FIELD EVALUATIONS IN MALAISE AND CANOPY TRAPS OF SELECTED TARGETS AS ATTRACTANTS FOR TABANID SPECIES (DIPTERA: TABANIDAE)[1]

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ABSTRACT. Various configurations of an inflated vinyl beach ball covered with black fabric were evaluated in Malaise and canopy (modified Manitoba) traps for possible use as an insecticide-impregnated visual target (T) for Tabanidae. In Malaise traps, T attracted 2× more flies than no T. When inflated with carbon dioxide, T was not significantly different from T filled with air, no matter which type of trap it was in. In canopy traps, 2 or 4 white spots applied to T did not increase its attractiveness to tabanids. When treated with octenol, T was 2–5× more attractive than an untreated T in canopy traps. However, when an octenol treatment was aged for 48 h, it was less effective than a fresh treatment. Overall, the 3 most frequently collected species, in order of abundance, were: *Tabanus lineola hinellus*, *Hybomitra vicina* and *Chrysops atlanticus*. Significantly more *T. l. hinellus* and *H. vicina* were collected at T with octenol than at T without octenol. Attempts to detect an insecticidal effect on flies captured in both types of trap that had been baited with Ts treated with permethrin were unsuccessful.

INTRODUCTION

Wide-area control of tabanid flies by conventional methods has proven impractical (Anderson 1985). Flies are distributed over large areas and readily reinvade treated areas. An effective, affordable strategy to lower fly densities is needed if seasonal annoyance and economic impact is to be reduced to acceptable levels (Gerhardt et al. 1973).

One strategy to reduce densities of tabanids is removal trapping. The idea is not new and has had limited success (Wilson 1968, Tabuchi and Yajima 1969, 1970; Hansens et al. 1971, Wall and Doane 1980). Although labor intensive and initially expensive, removal trapping offers minimal environmental impact, low maintenance, long-term effect and economy. Moreover, new materials and technologies now make available a wide selection of trap-configuration options that can be studied in the field. One example is the tactical deployment of insecticide-impregnated visual decoys, or targets for the management of pestiferous or disease-transmitting flies. Such devices have been shown to control riverine tsetse (*Glossina* spp.) in Nigeria (Oladunmade et al. 1985).

In this study, we chose to evaluate targets, that are not fixed in position, i.e., are moveable, to find those that have appropriate size, shape, texture, and color, and that can be combined with a chemical bait and an insecticide.

For this purpose, we considered sticky panels and balls (Wilson 1968, Snoddy 1970), various shaped decoys or targets, with different patterns and colors (Thompson 1969, Granger 1970, Hansens et al. 1971, Neys et al. 1971, Allan and Stoffolano 1986, Hribar et al. 1991) and with carbon dioxide or other chemical baits such as octenol (Wilson 1968, Tabuchi and Yajima 1969, 1970, French and Kline 1989, Hribar et al. 1992).

Various trap configurations were studied to identify: 1) a device that would attract anthropophilic tabanid species, such as *Chrysops atlanticus* Pechuman; 2) a device that would allow us to assess fly response to chemical attractants; and 3) a device whose design would be amenable to mass production and use in the field.

We chose canopy and Malaise traps for this purpose. Objects that are hung in the cone-shaped silhouette of the canopy trap increase the capture of tabanids (see references above), thereby facilitating its usefulness as an effective assessment tool. In comparison with the canopy trap the Malaise trap is poorly defined as a backdrop to the target. Thus, under these conditions a target in a Malaise trap might be responded to by the insect as an object by itself. This report is an assessment of selected targets we evaluated in canopy and Malaise traps from April 30 through August 30, 1991.

MATERIALS AND METHODS

Study area: The Wedge Plantation near McClellanville, SC, location of the University of South Carolina International Center for Public Health Research, served as the study site. It is a former rice plantation on the South Santee

[1] Mention of a commercial or proprietary product in this paper does not constitute an endorsement of this product by the United States Department of Agriculture.

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River. The highland portion, ca. 400 ha, consists of long-leaf pine/mixed pine and hardwood forest, former pastures and open, grassy areas. The remainder was ca. 400 ha of brackish marsh. Thousands of hectares of brackish marshes make up the Santee delta, and freshwater ponds and swamps of the area provide habitats for larvae of 72 species and subspecies of Tabanidae (M. A. Tidwell, unpublished data).

Canopy trap: Eight canopy traps modified after designs of Thorsteinson et al. (1965), Thompson (1969) and Thompson and Gregg (1974) were constructed (Fig. 1). Each trap has 4 foldable legs that are 1.8 m long; tent pegs are used to secure the trap to the ground. The trap skirt, fitted to enclose the legs, is one piece of UV-protected clear polyvinyl fastened at the top and extends down each leg 97 cm where it is tied. An inverted clear plastic jar with a removable screen funnel in its mouth is screwed to a jar lid that has been glued to the top. A hole is cut in the lid matching one in the top. Each jar contains 2.5 cm^2 of Vapona® plastic strip with 20% 2,2-dichlorovinyl dimethyl phosphate to kill trapped flies.

Malaise trap: Malaise traps (2), modified after the design of Townes (1962), were purchased from the John W. Hock Company, Gainesville, FL. Each trap is 5 m long × 2 m wide × 2 m high and is partitioned in the middle to intercept insects in flight. The partition causes flies entering from either side to move upward through a tubular path in the netting and into either one of the killing jars (Fig. 2).

Visual target: Shiny black spheres are reported to attract tabanids (Allan and Stoffolano 1986). The visual target we used is a 41-cm-diam vinyl ball fitted snugly with a black sateen polyester fabric cover. The target is light and moves in a breeze; it dries rapidly after being wet by rainfall, and the fabric cover can be impregnated with insecticide. The *standard* configuration for our visual target, designated henceforth as T, is the air-inflated vinyl ball covered with black sateen fabric. In the Malaise trap, the T is suspended from a 3-m long 0.95-cm (3/8 inch) concrete reinforcement bar of which the upper 60 cm is bent 20° from the vertical. The concrete reinforcement bar is driven into the ground and the T hung from the tip of the bent end by a string fastened to grommets in the cloth cover. The bottom of the T is 60 cm above ground level (Fig. 3).

In the canopy trap, T is suspended from a hook inside the trap so that its bottom half is exposed directly to air currents (Fig. 1). Because the Malaise trap was partitioned into 2 halves, flies approaching from either direction could be caught if attracted to either of 2 T, one hanging in each entrance (Fig. 2).

Test design: One pair of Malaise (locations M1 and M2) and 4 pairs of canopy traps (locations 1 through 8) were erected within a 100-ha area. Each pair, 50 m apart, constituted a treatment/control comparison. With all treatments, paired tests were chosen to minimize the effects of severe weather, accidents and differences in trap locations. For example, loss of one control

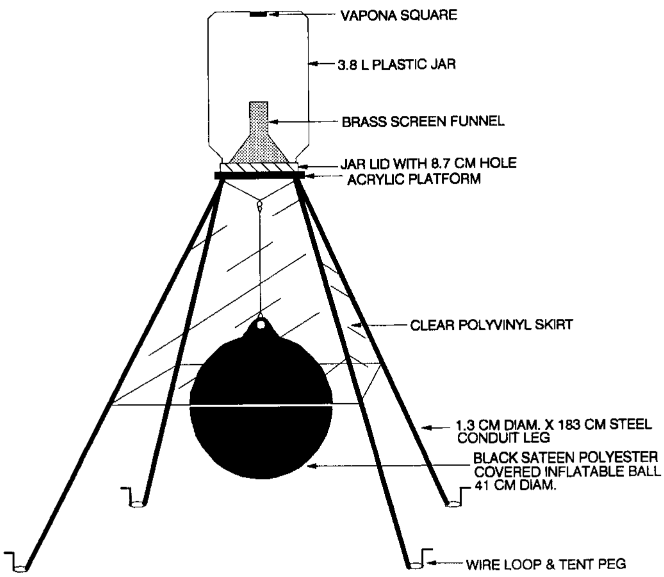

Fig. 1. Canopy trap and target.

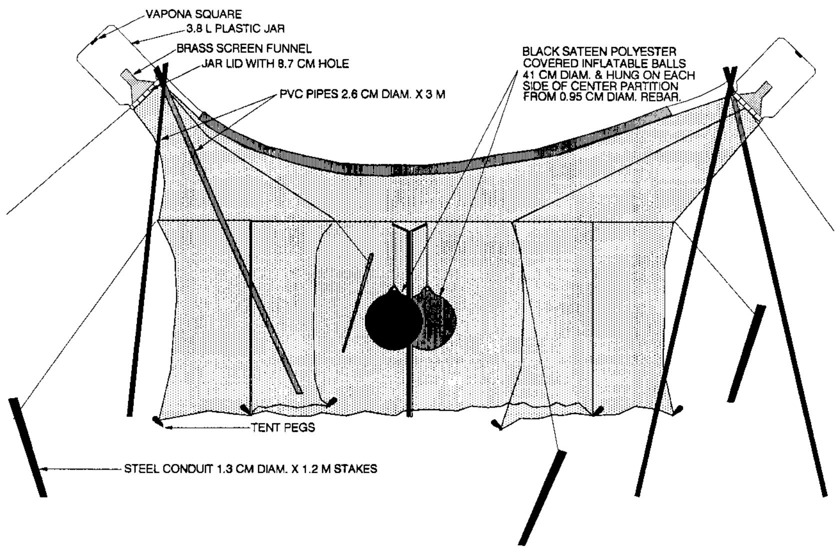

Fig. 2. Malaise trap and 2 targets positioned at each side of the screen partition.

among 7 treatments would mean loss of an entire test, whereas loss of one control among 4 paired tests would mean loss of only one of 4 tests.

Pairs were >200 m apart and were not visible from one site to the next. Site selection was based on published information and the authors' experience with both trap types. Thompson (1969) reports large open areas or dense forests are considered poor collection sites for tabanids. Consequently, the Malaise traps were placed near the tree line in an unshaded open grassy area, canopy traps along lightly shaded edges of wooded, open or lowland sites. Locations 1 and 2 were beside a gravel road in a mixed pine-hardwood forest; locations 3 and 4 at the edge of a pasture; locations 5 and 6 at the edge of a mowed field bounded by ponds, woods and a tree-lined unpaved road; and locations 7 and 8 on and near a dike between a blackwater cypress swamp and brackish marsh.

Tests began at 0800–1000 h, and 24 h later trapped flies were collected and stored in a freezer until identified, counted and recorded. Each day, treatments were reversed within each pair and replicated in each trap ≥3×/test site. Treatments were also evaluated at other sites within the study area, i.e., with one exception, ≥6 tests of each treatment were performed at ≥1 sites.

Treatments in Malaise traps consisted of:

1. T vs. no T, to determine if T increases the catch.
2. T inflated with carbon dioxide (CO_2) vs. Ts inflated with air, to determine if CO_2 increases catch as it diffuses from the vinyl ball. The air source was a battery powered pump, and the CO_2 from bottled gas.
3. Insecticide-treated (permethrin at 0.125 mg/cm^2) T vs. untreated T to determine if knockdown occurs when attracted flies touch the treated fabric. Collection jars without a killing agent.
4. T covered with a 15-mm thick black pile-like fabric vs. standard black sateen fabric covered T to determine if a textured or smooth T is more attractive.

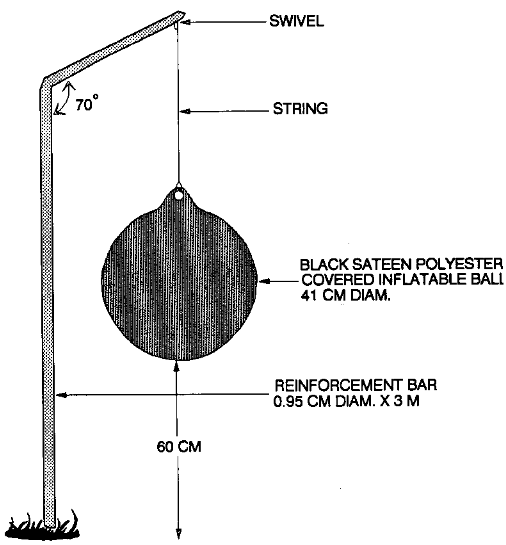

Fig. 3. Target hung from the steel bar.

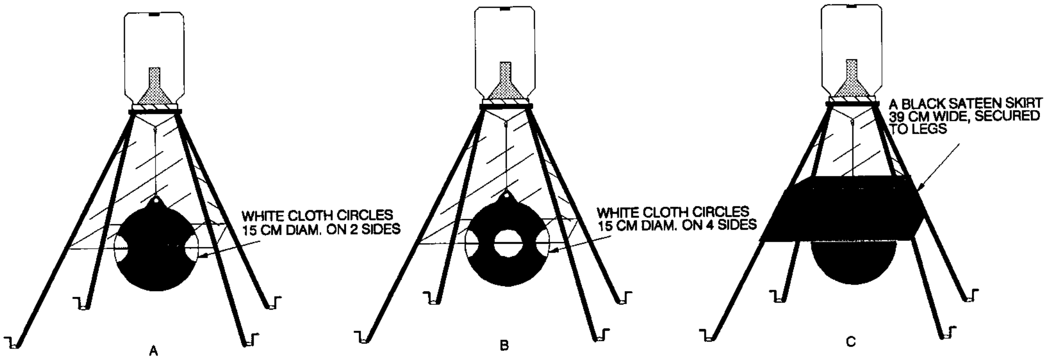

Fig. 4. Canopy trap: A) target with 2 white spots, B) target with 4 white spots, and C) trap with black skirt covering lower portion of the clear plastic cover.

Table 1. Mean number of tabanids captured in paired Malaise traps in 1991 comparing various candidate treatments added to standard Targets (T). Standard T was an air-inflated 41-cm-diam beach ball covered with black sateen polyester fabric.

Date	No. reps	T treatments	Means[1] Treatment	Control
May 28–June 11	8	T	211.5A	100.1B
May 1–9	6	T + CO_2	885.0A	836.3A
May 14–24	6	T + Permethrin[2]	566.3A	512.0A
June 12–21	7	T + Pile fabric	131.9A	128.0A
July 2–19	8	T + Pile fabric + Permethrin[3]	87.3A	59.5B
May 1–June 28	30	T Location M1	—	407.4A
		vs T Location M2[4]		380.9A

[1] Mean number of flies caught/day in trap with T (treatment) vs. trap without T (control), or with treated T vs. control T (untreated). Means followed by different letters are significantly different ($P = 0.05$).
[2] Cloth impregnated with 0.125 mg of permethrin/cm^2.
[3] Cloth impregnated with 0.25 mg of permethrin/cm^2.
[4] Total of 30 unpaired control tests analyzed.

5. Insecticide-treated (permethrin at 0.25 mg/cm^2) black fur-like fabric (see 4 above) covered T vs. untreated standard T, to determine if a textured T enhanced knockdown by increased fly/insecticide exposure. Collection jars without killing agent.

Treatments in canopy traps consisted of:

1. T inflated with CO_2 vs. air (see 2 above).

2. T with 2 (15 cm diam) white spots on opposite sides vs. T with no spots, to determine if spots increase catch (Hansens et al. 1971; see Fig. 4A).

3. T with 4 (15 cm diam) white spots on 4 sides vs. T with no spots, to determine if spots increase catch (Fig. 4B).

4. Trap with T and black sateen band 30 cm wide covering lower half of polyvinyl skirt vs. trap with T only, to determine if the black band increases the catch (Fig. 4C).

5. Insecticide-treated (permethrin at 0.125 mg/cm^2) T vs. untreated T, to determine if flies touch the treated fabric and are knocked down. Collection jars without killing agent.

6. T covered with thick pile-like black fabric (see Malaise treatment 4 above) vs. standard T to determine if a textured or smooth T is more attractive.

7. Insecticide-treated (permethrin at 0.25 mg/cm^2) black terry-cloth covered T vs. untreated black terry-cloth covered T, to determine if a textured T caused knockdown by increased fly/insecticide exposure. Collection jars without killing agent.

8. T plus 5 ml of 1-octen-3-ol (98% pure, hereafter referred to as octenol) vs. T, to determine if octenol increased catch, 24 and 48 h after treatment. Preliminary tests showed that octenol diffuses through the vinyl ball over 48 hours. To treat an inflated ball, air is released until the flow stops. Octenol is then pipetted through the open valve and the ball refilled with air. When the valve is closed, the ball is rotated

Table 2. Mean number of tabanids captured in paired canopy traps in 1991 comparing various candidate treatments added to standard Targets (T). Standard T was air-inflated 41-cm-diam beach ball covered with black sateen polyester fabric.

				Means[1]	
Date	No. reps	Test site	T treatment(s)	Treatment	Control
May 14–24	7	7, 8	T + Co2	29.3A	42.9A
May 1–June 11	19	All	T + 2 White spots	64.1A	54.1A
June 12–July 19	21	1, 2, 5, 6, 7, 8	T + 4 White spots	43.9A	61.1A
April 30–May 10	7	1, 2	T + Black band	82.3A	165.7A
May 6–10	3	3, 4	T + Permethrin[2] T + Permethrin[3]	26.7A	51.3A
June 12–21	7	3, 4	Terrycloth T + Permethrin[2]	21.4A	20.0A
July 5–19	31	1, 2, 3, 4, 5, 6	T + 5 ml Octenol	175.7A	35.6B
July 5–19	30	1, 2, 3, 4, 5, 6	T + 5 ml Octenol aged 48 h	147.0A	77.5B
July 5–19	30	1, 2, 3, 4, 5, 6	T + 5 ml Octenol T + 5 ml Octenol aged 48 h[4]	178.8A	147.0B
May 28–June 11	7	1, 2	T + 5 ml Octenol + CO_2 T + 5 ml Octenol[4]	862.4A	874.7A
May 28–June 21	8	7, 8	T + 5 ml Octenol T + 10 ml Octenol[4]	252.4A	223.5A
May 28–June 21	8	7, 8	T + 5 ml Octenol aged 48 h T + 10 ml Octenol aged 48 h[4]	151.4A	183.1B

[1] Mean number of flies caught/day in trap with treated T vs. trap with untreated T (control). Means followed by different letters are significantly different ($P = 0.05$).
[2] Cloth impregnated with 0.125 mg of permethrin/cm^2.
[3] Cloth impregnated with 0.25 mg of permethrin/cm^2.
[4] These means listed as control data in table.

to spread the treatment, then hung in the trap. The ball is treated every 48 hours.

9. T inflated with CO_2 plus 5 ml of octenol vs. T inflated with air plus 5-ml octenol, to determine if octenol and CO_2 in T was more attractive than octenol alone.

10. T plus 5 ml of octenol vs. T plus 10 ml octenol, to determine if additional octenol increased catch up to 48 hours.

The T plus octenol data for the 3 most abundant species of tabanids caught in canopy traps were analyzed to determine if sensitivity to octenol varied.

Data analysis: The paired data from all test series were analyzed by Student's *t*-test for significant differences (5% level) between treatments and controls. Total data from all Malaise trap control collections were analyzed to determine if there was significant variation in trap location.

RESULTS

A total of 69,954 tabanids representing 25 species were captured April 30–August 1991. The most abundant species were: *Tabanus lineola hinellus* Philip at 49,958, *Hybomitra vicina* Pechuman at 14,061, and *Chrysops atlanticus* at 2,608. The remaining 22 species were 5% of the total.

Tables 1 and 2 show fluctuations in overall numbers of flies captured between trapping

Table 3. Mean number of 3 tabanid species captured in canopy traps in 1991 when the standard Target (T) was treated with 5 ml of octenol aged 24 and 48 h. The standard T is an air-inflated 41-cm-diam beach ball covered with black sateen polyester fabric.

Species	Octenol age (h)	Mean no. trapped[1] Treatment	Control[2]
Chrysops atlanticus	24	10.8A	5.9A
C. atlanticus	48	5.9A	17.4B
Hybomitra vicina	24	50.9A	5.6B
H. vicina	48	24.3A	9.8A
Tabanus lineola hinellus	24	140.7A	28.8B
T. lineola hinellus	48	125.9A	53.7B

[1] Mean number of flies caught/day in trap with treated T vs. trap with untreated T (control). Means followed by different letters are significantly different ($P = 0.05$).

[2] The controls were canopy traps with the standard T without octenol.

dates. Some differences were due to reduced fly activity during inclement weather, but largely they were due to other factors such as position effects, seasonal population fluctuations and varied population peaks of abundant species. Highest captures of all species were in weeks 4–6 (late May to early June). *Hybomitra vicina* was most abundant weeks 1 and 2 in May, *C. atlanticus* weeks 2 and 3 in May and *T. lineola hinellus* weeks 3–8 (May to July) with highest numbers (>13,500) captured week 1 in June.

The mean number of tabanids captured in Malaise traps is shown in Table 1, and summarized as follows:

1. T attracted significantly more flies than no T.
2. T inflated with CO_2 was no more attractive than T inflated with air. Loss of CO_2 from T in 24 h averaged 3.3 g.
3. T treated with permethrin (0.125 mg/cm^2) had no significant effect on numbers of flies trapped.
4. T covered with a thick black fur-like cloth was no more attractive than the standard T.
5. T with a thick black fur-like cloth treated with permethrin (0.25 mg/cm^2), did not reduce fly capture due to knockdown as expected, but caught more flies than untreated T.

The mean number of tabanids captured in canopy traps is shown in Table 2, and summarized as follows:

1. T inflated with CO_2 was no more attractive than T inflated with air.
2. Two or 4 white spots did not make T more attractive.
3. A black sateen band over the trap skirt did not improve the catch.
4. T treated with permethrin (0.125 mg/cm^2) had no significant affect on numbers of flies trapped.
5. T with a black terry-cloth cover treated with permethrin (0.25 mg/cm^2), had no significant effect on numbers caught when compared with untreated black terry-cloth covered T.
6. T and 5 ml of octenol attracted significantly more flies up to 48 h than T without, but octenol-treated T aged 48 h attracted significantly fewer flies than treated T aged 24 hours.
7. T inflated with CO_2 and 5 ml of octenol was no more attractive than air inflated T and 5 ml octenol.
8. T and 10 ml of octenol was no more attractive than T and 5-ml octenol, but after 48 h of aging, 10-ml was significantly more attractive than 5-ml.

Mean numbers of the 3 most abundant species captured in paired canopy traps (T alone vs. T treated with 5-ml octenol) are shown in Table 3. *Chrysops atlanticus* was not attracted to T baited with octenol at 24 or 48 h after treatment. Moreover, >24 h after treatment, significantly more flies were caught in T control ($P = 0.05$). Significant numbers of *Hybomitra vicina* were attracted to T baited with octenol at ≤24 but not >24 to 48 h after treatment, whereas significant numbers of *T. lineola hinellus* were attracted to octenol baited T both time intervals after treatment.

DISCUSSION

Trials with Malaise traps established that T is attractive to tabanids. Octenol increased overall attractiveness of T, but CO_2 did not when released at the rate of 3.3 g/24 hours.

In traps with permethrin treated T, knockdown was insignificant among flies captured. Neither different types of treated fabrics nor doubling the dosage increased knockdown. Observation of fly behavior and actual contact with treated T failed because it was not possible to visually trace activity from initial approach to final capture or escape. A temporary groundcover of fiberglass screen under traps collected few fallen flies—cause of death unknown. However, when flies were forced to crawl briefly on T treated with permethrin at various dosages, they became moribund within 15–20 minutes. Thus, failure to find significant numbers of dead or knocked down flies in or under the traps may have been due to: 1) too brief or no contact with the treated T before capture, 2) contact with the treatment but flight without capture, and 3) ultimate survival or death, depending on lethality of acquired dosage.

Octenol with T was the most attractive combination tested. But it remains to be determined if the addition of permethrin to this attractive blend will kill or disable large numbers of flies. Failure to observe the anticipated knockdown effect in these studies necessitates the design of further assessment procedures to resolve the question, "Is the treated T a viable tabanid control device?"

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REFERENCES CITED

Allan, S. A. and J. G. Stoffolano, Jr. 1986. The effects of hue and intensity on visual attraction of adult *Tabanus nigrovittatus* (Diptera: Tabanidae). J. Med. Entomol. 23:83–91.

Anderson, J. F. 1985. The control of horse flies and deer flies (Tabanidae). Myia 3:547–598.

French, F. E. and D. L. Kline. 1989. 1-Octen-3-ol, an effective attractant for Tabanidae (Diptera). J. Med. Entomol. 26:459–461.

Gerhardt, R. R., J. C. Dukes, J. M. Falter and R. C. Axtell. 1973. Public opinion on insect pest management in coastal North Carolina. N. C. Ext. Agric, Ext. Serv. Misc. Publ. 97.

Granger, C. A. 1970. Trap design and color as factors in trapping the salt marsh greenhead fly. J. Econ. Entomol. 63:670–672.

Hansens, E. J., E. M. Bosler and J. W. Robinson. 1971. Use of traps for study and control of saltmarsh greenhead flies. J. Econ. Entomol. 64:1481–1486.

Hribar, L. J., D. J. Leprince and L. D. Foil. 1991. Increasing horse fly (Diptera: Tabanidae) catch in canopy traps by reducing ultraviolet light reflectance. J. Med. Entomol. 28:874–877.

Hribar, L. J., D. J. Leprince and L. D. Foil. 1992. Ammonia as an attractant for adult *Hybomitra lasiophthalma* (Diptera: Tabanidae). J. Med. Entomol. 29:346–348.

Neys, W. A., R. J. Lavigne and G. P. Roehrkasse. 1971. Attraction of Wyoming Tabanidae (Diptera) to decoys suspended from modified Manitoba fly traps. Univ. Wyoming Agric. Exp. Stn. Sci. Monogr. 22.

Oladunmade, M. A., W. Takken, L. Dengwat and I. Ndams. 1985. Studies on insecticide-impregnated targets for the control of riverine *Glossina* spp. (Diptera: Glossinidae) in the sub-humid savanna zone of Nigeria. Bull. Entomol. Res. 75:275–281.

Snoddy, E. L. 1970. Trapping deer flies with colored weather balloons (Diptera: Tabanidae). J. Georgia Entomol. Soc. 5:207–209.

Tabuchi, E. and A. Yajima. 1969. Control test of horse flies (Tabanidae) in the race course: I. improvement of traps. Exp. Rpt. Equine Health Lab. Tokyo, Japan 6:40–46.

Tabuchi, E. and A. Yajima. 1970. Control test of horse flies (Tabanidae) in the race course: II. collecting test of horse flies by an improved trap (Equine Health Laboratory Trap). Exp. Rpt. Equine Health Lab. Tokyo, Japan 7:1–11.

Thompson, P. H. 1969. Collecting methods for Tabanidae (Diptera). Ann. Entomol. Soc. Am. 62:50–57.

Thompson, P. H. and E. J. Gregg. 1974. Structural modifications and performance of the modified animal trap and the modified Manitoba trap for collection of Tabanidae (Diptera). Proc. Entomol. Soc. Wash. 76:119–122.

Thorsteinson, A. J., G. K. Bracken and W. Hanec. 1965. The orientation behavior of horse flies and deer flies (Tabanidae, Diptera): III. the use of traps in the study of orientation of tabanids in the field. Entomol. Exp. Appl. 8:189–192.

Townes, H. 1962. Design for a Malaise trap. Proc. Entomol. Soc. Wash. 64:253–262.

Wall, W. J., Jr. and O. W. Doane, Jr. 1980. Large scale use of box traps to study and control saltmarsh greenhead flies (Diptera: Tabanidae) on Cape Cod, Massachusetts. Environ. Entomol. 9:371–375.

Wilson, B. H. 1968. Reduction of tabanid populations on cattle with sticky traps baited with dry ice. J. Econ. Entomol. 61:827–829.