THE "AFS SWEEPER," A BATTERY-POWERED BACKPACK MECHANICAL ASPIRATOR FOR COLLECTING ADULT MOSQUITOES[1]

R. P. MEYER[2], W. K. REISEN[2], B. R. HILL[2] AND V. M. MARTINEZ[2]

Department of Biomedical and Environmental Health Sciences, School of Public Health, University of California, Berkeley, CA 94720

ABSTRACT. The "AFS (Arbovirus Field Station) Sweeper" was designed and constructed to collect mosquitoes from various resting sites in the southern San Joaquin Valley of California. The sweeper offers backpack portability and maneuverability, rapid exchange of screened collecting cartons, and increased suction from a 12-volt DC blower powered by 2 gel cell 6V8A batteries that are connected in series.

Field trials demonstrated that when the sweeper was operated for either 10 or 15 minutes per collection, the unit was effective for collecting male and female *Culex tarsalis, Cx. quinquefasciatus* and *Culiseta inornata* from different types of vegetation associated with foothill and valley agricultural habitats. The male to female sex ratios of *Cx. tarsalis* collected by the sweeper were significantly higher in the habitats sampled than the ratios in concurrent collections from artificial shelters.

INTRODUCTION

Since the introduction of the backpack suction sampler of Dietrick (1961) and the "CDC Sweeper" of Hayes et al. (1967), the basic design of these sweepers has been changed considerably to accommodate either increased area sampled (Nasci 1981) or greater portability (Davis and Gould 1973). We found the sweepers designed by Davis and Gould (1973) and Nasci (1981) were not suited (i.e., lacked sufficient portability, maneuverability and/or suction) for collecting resting mosquitoes from vegetation as well as natural and artificial shelters in foothill and agricultural habitats in Kern County, California, USA. Subsequently, the "AFS (Arbovirus Field Station) Sweeper" was designed to incorporate increased suction, gel cell battery operation, rapid exchange of 1 pint (.47 liter) screened collection cartons and greater maneuverability. Our paper gives detailed plans for constructing the "AFS Sweeper" and compares concurrent sampling of adult mosquito populations with the sweeper to samples from artificial shelters (red and cardboard boxes) and CO_2 light traps in 2 different habitats in Kern County.

MATERIALS AND METHODS

SWEEPER CONSTRUCTION The sweeper consists of 2 basic components: (1) a backpack frame that supports the blower and 2 CF6V8 Carefree® gel cell batteries connected in series, and (2) a collecting nozzle that houses a 1 pint (0.47 liter) paper can (screened on the bottom) within the handle assembly (Figs. 1 and 2). The details of the component assembly, use of hardware, and wiring are illustrated in Fig. 1. The parts needed to construct one sweeper unit are listed in Table 1. Most of the sweeper parts/components, with the exception of the gel cell batteries, were purchased locally from hardware, plumbing, automotive and electrical supply stores (total unit cost ca. $125). Any gel cell type rechargeable battery can be substituted for the 2 CF6V8A Carefree® batteries we used; however, the battery(s) must deliver 12 volts with a minimum of 16 amps of current to operate the blower at sufficient rpm's continuously for ca. 1-hr. The air displacement of the Dayton® 2C646 blower was ca. 2.12 m^3 min when connected to 2 fully-charged batteries. The improved suction capacity was more than adequate for aspirating resting mosquitoes from vegetation without injuring the adults that are held firmly against the collection carton screening. The sweeper (15″ nozzle) can also be used for collecting adults from artificial shelters, privys, chicken coops, etc. We recommend that several sets of fully charged batteries be available for exchange in the field during extensive sampling. The combined weight of the backpack components can be reduced slightly by eliminating the 90° ABS elbow (L) connecting ring (J) and short section of 4″ × ⅛″ pipe (K), and clamping the 4″ diam. defroster hose directly to the lip of the closet ring (I). The location of the power switch (mini line cord switch) on the pack frame is optional.

The placement of the screened collection carton within the handle assembly (Fig. 1 and 2 *4* (P)) allows for rapid and easy exchange of the

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[2] Arbovirus Field Station, P.O. Box 1564, Bakersfield, CA 93302.

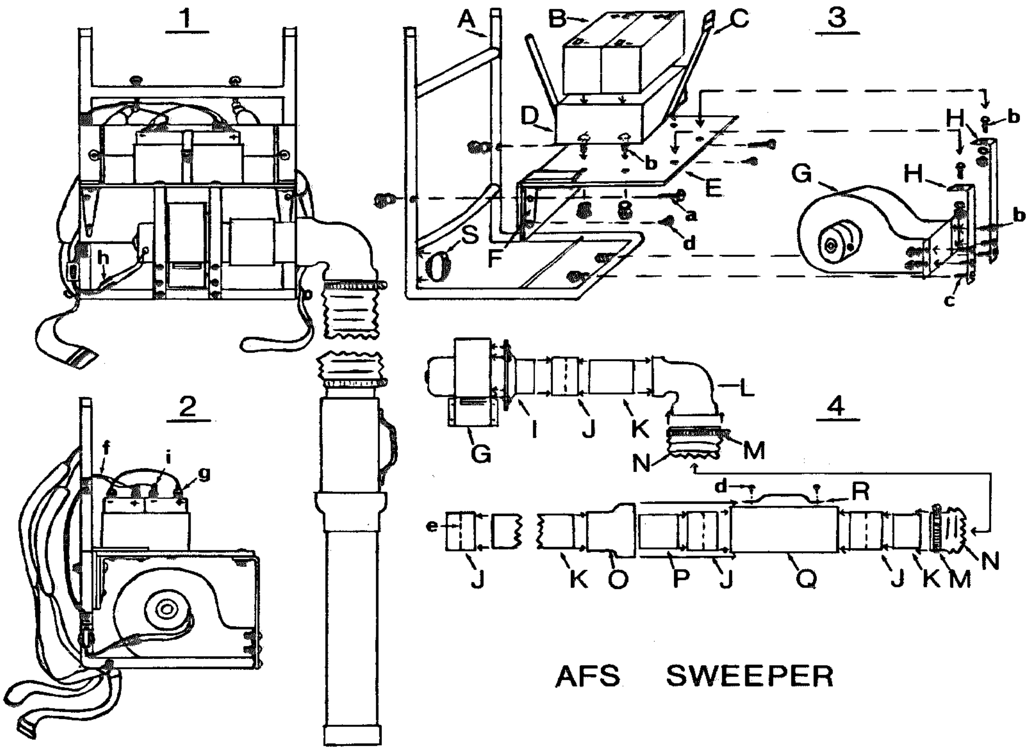

Fig. 1. Diagrams illustrating the construction of the "AFS Sweeper." Refer to Table 1 and the text for the descriptions of the components/parts A-S. *1* Rear view of sweeper, *2* side (left) view of sweeper, *3* assembly of the backpack, battery, and blower components, and *4* assembly of the collection component and nozzle.

cartons. Collection cartons are exchanged with the blower on. The nozzle is removed (Fig. 1), the carton containing the mosquitoes and other arthropods is sealed by replacing the lid, the covered carton is removed and replaced by an empty carton. The nozzle is slipped back over the front end of the handle assembly and the collector resumes sampling. The front rim of the handle assembly (Q) should be lightly greased to allow the nozzle to slip on and off easily.

The cartons containing adult mosquitoes are labeled and transported back to the laboratory in an insulated box or ice chest. When inverted with the screened end up, mosquitoes can be fed 10% sucrose and/or humidified with moist toweling to enhance survival. Adults handled in this manner were suitable for age-grading, blood meal identifications and pooling for arbovirus isolations.

Collection cartons are constructed from 1 pint (.47 liter) Fonda® paper cans. The bottom of the carton is removed and screened with either aluminum or fiberglass window screening, or a durable nylon screening. The mesh size should not restrict the air flow through the carton. Since the carton lid is replaced after each sample, the lip of the carton should be wrapped with a single thickness of ½″ adhesive tape to assure a snug fit. To prevent dried plant material from being sucked into the nozzle and clogging the screening on the collection carton bottom, screen the end of the nozzle with either ¼″ or ½″ hardware cloth. The elimination of plant material from collections increased adult mosquito survival and made processing much easier.

FIELD EVALUATION. The sweeper was used to sample adult mosquitoes resting in the vegetation understory at 2 sites, Breckenridge Road, Canyon B (foothill terrain) and John Dale Ranch (valley mixed agricultural), in Kern

Table 1. Parts list and source of the AFS sweeper components. (Components not mentioned in footnotes can be obtained at most local hardware, plumbing supply and auto supply (defroster hose) stores.)

Component[1]	Description	Quantity	Component[1]	Description	Quantity
A	L-shaped backpack frame (ca. 13″ x 20″ x 9″)	1	I	3″ ABS closet ring	1
			J	3″ ABS coupling ring	4
B[2]	Gel cell rechargeable batteries (CF6V8 Carefree®)	2	K	3″ x ⅛″ thick white ABS pipe (long nozzle: 30″, short nozzle: 15″)	ca. 4′
C	Nylon strap with buckle (½″ x 16″)	1	L	3″ 90° ABS long elbow	1
			M	3″ stainless steel hose clamp	2
D	Battery compartment (fabricated from 1½″ x 3″ aluminum moulding)	2′ length	N	4″ defroster hose	ca. 4′
			O	3″ x 4″ ABS reducer	1
E	¼″ plywood platform for battery and blower support (top: 8″ x 13″; back: 5″ x 13″)	ca. 2 ft.^{2}	P[4]	Collection carton: 1 pt. paper can with aluminum or nylon screened bottom (Fonda®, item no. 106)	12–24
F	4″ ‘L’ or shelving brackets	2			
G[3]	12 V (DC) Dayton® model 2C646 blower	1	Q	4″ x ¼″ ABS pipe	ca. 1′
			R	Screen door handle	1
H	Blower and battery supports (1″ x ⅛″ aluminum strips)	ca. 2′	S	Mini line cord switch	1
Miscellaneous hardware and electrical items					
a	1¾″ x ¼″ carriage bolts ¼″ hex nuts, ¾″ lock washers	2 ea.	e	½″ or ¼″ hardware cloth	ca. 1 ft.^{2}
			f	12 V heavy duty insulated wire	3′
b	10/24″ x ¾″ rnd. hd. machine screws, 10/24″ hex nuts and ¾″ lock wshrs.	10 ea.	g	Push-on type quick disconnects (¼″ female)	2
			h	Butt connectors	2
c	10/24″ x 1″ rnd. hd. machine screws, 10/24″ hex nuts and ¾″ lock wshrs.	2 ea.	i	Alligator clips	2
d	½″ x 16″ wood screws	12 ea.			

[1] Refer to Fig. 1.
[2] Eagle Picher, P.O. Box 130, Seneca, MO 64856.
[3] Dayton Electric Mfg. Co., Chicago, IL 60648.
[4] Fonda/Royal Lace Group, 2401 Morris Ave., Union, NJ 07083.

County during the spring and summer of 1982. Sweeper samples were of 10 min duration at Breckenridge Road and of 15 min duration at John Dale Ranch. Samples were taken from microhabitats such as grasses, low growing shrubbery, litter, under logs, soil cracks, etc., that appeared to provide adequate shelter for resting mosquitoes.

Sweeper efficiency was evaluated operationally by comparing mosquito species/sex abundance and diversity concurrently with collections from artificial shelters (red and cardboard boxes) and CDC miniature light traps (Sudia and Chamberlain 1962) augmented with dry ice (CO_2LT) placed within or adjacent to the habitats sampled by the sweeper. A more detailed description of the field sites and placement of artificial shelters and CO_2 light traps is presented in Reisen et al. (1983) (Breckenridge Road) and Reeves et al. (1983) (John Dale Ranch).

RESULTS AND DISCUSSION

The species composition and abundance of mosquitoes collected by the "AFS Sweeper" in artificial shelters and CO_2LT's in the 2 habitats are presented in Table 2. Compared to the other 2 sampling methods, sweeper efficiency was variable but representatively sampled males and females of *Culex tarsalis* Coquillett, *Cx. quinquefasciatus* Say and *Culiseta inornata* (Williston) (spring only). The male to female ratio of *Cx. tarsalis* was significantly higher in sweeper than in artificial shelter collections in both habitats. These data were interesting in that our sweeper samples were markedly biased towards the capture of males. We suspect that males of *Cx. tarsalis* were more easily aspirated by the sweeper and/or that females were more abundant in microhabitats separate from those we sampled. Davis and Gould (1973), using a similarly designed sweeper in Thailand, also found

Table 2. Relative abundance and species composition of mosquitoes sampled concurrently by the AFS Sweeper, artificial shelters and CO_2LT's in 2 habitats in Kern County, California, 1982.

		AFS Sweeper		Shelter		CO_2 light trap	
Locaton (Habitat)	Species	No. collected ♂/♀	Ratio ♂/♀	No. collected ♂/♀	Ratio ♂/♀	No. collected ♂/♀	Ratio ♂/♀
		[a](N = 15)		[b](N = 16)		[c](N = 9)	
[d]Breckenridge Road (Foothill)	*Anopheles franciscanus*	0	—	5/2	2.5:1	0/3	0.0 :3
	Culex peus-thriambus	0	—	3/2	1.3:1	0/1	0.0 :1
	Culex tarsalis	276/66	4.2:1***[f]	3976/1513	2.6:1	51/2941	<0.1 :1
	Culiseta incidens	0	—	10/25	0.4:1	0	—
	Culiseta inornata	64/2	32.0:1***	41/17	2.4:1	1/7	0.14:1
		(N = 19)		(N = 19)		(N = 29)	
[e]John Dale (Mixed agricultural)	*Aedes melanimon*	4/1	4.0:1	1/3	0.3:1	10/275	<0.1:1
	Aedes nigromaculis	0	—	0	—	0/8	0.0:8
	Aedes sierrensis	2/0	2.0:0	0	—	0	—
	Anopheles franciscanus	0	—	0/1	0.0:1	0	—
	Culex peus-thriambus	0	—	0/7	0.0:7	0/1	0.0:1
	Culex quinquefasciatus	32/26	1.2:1	50/42	1.2:1	0/121	0.0:121
	Culex tarsalis	708/394	1.8:1*	996/652	1.5:1	118/3276	<0.1:1
	Culiseta inornata	0/1	0.0:1	1/2	0.5:1	0/1	0.0:1

[a] No. of samples from vegetation and natural shelters.
[b] No. of sampling occasions: Breck. Rd., Cyn. B (data combined from 3 walk-in and 12 1 ft.^{3} red boxes), John Dale (data combined from 8 cardboard units sampled in July and 12 cardboard units sampled in August).
[c] No. of trap nights at Breck. Rd., Cyn. B (data from CO_2LT No. 2) and John Dale (data from CO_2LT Nos. 3 and 4).
[d] Sampling dates: April 5 to July 6.
[e] Sampling dates: July 7 to August 20.
[f] *** ($P < 0.001$), * ($P < 0.05$) significantly different from shelter when tested by contingency x^2 (Sokal and Rohlf 1969).

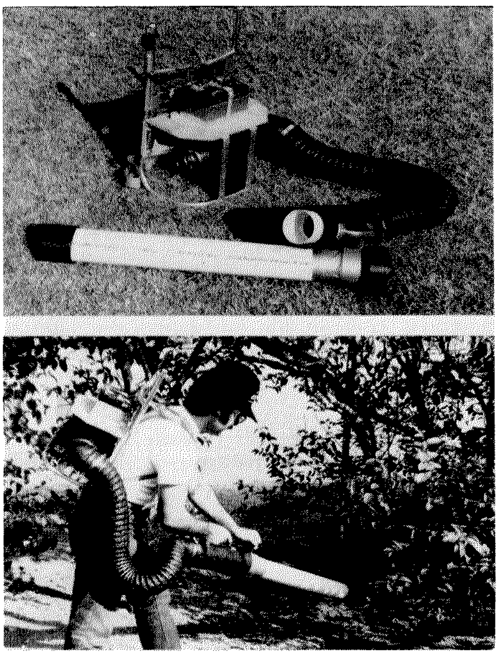

Fig. 2. Upper photo: AFS Sweeper with the nozzle removed showing the placement of the 1 pint collection carton; Lower photo: The sweeper in use.

spatial differences in sex ratios between 2 distinct habitats. The ratio of males to females was 1.34:1 (data combined from 10 species) in an orchard, but only 0.48:1 (data combined from 17 species) in a forest. Thus, the ability of the sweeper to collect representative samples of males and females that are proportionate to naturally occurring ratios is apparently dependent, in part, upon the ability of the sweeper to penetrate resting habitats and collect adults as they are distributed in nature. In conclusion, the "AFS Sweeper" was highly adaptable to our sampling requirements and was effective for collecting mosquitoes in the habitats we sampled.

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LIFETIME MATING PATTERN OF LABORATORY-ADAPTED *CULEX TARSALIS* MALES

MARTHA E. BOCK, WILLIAM K. REISEN AND MARILYN M. MILBY

Department of Biomedical and Environmental Health Sciences, School of Public Health, University of California, Berkeley, CA 94720

ABSTRACT. The lifetime mating pattern of *Culex tarsalis* males was determined under insectary conditions. Thirty males were individually confined in 4 liter carton cages and were offered new harems of 4–8 day-old virgin females each day from emergence to death. The numbers of males alive and females inseminated per day were used to calculate male life tables, applying statistical methods developed for female mosquitoes.

Male survivorship was estimated to be 98% per day and life expectancy was 29 days at emergence. The mortality rate was greatest between days 15 and 21 of adult life, when 33% of the cohort died. The number of males mating per day was greatest between days 2 and 9, decreasing to zero by day 37. Mating activity was renewed between days 46 and 55. The maximum number of females mated per male per night was 4. Mean lifetime reproductive effort was 12.2 females inseminated per male (range = 0 to 29). Four males accounted for 105 (29%) of the total 360 inseminations. Reproductive effort (females inseminated per male) increased as a function of male longevity, i.e., males living longer inseminated more females.

INTRODUCTION

The success of a genetic control program depends upon a thorough understanding of mosquito population dynamics and the lifetime pattern of reproduction of both sexes. While much is known about the reproductive biology of female *Culex tarsalis* Coq. (McDonald et al. 1979, Nelson and Milby 1982, Zalom et al. 1981), knowledge of male reproductive biology is limited to the laboratory observations of Asman (1975). Since the population dynamics and mating behavior of male mosquitoes is poorly understood, it is difficult to predict the potential contribution of genetically altered males to the gene pool of the target population and thus, decisions pertaining to release rates are often speculative.

Laboratory observations have indicated inter-specific differences in male mating performance which have been associated with variations in reproductive potential. Mahmood and Reisen (1982) found that the reproductive system of *Anopheles stephensi* Liston males rejuvenated after mating, with the replenishment of spermatozoa in the testes and postgonadal system and male accessory gland substance in the accessory glands. Conversely, Hausermann and