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Aerial Applications of Insecticides for Tsetse Fly Control in East Africa

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Since 1948, research has progressed in East Africa on the control of tsetse flies by aeria. applications of insecticides. Initial experiments proved that residual spray treatments were ineffective while repeated applications of coarse aerosols gave promising fly mortalities.

In recent years, with the development of more toxic insecticides used in conjunction with improved thermal exhaust equipment and modified rotary atomizers, sprays with fine aerosol characteristics have been produced at considerably reduced cost. Aerial applications of aerosols are confined to early morning and late afternoon when weather conditions are stable, but large areas can be treated during these short intervals, and the technique is efficient and economical. Control of tsetse flies has been good; where complete isolation of an area has been possible, eradication has been achieved.

It would be economically worth while to assess the possibility of increasing spray swath widths, and also to continue with research into the biological effectiveness of pyrethrum, primarily because of its absolute safety in use. There is a need for a simple method for the determination of tsetse fly populations in woodland and savanna habitats. Finally, it is recommended that the results of research to date should be brought more forcefully to the attention of government bodies and commercial airspray operators so that the techniques be more fully exploited.

Aircraft were used for the first time for the application of insecticides to control tsetse fly shortly after the Second World War. Air-spray operations for this purpose began in South Africa, where the techniques adopted were of a practical nature and were generally combined with other measures of control. A thermal exhaust device was used to apply a 5% solution of DDT, which was reported to have given satisfactory control of tsetse flies (du Toit, 1954). At about the same time, in East Africa, DDT-impregnated dust was applied on an island in Lake Victoria but proved to give unsatisfactory control (Steyn, 1949).

With the formation of the Colonial Insecticide Research Unit in Entebbe, Uganda, in 1945 (later the Tropical Pesticides Research Institute, Arusha, Tanzania), a programme of aerial spraying against tsetse fly began. The programme was designed on an experimental basis with supporting biological and physicochemical assessments. The earlier air-spray experiments were carried out with war surplus aircraft, applying sprays and coarse aerosols of DDT and HCH. Preliminary experiments indicated that sprays were ineffective against tsetse flies, because the forest canopy was too thick to allow adequate penetration of large spray droplets, resulting in sublethal dosages on the vegetation below the canopy (Hocking & Yeo, 1953). Applications of coarse aerosols, although giving higher mortalities of tsetse than did sprays, were not completely successful because most of the insecticide was blown away from the target area. With the development in recent years of improved aerosol-dispensing equipment, more toxic insecticides and a better understanding of the fate of aeroso lparticles in relation to prevailing weather conditions, appreciable advances in tsetse control have been made.

GENERAL CONSIDERATIONS

Conventional methods of applying pesticides from the air to control tsetse flies are unacceptable for a number of reasons. To minimize losses due to spray

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drift and to ensure maximal deposition on ground targets, residual sprays are applied from aircraft as relatively large spray droplets. The costs of such methods are high when one has to consider spraying several acres, but when square miles are involved the costs become astronomical. Secondly, conventional residual spraying is unsatisfactory for the control of fly in most woodland habitats, because the bulk of the spray emitted is deposited in the canopy of the trees and is therefore not available to the tsetse flies whose habitat is within a few feet of the ground. The amount of spray which penetrates a forest canopy as very small droplets is negligible and ineffective for tsetse fly control.

The problem of producing and dispersing aerosols has been essentially a mechanical one. In earlier work, coarse aerosols were applied from boom and nozzle spraying equipment. This type employed low-output hydraulic spray nozzles operated at high pressures. The nozzles were directed forwards into the airstream to effect greater atomization. Insecticides were formulated as solutions in volatile oils so that aerosol production was partially achieved by solvent evaporation. By this method, however, it is likely that only a small proportion of the liquid applied was in the form of droplets of aerosol size. An alternative method of producing aerosols was by means of thermal exhaust generators which were attached to the exhaust system of aircraft. Insecticide formulations in non-volatile oils were injected into this system, and the speed and temperature of the exhaust gases atomized the spray into very small droplets. This method had the advantage of producing small droplets which did not evaporate further to any significant degree. It had, however, the disadvantage that thermal decomposition was always a possibility, and some chemical breakdown of the pesticide occurred.

DOSAGE RATES

In earlier experiments, dosage rates per application of DDT and HCH were of the order of 0.20–0.25 lb/acre (0.22–0.28 kg/ha) and 0.030–0.040 lb/acre (0.034–0.045 kg/ha) respectively. The amount of liquid employed was generally about 0.25 UK gal/acre (2.8 litres/ha). Lately, however, these rates have been substantially reduced; e.g., dieldrin at 0.030 lb (0.014 kg) in 0.025 UK gal/acre (0.28 litre/ha) has been successful as have isobenzan and endosulfan at 0.012–0.024 lb (0.0054–0.011 kg) in 0.0125 UK gal/acre (0.14 litre/ha). More recently, fenthion at 0.044 lb (0.020 kg) in 0.004 UK gal/acre (0.045 litre/ha) and synergized pyrethrum at 0.0006 lb (0.0003 kg) in 0.016 UK gal/acre (0.18 litre/ha) have effected control.

SPRAY APPLICATION TECHNIQUES

When spraying an area of woodland, an aircraft is flown along parallel runs at regularly spaced intervals. The interval is known as the swath width and for this type of work has generally been from 50 yards to 70 yards (46 m–64 m). The height of the aircraft above the forest canopy is limited by safety factors; it is considered that optimum performance will be achieved when the aircraft is flown close to the top of the canopy and at right angles to the prevailing wind direction, full advantage thus being taken of spray drift.

To ensure that the pilot is flying on a true course and maintaining parallel spray runs, some method of ground marking is essential. Accurate marking in most forest habitats is difficult because it is usually impossible for the pilot to see the marker, or for the marker party to see the aircraft, especially when the length of a spray run is several miles. A variety of marker systems have been employed—for instance, long wooden or bamboo poles, on which are attached brightly coloured or fluorescent painted discs. When the poles are rotated, the discs can easily be seen flashing in the sunlight. In dull weather conditions, Aldis lamps are effective, even when located in dense bush. Coloured meteorological balloons suspended from lines are useful in open country, but they are difficult to control in a light breeze and are easily snagged in the branches of trees. Signal pistol cartridges are expensive and short-lasting, and smoke generators are rather cumbersome to handle. The use of a telescopic mast fitted with a flashing beacon might be the answer for most situations, but the initial expense is high. Often, grass fires are as effective an anything. Whatever method is used, it is essential that the marker party is mobile and in radio contact with the pilot. Quite often, the pilot can align the aircraft on approach by compass, and then rely on familiar objects to maintain a true course, especially when the spray runs are fairly short.

It is most important to know when the weather conditions are suitable for aerosol application so that spraying may commence. This responsibility must be left to the scheme manager, who should have access to local weather information, e.g., a crude meteorological station in the surrounding bush or open area. Details of the meteorological factors relating to aerosol application are given in the next section, but it is worth while noting some simple tests which are a useful guide for spraying:

(1) By noting the movement of aerosol particles sprayed from a hand dispenser at the site. Spraying may commence if the general movement is downward.

(2) Observation of smoke from fires in surrounding areas gives a good indication of air movement within a few feet of the ground.

(3) A trial spray swath should be made when conditions are doubtful. If conditions are suitable, the aerosol will be detected on the ground by smell, downwind of the aircraft's line of flight.

One application of insecticide will not kill all the adult tsetse flies, and it has been found necessary to extend the applications beyond the first pupal period to kill the offspring of survivors of the earlier applications. The number of applications required depends upon the percentage kill obtained. The most effective interval is about 3 weeks. In recent operations 6 applications have been effective. Operational data on all experiments completed to date by the Tropical Pesticides Research Institute are summarized in Table 1.

METEOROLOGY

Most periods during the day in the tropics are characterized by a negative vertical temperature gradient, caused by surface heating of the ground by insolation. Thus, convection currents give rise to vertical displacements of air and, in addition, eddy currents produced by the displacement of surface wind passing over rough ground bring about turbulent or unstable conditions. When aerosol particles having negligible mass are released under unstable conditions, they are carried upwards with the convection currents, gravity having little or no effect on their trajectories.

There are, however, periods immediately after dawn and before dusk (and during the night) when stable conditions prevail. These conditions are characterized by inversions, when the temperature of the air at some height above the ground is warmer than that at ground level. The colder air at ground level, having a higher density than the warmer air above, brings about a condition of stability, and horizontal air flow is laminar, i.e., layers of air pass smoothly over each other with little or no vertical displacement. Any vertical displacement which may occur is quickly brought to equilibrium by the air density profile.

A particle released under stable conditions will have a trajectory determined by its terminal velocity and the horizontal wind component. An aerosol droplet of 50 μ in diameter has a terminal velocity of approximately 10 cm/s. A droplet of this size, released from an aircraft flying close to a forest canopy of, say, 60 feet (18 m) in height is therefore airborne for several minutes. Once the droplet enters the forest canopy, it is subjected to the meteorological conditions inside the canopy. Studies of conditions within a woodland suggest that, when it is calm or when light winds prevail outside, there is under moderately dense canopies a continuous and slow transfer of air between canopy and ground which tends towards laminar flow (Thompson, 1953). For stronger winds, air motion becomes turbulent, but is much less under dense canopies. Slow dispersal of the aerosol will be achieved when conditions are quiet outside, promoting slow but widespread dissemination of the aerosol.

EQUIPMENT FOR AEROSOL PRODUCTION

Thermal exhaust devices

The technique of using exhaust gases of an aero engine to atomize insecticides is not a new one. Thermal exhaust equipment was used some time ago for the control of tsetse fly in South Africa (du Toit & Kluge, 1947; du Toit, 1954) and in East Africa (Hocking & Yeo, 1953; Hocking, Parr, Yeo & Anstey; 1953). In the USA it has also been used for mosquito control (Salmela et al., 1969). The earlier equipment used in East Africa was designed by the Engineering Section of the Chemical Defence Establishment, Porton, England (unpublished data from Adams and Stubbs) and the first smoke installation was designated E.A.1. However, this device gave uneven dosages as a result of a gravity-feed system from the tank to the outlet and was replaced towards the end of 1949 by a modified spray installation designated S.A.3 and exhaust smoke equipment designated E.A.2 (unpublished data from Hill and Stubbs).

The latter design differed in that the insecticide solution was pumped at a constant rate to the outlet, instead of a varying rate dependent upon the head of spray liquid in the tank. However, in practice, it was suspected that approximately 20% of the insecticide was thermally decomposed, and the droplet spectrum was too large for effective penetration into the resting

TABLE 1

SUMMARY OF ALL ANTI-TSETSE AERIAL OPERATIONS CARRIED OUT BY TROPICAL PESTICIDES RESEARCH INSTITUTE

Date	Reference	Aircraft	Equipment	Insecticide	Droplet-size (μ)[a]	Dosage: Volume gal/acre	Dosage: Volume l/ha	Dosage: Weight lb/acre	Dosage: Weight kg/ha	Swath width yd	Swath width m	Applications No.	Applications Interval (weeks)	Reduction in fly (%)[b]	Approximate costs £/mi²	Approximate costs $/km²	Remarks
1948	Hocking & Yeo (1953)	Anson I	Open pipe, gravity fed	2.5 % DDT	200–2 300 (700)	1.03	11.6	0.20	0.22	55	50	8	2	9	—		Poor penetration throughout forest canopy
„	„	„	„	2.5 % HCH	„	1.32	14.8	0.03	0.03	„	„	„	„	20	—		„
„	„	„	Thermal exhaust, gravity fed	10 %–20 % DDT	4–250 (90)	0.27	3.0	0.30	0.34	„	„	„	„	67	—		Poor weather conditions for aerosol treatment
„	„	„	„	10 % HCH	„	0.24	2.7	0.03	0.03	„	„	„	„	69	—		
1949	Hocking, Parr, Yeo & Robbins (1953)	„	Open pipe, gravity fed	4.6 % DDT	200–1 000 (350)	0.50	5.6	0.19	0.21	88	80	7	„	high	—		Immigration present
„	Hocking, Parr, Yeo & Anstey (1953)	„	Thermal exhaust, gravity fed	10 % DDT	4–250 (90)	0.25	2.8	0.20	0.22	55	50	8	„	ca 100	—		Bush leafless
„	„	„	„	10 % HCH	„	„		0.03	0.03	„	„	„	„	90	—		„
1950	Hocking, Yeo & Anstey (1954)	„	Pressurized boom	10 % DDT	5–200 (60)	0.25	2.8	0.25	0.28	35–70	30–64	7	„	95, 98	1 000	1 080	Bush leafy after third application
1951	Hocking, Burnett & Sell (1954a)	„	„	10 % HCH	„	0.13	1.5	0.03	0.03	75–90	69–82	„	„	64, 80	—		Heavy rains interrupted applications
1951–52	Hocking, Burnett & Sell (1954b)	„	„	10 % DDT	„	0.25	2.8	0.25	0.28	88	80	„	„	ca 100	—		
1952	Hocking & Yeo (1956)	„	„	„	„	„		0.20	0.22	70	64	6	„	95	—		Immigration present
„	—	„	„	11 % DDT	„	„		„		55	50	8	2 ½	99, 95	—		Full-scale operation
„	Foster, White & Yeo (1961)	Auster J5G	Rotary atomizers	5 % HCH	5–100 (60)	0.08	0.9	0.04	0.04	70	64	7	4	<50	400	430	Immigration present
1959–60	Burnett et al. (1961)	„	„	2.5 % dieldrin	„	0.13	1.5	0.03	0.03	55	50	8	„	99	370	400	Immigration, third application incomplete
1962–63	Burnett et al. (1964)	Cessna 182E	Thermal exhaust, pump fed	12 % dieldrin	„	0.025	0.28	„		52 ½	48	„	3	100	220	240	Complete eradication
„	„	„	„	10 % isobenzan	„	0.012	0.13	0.01	0.01	„		6	3–6	100	190	205	„

TABLE 1 (*continued*)

Date	Reference	Air-craft	Equipment	Insecticide	Droplet size (μ)[a]	Dosage: Volume gal/acre	Dosage: Volume l/ha	Dosage: Weight lb/acre	Dosage: Weight kg/ha	Swath width yd	Swath width m	Applications No.	Applications Interval (weeks)	Reduction in fly (%)[b]	Approximate costs £/mi²	Approximate costs $/km	Remarks
1964	Hocking, Lee, Beesley & Matechi (1966)	Cessna 182E	Thermal exhaust, pump fed	20% endosulfan	5–100 (60)	0.012		0.024	0.027	70	64	4	3	ca 95, 98	90	100	Immigration present
1966	Irving & Beesley[c]	Cessna 185	Rotary atomizers	95% fenthion	" (60–85)	0.004	0.04	0.004	0.004	110	100	3	"	ca 88, 96	90	100	"
1967	Lee et al.[d]	Cessna 180	Thermal exhaust, pump fed	20% endosulfan	<5–120 (70)	0.012	0.13	0.024	0.027	70	64	1	—	ca 75	—		Pilot trial, single application
"	Irving et al.[e]	Cessna 182E	Modified rotary atomizers	0.4% synergized pyrethrum	<5–80 (40)	0.016	0.18	0.0006	0.0007	"		6	3	95	160	175	Immigration, poor weather fourth application onwards

[a] With volume median diameter shown in parentheses.
[b] 2 figures refer to 2 species of tsetse fly.
[c] Irving, N. S. & Beesley, J. S. S. (1967) *Miscellaneous report* No. 621, Tropical Pesticides Research Institute, Arusha, Tanzania (unpublished).
[d] Lee, C. W., Park, P. O. & Gledhill, J. A. (1967) *Miscellaneous report* No. 635, Tropical Pesticides Research Institute, Arusha, Tanzania (unpublished).
[e] Irving, N. S., Lee, C. W., Parker, J. D., Beesley, J. S. S. & Lee, N. B. (1968) *Miscellaneous report* No. 638, Tropical Pesticides Research Institute, Arusha, Tanzania (unpublished).

sites of tsetse flies (Hocking, Yeo & Anstey, 1954). In 1950, thermal exhaust devices were superseded by boom-and-nozzle equipment which relied upon the volatilization of kerosene to produce coarse aerosols (Yeo & Thompson, 1954).

However, with the development of late of improved formulations of more toxic insecticides, the possibility of using thermal exhaust devices was reassessed. One of the simplest and most effective devices which has been lately developed for light aircraft consists of an Inconel tube, some 45.7 cm (18 in) in length and 7.6 cm (3 in) in diameter which is secured to the existing stub of the aircraft. The spray liquid is fed into the exhaust extension through a metering jet, located outside the exhaust system. A more recent device consists of fitting extensions to twin exhaust pipes, the extensions being 2 slightly curved stainless steel pipes 5.1 cm (2 in) in diameter and approximately 61 cm (24 in) in length. A standard 90 US-gal (340-litres) Sorensen spray tank is fitted below the fuselage and incorporates a 3-bladed, fan-driven, 1-in (2.54-cm) Simplex centrifugal pump. The flow of liquid is controlled by 2 Spraying Systems diaphragm check valves (type 4664, brass) each fitted with a 100-mesh strainer and a D4 orifice disc. The liquid then flows through 2 copper tubes 0.32 cm (0.125 in) in internal diameter to the inlet ports of the extension pipes. The point of entry into the extension pipes is 20.3 cm (8 in) below the manifold, where the temperature is estimated to be 600°C.

Rotary atomizers

Britten-Norman rotary atomizers have been used for some considerable time for dispersing pesticides from fixed-wing aircraft. The physical characteristics of the spray emitted from rotary atomizers are determined by the liquid throughput and the speed of rotation of the cage units. The units are driven by a 6-bladed windmill, whose blade angle and therefore speed of rotation can be adjusted between flights. The windmill is powered by the slipstream of the aircraft; for a forward speed of about 100 mi/h (160 km/h), 6000 rev/min–7000 rev/min are attained. The loading of the units with pesticide solutions reduces the speed slightly. At a throughput of 0.5 UK gal/min (22.7 litres/min) only 20% reduction in rotation speed is obtained and this is sufficient to produce homogeneous droplets of about 100 μ in diameter.

Rotary atomizer devices can be easily modified to produce aerosols in the range of 10 μ–40 μ in diameter (Lee et al., 1969), provided that the insecticide solution is a volatile carrier such as kerosene. While the technique relies on an appreciable degree of solvent evaporation, there is negligible loss of insecticide and, of course, no thermal decomposition.

BIOLOGICAL EFFECTIVENESS

It has been found in the laboratory that old female *Glossina morsitans* Westw. show a considerably greater tolerance to some chlorinated hydrocarbon insecticides than do young flies of either sex, and in particular that pregnant flies show an exceptional degree of tolerance, being approximately 9 times as tolerant as young flies (Burnett, 1961b).

Topical applications of insecticides to male *G. morsitans* and *G. swynnertoni* have shown that DDT is 2½ times more toxic to these *Glossina* species than is HCH (Burnett, 1961a, 1961b). A summary of the comparative toxicities of various insecticides to male *G. morsitans* is given in Table 2.

Most of the air-spray experiments against the savanna species of tsetse (*G. morsitans*, *G. swynnertoni* and *G. pallidipes*) have achieved a good degree of biological control. Mortalities of fly after completed treatments have been of the order of 90%, and have often exceeded 95%. In all but 2 experiments (Burnett et al., 1964; Hocking, Burnett & Sell, 1954b), complete eradication has not been achieved. Where no settlement or development has taken place, the fly population has generally recovered to its prespray level within a few months in areas where immigration is known to occur. Where eradication has been achieved, no flies have been caught in the area before

TABLE 2
COMPARATIVE TOXICITIES OF DIFFERENT INSECTICIDES TO MALE *G. MORSITANS* BY TOPICAL APPLICATION IN OIL SOLUTION

Insecticide	LD_{50} (μg)	Comparative toxicity	LD_{95} (μg)	Comparative toxicity
p,p'-DDT	0.0165	1	0.073	1
Aldrin	0.0135	1.2	0.052	1.4
γ-HCH	0.0064	2.6	0.021	3.5
Chlorbicyclen	0.0043	3.8		
Bromocyclen	0.0032	5	0.0125	6
Dieldrin	0.0017	10	0.005	14
Endrin	0.0017 c	ca 10		
Endosulfan	0.0012	14	0.0031	25
Isobenzan	0.0006	28	0.0017	43
Fenthion	0.005	3.3	0.016	4.5
Coumaphos	0.005 c	ca 3		
Diazinon	0.011	1.5	0.033	2
Dichlorvos Dimethoate	0.011 to 0.013	ca 1.4		
Parathion-methyl Trichlorphon Fenitrothion	0.02 to 0.03	ca 0.7		
Malathion	>0.11	<0.15		
Pyrethrins	0.002	8	0.004	18
Pyrethrins synergized	0.0009	18	0.004	24
Arprocarb [a]	0.008	2	0.0025	3
Arprocarb [a] synergized	0.008	2		

[a] *o*-isopropoxyphenyl methylcarbamate (OMS-33).

the end of the spray treatments. It appears that success in eradication is essentially determined by the ease of isolation of the area sprayed. For an area to be well isolated, it should be not less than 3 miles (5 km) from the nearest tsetse-infested area.

Where tsetse clearance is required for settlement schemes, control of fly by reductions of approximately 95 % of the population should reduce the transmission of sleeping-sickness or *nagana* in man or his cattle. The development of such areas would eventually exterminate the remaining population, provided that there is no source of reinfestation from neighbouring areas.

FUTURE DEVELOPMENTS

Research should be continued to assess pyrethrum sprays for tsetse fly control. Apart from the ease of availability of pyrethrum in East Africa, it has a potential use in spraying operations co-ordinated with settlement schemes, without any hazard to people or their livestock.

Efforts to reduce spraying costs could be achieved by extending swath widths. Physical assessments indicate that under certain conditions, swath widths might be extended to 200 yards (180 m) without any serious reduction in aerosol availability (Lee et al., 1969), but data on biological effectiveness are required.

There is real need to bring to the attention of government bodies and air-spraying operators the recent developments in air-spraying techniques. So far, in Rwanda, the Institut national pour l'Etude agronomique du Congo has treated some 35 mi^2 (90 km^2) using these methods. In Zambia, an area of approximately 500 mi^2 (1300 km^2) is currently being sprayed by a commercial operator.

It would be desirable to find some simple and efficient methods of determining tsetse fly populations in savanna and forest habitats. Marking and recapture methods have proved to be unsuccessful and man and cattle baiting techniques are not sensitive enough. The use of chemical attractants incorporated with traps might be considered, especially in areas of low population density.

RÉSUMÉ

LES ÉPANDAGES AÉRIENS D'INSECTICIDES DANS LA LUTTE CONTRE LA MOUCHE TSÉ-TSÉ EN AFRIQUE ORIENTALE

Depuis 1948, de nombreuses recherches ont été consacrées en Afrique orientale à la lutte contre la mouche tsé-tsé au moyen d'épandages aériens d'insecticides. Grâce à des essais préliminaires, on s'est rendu compte que les traitements par pulvérisation étaient dépourvus d'efficacité, le dôme de feuillage s'opposant à une pénétration suffisante des grosses gouttelettes d'insecticides, et que l'emploi des aérosols s'avérait plus rentable et assurait une meilleure destruction du vecteur. On a utilisé des aéronefs équipés de buses à pression hydraulique montées sur rampe pour l'application des concentrés d'insecticides volatils sous forme de fines gouttelettes ou d'aérosols. Des générateurs thermiques ont été aussi employés pour la pulvérisation de solutions d'insecticides non volatils.

Au cours des dernières années, on a mis au point des insecticides plus toxiques et, grâce au perfectionnement des générateurs thermiques et des appareils rotatifs, on est parvenu à produire des gouttelettes très petites ayant les caractéristiques des aérosols. Les épandages doivent tre pratiqués aux premières heures de la matinée et dans la soirée, lorsque les conditions météorologiques sont stables, mais en dépit de cette restriction, on peut traiter de grandes surfaces et la technique a fait la preuve de son efficacité. Le coût des opérations a été réduit de plus de 90 % depuis qu'on a amélioré les méthodes d'application et utilisé des produits plus actifs. Les résultats, en ce qui concerne la lutte contre les glossines, ont été bons, et des mortalités de l'ordre de 90-95 % ont été enregistrées. Chaque fois qu'on est parvenu à isoler complètement la région traitée, l'éradication du vecteur a été obtenue.

Il est d'un intérêt économique évident de poursuivre les recherches sur les possibilités d'emploi du pyrèthre dans la lutte contre la mouche tsé-tsé. Le produit, qui ne pose aucun problème d'approvisionnement en Afrique orientale, a en outre l'avantage d'être complètement inoffensif pour l'homme et le bétail. Le coût des opérations pourrait être diminué en étendant la superficie des bandes de terrain traitées à chaque passage. Enfin, il serait nécessaire de définir des méthodes simples et efficaces permettant de déterminer l'importance des populations de mouches tsé-tsé en régions de forêt et de savane.

REFERENCES

Burnett, G. F. (1961) *Bull. ent. Res.*, **52**, 531-539

Burnett, G. F. (1961) *Nature (Lond.)*, **192**, 188

Burnett, G. F., Chadwick, P. R., Miller, A. W. D. & Beesley, J. S. S. (1964) *Bull. ent. Res.*, **55**, 527-539

Burnett, G. F., Yeo, D., Miller, A. W. D. & White, P. J. (1961) *Bull. ent. Res.*, **52**, 305-316

Foster, R., White, P. J. & Yeo, D. (1961) *Bull. ent. Res.*, **52**, 293-303

Hocking, K. S., Burnett, G. F. & Sell, R. C. (1954a) *Bull. ent. Res.*, **45**, 605-612

Hocking, K. S., Burnett, G. F. & Sell, R. C. (1954b) *Bull. ent. Res.*, **45**, 613-622

Hocking, K. S., Lee, C. W., Beesley, J. S. S. & Matechi, H. T. (1966) *Bull. ent. Res.*, **56**, 737-744

Hocking, K. S., Parr, H. C. M., Yeo, D. & Robins, P. A. (1953) *Bull. ent. Res.*, **44**, 601-609

Hocking, K. S., Parr, H. C. M., Yeo, D. & Anstey, D. (1953) *Bull. ent. Res.*, **44**, 627-640

Hocking, K. S. & Yeo, D. (1953) *Bull. ent. Res.*, **44**, 589-600

Hocking, K. S. & Yeo, D. (1956) *Bull. ent. Res.*, **47**, 631-644

Hocking, K. S., Yeo, D. & Anstey, D. (1954) *Bull. ent. Res.*, **45**, 585-603

Lee, C. W., Coutts, H. H. & Parker, J. D. (1969) *Agric. Aviatn*, **11**, 12-17

Salmela, J., Sidlow, A. J. & Davis, A. N. (1960) *Mosquito News*, **20**, 275-280

Steyn, J. J. (1949) *J. ent. Soc. S. Afr.*, **12**, 124-129

Thompson, B. W. (1953) *Bull. ent. Res.*, **44**, 611-626

Toit, R. du (1954) *Onderstepoort J. vet. Res.*, **26**, 254

Toit, R. du & Kluge, E. B. (1947) *Vet. Res.*, **59**, 569-574

Yeo, D. & Thompson, B. W. (1954) *Bull. ent. Res.*, **45**, 79-92