive to flies, and very serious fly infestations can develop during composting (Suss et al., 1999). Significant quantities of space-spray, bait and larvicide are used in controlling the flies in MBT sites. There are resistance management concerns about this level of insecticide usage (Zhu Fang et al, 2016), and alternative more sustainable techniques are being sought. After composting, the dried waste is known as Refuse Derived Fuel (RDF). It is typically compressed into bales weighing around one tonne each, and then tightly wrapped in polythene film. Most of this waste is exported from the UK for use in power generation facilities overseas, e.g. in Scandinavia. The bales are stockpiled on dockside areas for up to several months, until a full shipload (several thousand bales) is ready for export. If the wrapping remains intact then the atmosphere within the waste is rapidly depleted of oxygen by the decomposition process (Ozbay and Durmusoglu, 2012) and fly larvae appear unable to develop within it. However, if the wrapping is damaged, then there is ingress of oxygen, and fly larvae can then develop within the exposed waste. There have been numbers of cases in the UK where severe housefly problems have been caused by storage of RDF bales.

The recyclables extracted from the household waste have a value, and so are also stockpiled to await sale, transport and reprocessing. For example, aluminium drinks cans and plastic food packaging are baled and may be stored for several months until a load has been stockpiled, or until the market price changes to make the shipment viable. However, the food residue within the containers is able to support fly development, and at some sites large infestations of houseflies, fruit flies (Drosophilidae) and scuttle flies (Phoridae), have developed in such bales.

There are also issues with the location of new waste processing and storage sites. Modern waste sites are often located in urban industrial zones, with other businesses or even residential areas nearby. Fly problems developing in these modern waste management sites often have a much greater impact on neighbours, than the more remote landfill sites.

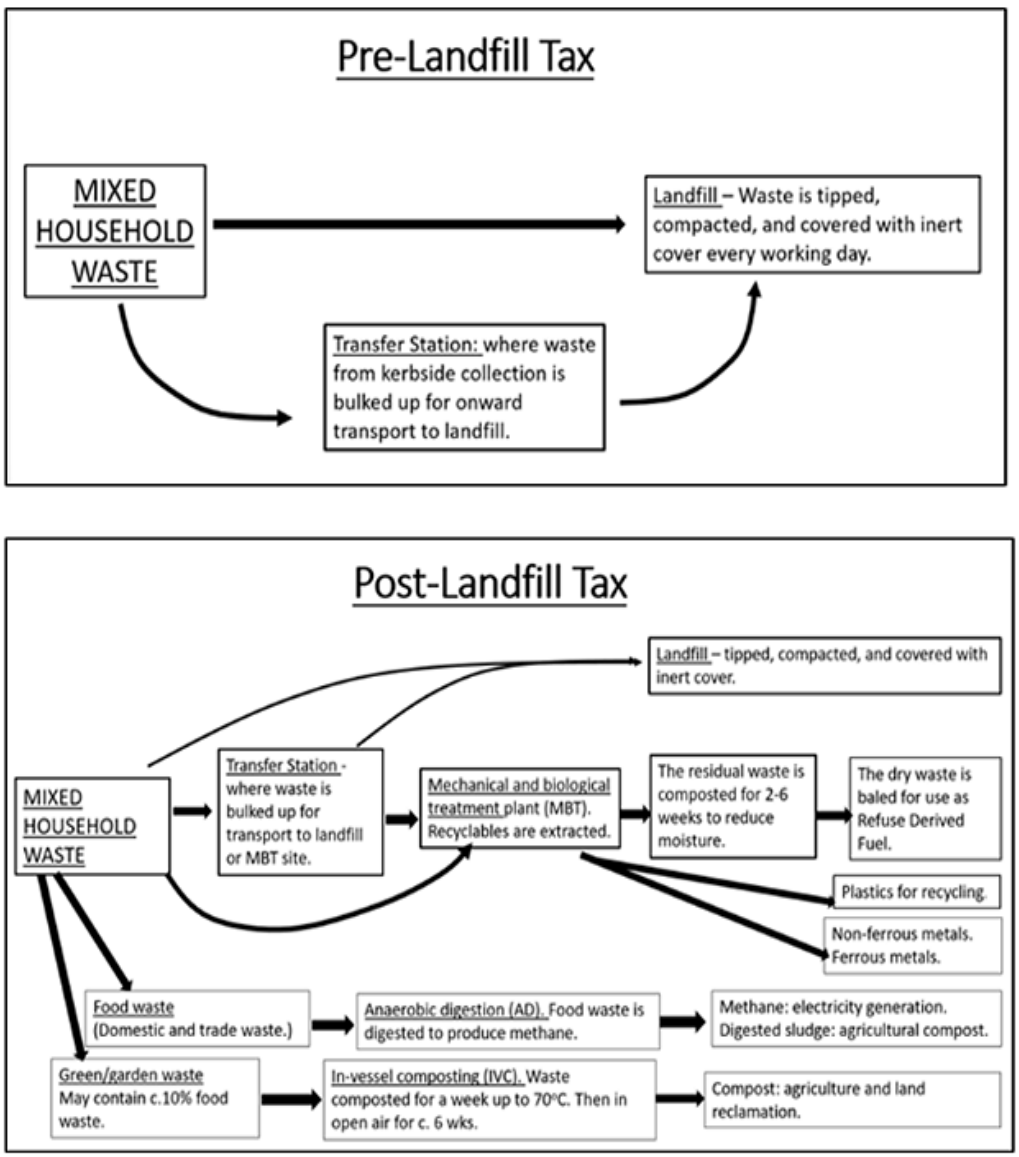

Figure 2. Impact of UK Landfill Tax on waste processing pathways.

Finally, by placing a charge on the disposal of waste, the Regulations also created an incentive to dispose of waste illegally, and so escape the charge. In the UK, there are frequent reports of cases where waste has been dumped illegally, and caused major housefly problems.

In summary, the UK Landfill Tax was successful in reducing the volume of waste going to landfill, and in stimulating a waste recycling industry. However it unexpectedly created a range of new fly problems on which the waste and pest management industries, and regulators, are still working. The diversion of waste from isolated out-of-town landfill sites to urban industrial zones, has accentuated the impact of these new fly problems.

HOUSEFLIES, POULTRY AND REGULATIONS

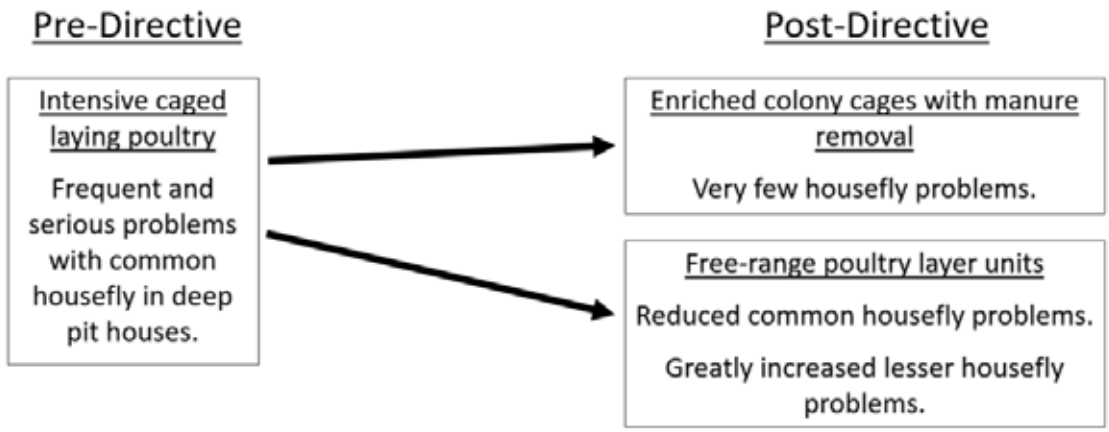

Figure 3. Impact of Welfare of Laying Hens Directive on housefly problems.

The second sector where recent legislation has had a very significant impact on housefly problems, is in poultry laying farms. In the late 20th century, the majority of laying poultry were housed in intensive caged units, otherwise known as battery cages. In this regime rows of small cages were stacked several tiers high, with individual poultry houses housing up to 100,000 hens or more. The houses were known as deep-pit units, with the manure accumulating in the base of house for the duration of the flock, typically about 13 months, before being removed. The temperature within the house usually remained above 18°C throughout the year so flies, especially the common housefly, colonised the manure in large numbers and at times dispersed to cause problems for neighbours. The fly problems associated with this method of production have been widely reported in the scientific literature, eg. Winpisinger (2005). Although poultry farms are essentially a rural business, the fly problems arising were urban in nature.
However there were also concerns about the welfare of birds kept in small cages. In 1999, EU 1999/74/EC, the Welfare of Laying Hens Directive (European Union, 1999), was passed. This required that by 1 January 2012, laying birds could no longer be kept in small intensive cages. Instead, farmers that wanted to continue with caged laying poultry, had to convert to larger 'enriched colony cages'. In this system, the birds' manure typically fell onto a belt on which it was dried, and was then removed from the poultry house and deposited in a purpose-built manure store. Faced with implementing this new Regulation, farmers had two main options:

> One option was to strip out all the old cages and install the larger colony cages. Those farmers who converted to the new colony cages found that an unintended outcome of complying with the Regulation, was an immediate and substantial improvement in the fly situation. The rapid drying and removal of the manure from the house prevented fly breeding, and removed the need for insecticide treatments. The usage of baits, sprays and larvicides fell dramatically, and fly nuisance cases involving such farms more or less ceased. The impact of this sudden change was felt not only by the farmers and their neighbours, but also by insecticide suppliers and manufacturers.
> Alternatively, other farmers chose instead to convert their poultry houses to less intensive free-range laying units. This system allows the birds to forage outdoors in a paddock, with their feed, water and laying boxes remaining indoors. Being less intensive, the temperature within free-range laying houses is lower than within the former intensive caged layers. This cooler environment is less suitable for the common housefly, but much more suitable for the lesser

housefly (*Fannia canicularis*, L.). In units where the manure remains within the free-range poultry house, farmers are now having to deal with sometimes serious infestations of lesser housefly, and the associated dispersion and nuisance issues (Tabaru, 1993). Lesser houseflies do not respond so well to insecticide fly baits, or even to larvicides (Tabaru and Kobayashi, 1991), so farmers are finding that control of this species is more challenging.

In summary, the introduction of the Welfare of Laying Hens Directive was intended to improve birds' welfare. In doing so it also had a very significant impact on the nature of fly problems associated with poultry in the UK (Figure 3). For those farmers that converted to the new approved colony cages, problems with common housefly virtually disappeared. However for farmers who instead converted to free range laying units, the common housefly has been replaced by the lesser housefly, which is proving very challenging to control. These changes have had a major effect not only on farmers, but also on the farms' neighbours, and insecticide suppliers and manufacturers.

CONCLUSIONS

In different ways, these two examples highlight the dramatic yet unintended impacts that changes to legislation can have on urban pests. The pest management industry, together with the poultry and waste industries themselves, are still working to develop the means to mitigate the impact of these unintended changes. Looking ahead, there are several different ways that the pest management industry can respond to this understanding of the interrelationship between legislation and urban pests:

The industry can passively observe and record, as this paper does, the impact of legislative changes on urban pests. However, although this may be a passive role initially, hopefully the identification, analysis and reporting of these impacts may guide and inform any subsequent changes in regulations.

Alternatively, the pest management industry can take a more pro-active stance in the vetting of draft regulations. Our industry should be more involved in consultation around policy-making, in order to identify and avoid unintended and negative consequences of new legislation.

Finally, pests that are largely restricted to and dependent on the urban environment, are potentially sensitive to changes that may affect their habitat, as has been shown in these two examples. This sensitivity opens up the potential for identifying and exploiting opportunities for manipulating the urban environment, in order to reduce pest numbers. In the interest of improving public health, we should consider ways in which legislation can be developed, not simply to facilitate action against individual infestations, but to drive changes across the urban environment that remove the conditions conducive to infestation.

The examples discussed here are specific to the UK. However, the concept of understanding the relationship between legislation and urban pests, and seeking ways to manipulate that relationship positively, are believed to be applicable internationally.

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