The boom and bust of the bush fly

We hate them and curse them, but where do they come from — those energetic little bush flies that crawl impudently over our faces in the summer? They are such a nuisance in Australia that they have become part of our folklore, especially in the outback. And, more seriously, they have been implicated in the transmission of the bacterial eye infection trachoma.

The making of the bush fly's food and larval home occurs millions of times each day across Australia.

But why do they breed up in such numbers only at certain times of the year, and what becomes of them down south in the winter? Why are some years worse than others, and why do the wretched creatures sit around on your back for hours? Most importantly, can this pest be controlled?

Attempting to answer questions such as these are a number of CSIRO scientists. Dr Dick Hughes and Dr Marina Tyndale-Biscoe, of the Organisation's Division of Entomology, established much of the fly's basic biology and physiology. Dr Hughes also revealed the details of its population biology in the temperate regions of south-eastern Australia. More recently, Mr John Matthiessen, in the Division's Perth laboratories, has studied the fly's population biology in the Mediterranean climate region of south-western Australia and in the arid interior.

The bush fly, *Musca vetustissima*, is a native insect that breeds in fresh dung. Before European settlement its major breeding sites would have been the faeces of large marsupials, humans, dingoes, and emus. Compared with cow pads, such droppings are small and produced relatively infrequently, at least by the carnivores and omnivores. About 150 bush flies can emerge from a human or dog stool, but ten times that number can be produced in a single cow's dropping. On average, cattle defaecate about 12 times a day, so the potential for the fly to multiply since the arrival of these new beasts has clearly been enormous, and cattle dung is now its major breeding site.

Bush flies can vary considerably in size, which scientists most readily measure as head width. This can range from about 1·2 to 2·7 mm. The size of the adult fly is important because it determines the fecundity of the females. Large female bush flies may each lay about 128 eggs in a lifetime, whereas small ones may only manage about 14. This difference arises for two reasons: firstly, the smaller flies produce fewer eggs in each batch and, secondly, as it takes much longer for these flies to mature their first egg batch, they lay fewer batches.

The size of an adult bush fly does not depend on what food it encounters, but is determined entirely by its original size as a larva. In turn, this depends on the quality of the dung in which the larva develops. To human senses, one piece of fresh dung appears much like another, but to the fly this isn't so. Good-quality, nutritious dung allows the development of large larvae and also gives them an improved survival rate.

The contrast between the lush annual pasture of spring, and the dry wheat stubble of summer. The difference in dung is just as great.

What makes cattle dung 'good' or 'bad' from a bush fly's point of view is the type of pasture on which the cattle are feeding. Quite simply, lush green pasture will usually give the best dung. South-western Australia has a Mediterranean climate with the rainfall concentrated in the winter months. The pasture is annual and dies off rapidly with the sudden onset of the dry summer. This means that the flies are largest — and therefore produce more eggs — in early spring, and smallest in summer.

The mortality of the insects also changes during the year. In spring, with an average of about 60 eggs produced per female, survival of eggs, larvae, and pupae need only be about 3% to replace the female and her mate, and so keep the population steady. In fact, survival then is often as high as 30%, giving an enormous population increase. But in summer survival is only about 1%, and with fewer eggs laid then anyway because the flies are smaller, a survival rate as high as 11% would be necessary in order to replace the parents.

As the population increases to its peak in late spring, the dung quality falls. For the flies, this seasonal decline is made even worse by overcrowding in the dung as the population begins to exceed the food supply. At about the same time, the fecundity, the larval survival, and the lifespan of the adults all decline, and so the population crashes.

Apart from the poorer food, another reason for the changes in survival rate (as opposed to the fecundity) is the presence

Shortly thereafter, the bush flies arrive, eggs may be laid, and larvae will develop.

of predatory or competing insects. These increase in number during the warmer weather. Some of the most important of the competing insects are the dung beetles, which feed on dung and break up the dung pads into small balls — useless for bush fly development — that they bury to use as brood chambers for the development of their own eggs and larvae. (For more on the use of dung beetles for bush fly control, see the box on page 10.)

The problem with bush flies is that they don't stay still. They can migrate a long way. In the more southerly parts of south-western Australia the flies don't survive the winter. But in the following spring and summer the area is re-invaded from the north and inland, helped by north-easterly winds. There must be permanent populations surviving somewhere.

Winter hideout

To find out where the flies can survive all year round, and what makes these places suitable, Mr Matthiessen and his assistants embarked on an extensive campaign of fly sampling in different places during the year. They used fly traps with baits of putrefied liver or, with themselves as 'bait', they caught approaching flies in the air using nets.

The return of the flies begins in October.

Flies were counted, measured, and sexed. Females were characterised according to the state of their egg development. Careful dissection of the flies enabled the researchers to determine approximately how long ago they had emerged from their pupae and how many cycles of egg-laying they had undergone.

The results of this work showed that permanent populations of flies remain inland beyond a line that crosses the study area from north-west to south-east (see the map). Only after the spring increase in the population of the overwintering region (a population characterised by greater numbers of newly emerged, therefore locally bred flies), do flies appear further south-west.

There, the scientists found that the first flies caught in spring (after months without them) were always old and large. This sudden appearance of old flies suggests that they could not have emerged locally, but had arrived from elsewhere. The large size of these immigrants meant that they would lay many eggs, so ensuring a good start to local breeding in the newly invaded area.

Work by Dr Hughes in eastern Australia has shown that bush flies can travel hundreds of kilometres a day, carried by strong north-westerly winds that precede fronts in spring. In Western Australia, such strong winds coming from the inland are not common at that time of year, but even so Mr Matthiessen has established that flies may reach the south-western tip of Australia, 350 km from their overwintering grounds, within about 3 weeks in October each year.

Why do flies survive the winter inland, but die out in the south-west? One obvious suggestion is the effect of temperature, but in fact the borderline of their winter hideout parallels the isohyets — that is, the contour lines connecting regions with the same rainfall. The winter distribution of the flies does not correspond to the isotherms, so temperature is probably not important. In fact, inland winter nights are often colder than those near the coast, where cloud cover makes the winters milder.

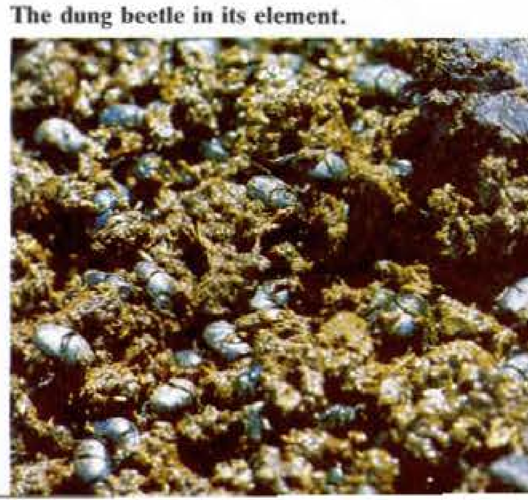
Laboratory studies by Dr Hughes, and field experiments in irrigated pastures by Mr Matthiessen, have shown that the larvae and pupae are very sensitive to drowning. It seems that prolonged abundant rain, by soaking cow dung and soil, can literally drown out the flies from an area. Hence their absence from the south-west of the study area during the winter months of high rainfall — a case of too much of a good thing! A balance exists between the need for some good rain, to allow the production of good-quality dung for egg-laying, and the death of the larvae by drowning in wet dung. Life wasn't meant to be easy, even for bush flies.

Mr Matthiessen believes that the flies can survive the odd frosty night, but of course with colder weather it takes them longer to complete their life cycle. In Victoria and southern New South Wales, winter is colder and more prolonged than in the west of the continent and the annual disappearance of flies there may owe as much to the cold as to rainfall.

Paradoxes

But differences in fly abundance are not only due to population fluctuations. Mr Matthiessen's comprehensive fly sampling and counting showed that, strangely, fly

The dung beetle in its element.



Bush fly control?

Entomologists have long realised that dung harbours natural predators and competitors of bush flies. Back in the 1960s, CSIRO scientists began looking for a method of biological control of bush flies using dung beetles. These insects bury fresh dung in which they lay their eggs. Their larvae then eat the dung from within the brood balls.

Most of our native dung beetle species live in forests and do not thrive on agricultural land, but dung beetles better adapted to pastures exist in many other parts of the world. In January 1968 the first deliberately introduced dung beetles — of African ancestry but bred under strict laboratory conditions — were released. They were certainly able to destroy cow pads, a potential boon not only in bush fly control but also for farmers concerned about the bad effects persistent pads have on pasture.

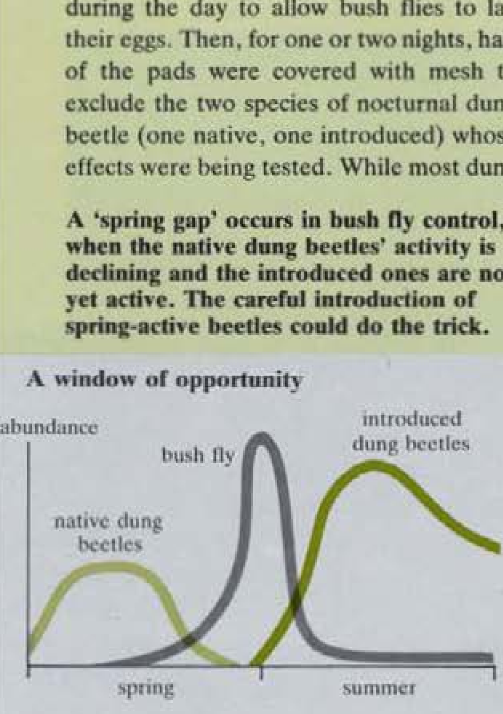
With such a mobile pest, eradication is almost certainly impossible, but have dung beetles at least helped to reduce fly numbers by increasing larval mortality? Dr James Ridsdill-Smith, a colleague of Mr Matthiessen at the Perth laboratories of the Division of Entomology, thinks they have.

Together, the two scientists performed experiments in which they observed the effect that excluding dung beetles had on the subsequent populations of bush flies out in the field. (Previous work in the laboratory had shown very clearly that dung beetles could reduce bush fly numbers, but proof in 'the real world' was also necessary.)

Out in the paddocks, the biologists put fresh dung on sand in shallow plastic containers that prevent fly larvae escaping. They left all of these dung pads exposed during the day to allow bush flies to lay their eggs. Then, for one or two nights, half of the pads were covered with mesh to exclude the two species of nocturnal dung beetle (one native, one introduced) whose effects were being tested. While most dung beetles are active by day, by choosing to work in an area where only nocturnal ones occur the researchers were able to allow the flies to lay their eggs naturally by day when the pads were open and at the same time easily control the effects of the dung beetles.

A 'spring gap' occurs in bush fly control, when the native dung beetles' activity is declining and the introduced ones are not yet active. The careful introduction of spring-active beetles could do the trick.

A window of opportunity



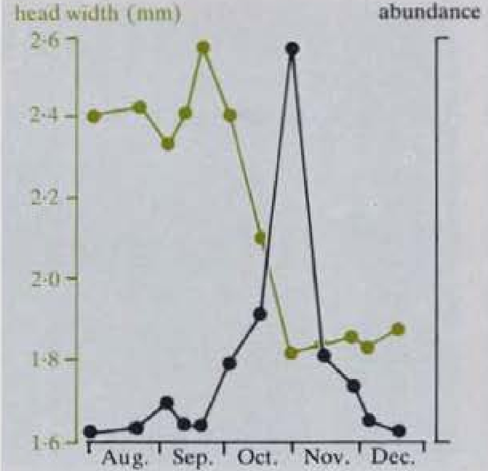
After setting up this experiment the scientists merely had to wait until the bush fly adults started emerging from the dung — and then count them. The experiment was repeated on a number of occasions at three different sites, and the results showed that each time significantly fewer flies emerged from uncovered, and thus dung beetle colonised, pads than from the covered ones. As the covers were mesh, the observed effect could not be due to a lack of air.

The dung beetles had little effect on the size of the flies, from which we can conclude that they are not starving the larvae that do survive; they are simply killing eggs and larvae through direct interference with the dung as they work to form their dung balls. But problems remain: the two species of beetles studied in the experiment are only active during a short part of the fly's breeding season, so their effect is brief. Because the native dung beetle is active only in late winter and early spring, the rapid build-up of fly populations in the late spring is still occurring. Most of the dung beetle species introduced so far are mainly active in the summer, which is when other insects can help reduce the fly population, which anyway is not thriving then.

So scientists in the Division are suggesting the introduction of other dung beetle species from Spain, which has a similar climate to that of south-western Australia. These species will be active during our spring — and that is when fly mortality is low and we need something to kill the pests. At present, Dr Keith Wardhaugh, of the Division of Entomology, is based at Cordoba in Spain to study the biology of dung beetles there so that appropriate species can be successfully bred for introduction into Australia. So let us hope that the 'spring gap' will eventually be plugged.

Field assessment of the impact of night-flying dung beetles (Coleoptera: Scarabaeidae) on the bush fly, *Musca vetustissima* Walker (Diptera: Muscidae), in south-western Australia. T.J. Ridsdill-Smith and J.N. Matthiessen. *Bulletin of Entomological Research*, 1984, **74**, 191–5.

Boom and bust



The population increase follows an increase in average fly size. When dung quality falls, this and overcrowding give a sharp decrease in size, which leads to a drop in fecundity and a population crash.

numbers appeared to be greater in the inland region of his study area, where wheat is grown and cattle density on the land is far lower than in the more intensively farmed areas further south-west. The two possible explanations for this apparently impossible state of affairs are rather subtle.

Inland, the growing season for pasture plants is shorter than in milder areas, because of the shorter rainy season. Therefore the plants have less time to lay down their woody tissue — lignin — which is indigestible to cattle, and makes for poor-quality feed. By rearing larvae on various dung samples and recording the size of the resulting adults, the scientists have shown that the sparse, dry pasture and wheat stubble occurring inland in the summer give rise to better dung than the profuse, dry, grassy pastures further south-west.

Secondly, fewer cattle inland mean less resources for the fly. The flies present will therefore be more insistent in their search for dung and more desperate for food, especially in the case of the females, which require protein for the development of their eggs.

Bush flies are attracted to humans, as to other mammals, although precisely what the attractive features are we don't yet know for sure. Remember that the experimental sampling for bush fly abundance involved either humans netting the insects, or the setting of baited traps. Both the humans and the baits would have attracted flies from far and wide in areas deprived of such resources. Thus, the numbers recorded may not accurately represent population densities, but they do reflect the general abundance and nuisance value of the creatures.

The pest status of the fly is not necessarily in direct proportion to its population density. A relatively low background population of flies can make themselves felt if they are desperate for protein (see below) or dung. Well-fed flies in an area with plenty of dung for egg-laying will bother you less.

For this reason it's very difficult to obtain accurate figures for the absolute population density of the insects. However, the biologists conclude that more flies exist in 'lush' areas, even though the well-fed individuals there are the very ones least likely to be attracted to the baits. Their conclusion is an inference based on the number of viable larvae counted in dung pads and the number of pads in a given area. Calculations from these facts suggest that there must indeed be far fewer flies where the resources are scarcer.

Another feature of this insect involves the adult female's requirement for protein during the process of egg development (oogenesis). You might think that large flies, which produce far more eggs in each batch, would need more protein than small flies. But it's often been observed, by biologists and bushmen alike, that small flies are more of a nuisance, and tend to be the ones that crawl around your mouth and eyes. Is there a scientific explanation to back this up? Are small flies more 'protein-hungry' and therefore more likely to feed on the secretions of your nose, mouth, and eyes?

To find out, Ms Lynne Hayles, also of the Division of Entomology, and Mr Matthiessen conducted an experiment on female bush flies of widely differing body size, feeding them measured quantities of protein-rich liver exudate. They found that, paradoxically, the large flies have lower protein requirements for oogenesis than small ones. Being larger, they may take in more each time they feed, and so receive more protein in absolute terms, but per egg laid they need less.

The researchers conclude that the reason lies in the flies' early life. Those that came from good dung would have greater reserves of protein that were laid down in their larval stage. These 'born with a silver spoon' flies are of course the larger ones. The small flies start off their adult life with a protein deficit; when it comes to egg production they thus need far more protein in their food and, being able to take in less with each meal anyway, must feed more often. This could explain why small bush flies appear to be more of a nuisance than large ones — a point that has recently been corroborated by Dr Bill Vogt and Dr Tyndale-Biscoe during trapping trials and laboratory experiments in Canberra.

Bush flies on the back.

The arid zone

A second aspect of Mr Matthiessen's work involved leaving the bush flies of the south-west and studying those of the arid interior, which nobody had examined before. He chose an area near Yalgoo, W.A., where the average annual rainfall is only 220 mm, falling predominantly in the winter, and one near Alice Springs, where the rain is more likely to fall in the summer. He found, as we might expect, that for most of the time the fly population is actually quite low. Cattle density is also low, so cattle dung is scarce and mostly of extremely poor quality because the cattle have to browse on woody mulga and other hardy desert plants.

Following the rare event of a good rainfall, the desert blooms for a short growing season with annual herbs and grasses that cattle relish. The dung quality obviously improves enormously and Mr Matthiessen found that the flies increased rapidly in both size and number. However, far sooner than calculations of reproductive success had predicted, their population then fell. At least one reason was a parasitic nematode worm, which normally exists at low levels, but increases in number following the growth in the fly population. The parasite's success then causes the fly population to crash back down to lower levels, resulting, of course, in a decrease in its own population. The nematode, however, is not seen in the agricultural region of south-western Australia.

Of the flies present in the arid regions (apart from during the rare times of rapid breeding), about 80% of the females were carrying fully mature eggs ready to lay. This compares with only 20% in the agricultural region of south-western Australia. The bank-up of these gravid flies in the desert population suggested to the researchers that many flies must have been carrying their eggs for some time. It seems that females will hold on to the eggs until they find suitable dung in which to deposit them. So the heavy egg-laden female flies that buzz persistently around an animal for hours, or congregate on the back of a tourist's T-shirt, may be patiently waiting for the animal or tourist to defaecate.

Thus the image of outback Australia as perpetually fly-ridden — the land of the cork hats — is not scientifically true. Flies are fewer in number there than in the country's lush agricultural areas, but those flies that are present are desperate for dung and protein and so congregate around any likely source. As you futilely wave your hand in front of your face, console yourself with this fact: flies from miles around find you attractive.

Roger Beckmann

More about the topic

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