GUEST EDITORIAL

Tsetse Research and Control: 1910 to 2000

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I have chosen the above title, not because work on tsetse flies began in 1910 and is likely to end in 2000, but because 1910 marked the appearance of the first part of Volume 1 of the *Bulletin of Entomological Research* and because a decade is a realistic period over which events can be predicted with some chance of being not too wildly inaccurate. This editorial will, I hope, be more forward-looking than retrospective although we might profitably begin by going back to 1910.

The first volume of the *Bulletin* contained 28 'Original Articles' and nine 'Miscellaneous' contributions; five of the former and eight of the latter were concerned with *Glossina* spp. I rather doubt that this proportion of papers on *Glossina* to those on other insects was maintained over the next 80 years, but I would hazard a guess that the *Bulletin* has published more papers on tsetse flies than any other journal. Certainly, to thumb through back numbers gives a picture of how research on the genus has evolved during the 20th century. In a Foreword to the first volume of the *Bulletin*, A.E. Shipley wrote that there was a 'necessity of placing entomological research in our tropical possessions in Africa on a proper basis'; he saw insect pests of man, animals and plants as the main cause of the 'almost complete closure of Africa [to Europeans] until quite recent times, with the exception of the narrow littoral fringe'. The most important need was to 'observe and note as completely as possible the life-histories, habits and habitats' of insect pests in Africa.

This is precisely what contributors to the *Bulletin* proceeded to do for *Glossina* species, although the essentials of the life-history of the genus, including its specialised mode of reproduction, were already known by 1910. Four of the five papers on *Glossina* in Volume 1 of the *Bulletin* described aspects of the natural history of various species–the fifth described a new species–and the emphasis on descriptive natural history was the pattern for the next few years. Later, these studies were to be superseded by increasingly sophisticated work on the ecology of *Glossina* species, involving continuous observations over several years, which analysed the responses of the insects to environmental factors such as climate, vegetation and hosts.

It is also possible to trace the development of methods for controlling *Glossina* species by reference to the *Bulletin*. Papers describing different approaches to habitat removal were followed by papers describing insecticide campaigns, the use of the sterile insect release method and, today's fashionable approach, the use of insecticide-impregnated traps and targets. Control was not overlooked even in 1910 as one of the 'Miscellaneous' contributions in Volume 1 referred to the need to search for 'attractive and repellent substances' to make trapping more efficient and for a thorough testing of 'Maldonado's trap' (which he had just used successfully against *G. palpalis* (Robineau-Desvoidy) on the Island of Principé). In view of the current interest in traps and targets, both of which can be made more efficient by 'attractive substances', one must ask whether anything in this world is new!

This necessarily brief overview of back numbers of the *Bulletin* has done scant justice to the role of the journal in charting the evolution of studies on the ecology and control of *Glossina* and no justice at all to the many other topics described in its pages–systematics, physiology, genetics, colonisation and others. It is, however, time to look to the final ten years covered by our title.

What will the *Bulletin*, and other journals, be publishing between now and 2000 about tsetse flies? Because of the widespread present interest in insecticide-impregnated traps and targets for tsetse control, ways in which these devices can be made more effective – and cheaper – will certainly be investigated and described. There are many questions to be answered about the design of traps and targets, about insecticides or insect sterilants to be applied to them, about olfactory attractants that can be used in conjunction with them and about ways in which flies respond to them. It is already clear that there is not a single set of answers to these questions for the genus *Glossina*. For example, species of the *morsitans*-group are highly responsive to the components of host odour which have so far been isolated and identified as attractants, but species of the *palpalis*-group are either not responsive or only slightly so to these same substances. Within the *morsitans*-group there are also differences – *G. pallidipes* Austen is much more responsive to the known odours (and much more readily caught in traps) than *G. morsitans* Westwood. There are also clear differences between the many types of trap that have been designed – the most effective for one species of *Glossina* is not necessarily the most effective for another. For all of these reasons, studies on the behaviour of all the *Glossina* species of economic importance can be well justified on grounds of cost-effectiveness and seem certain to feature prominently in the literature of the next few years.

The laboratory worker has an advantage over his colleague in the field because of the way in which he can control the many variables which affect the behaviour of an insect within its natural habitat. Laboratory studies on the behaviour of *Glossina* species go back to the 1930s but expanded in the 1960s following the establishment of laboratory colonies at the Tsetse Research Laboratory and elsewhere. The precise observations that can be made in the laboratory can be of great value in the interpretation of the necessarily much more complex data obtained from the field. For instance, the work of Brady (1972) on the nature of rhythms of activity has shed light on diurnal rhythms and refuge-seeking behaviour in the field. Nevertheless, the laboratory worker should not be divorced from the real world in the field, from where problems arise and to where solutions must apply. Scientific papers derived from a combined field and laboratory approach have been appearing with increasing frequency in recent years and it is a desirable trend that hopefully will continue.

Perhaps the most significant 'new' research tool that the tsetse field worker has had at his disposal in recent years has been the electrified net, which is invisible to the fly and has enabled studies of fly behaviour to be made in the absence of the human observer (Vale, 1974). The use of incomplete rings of nets around a potential host animal, some feature of the environment or some man-made artifact such as a trap or a target, has enabled samples of flies flying towards or away from the object to be obtained. From the composition of the catch on each side of the nets (species, number, sex, age, hunger stage) the nature of the behavioural response can be accurately described and quantified. This invaluable research tool has also assisted in demonstrating that the presence of man near a trap, target or potential host animal, can depress the catch of *G. morsitans* and of *G. pallidipes*. The effect of man on the behaviour and 'trapability' of species such as *G. palpalis*, *G. fuscipies* Newstead and *G. tachinoides* Westwood, all of which will feed readily on man, remains to be determined. The behaviourist has still much to learn from the electrified net, but this will be unable to provide all the answers. Ultimately we need to know what tsetse flies of different species, sexes, ages and physiological states do with their time. How long do they rest in exposed and sheltered resting sites (this is almost certainly always in excess of 23 hours in a day), how long do they spend in undirected flight, how long do they spend in flight directed by visual or olfactory stimuli and how do they behave in an odour plume originating from a host? How far do they fly – and is this predominantly in relation to obvious features of the environment, such as ecotones? All these questions could be answered if we could continuously monitor the activity of individual flies. This would also throw light on another virtually closed book. Whereas we

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can draw up a list of the causes of death of tsetse, we know virtually nothing about the extent of mortality that can be attributed to each of the abiotic and biotic factors involved. Such information will be essential if we are to fully understand the population dynamics of tsetse species so that we can make present control methods, particularly those involving the catching-out of fly populations, more cost-effective.

In recent years there has been a welcome reduction in the tendency to think in terms of *Glossina* species just as interesting insects to be studied or important pests to be controlled. It is well to remind ourselves that tsetse flies are benign until they become infected with trypanosomes and it is the disease, trypanosomiasis, with which we should primarily be concerned. Although this reminder is directed at entomologists, it is also appropriate to remind parasitologists, immunologists, physicians and veterinarians that trypanosomiasis is not just about their particular discipline. Whilst much is known about tsetse flies, trypanosomes and hosts, there is much we still do not understand – certainly in quantitative terms – about the interfaces between the well-studied organisms in the trypanosomiasis complex. This is clear from recent efforts to develop mathematical models of the disease.

Until recently the interface between the fly and the trypanosome had been much neglected; in particular it was not understood why usually only a very small proportion of the individuals in a tsetse population are infected with trypanosomes, even in areas where the disease is common. The biggest puzzle of all was why so few flies are infected in areas of epidemic human sleeping sickness. It is now known that the fly is not just a flying syringe and that it controls its susceptibility to infection with trypanosomes of the *Trypanosoma brucei* (including the organisms responsible for human disease) and *T. congolense*-groups, but almost certainly not of the *T. vivax*-group. In cyclical transmission, trypanosomes have to jump two major hurdles in the fly. Firstly, trypanosomes imbibed in a blood meal have to become established in the fly and, subsequently, they have to be replaced by forms infective to the mammalian host (a process referred to as 'maturation'). Both of these processes are controlled by the insect's immune system, which is lectin-based (Maudlin & Welburn, 1988). These findings have greatly improved our understanding of the epidemiology of the disease and, hopefully, more will be discovered in the next few years.

The interface between the fly and its mammalian host is also of critical importance. There is evidence that starvation can be an important cause of death in adult tsetse flies, that this can be density dependent and that it may play a major role as a regulating influence in population dynamics. The hosts of tsetse flies are usually wild mammals and reptiles, but for the construction of realistic models for trypanosomiasis the nature of the contact between the fly and the domestic animal is particularly important. Studies on the ambits and points of contact between *G. palpalis* and *G. morsitans* and N'dama cattle in The Gambia (a preliminary account is in Wacher *et al.*, 1988) are a novel approach to improving our knowledge of this aspect of the epidemiology of trypanosomiasis which merits repeating elsewhere in Africa.

Perhaps one may be excused in a Guest Editorial for concluding with a reference to one's own particular current hobby-horse. The main factor affecting the ecology of Africa today is the rapidly increasing human population. Trypanosomiasis is a dynamic disease, varying in form and severity from place to place and from time to time. Most of this dynamism can be related to the distribution, density and habits of the local species of *Glossina* – and these are changing rapidly, especially in densely populated countries, as human populations expand and modify the environment (Jordan, 1986). Sometimes these environmental changes are favourable to tsetse and sometimes they are so unfavourable that tsetse disappear. Whereas these changes need not necessarily be taken into account over the next ten years by those seeking to improve our knowledge of tsetse biology, they should be increasingly important to those involved with the development of control strategies. Those concerned with control in the past have usually seen their own tsetse problem as immutable and have designed their strategies accordingly. Today the problems are far from immutable and as human populations expand opportunities will occur to take advantage of areas of dense human settlement both as they directly affect tsetse populations and for their potential as effective barriers to fly movement. The problem of what (if anything!) can constitute an effective man-made barrier between fly-infested and fly-free areas has bedevilled tsetse control operations for many years. An important challenge for the next ten years will therefore be to predict ways in which increasing human populations will affect local tsetse populations and to build these predictions into strategies, not just involving vector control, for the effective control of trypanosomiasis. What progress will the *Bulletin* report in 2000?

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