INSECT PEST MANAGEMENT IN COASTAL AND ESTUARINE HABITATS

A summary Report of Progress on
Research Supported by the N.C. Sea Grant Program
and the N. C. Water Resources Research Institute

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INTRODUCTION

Control of the biting flies and mosquitoes affecting man and animals in coastal and estuarine zones is a difficult task, but is frequently necessary to prevent disease transmission and to provide relief from attack for the citizens and segments of the economy, especially the tourist and recreation industries. The extreme ecological importance of these areas makes it essential that the populations of these insect pests be managed by methods that are compatible with the estuarine ecosystem. Many of the biting flies and mosquitoes breed in the marshes which support an abundance of marine life and are a source of nutrients. Ecologically sound insect control in this situation requires the judicious meshing of different methods (chemical, cultural, biological) into a program of pest management.

The term "pest management" denotes an approach to the reduction of a pest problem in which decision-making is based on consideration of what is ecologically and economically in the long-term best interest of mankind. Inherent in the concept is an orientation to the entire pest population in a large area. The objective is to lower the mean level of abundance of that population by methods or a combination of methods which supplement the natural control agents, give long term alleviation of the problem, and cause the least disruption of the ecosystem. It is based on the realization that natural pest populations can not be eliminated; rather they must be managed so that they occur at tolerable levels.

The concept of pest management is in contrast to the more general practices of insect control which are based on immediate, short-term alleviation of a problem in a localized outbreak. This approach to pest control was fostered by the availability of synthetic chemical insecticides. The ad hoc control programs using these chemicals have led to environmental contamination, deleterious effects on non-target organisms and severe problems of insect resistance to the agents. Likewise, certain cultural practices, such as ditching and filling of marshes for mosquito control often have been practiced for the immediate short-term benefit of a locality with

inadequate consideration of the long-term effects. Short-term ad hoc control practices have been inadequate and must be replaced by pest management programs as rapidly as possible.

In the coastal and estuarine ecosystems, management of the biting fly and mosquito populations must take into account the long-term importance of these systems to mankind not merely the short-term demands of the public or of a segment of the economy. A management program will require measured and selective use of chemical and cultural practices tailored to local conditions and applied in a manner to supplement the natural control agents. The object will be to suppress the pest population below the level of economic importance to man with minimal interference with the estuarine ecosystem.

A pest management program adequate for meeting societies demands for control of biting flies and mosquitoes will incorporate some selective use of insecticides, strategic ditching and impoundment of marshes, personal protection procedures, and biological control agents (parasites, predators, and pathogens). Prerequisites to planning the proper mix of these methods is research on the ecology of the pests in relation to the individual methods and local conditions. Much more data are needed on the breeding habitats of these estuarine pests and the factors regulating their abundance.

Areas of Carteret Co. NC are being used as a model to develop the requisite data required for a pest management program in a coastal and estuarine situation. Initially it is necessary to determine: 1. What species of pests are present? 2. Which ones are of economic importance?, 3. Where do they breed?, and 4. What factors regulate their abundance? Research has been in progress (1970-71) on two phases:

1. The populations and breeding habitats of biting flies (Tabanidae).
2. The effect of ditching Juncus marsh on the production of mosquitoes.

Research is continuing in 1972 on those phases and, in addition, studies are being initiated on:

1. The populations and breeding habitats of biting gnats (Culicoides).
2. The economic thresholds of the major biting flies and mosquitoes.

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Personnel involved in this research program have been, T. D. Edwards, W. Dale, D. Kline, R. LaSalle, M. A. Tidwell, J. Dukes.

SUMMARY OF PROGRESS

1. Collection of adult Tabanidae for one season in several localities along the coast of North Carolina and for a season more intensively in Carteret County indicate the following species to be most abundant and of probable economic importance:

   Chrysops atlanticus
   Chrysops fuliginosus
   Tabanus nigrovittatus
   Tabanus quinquevittatus
   Tabanus lineola

   There are about 40 other species of Tabanidae which in particular times and places may become serious pests.

2. Less extensive survey procedures indicate the importance of biting gnats (Ceratopogonidae) in the coastal counties. Major pest species are: *Culicoides furens* and *C. melleus*. Four other species may become important pests under certain circumstances.

3. Observations on pest mosquitoes (Culicidae) indicate the pest status of *Aedes sollicitans*, *Aedes taeniorhynchus*, *Anopheles atropos*, *Anopheles bradleyi* and *Psorophora confinnis*. Probably about 6 other species may on occasion be important pests.

4. Experiments were conducted on the populations and movement of tabanids in *Spartina* and *Juncus* marshes. Populations were higher in the *Spartina* situation. District patterns of adult emergence and movement inland from the marshes were shown for *T. nigrovittatus*, *C. atlanticus* and *C. fuliginosus*.

5. Experiments were conducted to improve trapping and survey methods. The optimal height of sticky-panel traps was determined. A new covered sticky trap design proved very effective.

6. Soil samples from a Spartina marsh indicated the presence of tabanid larvae (C. fuliginosus and T. nigrovittatus) throughout the area sampled and not restricted to a zone near ditches as was hypothesized.

7. Tabanus lineola and T. quinquevittatus were demonstrated experimentally to transmit hog cholera virus to susceptible swine within 2 hrs. after biting a virus-source pig. Three other species of Tabanus were incriminated in in transmission. These results are scheduled for publication in the J. Veterinary Research early in 1972. This investigation was conducted in cooperation with the Animal Health Division, ARS, USDA and the N.C. Dept. of Agriculture.

8. In a comparison of mosquito populations breeding in high marshes, the most commonly encountered species were: Aedes sollicitans, Aedes taeniorhynchus, Anopheles bradleyi, Anopheles atropos, and Culex salinarius. The Aedes species were developing mostly in sites in or near the wooded margins of the marshes. The other 3 species were breeding throughout the marsh area. There was little difference between the ditched and unditched study areas in terms of the percent survival of the mosquitoes (i.e. the successful emergence of adult mosquitoes before a site dried). The ditched and unditched study areas were very similar in the number of periods of sufficient water accumulation to allow mosquito production.

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1.1 Seasonal Distribution of Tabanid Species in Coastal Areas of North Carolina, 1970.

Weekly collections of tabanids were made in the following coastal counties: New Hanover, Pender, Onslow, Carteret, Beaufort, Chowan, Gates and Perquimans. Most collections were by canopy traps left in a location throughout the season and periodically supplemented with CO_2. Other collections were made by netting from humans and livestock.

Of the 46 species collected, the 10 most numerous were: Chrysops niger taylori Philip, C. obsoletus Wiedmann, C. vittatus floridanus Johnson, Diachlorus ferrugatus (Fabricius), Tabanus lineola Fabricius, T. melanocerus Wiedemann, T. nigripes Wiedemann, T. nigrovittatus Macquart, T. pestiolatus Hine and T. quinquevittatus Wiedemann. These species are capable of being economically important pests in certain localities.

A summary of the collections is presented in Table 1.

Table 1. Seasonal Distribution of Tabanid Species in Coastal Areas of North Carolina, Based on Combined Weekly Collections, 1970.

Species	4/19 4/25	4/26 5/2	5/3 5/9	5/10 5/16	5/17 5/23	5/24 5/30	5/31 6/6	6/7 6/13	6/14 6/20	6/21 6/27	6/28 7/4	7/5 7/11	7/12 7/18	7/19 7/25	7/26 8/1	8/2 8/8	8/9 8/15	8/16 8/22	8/23 8/29	8/30 9/5	9/6 9/12	9/13 9/19	9/20 9/26	9/27 10/3
Chrysops																								
atlanticus							+		+					+	+	+	+							
brimleyi	+	+	+	+	+	+	+																	
callidus				+	+	+	+	+		+														
celatus				+	+	+	+								+	+	+							
dimmocki				+	+	+	+	+							+								+	
flavidus				+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+		+	+	
fuliginosus						+	+																	
geminatus			+	+																				
macquarti			+	+	+	+	+	+	+	+		+												
moechus							+																	
niger taylori	+	+	+	+	+	+	+																	
nigribimbo										+	+													
obsoletus					+	+	+	+	+	+	+	+	+	+	+	+	+				+			
pikei				+			+	+			+	+												
reicherti				+			+	+	+	+									+	+		+		
univittatus							+	+	+	+						+			+			+		
vittatus							+	+	+	+	+	+	+	+										+
vittatus floridanus							+	+	+	+	+	+	+	+	+									
Diachlorus																								
ferrugatus						+	+	+	+	+	+	+		+	+	+	+							
Leucotabanus																								
annulatus														+		+								
Chlorotabanus																								
crepuscularis										+								+		+				
Hybomitra																								
lasiophthalima	+	+	+	+					+	+		+		+	+									

Table 1. continued. Seasonal Distribution of Tabanid Species Based on Combined Weekly Collections at All Trap Locations, 1970.

Species	4/19 4/25	4/26 5/2	5/3 5/9	5/10 5/16	5/17 5/23	5/24 5/30	5/31 6/6	6/7 6/13	6/14 6/20	6/21 6/27	6/28 7/4	7/5 7/11	7/12 7/18	7/19 7/25	7/26 8/1	8/2 8/8	8/9 8/15	8/16 8/22	8/23 8/29	8/30 9/5	9/6 9/12	9/13 9/19	9/20 9/26	9/27 10/3	10/4 10/10	10/11 10/17
Tabanus aar															+	+	+	+	+							
americanus									+	+	+	+	+	+				+								
atratus							+	+	+						+		+	+		+		+				
calens																			+	+	+	+	+			
fulvulus				+			+	+	+		+	+	+													
fuscicostatus										+	+	+	+		+	+			+							
gladiator										+									+	+	+	+				
gracilis									+	+		+	+	+				+	+		+					
lineola			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+			+
melanocerus							+	+	+	+	+	+	+	+	+	+	+	+	+		+					
molestus							+				+		+					+								
mularis										+					+			+	+	+	+	+				
nigripes						+					+	+	+		+	+	+	+	+	+	+	+	+			
nigrovittatus					+	+	+	+	+	+	+	+	+				+	+	+	+	+		+			
pallidescens													+													
petiolatus						+	+	+	+	+	+	+	+	+	+	+	+	+	+							
pumilus		+	+	+	+	+	+	+	+		+						+									
quinquevittatus															+	+	+	+	+	+	+	+	+			
sparus milleri							+	+	+	+	+		+		+											
subsimilis		+	+	+	+	+	+	+			+	+	+			+	+	+	+	+	+					
sulcifrons																				+	+	+	+			+
trimaculatus				+	+	+	+	+	+	+	+	+	+													
zythicolor													+		+			+			+					+

1.2 Seasonal Distribution of Tabanid Species in Carteret Co., N.C., 1971.

Weekly collections were made at the following sites in Carteret Co.: Morehead City (vicinity of Newport River), Williston, Davis, North River, Gales Creek, and Atlantic Beach. Collections were by canopy traps periodically supplemented with CO_2. Additional collections were made by netting from humans. This seasonal study was supplemented by data from box traps and sticky panel traps as presented in section 2.

Of the 44 species collected, the most numerous and of probable economic importance were: Chrysops atlanticus Pech., C. fuliginosus, Wiedemann, Diachlorus ferrugatus (Fabricius), Tabanus nigrovittatus Macquert, T. quinquevittatus Wiedemann, T. lineola Fabricius.

A summary of the collections is presented in Table 1.

Table 1. Seasonal Distribution of Tabanid Species in Carteret Co., North Carolina, Based on Combined Weekly Collections, 1971.

Species	4/19 4/25	4/26 5/2	5/3 5/9	5/10 5/16	5/17 5/23	5/24 5/30	5/31 6/6	6/7 6/13	6/14 6/20	6/21 6/27	6/28 7/4	7/5 7/11	7/12 7/18	7/19 7/25	7/26 8/1	8/2 8/8	8/9 8/15	8/16 8/22	8/23 8/29	8/30 9/5	9/6 9/12	9/13 9/19	9/20 9/28
Chrysops																							
atlanticus					+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
brimleyi			+	+	+	+	+	+															
callidus					+																		
celatus					+	+	+			+													
cinaticornis					+	+																	
dommocki						+																	
dorsovittatus						+		+	+														
floridanus			+	+	+	+	+		+	+		+		+	+	+	+		+	+	+	+	
fulginosus		+	+	+	+	+	+	+															
macquarti					+		+	+	+	+													
niger taylori					+	+	+					+											
nigribimbo									+	+	+			+	+								
obsoletus									+	+	+	+			+								
pudicus										+													
piekei																						+	
vittatus														+									
vittatus floridanus										+	+	+	+		+								
Diachlorus ferrugatus										+	+	+	+	+	+								
Leucotabanus annulatus												+	+	+		+							
Chlorotabanus crepuscularis								+		+	+	+	+	+	+								
Hybomitra																							
daecke			+	+	+	+	+		+	+													
hinei							+	+	+	+	+	+	+		+								
lasiophthalima	+	+	+	+	+	+	+		+														

Table 1. continued. Seasonal Distribution of Tabanid Species in Carteret Co., North Carolina, Based on Combined Weekly Collections, 1971.

Species	4/19 4/25	4/26 5/2	5/3 5/9	5/10 5/16	5/17 5/23	5/24 5/30	5/31 6/6	6/7 6/13	6/14 6/20	6/21 6/27	6/28 7/4	7/5 7/11	7/12 7/18	7/19 7/25	7/26 8/1	8/2 8/8	8/9 8/15	8/16 8/22	8/23 8/29	8/30 9/5	9/6 9/12	9/13 9/19	9/20 9/28
Tabanus																							
aar																+	+		+		+	+	
americanus									+	+	+	+	+	+	+	+							
atratus						+	+	+	+	+		+				+	+		+	+	+	+	+
calens																							+
fulvulus										+													
fuscicostatus							+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+
fusconervosus									+	+	+												
gladiator						+										+				+	+	+	+
gracilis										+	+	+	+	+	+		+		+	+	+	+	
imitans									+	+													
lineola			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
melanocerus									+		+	+	+	+	+	+	+	+	+	+			
molestus									+						+								
nigripes					+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
nigrovittatus					+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
petiolatus									+	+	+	+	+	+	+	+	+	+	+	+	+		
pumilus				+	+	+	+	+	+	+			+										
quinquevittatus										+		+	+	+	+	+	+	+	+	+	+	+	+
sparus milleri									+	+	+	+		+		+	+						
sulcifrons																					+	+	+
trimaculatus								+															

2.1 Populations and Movement of Tabanids in a *Spartina* Marsh Habitat

The seasonal populations of adults and their movement in a *Spartina alterniflora* marsh were determined. The marsh was located along the Newport River, Morehead City, N.C. (Fig. 1). Sticky panel traps (18) were located 30 m apart in 3 lines extending from the marsh into an adjacent pine woods. Each sticky trap consisted of 4 black panels (ft^2) mounted on a pole 2 m about the ground. The flies trapped on the 8 surfaces were counted twice a week and the sticky material renewed. Additional data on the species and seasonal occurrence were provided by box traps and netting.

The principal species occurring were *Tabanus nigrovittatus*, *Chrysops atlanticus* and *C. fuliginosus*. Only a very few specimens of the other species were collected by the sticky traps, box traps or netting during the course of this experiment (25 May - 26 Sept. 1971).

T. nigrovittatus were most abundant during the period 5 June - 9 July although low numbers occurred in July and August. The numbers of flies were greatest on the marsh and decreased inland with low numbers trapped in the pine woods (Table 1).

Chrysops atlanticus (Table 2) occurred in low numbers throughout the season but had 2 distinct peaks of abundance (suggesting 2 generations perhaps). They were abundant during late May and early June (21 May - 15 June) and during late August (23 Aug. - 4 Sept.). They were most abundant in the traps located in the pine woods and decreased in numbers further out on the marsh.

Chrysops fuliginosus (Table 3) were abundant in the month of May and disappeared after the second week in June. They were most abundant in the traps along the transition zone between the edge of the marsh and the pine woods.

The box trap collections (Table 4) confirmed the seasonal distribution of Tabanus nigrovittatus and the near absence of other Tabanus species. This type of trap does not collect Chrysops in any significant numbers.

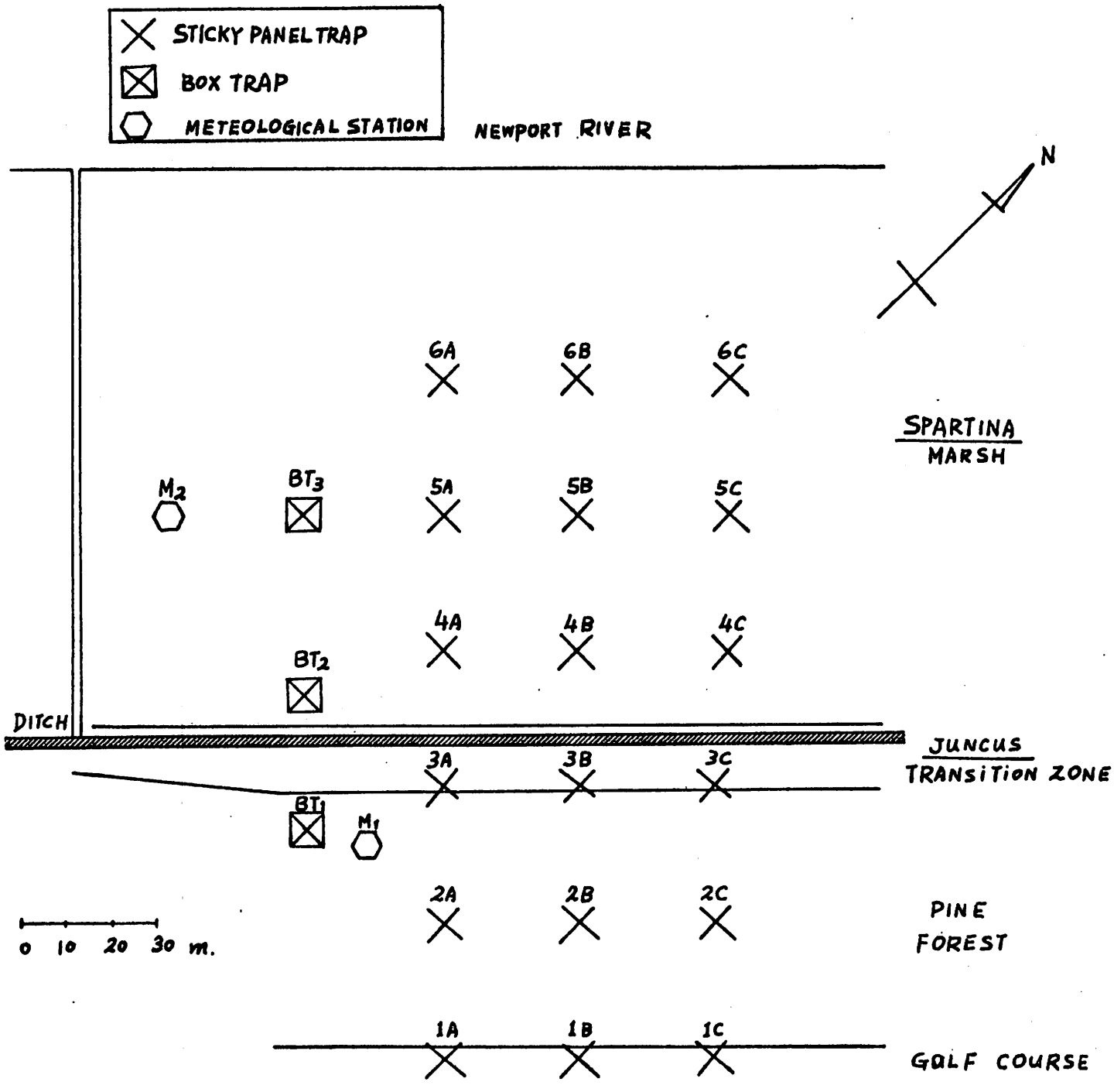


Fig. 1. Arrangement of sticky traps in a Spartina habitat, Morehead Golf Course, Morehead City, NC.

Table 1. Tabanus nigrovittatus Macq. collected by sticky panel traps at Morehead Golf Course, Morehead, N. C. 25 May - 26 Sept. 1971. Spartina marsh.
X = trap not in operation; $\bar{x}$ = avg. no. flies per trap per day; A,B,C = traps with total collection per interval indicated. 1 - 6 = trap positions.

Date	Interval days	1				2				3				4				5				6			
		A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$
5/25	2	X	X	X	-	0	0	X	0	0	1	X	0.2	3	7	X	2.5	X	X	X	-	X	X	X	-
5/31-6/2	2	1	1	1	0.5	0	1	1	0.1	3	8	22	4.1	43	38	21	6.9	47	29	47	20.5	37	94	72	33.8
6/5	3	19	10	5	3.7	1	1	6	0.9	17	17	91	13.9	96	79	104	31.0	124	76	109	34.3	167	326	355	94.2
6/8	3	46	35	11	10.2	6	15	7	3.1	33	46	166	27.2	214	154	188	61.7	218	156	154	58.6	285	491	494	141.1
6/11	3	48	18	15	9.0	11	14	12	4.1	27	42	140	23.2	138	132	163	48.1	170	165	162	55.2	288	363	372	113.6
6/15	4	31	27	15	6.1	18	23	11	4.3	29	38	150	18.1	79	92	105	23.0	106	86	135	27.2	128	167	584	73.2
6/18	3	16	14	4	3.8	10	10	5	2.8	21	27	22	7.8	27	20	26	8.1	37	42	42	13.4	50	52	179	31.2
6/22	4	7	7	4	1.5	7	10	5	1.8	21	32	82	11.2	51	45	69	13.8	63	57	80	16.6	75	107	267	37.4
6/25	3	14	12	4	3.3	8	9	9	2.9	22	28	92	15.8	28	45	48	13.4	50	47	58	17.2	115	184	176	52.8
6/29	4	16	8	5	1.6	9	14	8	2.6	23	37	108	14.0	39	52	49	11.7	50	50	60	13.3	124	159	178	38.4
7/2	3	3	7	2	1.3	5	15	2	2.5	16	24	54	10.4	27	32	43	11.3	54	29	56	15.4	74	138	140	39.1
7/6	4	3	4	0	0.6	0	8	2	0.8	10	11	24	3.7	6	12	18	3.0	18	8	10	3.0	20	23	31	6.2
7/9	3	2	1	0	0.3	1	5	2	0.9	14	9	18	4.6	6	6	15	3.0	17	12	9	4.2	57	40	29	14.0
7/13	4	3	0	3	0.5	3	1	2	0.5	10	7	32	4.1	3	10	13	2.2	9	11	8	2.3	8	17	9	2.8
7/16	3	0	1	2	1.0	2	3	0	0.5	5	3	15	3.7	6	6	10	2.4	15	5	17	4.1	17	41	24	9.1
7/20	4	0	0	1	0.1	1	4	1	0.5	4	4	25	2.8	3	8	4	1.2	12	4	4	1.7	17	31	23	5.9
7/23	3	1	0	0	0.1	0	2	0	0.2	0	0	8	0.9	3	0	1	0.4	1	0	0	0.1	0	1	6	0.8
7/27	4	1	0	0	0.1	2	2	0	0.3	1	4	14	1.6	4	2	12	1.5	9	3	6	1.5	16	12	14	3.5
7/29	2	0	1	0	0.2	0	0	2	0.5	1	3	12	2.7	3	4	7	2.3	13	3	13	3.2	14	13	13	6.7
8/3	5	0	2	0	0.1	0	3	1	0.3	1	3	13	1.1	3	6	9	1.2	14	2	8	1.6	8	17	20	3.0
8/6	3	0	1	1	0.2	0	1	0	0.1	1	1	6	0.9	1	1	6	0.9	5	2	1	0.9	6	7	8	2.3
8/10	4	0	3	0	0.3	0	1	0	0.1	3	1	16	1.7	1	2	1	0.3	2	1	4	0.6	7	2	4	1.1
8/13	3	0	1	1	0.2	0	0	0	0	2	0	7	1.0	1	1	1	0.3	4	1	3	0.9	5	7	1	1.4
8/18	5	0	0	0	0	0	0	0	0	0	0	4	0.3	0	0	1	0.1	1	0	0	0.1	4	4	2	0.7
8/20	2	0	1	0	0.2	0	0	0	0	1	4	4	1.5	0	1	1	0.3	3	2	2	1.2	6	9	5	3.3
8/23	3	0	0	0	0	2	1	0	0.3	0	1	7	0.9	0	0	1	0.1	3	8	1	1.3	0	10	9	2.1
8/28	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0.2	1	1	1	0.2
9/4	6	0	0	1	0.1	0	0	0	0	0	1	2	0.2	1	1	1	0.2	3	5	2	0.6	0	2	3	0.3
9/11	7	0	2	0	0.1	0	0	0	0	0	0	1	0.05	0	0	1	0.05	1	2	0	0.1	0	1	0	0.05
9/18	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.05	0	0	1	0.05	0	1	0	0.05
9/26	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.04
No.days	119	117	117	117	-	119	119	117	-	119	119	117	-	119	119	117	-	117	117	117	-	117	117	117	-
Subtotal	-	211	156	75	-	86	143	76	-	265	352	1135	-	786	756	919	-	1051	807	992	-	1529	2321	3030	-
Mean		1.8	1.3	0.6	3.8	0.7	1.2	0.6	2.5	2.2	3.0	9.7	14.9	6.6	6.4	7.8	20.8	9.0	6.9	8.5	24.4	13.1	19.8	25.9	58.8

Totals for columns: A=3928, B=4535, C=6227, A+B+C=14090
Totals for trap positions: #1=442, #2=305, #3=1752, #4=2461, #5=2850, #6=6880

Table 2 - Chrysops atlanticus Pech. collected by sticky panel traps at Morehead Golf Course, Morehead, N.C. - 25 May - 26 Sept. 1971. Spartina marsh.
X = trap not in operation; $\bar{x}$ = avg. no. flies per trap per day; A,B,C = traps with total collection per interval indicated. 1 - 6 = trap positions.

Date	Interval days	1				2				3				4				5				6			
		A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$
5/25	2	X	X	X	-	1	9	X	2.5	0	1	X	0.2	15	9	0	6.0	X	X	X	-	X	X	X	-
5/21-6/2	2	25	24	28	12.8	3	14	8	3.7	3	8	7	1.6	58	56	10	6.4	2	10	24	6.0	4	9	9	3.7
6/5	3	36	42	16	10.4	0	8	18	2.9	4	13	15	3.6	16	9	12	4.1	12	9	12	3.7	1	9	11	2.3
6/8	3	29	43	18	10.0	5	6	13	2.7	8	6	5	2.1	12	7	5	2.7	5	10	11	2.9	3	6	7	1.8
6/11	3	21	13	11	4.9	3	5	7	1.7	1	3	6	1.1	3	7	7	1.9	3	6	3	1.3	0	6	6	1.3
6/15	4	15	14	3	2.7	15	14	3	2.6	2	4	2	0.7	7	1	1	0.8	1	2	2	0.4	1	1	1	0.2
6/18	3	9	2	2	1.4	0	0	0	0	0	2	1	0.3	1	1	0	0.2	0	0	1	0.1	1	1	1	0.3
6/22	4	0	4	0	0.3	0	2	1	0.2	0	0	0	0	0	4	2	0.5	1	0	0	0.1	0	0	0	0
6/25	3	3	1	2	0.7	0	1	0	0.1	0	1	2	0.3	0	0	0	0	0	0	0	0	0	0	0	0
6/29	4	0	0	0	0	0	0	1	0.1	0	0	2	0.2	0	1	0	0.1	0	0	0	0	0	0	0	0
7/2	3	1	0	0	0.1	0	1	0	0.1	0	0	0	0	0	1	1	0.2	0	0	0	0	0	0	0	0
7/6	4	0	1	0	0.1	0	1	0	0.1	0	1	0	0.1	0	0	1	0.1	0	0	0	0	0	0	0	0
7/9	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/13	4	1	0	1	0.2	0	0	0	0	0	0	0	0	0	0	1	0.1	0	0	1	0.1	0	0	0	0
7/16	3	4	0	1	0.6	0	0	0	0	0	0	0	0	0	0	1	0.1	0	0	0	0	0	0	0	0
7/20	4	3	1	0	0.3	0	1	1	0.2	0	0	0	0	1	0	1	0.2	1	1	3	0.4	0	0	1	0.1
7/23	3	2	2	1	0.6	0	1	2	0.3	0	0	2	0.2	0	0	1	0.1	0	0	0	0	1	0	3	0.4
7/27	4	1	1	4	0.5	0	1	1	0.2	0	0	0	0	1	0	0	0.1	1	0	0	0.1	0	0	0	0
7/29	2	1	2	0	0.5	0	0	0	0	0	0	0	0	1	0	1	0.3	0	0	0	0	0	0	0	0
8/3	5	4	9	4	1.1	0	2	1	0.2	2	0	1	0.2	0	1	4	0.3	1	2	6	0.6	2	0	0	0.1
8/6	3	3	9	2	1.6	1	2	7	1.1	0	6	3	1.0	2	0	2	0.4	2	2	1	0.6	2	2	1	0.6
8/10	4	11	17	4	2.7	1	4	7	1.0	1	2	2	0.4	1	1	3	0.4	2	1	3	0.5	1	0	2	0.2
8/13	3	4	0	0	0.4	1	0	2	0.3	1	0	2	0.3	1	0	2	0.3	0	1	0	0.1	1	0	0	0.1
8/18	5	1	2	0	0.2	0	0	0	0	0	1	1	0.1	4	5	3	0.8	6	0	0	0.4	0	0	1	0.1
8/20	2	1	3	1	0.8	0	0	1	0.2	0	2	2	0.6	1	4	7	2.0	2	3	1	1.0	0	0	0	0
8/23	3	17	11	14	3.6	1	3	9	1.4	3	0	2	0.6	12	7	21	4.4	11	7	8	2.9	0	2	5	0.8
8/28	5	13	9	4	1.7	1	0	3	0.3	3	3	7	0.9	7	5	9	1.4	5	10	4	1.3	2	1	2	0.3
9/4	6	50	37	23	5.6	3	10	17	1.7	3	9	6	1.0	4	4	2	0.6	7	5	8	1.1	1	2	2	0.3
9/11	7	8	12	9	1.4	0	0	0	0	1	0	1	0.1	2	0	4	0.3	4	1	1	0.3	1	1	1	0.1
9/18	7	3	5	8	0.8	1	1	2	0.2	0	2	1	0.1	1	0	0	0.04	1	2	0	0.1	1	0	2	0.1
9/26	8	8	4	2	0.6	1	0	0	00.4	0	0	1	0.04	0	1	1	0.1	1	0	1	0.1	0	0	1	0.04
No. days	119	117	117	117	-	119	119	17	-	119	119	117	-	119	119	119	-	117	117	117	-	117	117	117	-
Subtotal		274	268	158	-	37	86	104	-	31	64	71	-	150	124	102	-	68	72	90	-	22	40	56	
Mean		2.34	2.29	1.35	6.0	0.3	0.7	0.9	1.9	0.3	0.5	0.6	1.4	1.3	1.0	0.8	3.1	0.6	0.6	0.8	2.0	0.2	0.3	0.5	1.0

Totals for columns: A = 582, B = 654, C = 581, A + B + C = 1817
Totals for trap positions: #1 = 700, #2 = 227, #3 = 166, #4 = 376, # 5 = 230, #6 = 118

Table 3 - Chrysops fuliginosus Wied. collected by sticky panel traps at Morehead Golf Course, Morehead, N.C. - 25 May - 26 Sept. 1971 - Spartina Marsh.
X = trap not in operation; $\bar{x}$ = avg. no. flies per trap per day; A,B, C = traps with total collected per interval indicated. 1 - 6 = trap positions.

Date	Interval days	1				2				3				4				5				6			
		A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$
5/25	2	X	X	X	-	58	149	X	51.8	496	893	X	347.2	392	484	X	219.0	X	X	X	-	X	X	X	-
5/31-6/2	2	13	14	9	6.0	94	127	6	10.2	358	287	43	34.0	155	225	25	20.0	16	20	22	9.7	10	17	21	8.0
6/5	3	1	4	2	0.8	6	6	2	1.6	9	7	27	4.8	12	0	1	1.4	10	6	4	2.2	4	2	0	0.7
6/8	3	3	1	0	0.4	0	3	2	0.6	3	4	8	1.7	0	5	0	0.6	1	0	3	0.4	1	0	0	0.1
9/26		No. C. fuliginosus collected.																							
No. days	10	8	8	8	-	10	10	8	-	10	10	8	-	10	10	8	-	8	8	8	-	8	8	8	-
Sub totals		17	19	11	-	158	285	10	-	866	1191	78	-	559	714	26	-	27	26	29	-	15	19	21	-
Mean		2.1	2.4	1.4	5.1	15.8	28.5	1.2	45.5	86.6	119.1	9.8	215.5	55.9	71.4	3.2	130.5	3.4	3.2	3.6	10.2	1.9	2.4	2.6	6.9

Totals for columns: A = 1642, B = 2254, C = 175, A + B + C = 4071
Totals for trap positions: #1 = 41, #2 = 453, #3 = 2835, #4 = 1299, #5 = 82, #6 = 55

Table 4. - Tabanus nigrovittatus Macq. collected in box traps at Morehead Golf Course, Morehead, N.C. 2 June - 26 Sept. 1971. Spartina marsh. X = trap not in operation. N = total number of flies captured in the interval. $\bar{x}$ = mean number of flies per day. % = percentage of T. nigrovittatus in the whole collection for that interval.

Date	Interval days	Trap 1			Trap 2			Trap 3		
		N	$\bar{x}$	%	N	$\bar{x}$	%	N	$\bar{x}$	%
June 5	3	131	43.6	99.2	XXXX	XXXX	XXXXX	248	82.6	99.2
June 7	2	25	12.5	96.2	XXXX	XXXX	XXXXX	209	104.5	99.5
June 12	5	39	7.8	100.0	XXXX	XXXX	XXXXX	204	40.8	99.5
June 14	2	22	11.0	91.7	XXXX	XXXX	XXXXX	214	107.0	100.0
June 15	1	8	8.0	100.0	XXXX	XXXX	XXXXX	146	146.0	99.3
June 18	3	40	13.3	100.0	184	61.3	100.0	334	111.3	100.0
June 22	4	32	8.0	100.0	265	66.2	99.6	557	139.2	99.8
June 25	3	32	10.6	94.1	213	71.0	99.1	420	140.0	99.3
June 29	4	17	4.2	100.0	157	39.2	99.4	273	68.2	100.0
July 2	3	15	5.0	100.0	80	26.6	98.8	186	62.0	100.0
July 6	4	13	3.2	86.7	46	11.5	100.0	66	16.5	100.0
July 9	3	23	7.6	95.8	78	26.0	100.0	199	66.3	99.5
July 13	4	12	3.0	100.0	49	12.2	98.0	153	38.2	100.0
July 16	3	5	1.7	100.0	39	13.0	100.0	100	33.3	100.0
July 20	4	5	1.2	100.0	23	5.7	100.0	58	14.5	100.0
July 23	3	3	1.0	100.0	7	2.3	100.0	27	9.0	100.0
July 27	4	2	0.5	100.0	31	7.7	100.0	87	21.7	98.9
July 29	2	2	1.0	100.0	9	4.5	100.0	92	46.0	100.0
Aug. 3	5	9	1.8	90.0	24	4.8	100.0	155	31.0	98.7
Aug. 6	3	6	2.0	85.7	11	3.7	100.0	41	13.7	97.6
Aug. 10	7	3	0.4	75.0	23	3.3	100.0	53	7.6	100.0
Aug. 13	3	2	0.7	66.7	16	5.3	94.1	32	10.7	94.1
Aug. 18	5	1	0.2	100.0	7	1.4	87.5	22	4.4	95.6
Aug. 20	2	3	1.5	100.0	6	3.0	100.0	53	26.5	98.1
Aug. 23	3	5	1.7	100.0	4	1.3	80.0	34	11.3	100.0
Aug. 28	5	1	0.2	100.0	5	1.0	100.0	18	3.6	94.7
Sept. 4	7	6	0.8	100.0	19	2.7	95.0	56	8.0	91.8
Sept. 11	7	1	0.1	100.0	9	1.3	81.8	15	2.1	100.0
Sept. 18	7	0	0	0	1	0.1	33.3	3	0.4	33.3
Sept. 26	8	0	0	0	0	0	0	0	0	0
Totals	119	447	3.8	95.8	1735	16.5	94.4	4055	34.1	96.5

2.2 Populations and Movements of Tabanids in a *Juncus* Marsh Habitat

The seasonal populations of adults and their movement in a ditched *Juncus roemerianus* marsh was determined. The marsh was located on a penninsula at Davis, N.C. flanked by Jarrett Bay and Core Sound. Sticky panel traps (24) were located 30 m apart in 3 lines extending from the marsh into an adjacent dense pine woods (Fig. 1). These were the same design of traps used at the *Spartina* marsh and collections and renewal of the sticky material were done in the same manner. Box traps and netting provided additional data.

The principal species were the same as at the *Spartina* marsh. *T. nigrovittatus* (Table 1) was most abundant during the month of June and declined to such low numbers after mid July that the experiment was terminated on 18 August. *T. nigrovittatus* was trapped in largest numbers in the transition region of *Juncus* and shrubs between the marsh proper and the near pure stands of *Juncus*.

Chrysops atlanticus (Table 2) were most abundant during the first 2 weeks of June. They were trapped in larger numbers in the woods and in very low numbers on the open marsh.

Chrysops fuliginosus (Table 3) were collected in low numbers in May and none were collected after 4 June. They were more abundant in the traps in the transition zone between the open marsh and the woods.

Box trap collections (Table 4) confirmed the dominance of *Tabanus nigrovittatus*. Netting confirmed the dominance of *C. atlanticus* and revealed larger numbers than suggested by the sticky traps. *C. atlanticus* continued to be abundant at different periods throughout the summer.

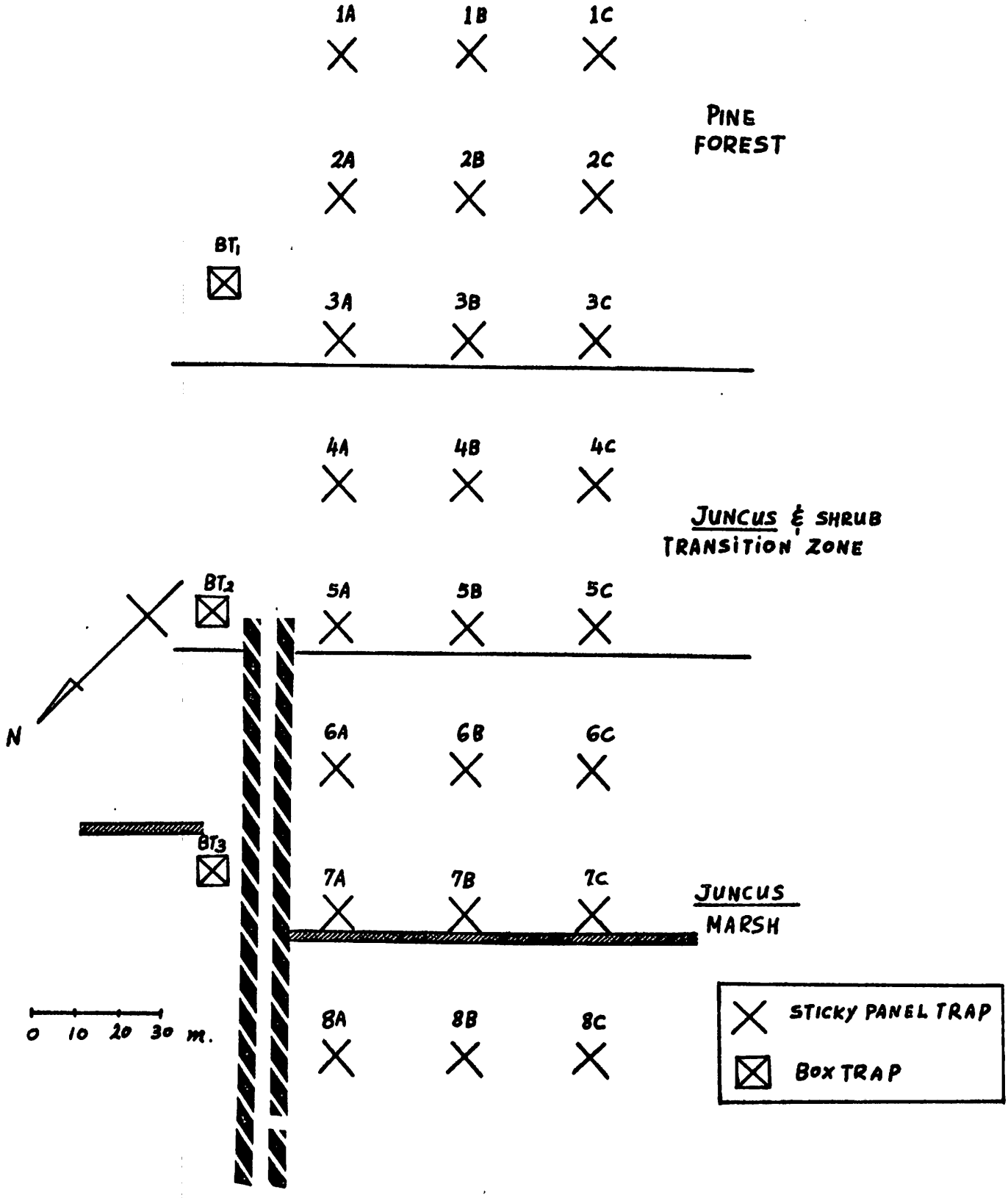


Fig. 1. Arrangement of sticky traps in a Juncus habitat, Davis, NC.

Table 1. *Tabanus nigrovittatus* Macq. collected by sticky panel traps at Davis Peninsula, Davis, N. C. 22 May - 18 August 1971. *Juncus* marsh.
X = trap not in operation; $\bar{x}$ = avg. no. flies per trap per day; A,B,C = traps with total collection per interval indicated. 1 - 6 = trap positions.

Date	Interval days	1				2				3				4				5				6				7				8			
		A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C		A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$
5/22	2	0	1	0	0.2	1	0	1	0.6	0	1	1	0.7	1	1	1	0.5	3	0	0	0.5	2	0	4	1.0	0	0	0	0	X	X	X	-
5/24	2	0	0	0	0	0	0	0	0	0	2	1	0.5	1	0	4	0.8	2	3	4	1.5	2	1	1	0.7	0	0	2	0.3	2	5	4	0.2
6/1	8	1	1	1	0.1	0	1	0	0.04	1	2	0	0.1	2	7	8	0.7	8	17	8	1.4	1	2	9	0.5	4	3	2	0.4	1	33	4	1.6
6/4	3	5	5	10	2.2	2	3	6	1.2	4	7	6	1.9	13	21	13	5.2	21	36	15	8.0	5	3	6	1.6	5	13	2	2.2	5	53	19	8.6
6/9	5	6	9	17	2.1	1	8	3	0.8	13	13	6	2.1	20	26	30	5.1	27	58	32	7.8	17	2	17	2.4	20	24	19	4.2	6	102	24	8.8
6/16	7	12	45	37	4.5	5	9	9	1.1	33	35	23	4.3	47	92	73	10.1	79	138	45	12.5	44	14	49	5.1	20	25	30	3.6	19	284	50	16.8
6/23	7	16	24	22	3.0	4	12	10	1.2	39	27	18	4.0	22	59	72	7.3	50	60	11	5.8	16	3	35	2.5	8	19	22	2.3	8	209	51	12.8
6/30	7	6	10	14	1.4	1	3	5	0.4	10	16	11	1.8	20	24	34	3.7	20	38	27	4.0	10	0	10	1.0	2	8	14	1.2	4	99	19	5.8
7/7	7	3	0	x	0.2	1	0	0	0.04	1	0	4	0.2	5	6	6	0.8	11	12	11	2.1	3	0	9	0.6	4	3	7	0.7	0	22	5	1.3
7/14	7	4	5	9	0.8	4	3	0	0.3	2	2	3	0.3	4	8	5	0.8	3	9	3	0.7	0	2	2	0.3	1	2	2	0.2	2	19	10	1.5
7/21	7	1	x	x	0.1	4	x	x	0.6	x	0	x	0	x	0	x	0	x	3	x	0.4	x	3	x	0.4	x	0	x	0	x	3	x	0.4
7/28	7	0	x	x	0	0	x	x	0	x	0	x	0	x	3	x	0.4	x	7	x	1.0	x	0	x	0	x	2	x	0.3	x	11	x	1.6
8/4	7	0	x	x	0	0	x	x	0	x	5	x	0.7	x	3	x	0.4	x	6	x	0.8	x	1	x	0.1	x	4	x	0.6	x	27	x	3.8
8/11	7	0	x	x	0	1	x	x	0.1	x	10	x	1.4	x	12	x	1.6	x	13	x	1.8	x	1	x	0.1	x	5	x	0.7	x	31	x	4.4
8/18	7	0	x	x	0	0	x	x	0	x	1	x	0.1	x	4	x	0.6	x	8	x	1.2	x	0	x	0	x	3	x	0.4	x	9	x	1.2
Subtotals		54	100	110	-	24	39	34	-	103	121	73	-	135	268	246	-	224	398	156	-	100	32	132	-	64	111	101	-	47	907	186	1140
No. days	90	90	55	48	-	90	55	55	-	55	90	55	-	55	90	55	-	55	90	55	-	55	90	55	-	55	90	55	-	55	90	55	-
Mean		0.6	1.8	2.3	4.7	0.3	0.7	0.6	1.6	1.9	1.3	1.3	4.5	2.4	2.9	4.5	9.8	4.1	4.4	2.8	11.3	1.8	0.4	2.4	4.6	1.2	1.2	1.8	4.2	0.8	10.1	3.4	14.3

Totals for columns: A = 967, B = 1973, C = 1038, A + B + C = 3978
Totals for trap positions: #1 = 264, #2 = 97, #3 = 297, # 4 = 646, #5 = 778, #6 = 264, #7 = 276, # 8 = 1140

Table 2 - Chrysops atlanticus Pech. collected by sticky panel traps at Davis Peninsula, Davis, N. C. - 22 May - 18 Aug. 1971 - Juncus marsh.
X = trap not in operation; $\bar{x}$ = avg. no. flies per trap per day; A,B,C = traps with total collection per interval indicated. 1 - 6 = trap positions.

Date	Interval days	1				2				3				4				5				6				7				8			
		A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$
5/22	2	4	0	2	1.0	2	2	10	2.3	0	1	1	0.3	3	0	0	0.5	5	0	0	0.8	0	0	0	0	0	0	0	0	X	X	X	
5/24	2	1	0	0	0.2	1	3	0	0.7	1	1	1	0.5	2	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/1	8	3	1	3	0.3	10	2	3	0.6	2	1	1	0.2	0	1	2	0.1	4	1	1	0.2	2	0	1	0.1	1	0	0	0.04	2	1	1	0.2
6/4	3	19	3	4	2.9	10	0	1	1.2	2	7	7	1.8	4	5	3	1.3	5	3	0	0.9	2	1	0	0.3	0	1	0	0.1	0	1	2	0.3
6/9	5	28	7	44	5.3	41	23	8	4.8	14	51	46	7.4	24	14	32	4.7	9	6	8	1.5	3	2	3	0.5	6	4	3	0.9	3	2	2	0.5
6/16	7	55	32	104	9.1	177	39	48	12.6	35	59	69	7.8	39	31	86	7.4	30	15	34	3.8	7	10	9	1.2	10	7	4	1.0	15	3	7	1.2
6/23	7	4	1	5	0.5	20	4	1	1.2	6	6	6	0.8	9	7	5	1.0	3	3	1	0.3	9	3	3	0.7	1	2	4	0.3	2	1	1	0.2
6/30	7	10	6	8	1.1	16	0	4	1.0	8	5	4	0.8	19	3	4	1.2	3	8	0	0.5	1	2	3	0.3	3	1	1	0.2	3	1	0	0.2
7/7	7	18	6	X	1.7	59	6	4	3.3	15	11	10	1.7	12	6	14	1.5	11	12	11	1.6	5	1	0	0.3	1	1	1	0.1	4	0	3	0.3
7/14	7	4	5	3	0.8	4	2	11	0.8	16	7	0	1.1	1	6	1	0.4	3	2	3	0.4	X	0	1	0.05	0	1	0	0.05	3	0	1	0.2
7/21	7	7	X	X	1.0	13	X	X	1.9	X	5	X	0.7	X	5	X	0.7	X	0	X	0	X	1	X	0.1	X	0	X	0	X	1	X	0.1
7/28	7	1	X	X	0.1	4	X	X	0.6	X	3	X	0.4	X	2	X	0.3	X	1	X	0.1	X	0	X	0	X	0	X	0	X	3	X	0.4
8/4	7	3	X	X	0.4	7	X	X	1.0	X	2	X	0.3	X	3	X	0.4	X	3	X	0.4	X	0	X	0	X	0	X	0	X	1	X	0.1
8/11	7	4	X	X	0.6	16	X	X	2.3	X	12	X	1.7	X	1	X	0.1	X	15	X	2.1	X	0	X	0	X	1	X	0.1	X	3	X	0.4
8/18	7	2	X	X	0.3	1	X	X	0.1	X	0	X	0	X	0	X	0	X	0	X	0	X	0	X	0	X	2	X	0.3	X	0	X	0
No days	90	90	55	48	-	90	55	55	-	55	90	55	-	55	90	55	-	55	90	55	-	48	90	55	-	55	90	55	-	55	90	55	-
Sub total		163	61	173	-	381	81	90	-	99	171	145	-	113	84	147	-	73	69	58	-	27	20	20	-	22	20	13	-	32	17	17	-
Mean		1.8	1.1	3.6	6.5	4.2	1.5	1.6	7.3	1.8	1.9	2.6	6.3	2.1	0.9	2.7	5.7	1.3	0.8	1.1	3.2	0.6	0.2	0.4	1.2	0.4	0.2	0.2	0.8	0.6	0.2	0.1	0.9

Totals for columns: A = 910, B = 523, C = 663, A + B + C = 2096
Totals for trap positions: #1 = 397, # 2 = 552, #3 = 415, #4 = 344, #5 = 200, #6 = 67, #7 = 55, #8 = 66

Table 3 - Chrysops fuliginosus Wied. collected by sticky panel traps at Davis Peninsula, Davis, N.C. - 25 May - 26 Sept. Juncus marsh,
X = trap not in operation; $\bar{x}$ = avg. no. flies per trap per day; A,B,C, = traps with total collection per interval indicated. 1 - 6 = trap positions.

Date	Interval days	1				2				3				4				5				6				7				8			
		A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$	A	B	C	$\bar{x}$
5/22	2	17	6	16	4.8	6	33	14	8.8	9	22	32	10.5	10	3	5	3.0	7	2	7	2.7	15	8	26	8.2	1	1	0	0.3	X	X	X	-
5/24	2	1	1	6	1.3	8	3	3	2.3	4	2	9	2.5	14	4	2	3.3	6	1	1	1.3	1	6	2	1.5	0	1	0	0.2	0	0	0	0
6/1	8	17	8	10	1.5	1	12	3	0.7	4	7	4	0.6	3	0	0	0.1	3	2	0	0.2	1	0	0	0.04	1	0	0	0.04	0	0	0	0
6/4-8/18	No. C. fuliginosus collected.																																
No. days	12	12	12	12	-	12	12	12	-	12	12	12	-	12	12	12	-	12	12	12	-	12	12	12	-	12	12	12	-	10	10	10	-
Sub total		35	15	32	-	15	48	20	-	17	31	45	-	27	7	7	-	16	5	8	-	17	14	28	-	2	2	0	-	0	0	0	-
Mean		2.9	1.2	2.7	6.8	1.2	4.0	1.7	6.9	1.4	2.6	3.8	7.8	2.2	0.6	0.6	3.4	1.3	0.4	0.7	2.4	1.4	1.2	2.3	4.9	0.2	0.2	0	0.3	0	0	0	0

Totals for columns: A = 129, B = 122, C = 140, A + B + C = 391
Totals for trap positions: #1 = 82, #2 = 83, #3 = 93, #4 = 41, #5 = 29, #6 = 59, #7 = 4, #8 = 0

Table 4. - Tabanus nigrovittatus Macq. collected in box traps at Davis Peninsula, Davis, N.C. 1 June - 18 August 1971. Juncus marsh. X = trap not in operation, N = total number of flies captured in the interval. $\bar{x}$ = mean number of flies per day. % = percentage of T. nigrovittatus in the whole collection for that interval.

Date	Interval days	Trap 1			Trap 2			Trap 3		
		N	$\bar{x}$	%	N	$\bar{x}$	%	N	$\bar{x}$	%
June 9	8	5	0.6	100.0	XXX	XXXX	XXXX	120	15.0	100.0
June 16	7	XX	XXX	XXXXX	XXX	XXXX	XXXX	46	6.6	95.8
June 23	7	78	1.1	96.3	305	43.6	99.3	324	46.3	99.4
June 30	7	33	4.7	94.2	89	12.7	98.9	155	22.1	100.0
July 7	7	6	0.8	85.7	7	1.0	100.0	57	8.1	93.4
July 14	7	4	0.6	80.0	20	2.8	90.9	29	4.1	100.0
July 21	7	0	0	0	6	0.8	100.0	18	2.6	100.0
July 28	7	3	0.4	100.0	11	1.6	100.0	7	1.0	70.0
Aug. 4	7	1	0.1	33.3	12	1.7	85.7	8	1.1	72.7
Aug. 11	7	3	0.4	100.0	17	2.4	89.5	24	3.4	96.0
Aug. 18	7	0	0	0	0	0	0	26	3.7	80.6
Total	71	128	1.8	76.6	367	5.8	95.5	814	10.4	91.6

3.1 The Effect of Height on the Capture of *Tabanus nigrovittatus* Macq. on Sticky-Panel Traps Under Salt Marsh Conditions

The greenhead marsh fly *Tabanus nigrovittatus* is one of the most abundant species of tabanid in *Spartina alterniflora* salt marshes in Carteret Co., N.C. Several methods for surveying tabanids were employed during summer and early fall of 1971. The use of sticky panel traps was one of the most satisfactory methods to study the distribution of this particular species under salt marsh conditions. Several factors affect the trapping efficiency of these panels. The position of traps is of prime importance. The visibility of the trap at a distance, it's contrasting silouette with the surroundings and it's height above free vegetation surface are factors necessary to consider when the selection of trap position is made.

The present experiment was conducted in a *Spartina* salt marsh adjacent to Morehead Golf Course, Carteret Co., N.C. from 12 June to 29 June, 1971. It's purpose was to determine the influence that the height of sticky panels has on the capture of *Tabanus nigrovittatus*.

Materials and Methods

Four one-level four-panel traps as described were used in this experiment. Each trap consisted of four one square foot mansonite panels arranged in a cross on a 1.80 meter (6 ft.) red stick. Thus there were 8 black sticky surfaces exposed. The traps were located in a row at 120 meter from the inland edge of the marsh with 30 meter of separation between them (Fig. 1). Each trap was the object of one height treatment as shown in the tables. The height range was measured from the bottom and top of the panels to the average height of the *Spartina* present in each site.

The panels of each trap were oriented in such a way that surfaces a and b of the first panel were directed to the magnetic north, c and d surfaces of the second panel to the south and g and h surfaces of the fourth panel to the west.

In addition a trap designed to present the four level ranges was tested. It consisted of one red stick (2" x 2" x 6') with 8 black masonite panels of one square foot each in four levels; 0-0.3, 0.3-0.6; 0.6-0.9 and 0.9-1.2 meters. Each level had two panels with four sticky surfaces (a,b,e and f) oriented from east to west. For convenience this trap was named "four-level eight-panel trap". The trap was located at 30 meters from the four "one-level four-panel traps" and 90 meters from the inland limit of the marsh.

The surfaces of all traps were covered with 3 mm. layer of Stickem® at weekly intervals. This was done after scraping the old sticky material from the trap. Fly counts were made twice a week.

Results

Summaries of the results are presented in Tables 1, 2 and 3. Table 1 shows the number of Tabanus nigrovittatus collected in one-level four-panel traps. One-level four-panel traps 0.3-0.6 and 0.6-0.9 meters high gave the largest collections of Tabanus nigrovittatus.

In order to see if the four-levels located in the same trap influence the collections, the results from the four-level eight-panel traps were compared against the results of the one-level four-panel traps considering only the two panels with the same orientation, that is surfaces c, d, g and h. Table 2 shows the collections from 4 surfaces of the one-level four-panel traps (surfaces c, d, f, g) and Table 3 the collections from the four-level eight-panel trap.

The vertical distribution of the percentages for 4 surfaces of the one-level four-panel trap is almost the same as when the whole trap is considered, that is greater collections were made at 0.3-0.6 and 0.6-0.9 meter levels. Table 3 shows the vertical distribution of percentages for four-level eight-panel trap Again, 0.3-0.6 and 0.6-0.9 meter heights resulted in larger collections than the other levels. However, the differences in collections between high and low efficiency levels in this kind of trap were greater.

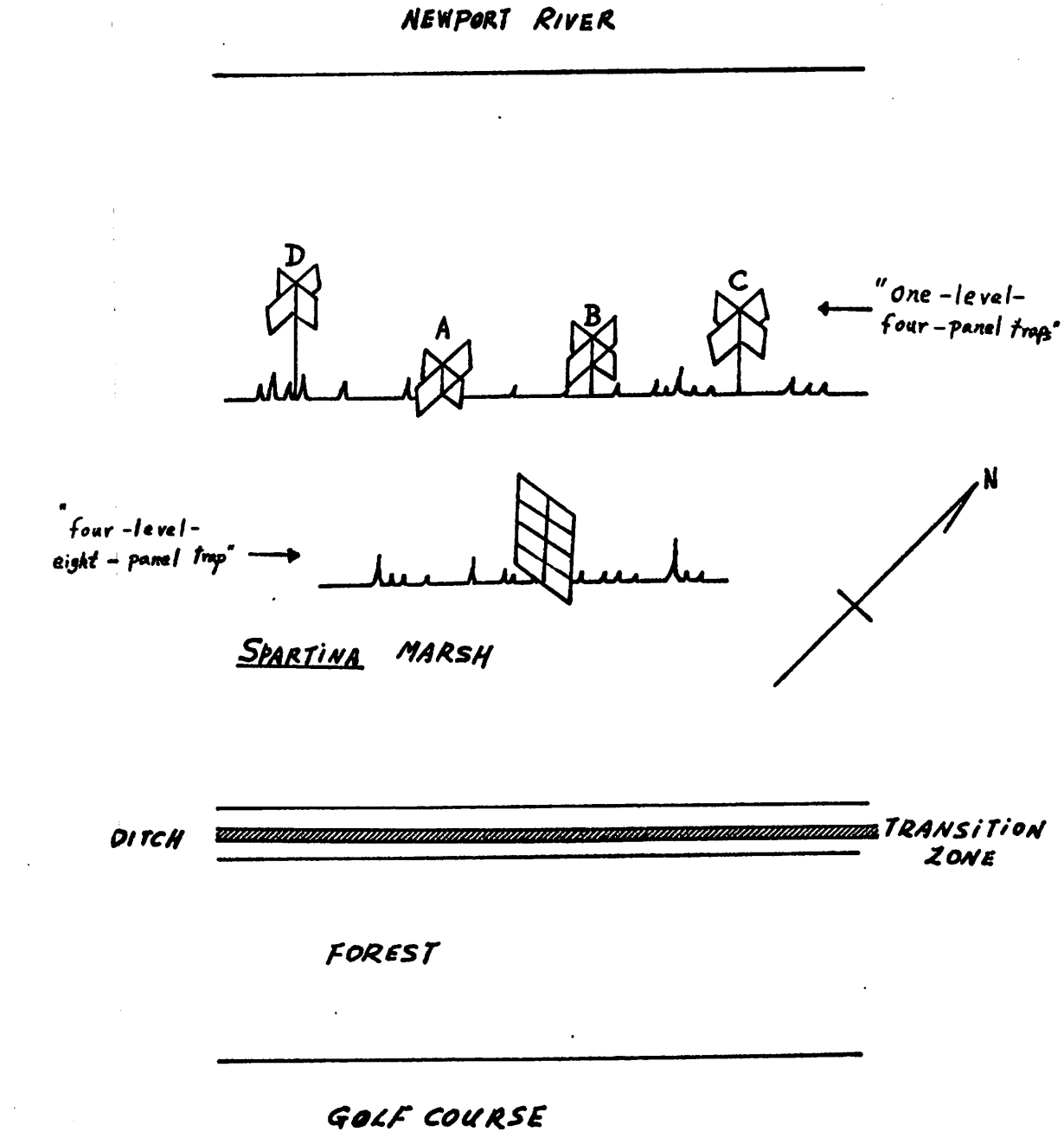


Fig. 1. Arrangement of traps in height experiments.

Table 1. - Number and percentage of Tabanus nigrovittatus Macq. collected at 4 heights of sticky panel traps ("one-level-four-panel traps"). Morehead City, N.C. 12-29, June 1971. Spartina marsh.

Trap	Height Meter	Jun 12		Jun 15		Jun 18		Jun 22		Jun 25		Jun 29		Total	$\bar{x}$
		N	%	N	%	N	%	N	%	N	%	N	%	N	%
A	0.0-.3	100	13.0	431	162	129	15.2	198	16.0	196	21.2	176	21.0	1230	16.48
B	0.3-0.6	190	24.6	802	30.2	220	25.9	437	27.1	238	25.7	214	25.5	2181	29.23
C	0.6-0.9	227	29.4	838	31.6	321	37.8	438	35.3	316	34.1	272	32.4	2412	32.32
D	0.9-1.2	225	33.0	584	22.0	179	21.1	267	21.5	176	19.0	178	21.1	1639	21.96
Total		772		2655		849		1240		926		840		7462	

Table 2. - Number and percentage of Tabanus nigrovittatus Macq. collected at 4 heights on 4 surfaces of the "one-level-four-panel traps."

Trap	Level range meter	Jun 12		Jun 15		Jun 18		Jun 22		Jun 25		Jun 29		Total	$\bar{x}$
		N	%	N	%	N	%	N	%	N	%	N	%	N	%
A	0-0.3	51	13.5	197	15.1	51	11.9	102	16.1	99	20.2	95	21.2	595	16.15
B	0.3-0.6	83	22.0	385	29.5	103	24.0	165	26.0	129	26.3	116	25.9	981	26.62
C	0,6-0.9	109	28.8	417	31.9	172	40.0	229	36.1	163	33.3	146	32.6	1236	33.54
D	0,9-1.2	135	35.7	307	23.5	103	24.1	138	21.8	99	20.2	91	20.3	873	23.69
Total		378		1306		429		634		490		448		3685	

Table 3. - Number and percentage of Tabanus nigrovittatus collected at 4 heights of sticky panels in a "four-level-eight-panel trap."

Trap	Level range meter	Jun 12		Jun 15		Jun 18		Jun 22		Jun 25		Jun 29		Total		$\bar{x}$
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	
A	0-0.3	4	1.1	42	4.2	13	4.2	8	1.8	5	2.4	8	3.4	80	3.07	
B	0.3 -0.6	146	37.7	411	40.6	119	38.1	161	36.5	72	34.1	94	40.0	1003	38.50	
C	0.6 -0.9	196	49.7	441	43.6	138	44.2	188	42.6	108	51.2	115	48.9	1186	45.53	
D	0.9 -1.2	48	12.2	118	11.6	42	13.5	84	19.1	26	12.3	18	7.7	336	12.90	
Total		394		1012		312		441		211		235		2605		

3.2 Evaluation of Covered and Uncovered Sticky-Panel Traps in the Capture of *Tabanus nigrovittatus* Macq. in Salt Marsh Conditions

Tabanus nigrovittatus is the most common tabanid in *Spartina alterniflora* salt marshes of Carteret Co., N.C. During the summer and early fall of 1971 different types of surveying methods were employed to determine the seasonal abundance, distribution and movements of this species in the marsh. One of the most promising methods was the use of sticky panel traps. During August 1971 rains were common in Carteret Co., and it was observed that one of the limitations for this trap was the presence of water on the sticky surfaces making them unsuitable for the capture of flies.

Methods

Three sticky panel traps were used. Each trap had a total exposed surface of 8 ft^2 in 4 panels. The traps were located in a triangle with 50 m between them. The bottom of the panels was 1.2 meters above the average height of the grass (0.3 meters). Two of three traps were protected with removable cylinder-shaped caps. The caps were made with transparent plastic covering the sides and top of a cylindrical wire frame (o.6 cm diameter and 30cm height). One of the caps had the side-painted black. At the beginning of the experiment the caps were located on the traps at random but they were subject to daily clockwise rotation in such a way that each trap had the opportunity to receive each treatment for three times.

A layer of sticky substance ("Stickem") was daily applied to all surfaces after scraping the old one. The counts were made daily and the flies identified in the laboratory.

RESULTS

The results are presented in Table 1 and Figure 1. Traps covered with black-sided caps captured a much greater number of T. nigrovittatus than the remainder two treatments. This shows the great influence that the black color has on the capture of this species. The traps covered with transparent caps captured much fewer T. nigrovittatus than did the traps with black caps, but about twice as many flies as captured by the uncovered trap.

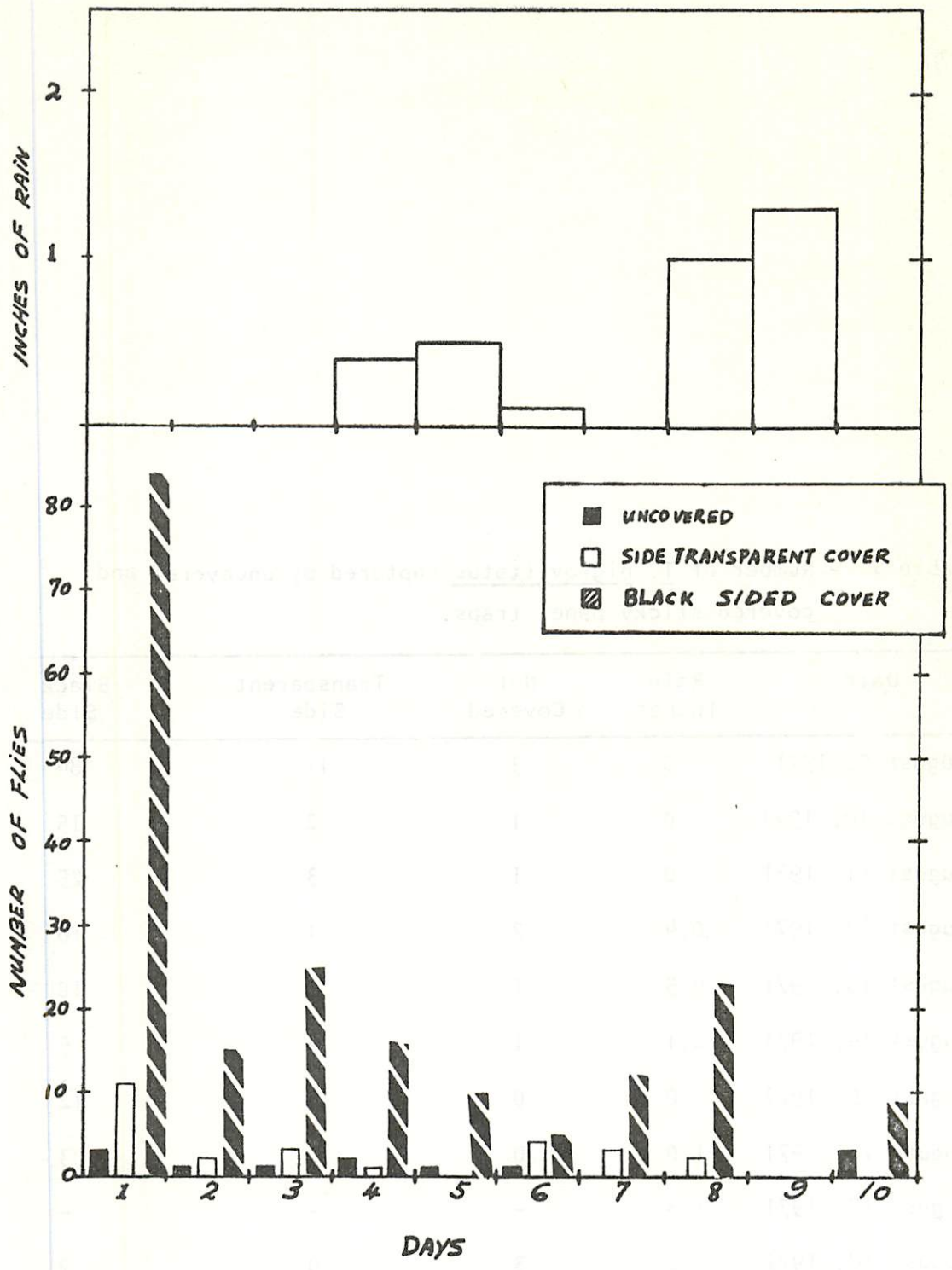


Fig. 1. Collections of Tabanus nigrovittatus from covered and uncovered sticky traps in relation to rainfall.

Table 1. - Number of T. nigrovittatus captured by uncovered and covered sticky panel traps.

Date	Rain Inches	Not Covered	Transparent Side	Black Side
August 9, 1971	0	3	11	84
August 10, 1971	0	1	2	15
August 11, 1971	0	1	3	25
August 12, 1971	0.4	2	1	16
August 13, 1971	0.5	1	0	10
August 14, 1971	0.1	1	4	5
August 15, 1971	0	0	3	12
August 16, 1971	1.0	0	2	23
August 17, 1971	1.3	-	-	-
August 18, 1971	0	3	0	9
Total		12	26	199

3.3 Effect of Height of Sticky-ball Traps on the Collections of *Chrysops atlanticus* Pech. and Other Tabanidae Under Pine Forest Conditions

During the summer and early fall, *Chrysops atlanticus* Pech. is the most abundant species of deer flies in pine forest and inland marsh areas of Carteret Co., N.C. Methods of sampling the population are unsatisfactory. Various attempts were made to have consistent indices of the abundance of this species during June - September 1971. Among the survey methods employed, overhead-netting was the most acceptable of all and was followed by sticky panel traps. The last method has the advantage of its permanence in the field collecting specimens over relatively long periods of time. Early in the season the importance of the height of the sticky panel traps in the capture of *Tabanus nigrovittatus* Macq. was demonstrated. Observations suggested that a spherical trap is better than a flat panel for capturing *Chrysops atlanticus*. Therefore, the collection efficiency of sticky-ball traps was determined at several heights.

Materials and Methods

The sticky traps were hung at various heights from a horizontal looped nylon rope tied between two trees 10 m above the ground (Fig. 1-A). The traps were plastic beach balls, 50 cm. in diameter, painted black and covered with a 3 mm. layer of "Stickem". A nylon string tied to each ball went through the loop of the horizontal nylon rope and then to the ground so the height of the traps could be easily changed. Each ball was provided with 12 ounce weights (Fig. 1-B) to reduce movement . Three traps were used at 3 levels in each experiment. The position of each trap was changed daily.

Daily counts of insects and reapplication of "Stickem" were made. Two experiments were conducted. In both cases the habitat conditions were the same, the traps were located in a four meters wide path in a pine forest where a high population of Chrysops atlanticus was present.

Results and Conclusions

The first experiment (July 22 - Aug. 4) was at Davis, N.C The levels included were 2, 4, and 8 meters above the ground. Six combinations of ball traps were tested (Fig. 2). The results of these experiments are presented in Table 1. As shown the number of Chrysops atlanticus and Tabaninae captured decreased with increasing height. The sticky ball traps located 2 meters above the ground collected higher numbers of Chrysops atlanticus than the other two levels. Only a few other tabanids were collected.

A second experiment was conducted at Lake Shore Drive in the vicinity of Morehead City Golf Course, from August 12 to August 21. The heights included were 0.5, 1.0 and 2.0 meters above the ground. Six combinations of the traps were used (Fig. 2). The results for this experiment are presented in Table 2. The traps located at 0.5 and 1.0 meter levels collected about equal numbers of Chrysops atlanticus and other tabanids. Traps at 2 meters captured less flies than traps at the other 2 levels.

These experiments indicate that sticky-ball traps will capture the largest numbers of Chrysops atlanticus at 1-2 meters above the ground, depending upon the surroundings. Further evaluation and refinement of this sampling method is warranted.

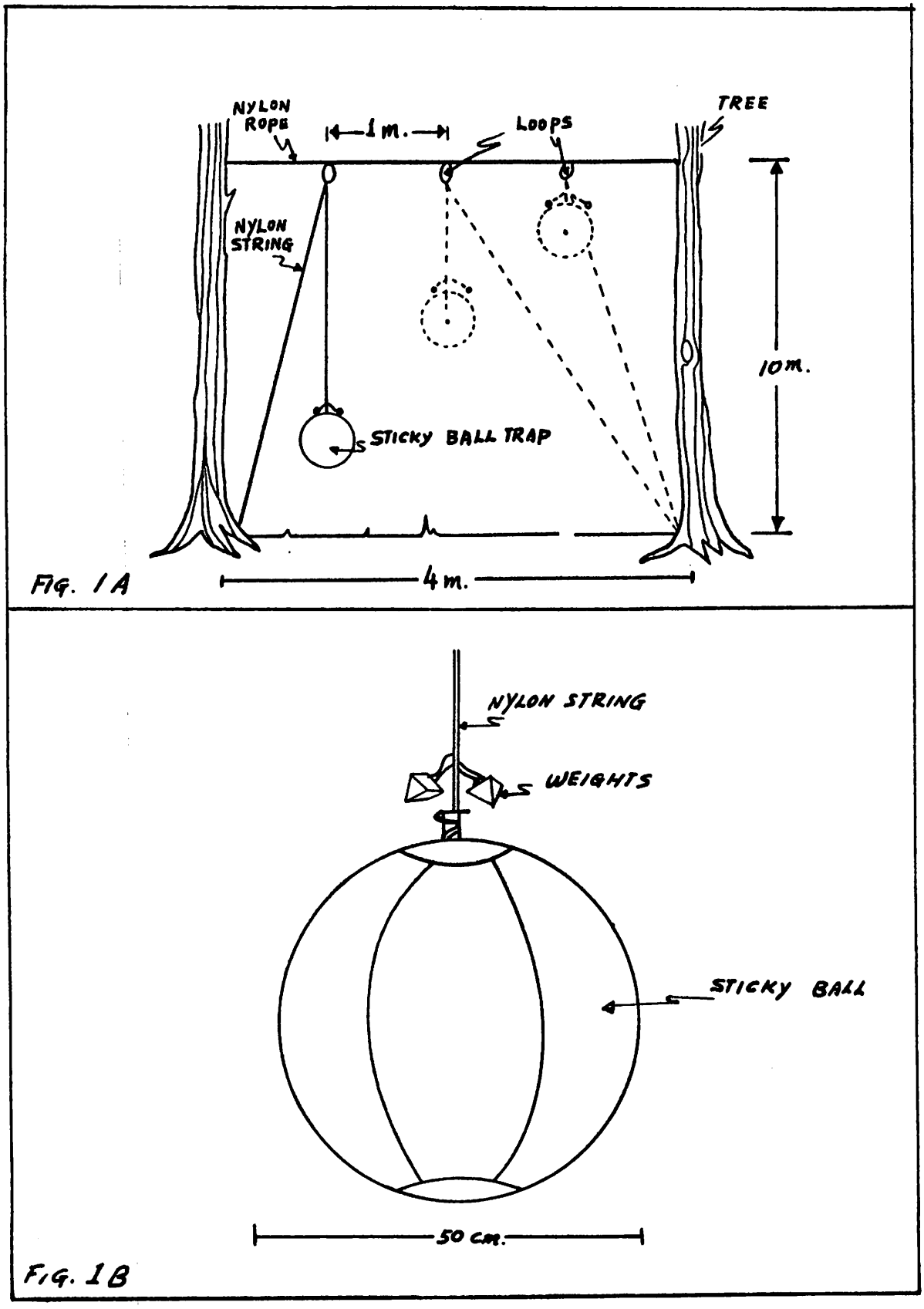


Fig. 1. Arrangement of sticky ball traps.

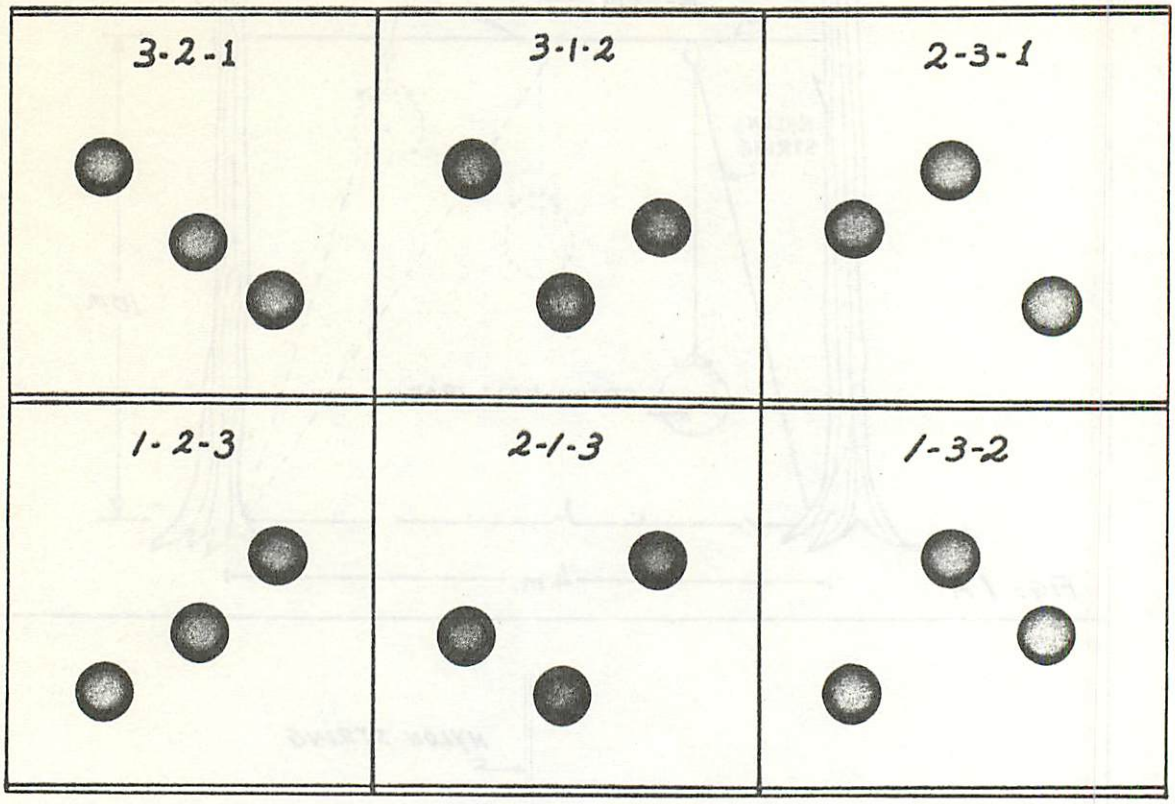


Fig. 2. Height sequence in test of sticky ball traps.

Table 1 - Number of tabanids captured by sticky-ball traps at Davis, N.C.

Level	Date	Combination used	Number of specimens per ball				
			Chrysops atlanticus	Diachlorus ferrugatus	Tabanus lineola	Tabanus nigripes	Tabanus nigrovittatus
1 (2m.)	July 22	3-1-2	8	0	0	0	0
	July 26	2-3-1	4	0	0	0	0
	July 27	3-1-2	7	1	0	0	0
	July 28	3-2-1	7	0	0	0	0
	July 29	2-1-3	3	0	0	0	0
	August 2	1-2-3	2	0	1	0	0
	August 3	1-3-2	2	0	0	1	1
	August 4	2-3-1	0	0	0	0	0
	Total		33	1	1	1	1
2 (4m.)	July 22	3-1-2	3	0	0	0	0
	July 26	2-3-1	0	0	0	0	0
	July 27	3-1-2	0	0	0	0	0
	July 28	3-2-1	0	0	0	0	0
	July 29	2-1-3	3	0	0	0	0
	August 2	1-2-3	0	0	0	0	0
	August 3	1-3-2	1	0	0	0	0
	August 4	2-3-1	0	0	0	0	0
	Total		7	0	0	0	0
3 (8m.)	July 22	3-1-2	1	1	0	0	0
	July 26	2-3-1	0	0	0	0	0
	July 27	3-1-2	0	0	0	0	0
	July 28	3-2-1	0	0	0	0	0
	July 29	2-1-3	0	0	0	0	0
	August 2	1-2-3	0	0	0	0	0
	August 3	1-3-2	0	0	0	0	0
	August 4	2-3-1	1	0	0	0	0
	Total		2	1	0	0	0

Table 2. - Number of tabanids captured by sticky ball traps at Lake Shore Drive, Morehead City, N.C.

Level	Date	Combination Used	Number of specimens per ball: Chrysops atlanticus	Chrysops flavidus	Tabanus lineola	Tabanus nigrovittatus
	August 12	3-1-2	3	0	1	3
	August 13	3-2-1	0	0	0	2
	August 14	2-1-3	1	0	0	0
1	August 15	1-2-3	5	0	0	1
(0.5m.)	August 16	1-3-2	0	0	0	1
	August 17	2-3-1	8	0	0	1
	Total		17	0	1	8
	August 12	3-1-2	0	0	1	0
	August 13	3-2-1	1	0	0	1
	August 14	2-1-3	1	0	0	1
2	August 15	1-2-3	0	0	0	1
(1.0m.)	August 16	1-3-2	0	0	1	3
	August 17	2-3-1	22	0	0	2
	Total		24	0	2	8
	August 12	3-1-2	3	1	0	0
	August 13	3-2-1	0	0	0	1
	August 14	2-1-3	0	0	0	0
3	August 15	1-2-3	0	0	0	0
(2.0m.)	August 16	1-3-2	2	0	0	0
	August 17	2-3-1	5	0	0	0
	Total		10	1	0	1

4. Larval Collections from a *Spartina* Marsh

Samples (10 qt pail) of soil from the *Spartina alterniflora* marsh along Newport River were washed to recover larvae of Tabanidae. Some of the residue after washing was held in Tullgren funnels to recover additional larvae. Sampling was done at right angles to a drainage ditch running from the upland perimeter ditch to the river in nearly a straight line.

As shown in Table 1, a few larvae of *Chrysops fuliginosus* and *Tabanus nigrovittus* were found in about half of the sample sites in a variety of distances from the ditch and from the upland. In addition, samples were taken at 1 m intervals in the range of 10 - 40 m from the ditch in line with sample row 5 (middle of the marsh). Those samples yielded 8 *C. fuliginosus* and 1 *T. nigrovittatus*. The data indicate that these tabanids are breeding throughout the *Spartina* marsh and apparently are not restricted to a particular zone near the ditches.

Table 1. Recovery of larvae of Tabanidae from soil in Spartina marsh, Newport River, Morehead City, N.C., April 1971. Numbers in parenthesis () are Chrysops fuliginosus and numbers without parenthesis are Tabanus nigrovittatus.

Meters from Ditch (b)	Row No. (2)										
	1	2	3	4	5	6	7	8	9	10	Total
1	0	(1)	1	1	1	1	0	0	(1)	(1)	4(3)
2	2	1	0	1	0	0	0	0	0	0	4(0)
3	1	1(1)	3	(2)	0	(1)	0	0	0	0	5(4)
4	1	2	0	0	0	0	(1)	0	(1)	1	4(2)
5	(1)	0	1	1	0	1	0	(1)	0	0	3(2)
6	0	0	0	(1)	(2)	0	0	(2)	2(1)	0	2(6)
7	0	0	1(1)	1	(1)	0	0	0	2	0	4(2)
8	0	0	0	(2)	1	0	0	(2)	(1)	2	3(5)
9	(1)	(2)	0	0	0	1	(1)	(2)	(1)	0	1(7)
10	(5)	(2)	0	0	0	0	0	1	0	0	1(7)
composite residues 1 - 10 m	(4)	0	0	(1)	0	(2)	(5)	(2)	(9)	(15)	0(38)
TOTAL	4(11)	3(6)	5(1)	4(6)	2(3)	3(3)	0(7)	1(9)	4(14)	3(16)	

(a) Row #1 about 6 m from upland border and row #10 close to edge of river. Other rows very roughly evenly spaced in between.

(b) Ditch refers to natural drainage ditch running from upland to the river. Sample rows were at right angles to this ditch.

5. Effect of Ditching on Mosquito Production from Juncus Marsh.

Objective. The broad objective of this study was to compare the mosquito breeding in ditched and unditched areas to determine the effectiveness of ditching in preventing the successful emergence of adult mosquitoes from Juncus salt marshes in North Carolina. Specific objectives of the project included determining what mosquito species were breeding on the salt marsh, where on the marsh they were breeding, the relationships of such factors to breeding as the frequency of flooding (inversely related to elevation), soil composition, plant cover, presence of water-holding depressions, distance from maximum high tide level, distance between breeding sites and ditches, and salinity of breeding site water. Also included in the study was a determination of the relationship of the above-listed factors to adult production and the economic significance of each marsh mosquito species.

Procedure. A tract of approximately 150 acres of salt marsh at North River, in Cartaret County near Beaufort, N. C. was chosen for the study. One-half of this tract was unditched and served as the control for the other half, which was crossed by a series of straight draglined ditches (excavated in 1968) extending from the wooded high ground across the marsh to the river. The paralleled ditches were approximately 150 feet apart. A relatively large portion of this North River tract was used as a general survey area and was traversed at least once a week to gain a general impression of the mosquito breeding occurring throughout the area.

A smaller portion of the tract was set aside for more intensive study. This entailed gridding the area into sections or lanes marked with five foot stakes. These sections were laid out parellel to North River (Fig. 1).

After this gridding was completed, an intensive survey for mosquito breeding sites was undertaken. Each site found, 43 in all, was marked with a three-foot stake, numbered and its general location charted. Each site is represented by an encircled X on the drawing of the study area shown in Figure 1. All of these sites were located in Areas 1 to 6, with 26 sites being in the control portion and 17 in the ditched portion. Areas 7 to 13 contained 50 marked but unnumbered randomly - selected sites which were checked once or twice a week. These were part of the general survey area.

All of the numbered sites were visited 2 to 4 times a week. During each of these visits, the depth, temperature and salinity of the water were measured. Additionally, the size of the breeding mosquito population present was estimated and its species makeup determined. Four series of 5 ground water holes each were dug in the study area, two in the ditched portion and two in the control portion, to determine changes in ground water level. Late in the summer, a description of the vegetation was made for each site to see if any correlation could be found between vegetative cover and the occurrence of mosquito breeding. This analysis was carried out by estimating the area covered by each plant species within a 100 square foot area surrounding the breeding site. A recording tide gauge placed in the ditch separating the ditched and unditched portions of the study area was used to determine the frequency of marsh floodings. Two New Jersey light traps, one on high ground at the edge of the study area and another at Williston, 10 miles east, were used to assess the number and species composition of the adult mosquito population in that portion of Carteret County. During the months of June, July and August, a series of human biting counts were also taken at regular intervals approximately 100 feet from the North River marsh. Each count began at 8 p.m. and continued until 11 p.m. This three-hour period was divided into 30 minute intervals and all mosquitoes caught during each of these intervals were placed in vials and subsequently identified to species.

Results. Before examining the results obtained (summarized in Table 1), the following explanation of the factors used in the table need to be made.

A. Mean number of specimens taken per site. This was determined by dividing the total number of mosquito larvae from the separate ditched and unditched areas by the number of sites in the respective areas.

B. Percent specimens taken per area. Determined by dividing the number of specimens taken from the ditched and unditched areas separately by the total taken from North River.

C. Mean relative species abundance per site. Determined first by dividing the number of specimens of each species identified by the total number of specimens identified from a particular site, giving the percent relative species abundance for each site and finally by adding the percent relative species abundance per site for the ditched and unditched sites separately and dividing by the number of sites in each area.

D. Percent survival. This value was based on the sole condition of whether or not mosquitoes emerged before the particular site dried up. All mosquito larvae collected were reared in the laboratory, while at the same time keeping close watch on all sites to determine when they became dry. If, for instance, adults emerged in the laboratory a day or two before the site from which they were taken dried up, then it was presumed that they would have survived in nature. No other mortality factors were considered, since the study's main concern was to determine whether or not the ditching was increasing the drain-off of water in the salt marsh sufficiently to prevent the emergence of adults.

E. Percent relative species abundance for entire North River area. Determined by combining the number of identified specimens of a particular species taken from both the ditched and unditched areas and dividing this quantity by the total number of specimens identified from North River.

F. Percent relative species abundance for the separate ditched and unditched areas. Determined by dividing the number of specimens of a particular species taken from the ditched and unditched areas separately by the total number of specimens of that species taken from North River. For example, 32% of all specimens taken from North River were Aedes sollicitans. Of that percentage, 57% were taken from the ditched area and 43% from the control area.

G through K. Self-explanatory.

L. Mean breeding index/site. Determined with a formula developed by Belkin (1954). $B.I. = \frac{SA \times PD \times TLP}{ND \times ND \times 10}$, where:

B. I. = breeding index.

SA = surface area of body of water serving as effective breeding site in square feet.

PD = Positive dips obtained (those dips in which mosquito larvae are found).

TLP = Total number of larvae and pupae obtained.

ND = Total number of dips taken, disregarding all negative dips prior to the first positive dip.

This index was used to compare the breeding potentials of ditched and unditched sites at North River. The much higher value obtained for the ditched area was due to Site #4 (see Fig. 1) which had a mean breeding index of 262.4. It was the most prolific breeding area at North River, producing approximately 25% of all mosquitoes taken.

According to Table 1, the five most commonly encountered species of mosquitoes were: Aedes sollicitans, Aedes taeniorhynchus, Anopheles bradleyi, Anopheles atropos and Culex salinarius. The two Aedes species were found to be most numerous in sites located in or near the wooded regions. The

remaining three species were taken in fairly constant numbers throughout the entire study area (see Fig. I).

The mean frequency of flooding per month for North River was 9.1 times for the interval March 1 - August 31, 1971. This produced a mean number of wet intervals per site for the ditched portion of 2.1 7-14 day intervals, 1.9 15-21 day intervals and 0.9 intervals of 22 days or longer; and for the unditched portion 1.0, 1.8 and 1.5 respectively (see Table 1, factor I).

The soil composition for the North River salt marsh has not yet been determined, but will be during the 1972 season.

The information obtained from the vegetation analysis, as presented in Table 3, shows that the mean relative plant species abundance per site for the ditched study area was 51% Distichlis spicata, 34% Juncus roemerianus, 10% Panicum virgatum and approximately 2.0% for Spartina patens, Baccharis halimifolia, Scirpus robustus, Borrichia frutescens and Iva ciliata. The remaining area of 3% was unvegetated. For the unditched area it was 43% Juncus roemerianus, 31% Distichlis spicata and approximately 3% for Panicum virgatum, Borrichia frutescens and Spartina alterniflora. The remaining area of 17% was without vegetation.

All 44 intensive study sites, as well as the approximately 100 sites in the general survey area were water-holding depressions ranging from a depth of 1.5" to 7". No mosquitoes were taken in several of these depressions.

The distance from maximum high tide level of each site can be seen in Figure 1 and the distance of each site from a ditch was found to vary from 23.1 to 598.7. Studies on the ground water levels in the ditched portion have shown that in general the water in the ground water holes (holes A and E of Fig. 3) nearest to the ditch (within five feet), quickly drained, keeping the water usually below marsh level. However, the levels of the next inner

two holes (holes B and D), each a distance of approximately 40 feet from the ditch were slower to drain, taking on the average about 2-3 days to drop below marsh level. The middle ground water hole (hole C, Fig. 3) took as long as four days to drain. As would be expected from these data, most of the ditched area breeding sites were located approximately midway between the ditches.

The mean salinity, which was determined by a refractometer, for the ditched sites was 16.5 ppth and for the unditched portion, 17.1 ppth. The range in salinity for the entire study area was 1.5 - 32.5 ppth, the upper limit being very close to that of sea water, i.e. 35 ppth.

By considering ditching and its effect on the drainage of the marshes to be the only factor causing larval and pupal mortality, the percent survival (factor D, Table 1) was determined. The resulting percent survival determined for the mosquitoes in the ditched portion was approximately 50% for Aedes sollicitans and Aedes taeniorhynchus, 45% for Anopheles bradleyi, 33% for Anopheles atropos and 6% for Culex salinarius. In the control portion it was approximately 50% for Anopheles bradleyi and Anopheles atropos, 43% for Aedes sollicitans and 27% for Aedes taeniorhynchus. The mean percent survival for all species combined for the ditched portion was 37%, whereas for the control area it was 42%. This means that of all mosquitoes taken from the ditched portion, 37% survived, and of those taken from the control portion, 42% survived. This difference is probably not significant.

An attempt to determine the economic importance of each marsh breeding mosquito species encountered was carried out by conducting a series of human biting counts at North River at a site situated approximately 100 feet from the marsh area. The collections were made at regular intervals during the months of June, July and August. According to Figure 2, bottom graph, both

species of Anopheles were more often taken biting per 30 minute interval than either species of Aedes. Culex salinarius and Psorophora confinnis, a woodland species, were, at times, particularly annoying, reaching even higher numbers per 30 minute interval than either Anopheles or Aedes species.

Light trap results (Fig. 2, middle graph) also show a higher incidence of Anopheles species for the interval March 1 - August 17, 1971 than for either Aedes species for both the North River and Williston areas.

Table 1

Accumulative Data for the Interval March 1st - August 17, 1971 North River, Carteret County, N. C.

(Mean frequency of flooding/month = 9.1)

		DITCHED AREA Sites # 2-15 and 17			UNDITCHED AREA Sites # 16 and 18-42	
A.	Mean # of specimens taken per site	233			93	
	Range	8 - 1540			18 - 237	
B.	% specimens taken per area	58.5%			41.5%	
C.	Mean relative species abundance %/site	*Aedes sollicitans*	34%		20%	
		Aedes taeniorhynchus	17%		5%	
		Anopheles bradleyi	37%		50%	
		Anopheles atropos	8%		24%	
		Culex salinarius	2%		0%	
D.	% Survival	*Aedes sollicitans*	49%	MEAN FOR	43%	MEAN FOR
		Aedes taeniorhynchus	48%		27%	
		Anopheles bradleyi	45%	AREA 37%	54%	AREA 42%
		Anopheles atropos	33%		47%	
		Culex salinarius	6%		0%	
E.	Relative species abundance % for entire N. River area ditched and unditched combined	*Aedes sollicitans*	32%			
		Aedes taeniorhynchus	28%			
		Anopheles bradleyi	28%			
		Anopheles atropos	11%			
		Other	1%			
		DITCHED			UNDITCHED	
F.	Relative species abundance % for separate area	*Aedes sollicitans*	57%	+	43%	= 100%
		Aedes taeniorhynchus	87%	"	13%	" "
		Anopheles bradleyi	43%	"	57%	" "
		Anopheles atropos	20%	"	80%	" "
		Culex salinarius	100%	"	0%	" "
G.	Mean # of dry periods per site	7.1			5.5	
		Range 2 - 11			2 - 10	
H.	Mean number of days dry/dry period/site	34.8	Range (14 - 52)		34.2	Range (5 -76)
I.	Mean number of wet intervals per site		7-14	15-21 22+ days	7-14	15-21 22+days
		Range	2.1	1.9 .9	1	1.8 1.5
		Range	0-5	0-4 0-3	0-4	0-4 0-3
J.	Mean Depth/Site	3.2"	Range (1.5 - 7.0)		2.8"	Range (1.5 - 4.1)
K.	Mean salinity/ Site (ppth)	16.5	Range (7 - 18.7)		17.1	Range (9.2 - 24.5)
L.	Mean Breeding Index/Site	23.8	Range (.004 - 262.4)		2.3	Range (.2 - 7.9)

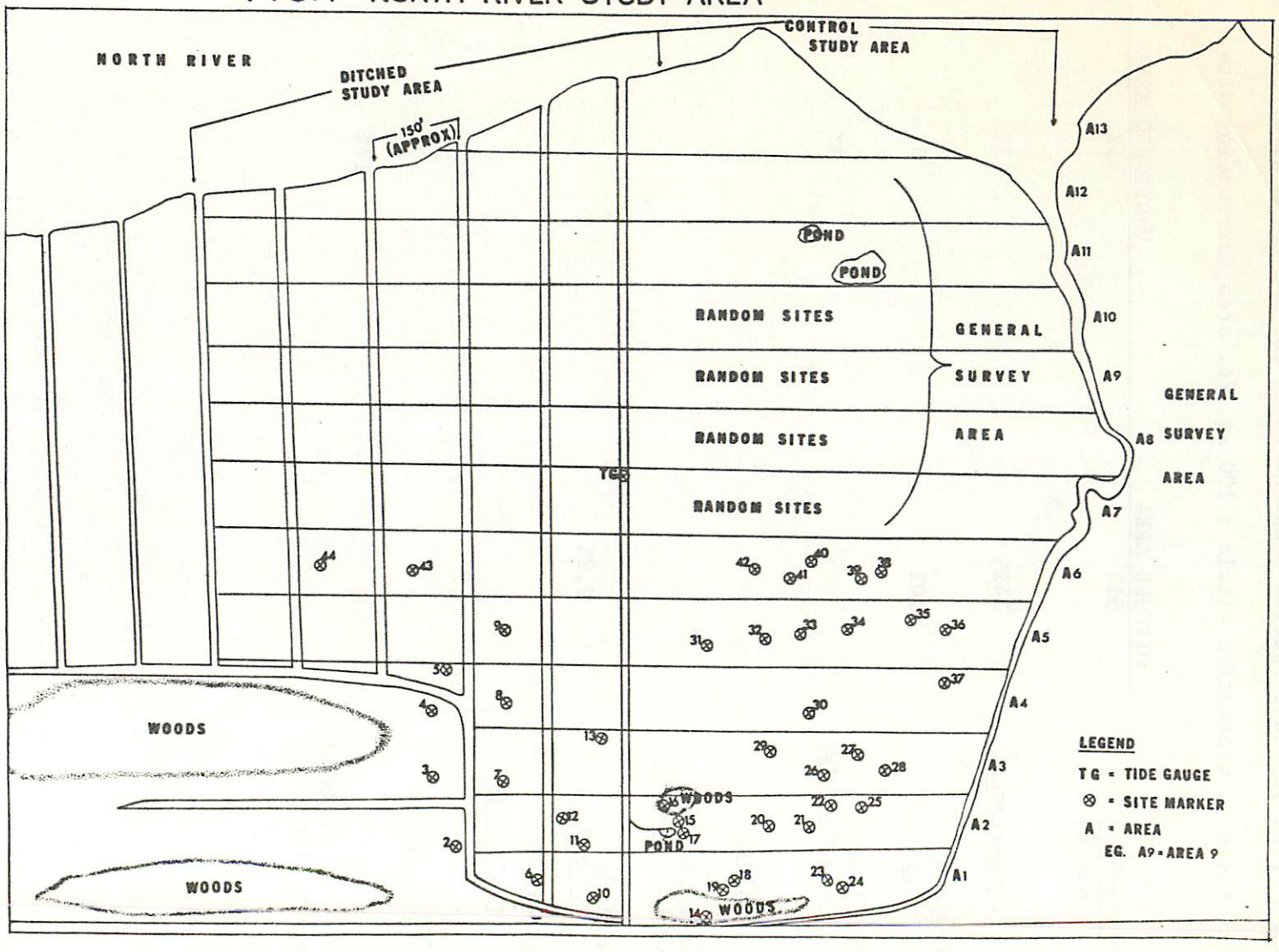
Table 2

Mean Relative Plant Species Abundance/Site for the North River Study Area.

(%) Based on vegetation within a 100 sq. ft. area surrounding site.

	DITCHED AREA	UNDITCHED AREA
Distichlis spicata	51%	31%
Juncus roemerianus	34%	43%
Panicum virgatum	10%	3%
Spartina alterniflora		3%
Spartina patens	2.2%	
Baccharis halimifolia		
Scirpus robustus		
Borrichia frutescens		
Iva ciliata		3%
Area of site with no emergent vegetation	3%	17%

FIG.1 NORTH RIVER STUDY AREA



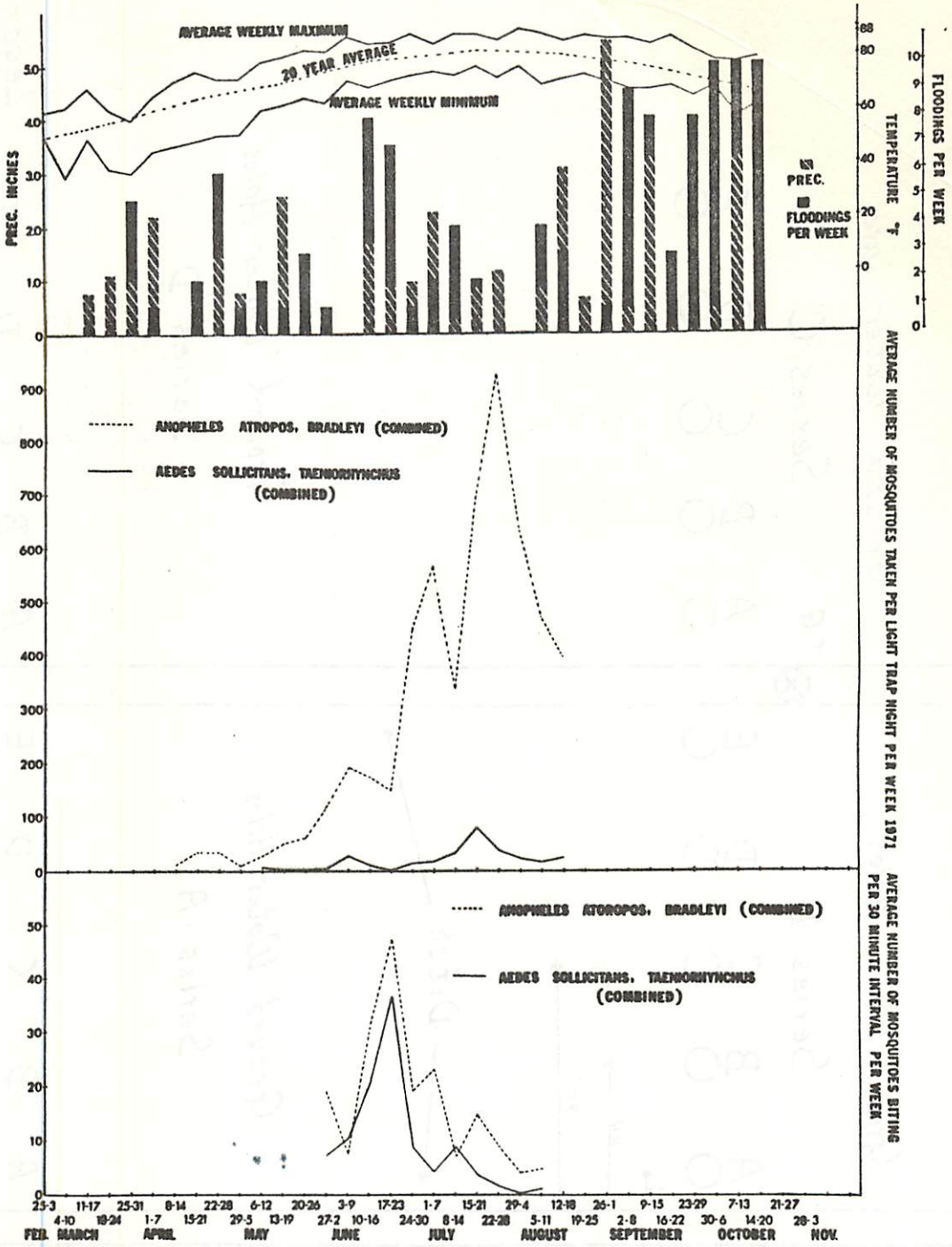


FIG. 2 ACCUMULATIVE DATA FOR THE INTERVAL MARCH 1st - AUGUST 17, 1971 NORTH RIVER CARTERET COUNTY, N. C.

Fig. 3

Location of Ground Water Level Holes at North River