

THE EFFECTS ON LONGEVITY AND FECUNDITY OF *GLOSSINA TACHINOIDES* AFTER FEEDING ON PIGS TREATED WITH IVERMECTIN

by

P. VAN DEN BOSSCHE & S. GEERTS

*Institute of Tropical Medicine, Veterinary Department,
Nationaalestraat 155, B-2000 Antwerpen, Belgium*

Summary — Teneral male and mature female *G. tachinoïdes* were allowed to feed on piglets treated subcutaneously with a single injection of 1 or 3 mg ivermectin per kilogram, from day 1, 8, 15 or 22 after treatment. The effects of a single bloodmeal were limited especially for the flies fed on the pig treated with 1 mg/kg ivermectin. Hundred % mortality could be observed, however, in male teneral flies fed once on the pigs, treated with 3 mg/kg ivermectin, until 8 days after the injection of the product. Effects on fecundity were present until 22 days after treatment.

Mortality in male teneral flies, fed permanently on the pigs treated with 1 or 3 mg/kg ivermectin and receiving their first meal between 1 and 15 days after injection, varied from 79.2 to 100 %, and dropped to zero from day 22 onwards. Mortality in female flies, however, was much lower but fecundity was seriously affected. No viable offspring was produced by the flies fed on the pigs treated with both doses of ivermectin from day 1 or 8 post treatment onwards. Fifteen days after the injection of ivermectin the fecundity of the female flies fed on the pigs treated with 1 or 3 mg/kg of the product was respectively 75.7 % and 33.3 %. From day 22 onwards reproduction became normal again.

KEYWORDS: *Glossina tachinoïdes*; Tsetse Control; Ivermectin; Pigs

Introduction

The activity of ivermectin against tsetse flies was first reported by Distelmans *et al.* (4). Afterwards several investigators have evaluated the effect of ivermectin on tsetse flies in vitro and in vivo using guinea-pigs, rabbits, cows and horses (5, 8). Langley and Roe (5) concluded that, where domestic animals constitute major hosts of tsetse flies, treatment with ivermectin can be expected to achieve some measure of fly population reduction. This situation exists in some foci of peridomestic trypanosomiasis where the flies feed almost exclusively on pigs (3). Up to now the efficacy of ivermectin after administration to pigs has only been studied in vitro by feeding tsetse flies on defibrinated pig blood containing different concentrations of the drug (5). Therefore this study was undertaken to study the effects of ivermectin on survival and reproduction of tsetse flies after a single subcutaneous injection of the compound into pigs.

Materials and methods

Teneral male and mature female (between the first and the second reproductive cycle) *Glossina tachinoïdes* were used in the tests. They were maintained in the routine guinea-pig fed colony at the Veterinary Department

of the Institute of Tropical Medicine (9). The flies were kept in standard oblong cages (160 × 70 × 40 mm) at a maximum density of 20 flies per cage. The climatic conditions were 25 ± 0.5°C and 80 ± 5% RH. The flies were fed daily for 5 days a week (not during the weekend). To test the effect of ivermectin on tsetse flies, a total of five piglets of the Belgian landrace weighing 10 to 12 kg were used in two experiments. The experimental set-up is presented in Table 1. Three pigs were injected subcutaneously with ivermectin (Ivomec® , MSD): one at 1 mg/kg and two others at 3 mg/kg. Two control pigs received the same volume of propylene glycol, the vehicle of ivermectin.

TABLE 1
Experimental Set up

	Experiment 1				Experiment 2			
No. of pigs treated with ivermectin								
1 mg/kg	1				—			
3 mg/kg	1				1			
No. of control pigs	1				1			
Feeding schedule of the flies	S		D		S		D	
Mean No. of flies per pig from day post treatment	M	F	M	F	M	F	M	F
d. 1	10	15	11	12	10	13	10	13
d. 8	12	12	13	10	11	10	12	10
d. 15	15	11	12	10	13	11	14	—
d. 22	22	13	15	11	23	16	25	18

M: male flies
F: female flies

S: single feeding
D: daily feeding

For the pigs treated with 3 mg/kg ivermectin, the average of the result of the two experiments is presented except when otherwise mentioned. In order to allow an undisturbed feeding of the flies the pigs were first sedated with azaperone (Stresnil® , Janssen Pharmaceutica) at 10 mg/kg and then anaesthetised with phencyclidine chloride (Sernylan® , Parke-Davis) at 1 mg/kg or ketamine hydrochloride (Imalgène® , Rhône Mérieux) at 1 mg/kg. The remanence of ivermectin was evaluated by feeding the flies on the treated pigs beginning on day 1, 8, 15 and 22 after the injection of the product. Two schedules of feeding the flies were used. In the first one, group of flies received a single bloodmeal on the treated pig on each of the above-mentioned days and were fed on the control pig for another 6 days. Those flies, which did not feed on the ivermectin treated pig, were discarded. In the second schedule batches of flies were fed daily for seven days on the treated pigs starting on day 1, 8, 15 and 22 days post ivermectin treatment. Groups of ten control flies were fed on the control pig during the same period. Mortality was recorded after this period and was corrected according to the formula of Abbott (1), using the mortality figures of the control flies.

To evaluate the fecundity, the number of normal pupae produced was calculated on the basis of the number of inseminated females during a period of 3 consecutive reproductive cycles (27 days).

Results and discussion

a) Mortality of *G. tachinoides* after single or daily bloodmeals containing ivermectin

As can be seen in table 2, the mortality rate of the male flies after one bloodmeal on the pig treated with 3 mg/kg ivermectin was much higher than that of the female flies. Treatment of the pigs with 1 mg/kg ivermectin had virtually no effect on both male and female flies.

TABLE 2
Corrected mortality of male (M) and female (F) *G. tachinoides*
one week after a single meal on pigs treated with ivermectin

Days after treatment	Sex of the flies	% corrected* mortality after feeding on pigs treated with ivermectin at	
		1 mg/kg	3 mg/kg
1	M	0	100
	F	6.6	10.9
8	M	0	100
	F	0	15
15	M	0	0.6
	F	0	0
22	M	0	0
	F	0	0

* The mortality in the control flies varied between 0 and 0.8%.

Figures 1 and 2 show the cumulative mortality of the flies, receiving daily bloodmeals on pigs treated with 1 mg/kg and 3 mg/kg ivermectin respectively. In the male and female flies starting on day 22 after treatment of the pig

% mortality

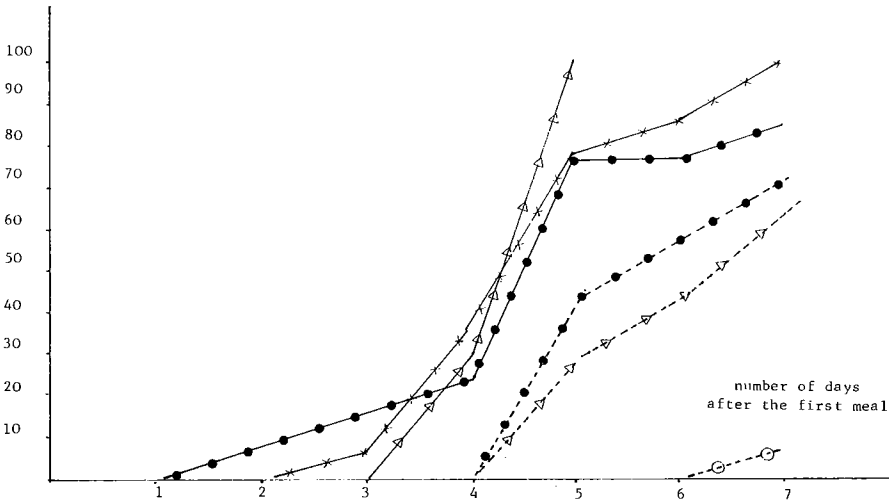


Figure 1

Cumulative mortality of male (—) and female (---) *G. tachinoides* fed permanently on the pig treated with ivermectin (1 mg/kg) and started on day 1 (—●—●—), 8 (—●—●—), 15 (—×—×—)° and 22 (—○—○—)° after treatment of the pig.

Legend: ° Mortality was zero in the female flies started on day 15 and in the male group started on day 22 post treatment.

with ivermectin at 3 mg/kg there was no mortality any more. In the flies feeding on the 1 mg/kg treated pig, however, there was surprisingly a low mortality (7.7%) in the female flies. As could be expected, the male flies were generally more susceptible than the female ones. The mortality of the males varied between 79.2 and 100%, even when the flies started feeding on day 15 after treatment with 1 mg/kg only. Female mortality, however, never reached 100%. On day 15 post treatment there was no mortality at all in the group of female flies feeding on the pig treated at 1 mg/kg ivermectin, whereas in those feeding on the pig treated at 3 mg/kg mortality reached only 23.75% at the end of the observation period. In the groups, which started feeding on day 1 and 8 after treatment, the mortality of the females varied between 60.6 and 73.3% and was very similar for the flies feeding either on the pigs treated with 1 mg/kg or 3 mg/kg ivermectin.

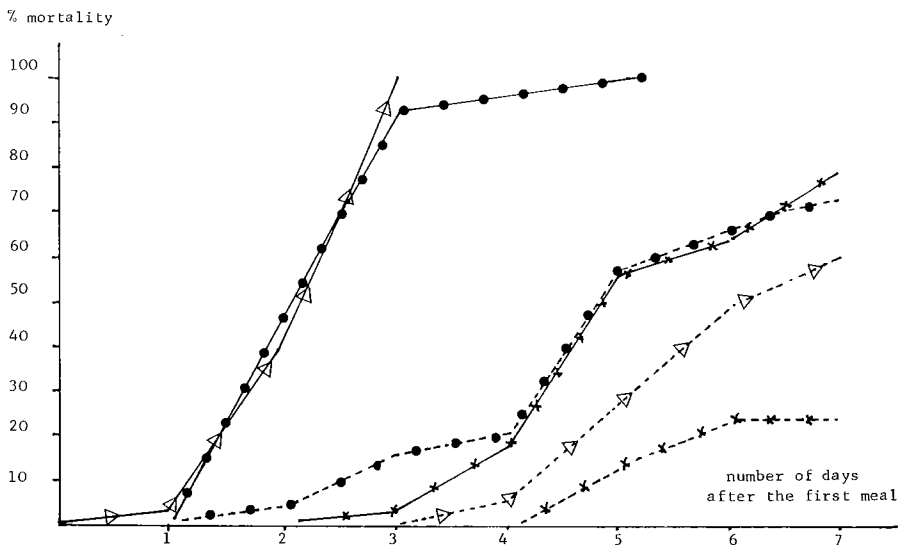


Figure 2

Cumulative mortality of male (—●—) and female (---△---) *G. tachinoïdes* fed permanently on the pigs treated with ivermectin (3 mg/kg)^o and started on day 1 (—△—), 8 (—●—) and 15 (---×---) post treatment. ^o Mean of two experiments.

Legend: No mortality was present in the male and female flies, started on day 22 post treatment.

b) Effects on fecundity of *G. tachinoïdes* after single or daily bloodmeals containing ivermectin

As can be seen in table 3, none of the flies which started feeding on day 1 or 8 after treatment of the pigs with 1 or 3 mg/kg ivermectin and fed permanently on these animals, produced any viable offspring.

The flies having daily bloodmeals (from day 15 onwards) on the pigs, treated with 1 mg/kg ivermectin, showed a disturbed pupariation during the first reproductive cycle, whereas those feeding on the pig treated with 3 mg/kg had a disturbed first and second reproductive cycle. Reproduction

was normal afterwards. The most commonly observed phenomenon was the failure of third instar larvae to pupate.

TABLE 3
Effects of ivermectin on the fecundity of *G. tachinoides*

A. Single bloodmeal

Dosis of ivermectin	% fecundity* of <i>G. tachinoides</i> feeding once on day after treatment			
	1	8	15	22
1 mg/kg	75	75	82.5	100
3 mg/kg	0	0	75	96.5

B. Daily bloodmeal

Dosis of ivermectin	% fecundity* of <i>G. tachinoides</i> feeding permanently from day after treatment			
	1	8	15	22
1 mg/kg	0	0	75.7	100
3 mg/kg	0	0	33.3	100

$$* \% \text{ fecundity} = \frac{\text{No. of normal pupae produced during 27 days}}{\text{No. of inseminated females}} \times 100$$

The average weight of the produced pupae was lower than the weight of the pupae produced by the guinea-pig fed flies of the colony (17.82 mg) but was similar to that of the control group (14.7 mg). In spite of the lower pupal weight their hatching rate was high (97%).

Conclusions

From the results presented above it can be concluded that single feeding on pigs treated with 1 mg/kg has little effect on fly reproduction and longevity.

The effects of a dosis of 1 mg/kg, however, are very similar to those of a dosis of 3 mg/kg, when daily feeding on the treated pig occurs, and last for at least 15 days. Therefore a 2-weekly treatment with 1 mg/kg ivermectin will be necessary during 1 or 2 months in order to control tsetse flies, feeding exclusively on pigs. If, however, feeding does not occur exclusively on pigs, a 2 weekly treatment with 3 mg/kg is recommended.

It is striking that the effects of ivermectin treatment of pigs are not lasting as long as those observed by other authors working with cattle and horses. Langley and Roe (5) still showed some effects on the fecundity of *G. m. morsitans*, fed daily on a horse, 28 days after treatment with 0.4 mg/kg ivermectin (twice the normal dose). The results are difficult to compare, however, since the experimental set up was different and since another species of flies was used. As suggested by Strong and Brown (7), flies belonging to the *palpalis* group might be less sensitive than those of the *morsitans* group but further evidence is necessary to prove this (preferably by comparing both species feeding on the same host). It is known, however, that the biological half life of ivermectin is much shorter in pigs than in other

domestic animals (6) and this might be the most important reason for the shorter remnant activity of ivermectin in pigs.

Finally it has to be noticed that ivermectin is also very active against most species of nematodes, against mange (*Sarcoptes scabiei*), lice (*Haematopinus suis*) and even ticks (2). The drug is very safe in pigs and even at 30 mg/kg (100 times the use level) no mortality and no specific gross or histologic changes were observed (Pulliam, cited in 2). A period of at least one month, however, is necessary before slaughtering the animal for human consumption.

Acknowledgements — *The excellent technical assistance of J. Van Hees is gratefully acknowledged. The authors like to thank also Prof. J. Mortelmans for his valuable comments and general help in various ways. This work was partially financed by a grant from WHO.*

Longévité et fécondité de *Glossina tachinoïdes* nourries sur des porcs traités avec de l'ivermectine.

Résumé — Des mouches ténérales mâles et adultes femelles de *Glossina tachinoïdes* ont été nourries sur des porcs, traités avec l'ivermectine à la dose de 1 ou 3 mg/kg, à partir de 1, 8, 15 ou 22 jours après l'injection sous-cutanée du produit. Les effets d'un repas simple étaient assez limités pour les glossines, qui se nourrissaient sur un porc, traité avec ivermectine à 1 mg/kg. A 3 mg/kg par contre une mortalité de 100% était constaté jusqu'à 8 jours après l'injection chez les mouches ténérales mâles, tandis que les effets sur la fécondité des femelles étaient présents jusqu'à 22 jours après le traitement.

En ce qui concerne les glossines, qui recevaient un repas de sang journalier (1 ou 3 mg/kg ivermectine) à partir du 1^{er} jusqu'au 15^{ème} jour après traitement, la mortalité chez les mâles variait de 79,2 à 100% et tombait à zéro à partir du 22^{ème} jour. Chez les mouches femelles, la mortalité était beaucoup plus basse, mais il y avait des effets importants sur la reproduction, surtout à cause de perturbations au cours de la pupaison. Aucune larve viable était produite par les glossines, qui avaient sucé à partir de 1 ou 8 jours après traitement des porcs avec 1 ou 3 mg/kg ivermectine. Quinze jours après l'administration du produit, la fécondité était 75,7 et 33,3% chez les mouches, qui se nourrissaient sur des porcs, traités avec 1 et 3 mg d'ivermectine respectivement, tandis que la capacité reproductrice devenait de nouveau normale à partir de 22 jours après le traitement.

Overleving en vruchtbaarheid van *Glossina tachinoïdes* gevoed op varkens die met ivermectine werden behandeld.

Samenvatting — Tenerale mannelijke en volwassen vrouwelijke *Glossina tachinoïdes* vlieger werden vanaf dag 1, 8, 15 of 22 éénmaal of dagelijks gevoed op varkens, die behandeld werden met één subcutane injectie van 1 of 3 mg ivermectine per kg. De effecten van een éénmalige bloedmaaltijd waren tamelijk beperkt voor de vliegen, die bloed zogen bij een varken dat met 1 mg/kg ivermectine was behandeld. Bij behandeling met 3 mg ivermectine per kg echter werd een mortaliteit van 100% gekonstateerd tot 8 dagen na de injectie bij de mannelijke tenerale vliegen, terwijl de effecten op de fecunditeit bij de vrouwelijke vliegen voelbaar waren tot 22 dagen na de behandeling.

Voor wat betreft de vliegen, die een dagelijkse bloedmaaltijd kregen (1 of 3 mg/kg ivermectine tussen dag 1 en 15 na behandeling, varieerde de mortaliteit bij de mannelijke vliegen tussen 79,2 en 100%. Vanaf dag 22 was er geen sterfte meer. Bij de vrouwelijke vliegen was de mortaliteit lager, maar waren er belangrijke effecten op de reproductie, voornamelijk tengevolge van stoornissen in de popvorming. Bij behandeling van de varkens met 1 of 3 mg/kg ivermectine werden geen levensvatbare larven geproduceerd door vliegen, die zogen vanaf 1 of 8 dagen na behandeling. Vijftien dagen na de ivermectine toediening, was de fecunditeit respectievelijk 75,7 en 33,3% voor de vliegen die zich voedden op varkens behandeld met 1 of 3 mg/kg ivermectine terwijl bij beide dosissen de reproductie normaal werd vanaf 22 dagen na behandeling.

Received for publication on March 2, 1988.

REFERENCES

1. Abbott WB: A method for computing the effectiveness of an insecticide. J. Econ. Entomol. 1925, 18, 265.

2. Campbell WC: Ivermectin: an update. *Parasit. Today*, 1985, **1**, 10-16.
3. Dagnogo M, Lohuirignon K, Gouteux JP: Comportement alimentaire des populations péri-domestiques de *G. palpalis* et de *G. tachinoïdes* Westwood du domaine guinéen de Côte d'Ivoire. *Cah. ORSTOM sér. Ent. méd. Parasit.*, 1985, **23**, 3-8.
4. Distelmans W, D'Haeseleer F, Mortelmans J: Efficacy of systemic administration of ivermectin against tsetse flies. *Ann. Soc. Belge Méd. Trop.*, 1983, **63**, 119-125.
5. Langley P, Roe JM: Ivermectin as a possible control agent for the tsetse fly *Glossina morsitans*. *Entomol. Exp. Appl.*, 1984, **36**, 137-143.
6. Lo PKA, Fink DW, Williams JB, Blondinger J: Pharmacokinetic studies of ivermectin: effects of formulation. *Vet. Res. Comm.*, 1985, **9**, 251-268.
7. Strong L, Brown TA: Avermectins in insect control and biology: a review. *Bull. Ent. Res.*, 1987, **77**, 357-389.
8. Van Den Abbeele J, D'Haeseleer F, Goossens M: Efficacy of ivermectin on the reproductive biology of *Glossina palpalis palpalis* (Rob.-Desv.) (Glossinidae: Diptera). *Ann. Soc. Belge Méd. Trop.*, 1986, **66**, 167-172.
9. Van den Bossche P, Van Hees J: A simple and cheap method for breeding of tsetse flies. *Tropicultura* (in press).