1990

ARE MOSQUITO REPELLENTS EFFECTIVE?
A SUMMER RESEARCH PROJECT
UNIVERSITY OF NOTRE DAME ENVIRONMENTAL RESEARCH CENTER

Mary Bernard
Senior Biology Major
Research Advisor:
Prof. George Craig

ABSTRACT

Sixteen various insect repellents were field-tested during the months of May, June, and July of 1990. Tests were performed at UNDERC in areas with heavy mosquito populations. Student volunteers were used to collect mosquitoes coming to bite. On the average, four volunteers acted as controls and experimentals for two five-minute intervals. The landing/biting mosquitoes were collected with battery-powered hand-held aspirators. The insects were then frozen, and later identified to species. Counts of twenty-five to fifty mosquitoes per five minute period were typical. This experiment is a continuation of a similar experiment conducted the previous summer on the same land by Kurt Shubert.

It was found that a great many variables affected biting rate. The most important was the temperature. Trials were conducted at sundown and some evenings were too cold. Satisfactory results were obtained for forty-two tests. Skin temperature, variability among collectors, testing at zero, two, and four hours after application were all tested.

The results indicate reliable repellents are a rarity among the boastful commercial claims. Formulations containing DEET worked well both immediately and two hours after application. Skin So Soft and Green Ban Herbal are more pleasant short term alternatives. Area repellents were rather disappointing. Naphthalene flakes and citronella candles were useless. Sonic devices, such as the dragonfly mimic, and gravid mosquito hum, were totally ineffective and are classified as fraudulent. The only one which showed any promise was the burning repellent by Johnson Wax, Bug Barriers.

INTRODUCTION

This type of field testing of insect repellents is important for a variety of reasons. There is an abundance of products on the market today which claim to be the consumer's answer to his prayers. Some of these claims are completely baseless; consumers should be aware of these frauds. In less extreme situations, they should just be aware of the best buys. People use repellents to prevent bites from potential disease carrying insects. Repellents should also reduce the harassment encountered when venturing outside. No one wants to spend glorious summer days and evenings swatting at the pestering insects. In addition, even though laboratory testing is vital to scientific research, field experimentation provides a more accurate idea as to how repellents really fare. Field testing exposes the repellents to all the variables that they need to overcome, including the indigenous arthropod populations. Repellent testing is important scientifically and commercially, as well as to the general public.

Studies on the local mosquito species have been conducted on UNDERC grounds for approximately the last twenty years with a total of thirty-one species collected. Most of the species found are of the Aedes communis, or black-legged group, or of the Aedes excrucians, or white striped-legged group. The black-legged species emerge earlier in the year, in general, from vernal ponds. The striped-legged mosquitoes tend to emerge later from more permanent bodies of water. In the student's guide there is a statement, "Bloodsucking arthropods can make life unpleasant in late May and early June, unless one uses ample repellent" (A Student's Guide to U.N.D.E.R.C., p.10). Obviously, the area is quite conducive to field studies on mosquito repellents.

MATERIALS AND METHODS

Sixteen repellents were tested over the course of eight weeks for a total of forty-two tests. The trials began on May twenty-sixth and ended on July twentieth. Each repellent was tested at least twice. See Appendix B for the types of time tests to which it was subjected. Appendix A has abreviations used in this report. Those repellents which performed poorly during the initial immediate application trials repeated that type of trial to insure confidence in the results. Those repellents which seemed to work were then tested after a delay. Only the deet repellents did well enough after approximately a two hour delay to warrant a four hour test.

The repellents can be separated into two main categories: personal repellents and area repellents. The personal repellents can then be further divided. These consist of: the standard--Johnson Wax Deep Woods Off; the clothing only repellent--Permanone; deet repellents--Neverbite and Revco; electronic devices--Bug Shield and Mosquito Hawk; the herbal repellent--Green Ban; products not marketed as repellents--Skin So Soft and baby oil; and, finally, the unknowns--Albert Laboratories' Insect Repellent Hair Spray, and Alberto Culver's Product A and Product B. The remaining are area repellents: Bonide's Mosquito Beater; citronella candles; Johnson Wax Off! Yard and Patio Bug Barriers; and Pic Repellent Coils. See Appendix C for a list of the repellents and their ingredients.

Shubert tested nine repellents in 1989. Of these, eight were retested in 1990. These eight included Mosquito Beater, Pic Repellent Coils, Skin So Soft, Neverbite, baby oil, citronella candles, Bug Shield, and Mosquito Hawk. He also tested Revenge which was not tested in 1990 because of the inconvenience of

trying to test it outside.

The repellents were tested on UNDERC property owned by the University of Notre Dame. The property is located mainly in Gogebic County, on the upper peninsula of Michigan, but also extends into Vilas County, Wisconsin. The property consists of 7345 total acres, 6135 acres of land, and thirty "lakes and bogs with a combined surface area of 1210 acres... The UNDERC property is bounded on three sides by units of the Ottawa National Forest" (A Student's Guide to U.N.D.E.R.C., p.1).

Generally, four volunteers went out each day, and two five minute trials were completed. For five minutes the volunteers would suck up any landing/biting mosquitoes with the aspirators. The aspirators were nothing more than modified flashlights with plastic vials placed on the ends. The second trial was done after the first trial vials were labeled, and the aspirators reassembled. The whole process did not involve more than twenty to twenty-five minutes; although, time intervals were recorded by the half-hour. People stood a few feet away from each other, probably ten feet on average. With infrequent exceptions the trials were conducted right before sundown, between eight-thirty and nine-thirty in the evening. Twilight is the ideal time. The first measure was always to take people's skin temperature. Sometimes people did not register a temperature on the thermometer; however, it was the accepted belief that they were in no danger of any harm. If a person did not register, he was assigned a temperature of eighty-eight degrees.

In the beginning, some confusion stemmed from the fact that volunteers were not sure if they should collect mosquitoes from just their arms or their entire bodies. Topical repellents were only applied to forearms. Head nets were worn for all but the hair spray tests. Ideally, a repellent should repel all mosquitoes from the subject, but this obviously was not the reality for the

liquid repellents. For example, everyone was pleasantly surprised at how well Green Ban worked on the forearms where the oil was rubbed on the skin, but the insects continued to land on people's legs. That is why Dr. Craig who collected mosquitoes from his entire body collected ten mosquitoes while the three other volunteers only gathered zero, one, and four mosquitoes each. This dilemma was resolved with the clarification that if a topical repellent was the subject of a particular test then the mosquitoes were taken from the arms only. If the repellent was one that should repel insects from the entire area, then the insects were taken off the entire body. This includes area repellents and electronic devices. It was noticed that mosquitoes landing on clothing were much more difficult to catch.

The insects were frozen in the vials and identified the following day. Every once in a while for varying reasons the identifications could not be made. If, for example, the adults got wet, then they could not be identified. Normally, this was not a problem.

Each repellent was tested at least twice during the course of the summer. As one can see, not only do the dominating populations shift over the season, but the biting pressure fluctuates on a daily basis. In attempts to determine ideal biting conditions, variables such as outside temperature and relative humidity were read at the testing location at the start of the trial from a portable meter Humidiguide by Taylor. The temperature and humidity would sometimes change quite dramatically during a test because these tests occurred at sundown, so the readings were always taken at the beginning for consistency sake. General weather conditions were also noted. As often as possible, trials were run on a daily basis. Initially, trials were delayed a week because the mosquitoes had either not emerged, or were not yet biting. There were also days on which trials were canceled because it was so cold that the mosquitoes were not

active. Other days unfavorable weather kept the volunteers inside.

Data was kept on the volunteers. A list of them can be found in Appendix D. Skin temperature of each volunteer was taken daily with plastic forehead thermometers. The accuracy of these may be questioned as they were bought in a local drugstore and are intended for inside use, but again they provide a relative idea of the volunteer's skin temperature.

The inconsistencies in the amounts of mosquitoes collected per volunteer was a major concern. Individual attractiveness was noticed by all. Among the thirteen volunteers in this experiment, the individual variability dilemma was almost alarming at times. Some felt consistently attractive to the insects, such as Mary Bernard, Michael Chambers, And George Craig, while others felt mosquitoes avoided them. Some of this effect may have been due to the maintenance and fluctuations of concentration and eagerness levels. Some undoubtedly resulted from physical factors. Temperature, moisture, carbon dioxide, age, sex, and body odor all are factors in attracting mosquitoes (Craig 1963). Craig also states that women fluctuate in attractiveness because of the menstrual cycle; however, Rutledge claimed in 1988 that more study was necessary before any sex related conclusions were to be made. To eliminate discrepancies in the immediate application tests, individuals acted as both the controls and experimentals. In the time lapse experiments, the person wearing the repellent unfortunately could not act as a control; therefore, individual variability remained unavoidable in these tests. At least four people were taken out each night to reduce variability and add validity to a repellent's effectiveness.

People needed to be careful with the equipment also. The battery powered aspirators were picked up by the volunteers right after they had applied repellent. Many of the personal repellents were lotions or liquids. Everyone wiped his/her hands before handling the aspirators, but there is always the

chance of equipment contamination. The same aspirators were used constantly, and some's suction was not as strong as the rest. They still worked, but this seemed to shake some of the volunteer's confidence, and most likely resulted in the capture of a few less insects than anticipated. Hopefully, the fact that there were four people involved in a given trial weakened the effect this may have reeked on the results. Additionally, one person monitored the time. Once again, this was crucial for the goal of consistency because sometimes a watch with a second hand was not available.

A few different locations were used as collection sites. The tests began at Tender Bog, a small bog set in the woods. Because of the variability at this test site, it is important to note the topography of the surroundings. A small road about fifty feet long leading into the woods intersects the main road. At the end of this dirt road is a boardwalk through the woods leading to the bog. The first trial, in which the standard Off was evaluated, was split up with two people remaining on the side of the main road and two people going back to the dock on the water. Since so few mosquitoes were out on the roadside, all four volunteers came back to the dock for the second round. During another trial, which was conducted in its entirety on the path, it was noticed that the exact location of the path made a difference in the number of mosquitoes collected. Those closer to the bog in the more open area attracted less mosquitoes then those under the coverage of the forest. Mosquitoes preside in protected areas, and repellents do not dissipate as quickly and therefore work better in lighter wind in protected areas.

Other test sites utilized involved the dock at Bay Lake, a rather large lake, the woods next to an open field, near a marsh, but not a large permanent water body, Tuesday Bog, and Firestone Bog. All of the bog sites are similar in that dirt roads leading to the water provide an open area surrounded by woods

next to the water. See Appendix E for a list of testing locations. The list of mosquito populations in Appendix K also provides the location of collection.

Density is an important consideration for area repellents. The distance between the individual coils for the burning type, such as Bug Barriers and Repellent Coils, as well as the number used in the given area will effect the speed at which the repellent dissipates. The amount of naphthalene flakes sprinkled in a given area should be a consideration for Mosquito Beater's use. Keeping these factors in mind and working with the material at hand, the experiments were designed as reasonably and consistently as possible. Part of the beauty and/or frustration of these trials is the fact that outside conditions alter daily, if not hourly. If a repellent is going to be worth its purchase value then it should work in a broad range of outside conditions.

In the same mind frame, the amount of a personal repellent used will effect the results. To avoid discrepancies, in the hope of standardizing the amount, portions were partitioned to the volunteers by Mary Bernard. The one great consistency to the summer was the fact that one person attended every trial. Although twelve others volunteered, everyone understood the procedures after a couple of trials. A smaller pool of volunteers may be more desirable, but may also be much more difficult to gather. The risk of people not trying as hard to capture mosquitoes increases the more times people are subjected to the torture of being bitten when the repellents are not very effective and the mosquitoes are hunting mammalian blood greedily.

An additional factor in biting pressure is the time of day. Shubert took his trials at twilight. Experience has shown this to be the time of day with the heaviest biting. Some of the tests were carried out in the late afternoon due to necessity. During these trials the volunteers noted a remarkable decrease in the aggressiveness of the insects. For example, a test at North Gate Bog on June

fourteenth from five-thirty to six o'clock resulted in control numbers of twenty-four, three, eight, and three per individual. These are not impressive numbers, and as a result the test was redone the next day.

Shubert wrote in his paper that he gathered control data first to insure that population depletion did not become a hinderance to his conclusions. Controls in this case were also taken first for the immediate application tests, but were taken during both trials for the other tests. For the area repellents two people stood amongst the repellent for the first trial, while the other two were in the vicinity but outside the range and upwind of the repellent to serve as controls. Everyone switched roles for the second trial. For time lapse trials the same two people would act as controls for both trials. Something to think about is the possibility that there might be more mosquitoes around for the second trials than the first because then the mosquitoes have had time to discover the warm blooded animals.

One final point concerns the identifications to species. Most of the identifications were done by Dr. George Craig due to the difficulty of distinguishing adult females, and to his long standing experience and expertise. Dr. Craig, however, was not available for the entire duration of the experiment, so Mary Bernard did the identifications with guidelines set by Craig. Because this was her first time identifying these dipterans, and due to the absence of a key, the identifications may not be one hundred percent correct for a few of the weeks in June.

RESULTS

The data from the trials was compiled and condensed for interpretation. The statistical test chosen to evaluate the repellents was the T-test. The purpose of a T-test is to compare two means to see if they are significantly different from each other. The relevant value obtained is the p value, or the probability value. If p is equal to or less than .05 then the means are significantly different. Expressed another way, if p is equal to or less than .05, then there is a ninety-five percent chance that the two means are significantly different. This was a convenient test for the comparison of two variables, and it was also the test used by Shubert the year before. The T-tests were run comparing the mean for the control samples to the mean for the experimental samples for each day. Appendix F, G, and H give the means and the probability values for each test.

According to these statistics, a list of effective repellents includes Off, Revco, Neverbite, Green Ban, Skin So Soft, Product B, Bug Barriers, and the deet hair spray when applied to the hair, effective for preventing bites on the head only. Off and Skin So Soft were also both effective two hours after application. Revco received a value of .082 and Neverbite a value of .078 after two hours of wear, suggesting that the repellent weakens around that time. Skin So Soft for its first trial received a value of .087, but proved significant during its next two trials with values of .026, and .006 after two hours. The first test day can almost be disregarded entirely because by moving about seven feet on the boardwalk at Tender Bog towards the open water, Mary Bernard who was a control for both trials captured half as many mosquitoes on the second trial as compared to the first trial only a few minutes earlier. For the two hour test done later

in the season only one person was able to act as a control, while there were three experimentals. This no doubt led to a highly favorable statistic, but nonetheless the repellent did indeed work. Nothing came out as a valid repellent four hours after application. Even Off received a value of .623, signifying its loss of effectiveness over time.

Those tests with a resulting probability value of .05 or less indicate effective repellents, except in the case of the .02 value for one of the Mosquito Beater tests. If one looks at the means for that test, the control numbers are much less than the experimental figures. Consequently, the data suggests this is an attractant to mosquitoes. This was certainly how it felt during the trials. Mosquito Beater was tested three separate times. The p values for the other tests equaled .459 for a June eighteenth test, and .101 for a July thirteenth test. These other values do not suggest that the material attracts mosquitoes. The reason the product may have produced those surprising results is that if the product just does not work and more mosquitoes became active as time wore on, then the product would appear to attract the insects.

Sensitivity of mosquitoes to repellents may vary among species (Rutledge et al. 1978); although, in the case of Altman's investigations in Alaska they did not (1955). Field tests expose repellents to the various indigenous species. It is important commercially that the repellents work against all the local species. A list of the species caught is in Appendix I. The data for the species of mosquitoes captured shows a definite shift in the populations. The graphs in Appendix J illustrate the shift. The data, Appendix K shows a decline in the abundance towards the middle of June, a resurgence and another decline in the beginning of July, and another resurgence in the middle of July. The majority of mosquitoes were Aedes punctor, provocans, communis, cinereus, and Mansonia perturbans. The Aedes communis group showed dominance and great

diversity in the early summer and although the mosquitoes persisted through the season, they dropped in number towards the end. Through the weeks, more of the Aedes excrucians group emerged. Towards the end, the majority of mosquitoes were of the Mansonia perturbans species. These are aggressive biters that appear as the sun sinks below the tree line.

As the season wore on, and the numbers of species appeared to decline, the time of the which the test was conducted became most crucial. Attempts were made to begin the trials at eight-thirty, but no mosquitoes could be found before nine o'clock. As the trials progressed, the insects appeared in hordes. This resulted in amazing increases in the numbers of mosquitoes collected between the first and second trials of repellents which plainly did not work.

A observation made as sort of an aside surrounded North Gate Bog which has not been used in extensive testing for quite a few years. Curiously, a predominance of Aedes cinereus landed on the volunteers at this bog; although no conclusions can be made as to why. This may have been purely coincidental, or it may be important. Further study may be warranted.

Only female mosquitoes bite animals. They require the blood meal for their eggs. Occasionally a few males showed up in the vials for identification. These males were either an outright exception to the rule and were no doubt landing randomly, or they were in the process of mating when they landed on people. This was a rare occurrence and even though it was noted, it should not be viewed as significant.

In addition to T-tests, statistical correlations were also done on the other variables. It has been documented that "Mosquitoes show a preference for high humidity" (Powell et al. 1966); however, correlations between the temperature and relative humidity to the biting pressure showed that neither can be used to predict the abundance of mosquitoes which are active on a given day.

Biting pressure is determined by the total number of mosquitoes caught during the control trial. Data of the temperature and relative humidity is in Appendix L. The correlation between the temperature and biting pressure was -.230 which produced a probability value of .177. Again, the p value must be .05 or below. The correlation between the relative humidity and biting pressure was .042, and the following probability value equalled .809. This agrees with observations made during the summer. No one could ever really use the weather to predict how many mosquitoes would be out and where they would be lurking.

Another correlation was tried between the time of the test and the biting pressure. Although there felt like a difference at the time, the test produced a correlation value of -.053, and a probability value of .758. It has also been documented that different mosquito species are indeed more active at certain times of the day, so the data here may not be precise enough to make any judgement calls.

Furthermore, data concerning skin temperature was analyzed. No correlation can be made between skin temperature and biting pressure which logically makes sense. A person's skin temperature which varies so little has no effect on how many mosquitoes will be in the area, a largely variable factor. On the other hand, a strong correlation is found between a person's skin temperature and the percentage of active mosquitoes he/she will attract. Those with a lower skin temperature attract fewer mosquitoes. The correlation was .203 which translated into a probability value of .010. The table of data is in Appendix M. This trend is plotted out in Appendix N.

DISCUSSION

It is interesting to note the repellents which actually performed their duty of repelling mosquitoes. Those which were effective included the deet repellents, a bath oil, a combination of herbal oils with citronella being one of the components, an unknown oil b, and one burning area repellent of esbiothrin, vegetable matter, and wood fiber. This seems to indicate that there are a variety of materials which will repel mosquitoes. Other laboratory studies have found essential oils, pyrethrum, and petroleum fractions with high naphthalene contents to be effective repellents. The results of the essential oils, specifically citronella oil, agrees with these UNDERC tests; however, the UNDERC results conflict with the results from the other laboratory study by R.A. Wirtz and colleagues on Mosquito Beater and the pyrethrum coils (Wirtz et al. 1980).

The repellents with deet as an active ingredient were expected to work. Many trials have been done in the past testing this compound (Wirtz, et al. 1980). C.E. Schreck tested deet on Anopheles albimanus and found it effective at a one hundred percent concentration level for up to two hours. He also stated that there is evidence of lasting effects in the field for three or more hours against this same species (Schreck 1985). The difference illustrates that both laboratory and field tests are necessary. The Skin So Soft bath oil has been known to work by many (Rutledge 1988). Rutledge and colleagues found that Skin So Soft does indeed work, and credited its success to the compounds diisopropyl adipate and benzopheone. They suggested that the fragrance added helpful fixatives (Rutledge et al. 1982). Khan et al. discovered in 1975 that fixatives enhanced the protection time from a repellent. Citronella has also been tested

before. It is interesting to note that in this experiment the scent of citronella was not enough to repel mosquitoes, but the oil which adhered to the skin was effective.

It is difficult to imagine that hair spray is usually what people think of when buying repellent. As a brunette, Mary Bernard appreciated it; she found mosquitoes were frequently attracted to her head. Michael Chambers another volunteer with brown hair agreed. The spray on the hair did indeed work. This is expected because the main ingredient is deet; however, the spray did not help protect the arms at all. As an overall repellent, the idea is unsuccessful.

Shubert's findings, Appendix O, agree with these for six of the eight similar repellents. The two which provided contradictory results were baby oil and the Repellent Coils. A sizable discrepancy between Kurt's results and those of 1990 involved baby oil. He again obtained a probability value of .001, where the 1990 tests showed the product to be ineffective. It is interesting that he found it effective because Skin So Soft is mainly mineral oil and fragrance whereas baby oil is just mineral oil. Anyhow, baby oil did not repel mosquitoes.

Topical oils wear off after awhile because of abrasion, absorbtion, evaporation, and sweating (Khan et al. 1972), (Rutledge et al. 1985), and so lose their effect; the problem with the area repellents seems to be that they can not establish a deterrent environment. Shubert noticed in his experiments the lack of suitability of some area repellents for outside use due to the alacrity of dissipation in the open air. The only one which worked at all in 1990 was Bug Barriers.

It was breezy on the days citronella candles and repellent coils were tested. Even so, to look at the candles almost immediately congers up doubt because they are so small, and they just are not as smokey as the Bug Barriers. On the other hand, the repellent coils are similar in design to the Bug Barriers.

Shubert found them to be effective; he obtained a probability value of .001. It was a still day when the Bug Barriers were tested and proved significant. The first time they were evaluated, they came up with a value of .084; this is not significantly valid. On this day again, there was no wind, but the first trial was an immediate test. The trial the product proved sufficient was conducted after the sticks had been burning for forty-five minutes. One of the 1990 tests produced a probability value of .064 for the coils, but the two other tests provided values of .156 and .796. The wind could have possibly been the determining factor for all of these repellents.

Another surprise came from the clothing repellent Permanone. Papers have been written on how permethrin alone and in combination with deet has been quite successful in the field in Australia, Pakistan, and Malaysia (Frances 1987), (Sholdt et al. 1988), (Yap 1986). In the UNDERC test, the repellent tested alone was a complete failure.

No repellent received desirable probability values four hours after application. This was somewhat disappointing because the only repellents that even warranted a trial at this point were the deet repellents. The claim made on the Off package states that the repellent is effective up to ten hours. This data suggests that in under four hours the effect of the repellent has worn off sufficiently to require another dose. This experiment demonstrates just how badly a truly effective repellent is needed. There are repellents which will work, but none for an extended period of time.

In general, logic seems to make personal repellents preferable. If an area repellent is not one hundred percent effective, which none of them are, then once a mosquito penetrates the area, the people in the area are almost guaranteed victims. A personal repellent also allows its wearer to unrestricted freedom to roam. It is also important that repellents be able to endure under heavy biting

pressure which tends to reduce protection time (Rutledge et al. 1989).

New repellents and protective devices are constantly appearing all over. Appendix P exhibits an advertisement taken from the Boston Globe over the summer at the same time these tests were being run. The fact that three of the products tested this summer were products not yet on the market--product a and b, and the hair spray--indicates that research is still being done to find a better repellent, and also that some manufacturers are cooperating with science to produce a valid consumer good. The blatantly fraudulent gimmicks, such as the electrocuting devices called Zappers (Nasci et al. 1983), and the noise makers tested in this experiment, prove that one must still be cautious as to what one believes. The electronic devices, Appendix Q displays the advertisement for one, were designed on absolutely no scientific evidence, and therefore not surprisingly, failed.

ACKNOWLEDGEMENTS

This study could not have been possible without the generous support from a number of individuals. First off, I would like to extend my sincerest gratitude towards the Hank family who finances the UNDERC program in which this research and countless other projects have been conducted. Secondly, I would like to thank Dr. George Craig for all his help in advising me through this project. Thirdly, I would like to thank Dr. Martin Berg for his invaluable contributions and assistance with my endless computer problems. Also, I would like to thank Gary Kohlhepp for his computer guidance. Last but not least, my list of twelve volunteers can not be forgotten since they are the backbone of the entire experiment; I hope these people realize how grateful I am for their uncomplaing loyalty to this project. Thank you Christine Allison, Dr. Berg, John Carozza, Michael Chambers, Dr. Craig, Terrence Ehrman, John Gimnig, Eileen Perkins, Tim Piero, Jennifer Slate, Damon Sinars, and Christine Taafe. I especially appreciate Tim Piero's contributions because he volunteered twenty-four times, approximately double the average number per volunteer.

BIBLIOGRAPHY

Altman, Robert M., and Carroll N. Smith. 1955. Investigations of repellents for protection against mosquitoes in Alaska, 1953. J. Econ. Entomol. 48(1):67-72.

Berg, Martin B., and Ann St. Amand, eds. 1985. A Student's Guide to U.N.D.E.R.C.

Cassani, John R., and H.D. Newson. 1980. An annotated list of mosquitoes reported from Michigan. Mosq. News 40(3):356-368.

Craig, George B. 1963. Mosquitoes and man's attractive power. Proc. N.J. Mosq. Extermination Assoc. 50:250.

Frances, S.P. 1987. Effectiveness of deet and permethrin, alone, and in a soap formulation as skin and clothing protectants against mosquitoes in Austalia. J. Am. Mosq. Control Assoc. 3(4):648-650.

Gwadz, Robert W. 1969. Regulation of blood meal size in the mosquito. J. Insect Physiol. 15:2039-2044.

Khan, A.A., H.I. Maibrach and Derek L. Skidmore. 1975. Addition of perfume fixatives to mosquito repellents to increase protection time. Mosq. News 35(1):23-26.

Khan, A.A., H.I. Maibrach and D.L. Skidmore. 1972. A study of insect repellents. 2. Effect of temperature on protection time. J. Econ. Entomol. 66(2):437, 438.

Meek, C.L., M.V. Meisch and T.W. Walker. 1985. Portable, battery-powered aspirators for collecting adult mosquitoes. J. Am. Mosq. Control Assoc. 1(1):102-105.

Mehr, Zia A., L.C. Rutledge, E.L. Morales, V.E. Meixsell and D.W. Korte. 1985.

Laboratory evaluation of controllled-release insect repellent formulations. J. Am. Mosq. Control Assoc. 1(2):143-147.

McGovern, T.P., and C.E. Schreck. 1988. Mosquito repellents: monocarboxylic esters of aliphatic diols. J. Am. Mosq. Control Assoc. 4(3):314-321.

Mc Govern, Terrence P., C.E. Schreck and J. Jackson. 1980. Mosquito repellents: cyclohexanealkanoic carboxamides as repellents for Aedes aegypti, Anopheles quadrumaculatus, and Anopheles albimanus. Mosquito News 40(3):394-398.

Nasci, Roger S. 1985. Behavorial ecology of variation in blood-feeding and its effect on mosquito-borne diseases. In: Lounibos, L.P., J.R. Rey, and J.H. Frank (Eds.) Ecology of Mosquitoes: Proceedings of a Workshop. Vero Beach, Fla.: Florida Med. Entomol. Labs. pp. 293-303.

Nasci, Roger S. 1984. Variations in the blood-feeding patterns of Aedes vexans and Aedes trivittatus (Diptera: Culicidae). J. Med. Entomol. 21(1):95-99.

Nasci, Roger S., Cedric W. Harris and Cyresa K. Porter. 1983. Failure of an insect electrocuting device to reduce mosquito biting. Mosq. News 43(2):180-184.

Powell, John A., Harald Esch and George B. Craig, Jr. 1966. Electronic recording of mosquito activity. Entomol. Exp. Appl. 9:385-394.

Rutledge, L.C. 1988. Some corrections to the record on insect repellents and attractants. J. Am. Mosq. Control Assoc. 4(4):414-425.

Rutledge, L.C., Ruth Lynn Hooper, R.A. Wirtz and Raj K. Gupta. 1989. Efficacy of diethyl methylbenzamide (deet) against Aedes dorsalis and a comparison of two end points for protection time. J. Am. Mosq. Control Assoc. 5(3):363-368.

Rutledge, L.C., M.A. Moussa, C.A. Lowe and R.K. Sofield. 1978. Comparative sensitivity of mosquito species and strains to the repellent diethyl

toluamide. J. Med. Entomol. 14(5):536-541.

Rutledge, L.C., R.A. Wirtz, and M.D. Buescher. 1982. Repellent activity of a proprietary bath oil (Skin-So-Soft). Mosq. News 42(4):557-559.

Rutledge, L.C., R.A. Writz, M.D. Buescher and Z.A. Mehr. 1985. Mathematical models of the effectiveness and persistence of mosquito repellents. J. Am. Mosq. Control Assoc. 1(1):56-62.

Schreck, C.E. 1985. The status of deet (N,N-diethyl-m-toluamide) as a repellent for Anopheles albimanus. J. Am. Mosq. Control Assoc. 1(1):98-100.

Sholdt, L. Lance, Carl E. Schreck, Akhtar Queshi, Steve Mammino, Abdul Aziz, and Muhammed Iqubal. 1988. Field bioassays of permethrin-treated uniforms and a new extended duration repellent against mosquitoes in Pakistan. J. Am. Mosq. Control Assoc. 4(3):233-236.

Shubert, Kurt. 1989. An evaluation of area and personal mosquito repellents.

Wilmot, Tom R., Jeanne M. Henderson and Douglas W. Allen. 1987. Additional collection records for mosquitoes of Michigan. J. Am. Mosq. Control Assoc. 3(2):318.

Wirtz, R.A., J.D. Turrentine, Jr. and L.C. Rutledge. 1980. Mosquito area repellents: laboratory testing of candidate materials against Aedes aegypti. Mosq. News 40(3):432-439.

Yap, H.H. 1986. Effectiveness of soap formulations containing deet and permethrin as personal protection against outdoor mosquitoes in Malaysia. J. Am. Mosq. Control Assoc. 2(1):63-67.

APPENDIX A: Names and Abreviations Used in This Paper

NAME	SYMBOL
repellent	REPELLEN$
experimental: immediate	EXPER
experimental: 2+/-1 hours after application	EXPER2
experimental: 4+/-1 hours after application	EXPER3
probability value p	P
p<= .05, significant difference between control and repellent	VALUE (column name in systat) VALID
volunteers	VOLUNTEE$
outside temperature	TEMP
relative humidity	RH
time of experiment	TIME
percent of total	PERC
volunteer's skin temperature	SKINT
Aedes punctor	PUNCTOR
Aedes provocans	PROV
Aedes communis	COMMUN
Aedes abserratus	ABS
Aedes excrucians	EXCRUC
Aedes cinereus	CINEREUS
Aedes diantaeus	DIANT
unknown species	UNKNOWN
male mosquito	MALE
Aedes vexans	VEXANS
Mansonia perturbans	MANSONIA
Aedes canadensis	CANADENS
Anopheles punctepennis	ANPUNCT

Anopheles walkeri	ANWALK
Aedes fitchii	FITCHII
place where experiment was conducted	PLACE$
Tender Bog	tender
road leading to dock leading to Tender Bog	tender r
dock of Tender Bog	tender d
road and dock at Tender Bog	tender r d
intersection of main road and road leading to Tender Bog	tender r2
Bay Lake: dock area	bay
North Gate Bog	no gate
woods next to volleyball court at UNDERC	woods
Tuesday Bog	tuesday
Firestone Bog	firestone
Johnson Wax Off	off
Green Ban	green ban
Avon Skin So Soft	sss
Mosquito Hawk	hawk
Product B	b
Product A	a
Baby oil	oil
Revco	revco
Never Bite	nevbite
Bug Shields	shield
Johnson Wax Bug Barriers	barriers
Citronella candles	citron
Pic Repellent Coils	coils
Permanone	perm
Skeeter Beater	beater
Hair Spray	hairspr

Aedes trivitatus	TRIVITAT
total mosquitoes in control	TOTAL

APPENDIX B: Repellents and the Time Tests to Which Each Was Subjected

REPELLENT	IMMEDIATE APPL.	2 HOURS	4 HOURS
OFF	5/26	7/9	7/9
PERMANONE	7/20	6/17	
NEVERBITE	6/6	7/18	7/18
REVCO	6/4	6/28	6/29
BUG SHIELD	6/7, 6/24		
MOSQUITO HAWK	5/30, 6/24, 7/10		
GREEN BAN	5/27	6/19	
SKIN SO SOFT	5/28, 6/13	5/28, 6/26	
BABY OIL	6/2, 6/20		
HAIR SPRAY	7/16, 7/17		
PRODUCT A	6/1, 6/25		
PRODUCT B	5/31	6/21	
MOSQUITO BEATER	7/1	6/18, 7/13	
CITRONELLA CANDLES	6/10	7/3	
BUG BARRIERS	6/9	7/2	
REPELLENT COILS	6/14, 6/15	7/12	

APPENDIX C: Repellents Tested During the Summer of 1990 at UNDERC

PERSONAL REPELLENTS

STANDARD:

1. Johnson Wax DEEP WOODS OFF
   liquid
   Active Ingredients:
   N,N diethyl meta toluamide (DEET) 95%
   Other isomers 5%

CLOTHING REPELLENT

2. PERMANONE
   spray
   Active Ingredients:
   Permethrin (3 phenoxyphenyl) methyl (+-) cis/trans 3-(2,2-dichloroethenyl) 2,2-dimethylcyclopropanecarboxylate. cis/trans ratio: min. 35% (+-) cis and max. 65% (+-) trans) .50%
   Inert Ingredients: 99.5%

DEET REPELLENTS:

3. NEVER BITE
   liquid
   Active Ingredients:
   N,N diethyl meta toluamide 95%
   Other isomers 5%
4. REVCO INSECT REPELLENT
   spray
   Active Ingredients:
   N,N diethyl meta toluamide 14.25%
   Other isomers .75%
   Inert Ingredients 85%

ELECTRONIC DEVICES:

5. MOLTRON BUG SHIELD
   small, personal, electonic gadget
   repels with high pitched noise
6. MOSQUITO HAWK
   small, personal, sonic gadget
   mimics dragonfly

HERBAL REPELLENT:

7. GREEN BAN
   liquid
   Ingredients:
   *Citronella, pennyroyal, sassafras, cajuput, lavender, bergamot in a base of calendula, soy, and tea tree oils

PRODUCTS NOT MARKETED AS REPELLENTS:

8. AVON SKIN SO SOFT
   liquid

Ingredients:
mineral oil
isopropyl palmitate
dicapryl adipate
fragrance
dioctyl sodium sulfosuccinate
BHT
lanolin alcohol
D&C Yellow #11 and D&C Red #17

9. BABY OIL
liquid
Ingredients:
mineral oil

UNKNOWNS:

10. ALBERT LABORATORIES--INSECT REPELLENT HAIR SPRAY (#89C140)
hair spray
Active Ingredients:
DEET and unknowns

11. ALBERTO CULVER--PRODUCT A
white cream
Active Ingredients:
unknown

12. ALBERTO CULVER--PRODUCT B
liquid (oil)
Active Ingredients:
unknown

AREA REPELLENTS

13. BONIDE MOSQUITO BEATER
crystal flakes
Active Ingredients:

Methylated naphthalenes	16%
Naphthalene	4.5%
Beta-butoxy beta'-thiocyan diethyl ether	1%
Butoxypolypropylene glycol	.5%
Petroleum distillate	9%
Inert Ingredients:	69%

14. CITRONELLA CANDLES
candles
Active Ingredient:
citronella

15. JOHNSON WAX OFF! YARD & PATIO BUG BARRIERS
burnig sticks (incense-like)
Active Ingredients:

Esbiothrin (d/L-allethrolone d-trans chrysanthemate)	.15%
Vegetable matter and wood fiber	98.24%
Inert Ingredients:	1.61%

16. PIC MOSQUITO REPELLENT COILS
burning sticks (incense-like)
Active Ingredients:

	D-cis, trans allethrin (allyl homolog of cinerin 1)	.24%
	Other isomers	.01%
Inert	Ingredients:	
	Vegetable matter and wood fiber	65%
	Pyrethrum Marc	32%
	Green dye	.35%
	Potassium nitrate	.90%
	Sodium benzoate	.50%
	Polyethylene glycol	1.00%

APPENDIX D: The Thirteen Volunteers

VOLUNTEER	SEX	AGE	LETTER
MARY BERNARD	female	20	A
MICHEAL CHAMBERS	male	20	B
GEORGE B. CRAIG	male	59	C
TERRENCE EHRMAN	male	21	D
CHRISTINE TAAFE	female	19	E
TIM PIERO	male	20	F
JENNIFER SLATE	female	20	G
JOHN GIMNIG	male	20	H
JOHN CAROZZA	male	21	I
MARTIN BERG	male	33	J
CHRISTINE ALLISON	female	21	K
EILEEN PERKINS	female	20	L
DAMON SINARS	male	20	M

APPENDIX E: List of Testing Locations UNDERC 1990

TENDER BOG

1. Dock of Tender Bog
2. Boardwalk leading through the woods to Tender Bog
3. Road leading to the boardwalk to Tender Bog
4. Intersection of Main Road and road leading to the boardwalk

BAY LAKE

5. Docking area

NORTH GATE BOG

6. Parking area next to the bog

WOODS

7. Woods next to the volleyball court
   (This area is near a marsh, but not near a bog or lake.)

TUESDAY BOG

8. Docking area

FIRESTONE BOG

9. Road leading to "docking area"

APPENDIX F: REPELLENTS--IMMEDIATE APPLICATION TEST RESULTS

REPELLENT	DATE	CONTROL	EXPERIMENT	P VALUE	VALIDITY
OFF	5/26/90	18.75	0	.040	valid
GREEN BAN	5/27/90	28	3.75	.030	valid
SKIN SO SOFT	5/28/90	27.25	3.25	.087	
MOSQUITO HAWK	5/30/90	18	20	.575	
PRODUCT B	5/31/90	35	12.5	.044	valid
PRODUCT A	6/1/90	13.5	8.75	.519	
BABY OIL	6/2/90	25.5	8.75	.086	
REVCO	6/4/90	15.25	.25	.021	valid
NEVERBITE	6/6/90	16.5	0	.040	valid
BUG SHIELD	6/7/90	12.25	15.75	.482	
BUG BARRIERS	6/9/90	9.25	.75	.084	
CITRONELLA CANDLES	6/10/90	14.75	9.5	.215	
SKIN SO SOFT	6/13/90	20.5	.5	.026	valid
REPELLENT COILS	6/14/90	9.5	1.25	.156	
REPELLENT COILS	6/15/90	14	5.5	.064	
BABY OIL	6/20/90	10	8.75	.744	
MOSQUITO HAWK	6/24/90	27.667	10.333	.102	
BUG SHIELD	6/24/90	27.667	10.667	.093	
PRODUCT A	6/25/90	7.5	10	.452	
SKEETER BEATER	7/1/90	7	16.5	.02*	not valid
MOSQUITO HAWK	7/10/90	54.5	43.5	.143	

HAIR SPRAY-- ARMS	7/16/90	25	5	.143	
HAIR SPRAY-- ARMS	7/17/90	10	16.667	.329	
HAIR SPRAY-- HAIR	7/16/90 7/17/90	8	.5	.027	valid
PERMANONE	7/20/90	24.25	46.5	.215	

APPENDIX G: REPELLENTS--TWO HOURS AFTER APPLICATION

REPELLENT	DATE	CONTROL	EXPERIMENT	P VALUE	VALIDITY
SKIN SO SOFT	5/28/90	27.25	7.5	.118	
PERMAMONE	6/17/90	6.5	3.5	.453	
SKEETER BEATER	6/18/90	5.25	2.5	.459	
GREEN BAN	6/19/90	18	6.25	.080	
PRODUCT B	6/21/90	15.5	10	.118	
SKIN SO SOFT	6/26/90	8.5	2.833	.006	valid
REVCO	6/28/90	4.5	.25	.082	
BUG BARRIERS	7/2/90	4.25	1	.014	valid
CITRONELLA CANDLES	7/3/90	6.25	4.25	.480	
OFF	7/9/90	14	3.5	.049	valid
REPELLENT COILS	7/12/90	9.75	10.5	.796	
SKEETER BEATER	7/13/90	32.75	20.75	.101	
NEVERBITE	7/18/90	12.5	2.5	.079	

APPENDIX H: REPELLENTS--RESULTS FOUR HOURS AFTER APPLICATION

REPELLENT	DATE	CONTROL	EXPERIMENT	P VALUE	VALIDITY
REVCO	6/29/90	13.5	6.5	.149	
OFF	7/9/90	14	10.5	.623	
NEVERBITE	7/18/90	12.5	4	.078	

APPENDIX I: LISTING OF THE SPECIES FOUND
DURING THE TRIALS OF THE SUMMER OF 1990

BLACK-LEGGED GROUP

Aedes punctor
Aedes provocans
Aedes abserratus
Aedes communis
Aedes diantaeus

WHITE STRIPED-LEGGED GROUP

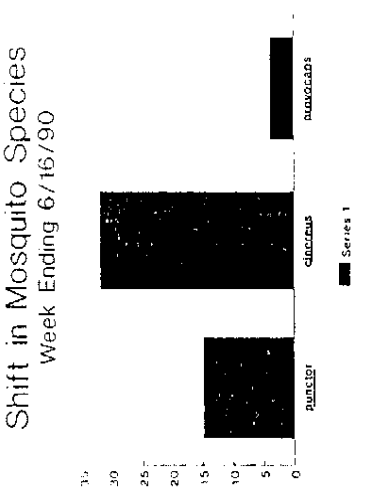
Aedes cinereus
Aedes excrucians
Aedes fitchii
Aedes vexans
Aedes canadensis
Mansonia perturbans
Aedes trivitatus

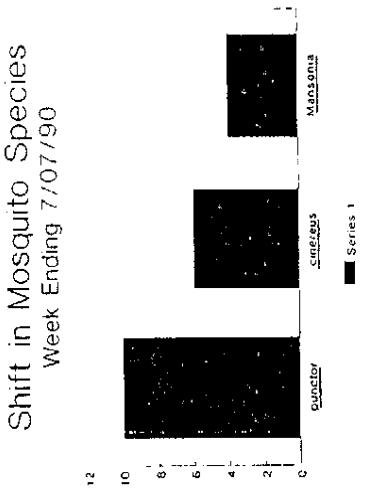
ANOPHELES

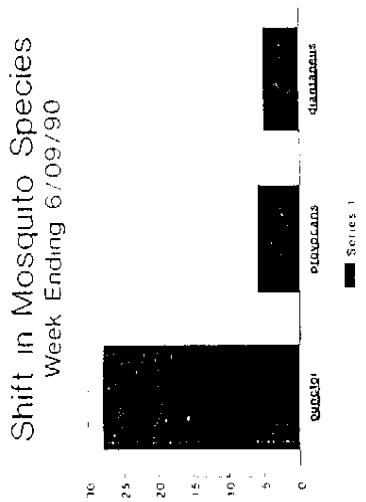
Anopheles punctepennis
Aonpheles walkeri

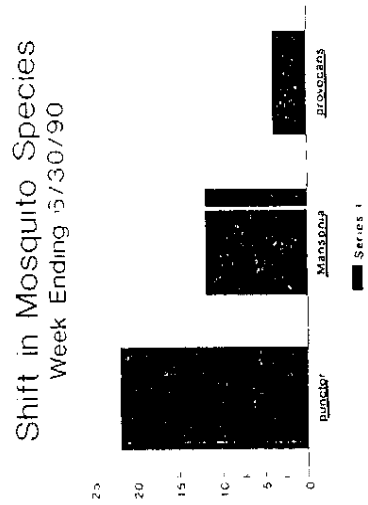
APPENDIX J: Shift in Dominate Mosquito Species

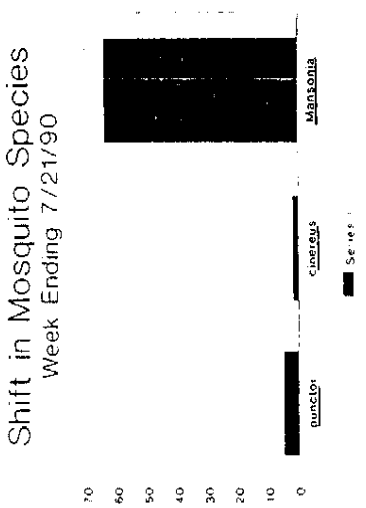
The next eight graphs illustrate the change in the top three dominate mosquito species by week for the weeks in which trials were conducted. The means were used for comparison because different numbers of trials were conducted each week.

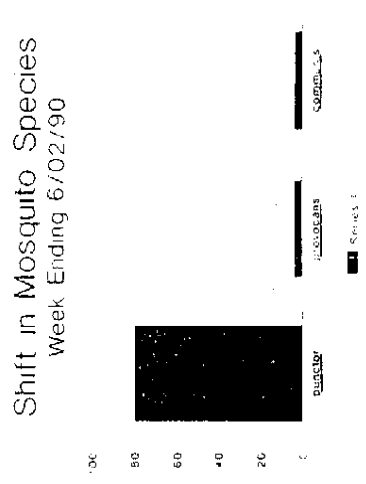


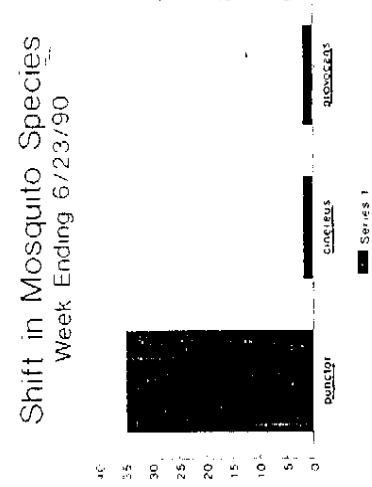


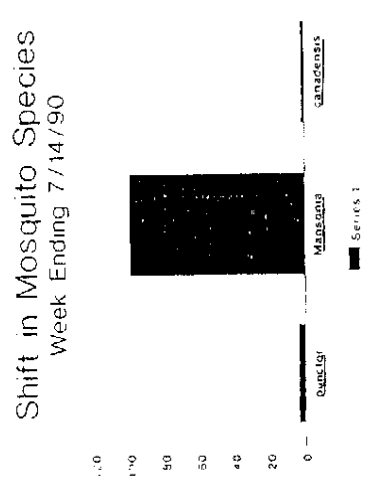








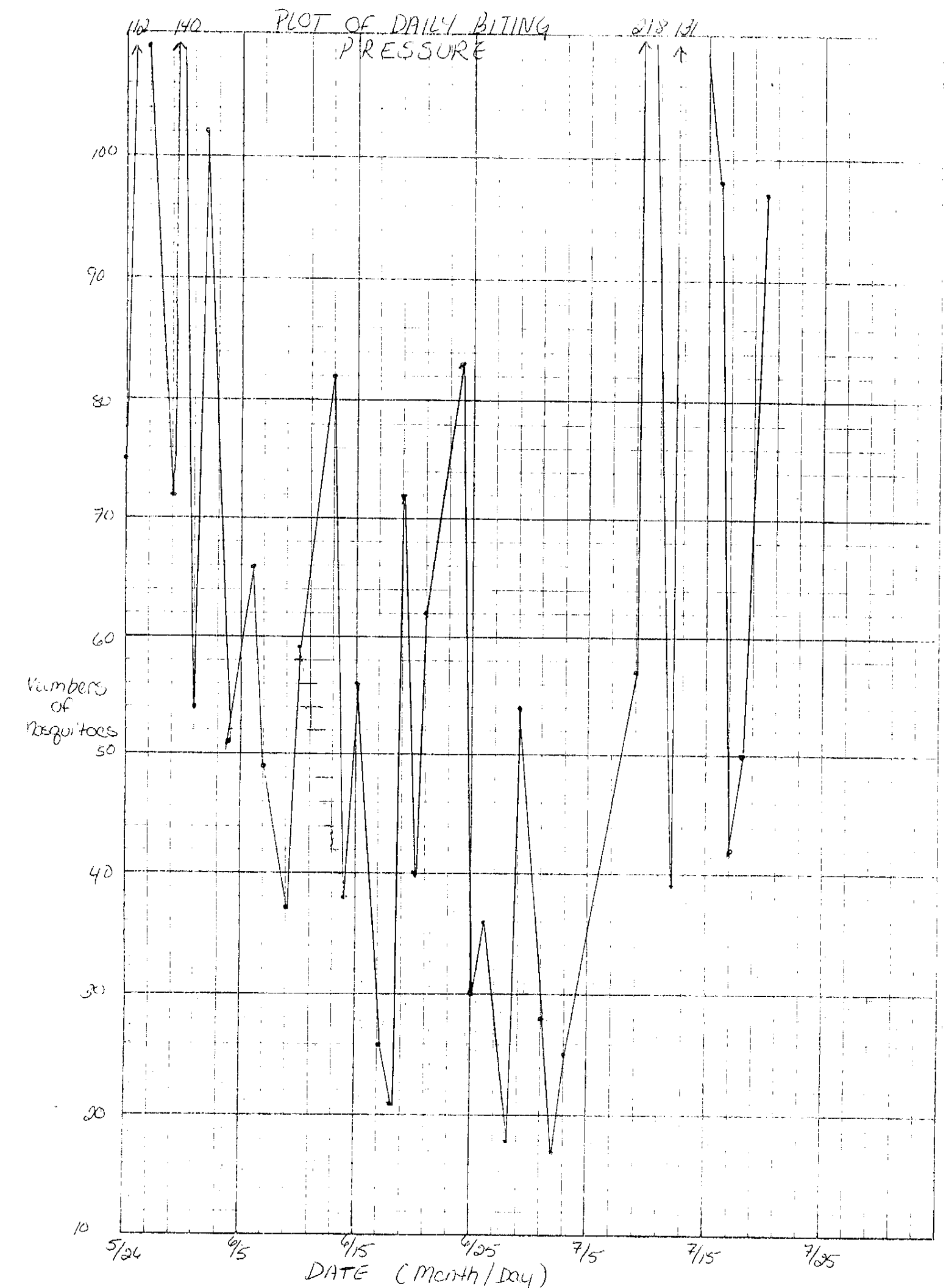




APPENDIX K: The Next Two Pages Include Data on Species Numbers Throughout the Summer

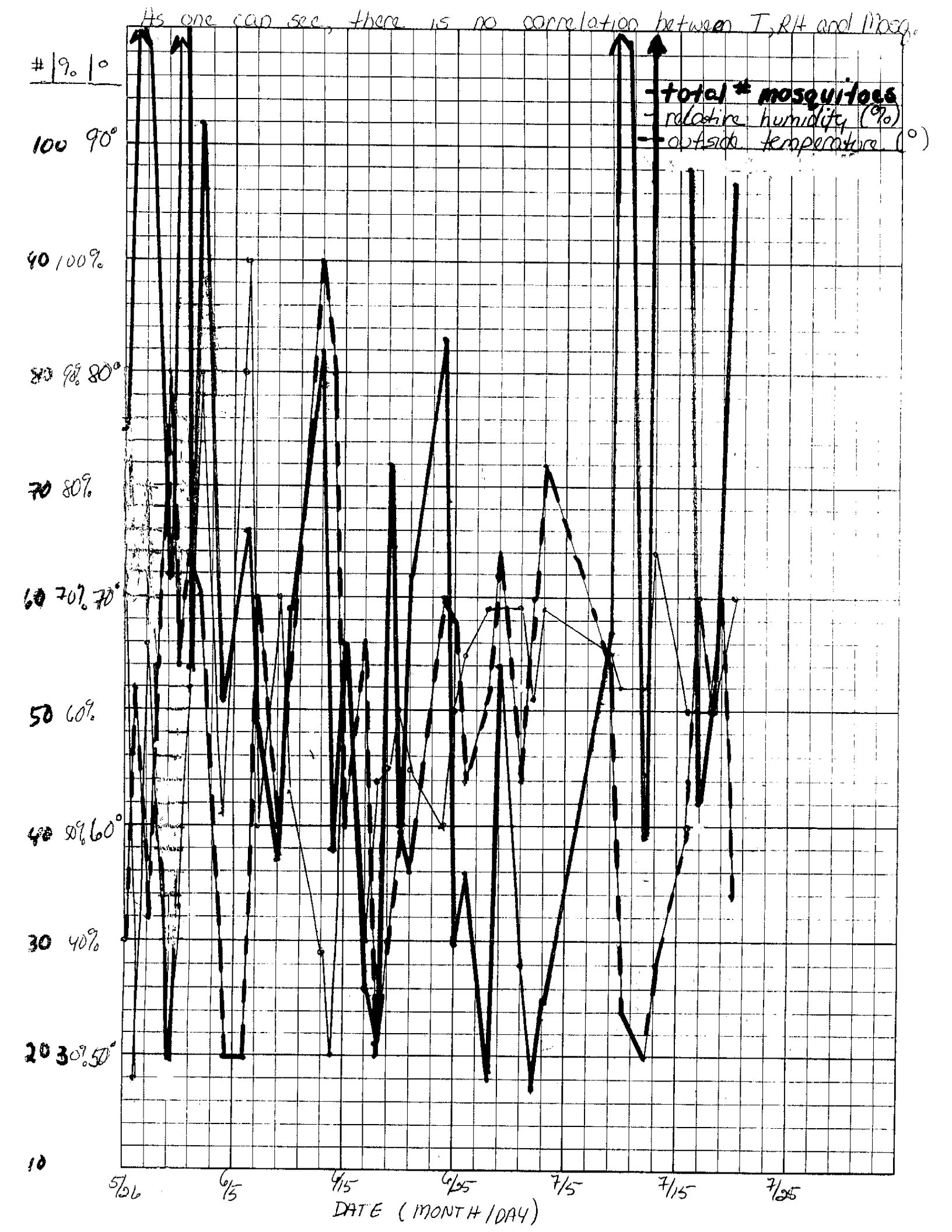
	DATE	FUNCTOR	PROV	COMMUN	ABS	EXCRUC	FINEBOUS	DIANT	UNKNOWN	MALE	VEXANS	MANSONIA	CANADENS	TRIWITAT	ANPUNCT	ANWALK	FITCHII	TOTAL
1	5.260	65.000	3.000	7.000														
2	5.270	103.000	3.000	2.000	4.000													75
3	5.280	97.000	7.000	5.000														112
4	5.300	64.000	2.000	2.000	4.000													109
5	5.310	104.000	6.000	7.000	6.000	2.000	13.000											72
6	6.010	45.000	3.000		3.000		4.000	1.000										140
7	6.020	85.000	6.000	8.000				1.000										54
8	6.040	50.000	5.000	5.000	9.000			1.000										102
9	6.060	24.000	6.000	4.000	1.000		1.000		30.000									51
10	6.070	20.000	5.000	2.000	1.000	2.000	8.000	9.000	1.000	1.000								66
11	6.090	16.000	8.000	4.000		1.000		8.000										45
12	6.100	19.000	10.000	2.000		3.000	23.000	2.000	0.000	0.000								37
13	6.130	3.000	3.000	2.000	2.000		71.000	1.000	0.000	0.000								59
14	6.140	2.000	2.000	1.000		1.000	32.000	0.000	0.000	0.000	1.000							82
15	6.150	34.000	1.000	4.000	4.000	2.000	1.000	8.000	0.000	0.000		0.000	2.000					38
16	6.170	15.000	0.000	2.000	4.000	1.000	3.000	1.000	0.000	0.000	0.000	0.000	0.000					56
17	6.180	7.000	4.000	0.000	0.000		7.000	1.000	0.000	0.000	0.000	1.000			1.000			26
18	6.190	61.000	5.000	5.000	0.000							1.000	0.000					21
19	6.200	34.000		3.000	1.000		1.000					1.000	0.000		1.000			72
20	6.210	57.000	2.000		2.000	1.000												40
21	6.240	50.000	5.000	9.000	3.000							16.000						62
22	6.250	10.000	8.000				1.000					9.000						83
23	6.260	22.000	4.000				4.000					6.000						30
24	6.280	13.000		1.000					1.000			3.000						36
25	6.290	15.000	4.000	3.000	1.000	1.000	2.000					28.000						18
26	7.010	20.000	2.000	2.000								4.000						54
27	7.020	5.000	2.000		2.000	1.000	1.000					5.000	1.000					28
28	7.030	4.000	2.000				17.000					2.000						17
29	7.090	3.000	5.000	3.000			1.000				1.000	37.000	3.000					28
30	7.100	3.000	1.000	2.000	1.000		1.000					208.000	2.000					57
31	7.120	2.000	1.000									36.000						218
32	7.130	6.000		1.000			4.000					117.000					1.000	39
33	7.160	1.000	1.000									95.000				1.000		131
34	7.170	5.000					2.000					34.000						98
35	7.180	4.000					4.000					40.000						42
36	7.200	8.000					1.000					88.000		1.000				50
																		97

	PLACE$
CASE 1	tender r d
CASE 2	tender d
CASE 3	tender d
CASE 4	tender
CASE 5	tender
CASE 6	tender
CASE 7	tender
CASE 8	bay
CASE 9	tender
CASE 10	tender
CASE 11	tender
CASE 12	tender
CASE 13	no gate
CASE 14	no gate
CASE 15	tender
CASE 16	tender
CASE 17	woods
CASE 18	bay
CASE 19	bay
CASE 20	bay
CASE 21	bay
CASE 22	tuesday
CASE 23	bay
CASE 24	bay
CASE 25	tender
CASE 26	bay
CASE 27	tender r
CASE 28	bay
CASE 29	tender r2
CASE 30	tender r2
CASE 31	tender r2
CASE 32	tender r2
CASE 33	firestone
CASE 34	firestone
CASE 35	firestone
CASE 36	firestone


PLOT OF DAILY BITING PRESSURE
162
140
218
181
100
90
80
70
60
50
40
30
20
10
Numbers of Mosquitoes
5/26
6/5
6/15
6/25
7/5
7/15
7/25
DATE (Month / Day)

APPENDIX L: Data on Temperature and Relative Humidity on the Next Two Pages

		DATE	TEMP	RH	TOTAL
CASE	1	5.260	55.000	70.000	75.000
CASE	2	5.270	66.000	49.000	112.000
CASE	3	5.280	51.000	66.000	109.000
CASE	4	5.300	80.000	30.000	72.000
CASE	5	5.310	66.000	43.000	140.000
CASE	6	6.010	72.000	62.000	54.000
CASE	7	6.020	70.000	90.000	102.000
CASE	8	6.040	50.000	51.000	51.000
CASE	9	6.060	50.000	90.000	66.000
CASE	10	6.070	70.000	50.000	49.000
CASE	11	6.090	60.000	70.000	37.000
CASE	12	6.100	67.000	53.000	59.000
CASE	13	6.130	85.000	39.000	82.000
CASE	14	6.140	80.000	30.000	38.000
CASE	15	6.150	60.000	65.000	56.000
CASE	16	6.170	68.000	40.000	26.000
CASE	17	6.180	50.000	54.000	21.000
CASE	18	6.190	55.000	55.000	72.000
CASE	19	6.200	60.000	60.000	40.000
CASE	20	6.210	58.000	65.000	62.000
CASE	21	6.240	70.000	50.000	83.000
CASE	22	6.250	69.000	60.000	30.000
CASE	23	6.260	62.000	65.000	36.000
CASE	24	6.280	66.000	69.000	18.000
CASE	25	6.290	72.000	69.000	54.000
CASE	26	7.010	62.000	69.000	28.000
CASE	27	7.020	70.000	61.000	17.000
CASE	28	7.030	76.000	69.000	25.000
CASE	29	7.090	67.000	65.000	57.000
CASE	30	7.100	52.000	62.000	218.000
CASE	31	7.120	50.000	62.000	39.000
CASE	32	7.130	54.000	74.000	131.000
CASE	33	7.160	60.000	60.000	98.000
CASE	34	7.170	70.000	60.000	42.000
CASE	35	7.180	65.000	60.000	50.000
CASE	36	7.200	57.000	70.000	97.000

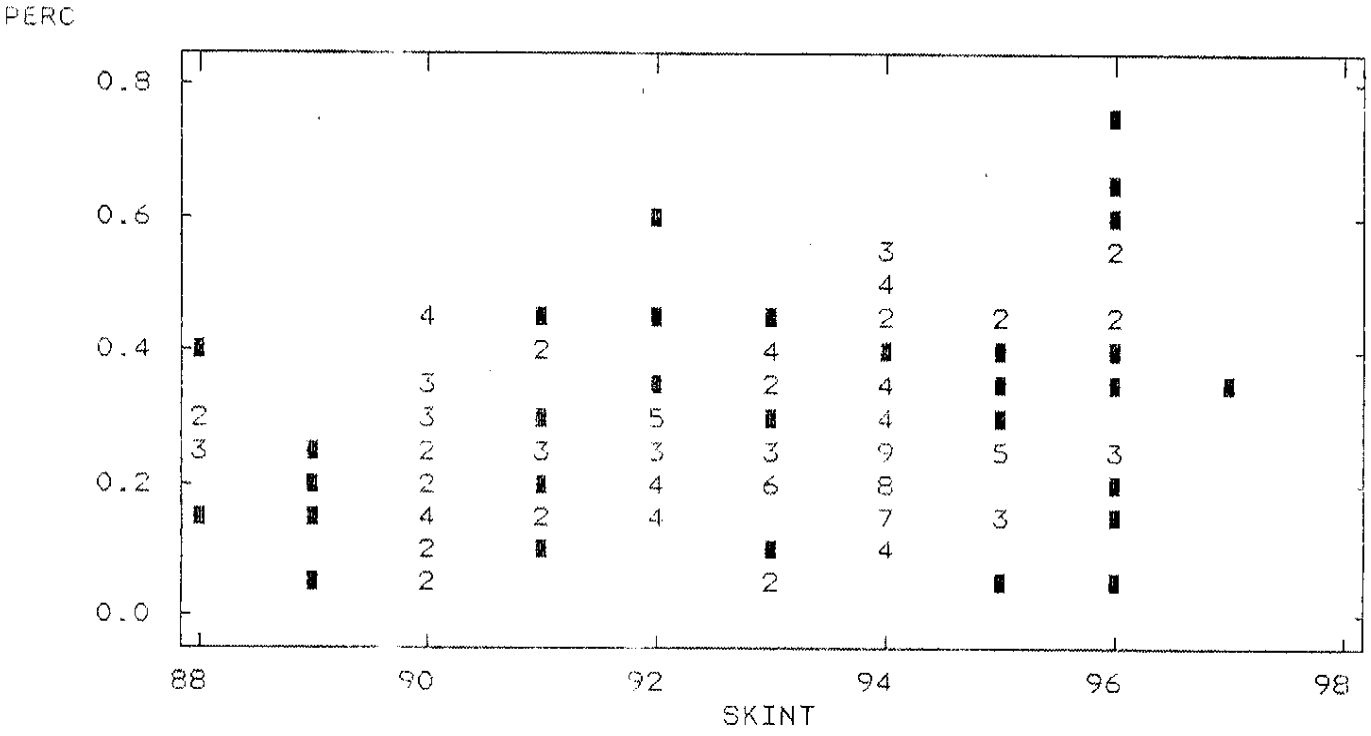

As one can see, there is no correlation between T, RH and Mosq.
| % | °
total # mosquitoes
relative humidity (%)
outside temperature (°)
100 90°
40 100%
80 90% 80°
70 80%
60 70% 70°
50 60%
40 50% 60°
30 40%
20 30% 50°
10
5/26
6/5
6/15
6/25
7/5
7/15
7/25
DATE (MONTH/DAY)

APPENDIX M: Data of Skin Temperature and the Number of Mosquitoes Collected

		SKINT	CONTROL	TOTAL	PERC	VOLUNTEE$
ASE	1	88.000	14.000	39.000	0.359	m
ASE	2	88.000	15.000	66.000	0.227	c
ASE	3	88.000	8.000	40.000	0.200	f
AS	4	88.000	11.000	39.000	0.282	e
AS	5	88.000	57.000	218.000	0.261	m
ASE	6	88.000	3.000	21.000	0.143	f
CASE	7	88.000	28.000	131.000	0.214	f
ASE	8	89.000	22.000	131.000	0.168	e
ASE	9	89.000	3.000	98.000	0.031	hair
ASE	10	89.000	12.000	98.000	0.122	arm
ASE	11	89.000	51.000	218.000	0.234	g
ASE	12	90.000	14.000	112.000	0.125	f
ASE	13	90.000	3.000	39.000	0.077	f
SE	14	90.000	13.000	98.000	0.133	hair
SE	15	90.000	23.000	75.000	0.307	c
SE	16	90.000	58.000	218.000	0.266	b
SE	17	90.000	52.000	218.000	0.239	a
SE	18	90.000	31.000	98.000	0.316	arm
SE	19	90.000	3.000	75.000	0.040	c
SE	20	90.000	7.000	98.000	0.071	hair
SE	21	90.000	32.000	98.000	0.327	arm
SE	22	90.000	5.000	50.000	0.100	c
SE	23	90.000	12.000	51.000	0.235	a
SE	24	90.000	21.000	50.000	0.420	c
SE	25	90.000	9.000	56.000	0.161	i
SE	26	90.000	21.000	50.000	0.420	c
SE	27	90.000	5.000	50.000	0.100	c
SE	28	90.000	6.000	36.000	0.167	d
ASE	29	90.000	0.000	21.000	0.000	k
SE	30	90.000	29.000	66.000	0.439	f
SE	31	90.000	10.000	40.000	0.400	e
SE	32	90.000	15.000	56.000	0.268	m
SE	33	90.000	6.000	21.000	0.286	a
SE	34	91.000	5.000	17.000	0.294	i
SE	35	91.000	9.000	42.000	0.214	hair
SE	36	91.000	14.000	102.000	0.137	m
SE	37	91.000	25.000	102.000	0.245	c
SE	38	91.000	51.000	131.000	0.389	b
SE	39	91.000	21.000	51.000	0.412	c
SE	40	91.000	9.000	42.000	0.214	arm
SE	41	91.000	5.000	26.000	0.192	g
SE	42	91.000	4.000	42.000	0.095	arm
ASE	43	91.000	34.000	97.000	0.351	f
SE	44	91.000	3.000	26.000	0.115	k
ASE	45	92.000	25.000	97.000	0.258	a
ASE	46	92.000	7.000	49.000	0.143	g
ASE	47	92.000	21.000	102.000	0.206	f
ASE	48	92.000	20.000	140.000	0.143	e
ASE	49	92.000	28.000	97.000	0.289	b
ASE	50	92.000	23.000	72.000	0.319	b
ASE	51	92.000	10.000	36.000	0.278	a
ASE	52	92.000	7.000	36.000	0.194	a
ASE	53	92.000	20.000	83.000	0.241	i
SE	54	92.000	7.000	36.000	0.194	a
A	55	92.000	23.000	56.000	0.411	a
AS	56	92.000	10.000	97.000	0.103	c
ASE	57	92.000	10.000	36.000	0.278	a
ASE	58	92.000	10.000	36.000	0.278	a
ASE	59	92.000	7.000	36.000	0.194	a
ASE	60	92.000	20.000	83.000	0.241	i
ASE	61	92.000	2.000	17.000	0.118	e
ASE	62	92.000	13.000	72.000	0.181	b
ASE	63	92.000	12.000	21.000	0.571	m
ASE	64	93.000	9.000	56.000	0.161	f
ASE	65	93.000	16.000	50.000	0.320	k
ASE	66	93.000	16.000	50.000	0.320	k
ASE	67	93.000	8.000	50.000	0.160	k
ASE	68	93.000	2.000	57.000	0.035	h
ASE	69	93.000	14.000	57.000	0.246	c
ASE	70	93.000	3.000	37.000	0.081	f
ASE	71	93.000	18.000	62.000	0.290	a
ASE	72	93.000	21.000	57.000	0.368	c
ASE	73	93.000	22.000	140.000	0.157	k
ASE	74	93.000	20.000	57.000	0.351	h
ASE	75	93.000	21.000	57.000	0.368	c
ASE	76	93.000	4.000	17.000	0.235	f
ASE	77	93.000	23.000	54.000	0.426	f
ASE	78	93.000	5.000	30.000	0.167	f
ASE	79	93.000	11.000	62.000	0.177	a
ASE	80	93.000	14.000	57.000	0.246	c
ASE	81	93.000	2.000	57.000	0.035	h
ASE	82	93.000	20.000	57.000	0.351	h
ASE	83	93.000	8.000	50.000	0.160	k
ASE	84	94.000	19.000	37.000	0.514	a
ASE	85	94.000	9.000	37.000	0.243	i
ASE	86	94.000	42.000	102.000	0.412	a
ASE	87	94.000	19.000	83.000	0.229	a
ASE	88	94.000	6.000	54.000	0.111	a
ASE	89	94.000	44.000	83.000	0.530	a
ASE	90	94.000	17.000	59.000	0.288	a
ASE	91	94.000	12.000	26.000	0.462	a
ASE	92	94.000	16.000	66.000	0.242	a
SE	93	94.000	6.000	26.000	0.231	a
ASE	94	94.000	19.000	83.000	0.229	a
SE	95	94.000	3.000	38.000	0.079	e
ASE	96	94.000	8.000	38.000	0.211	b
ASE	97	94.000	8.000	40.000	0.200	h
ASE	98	94.000	3.000	38.000	0.079	g
ASE	99	94.000	39.000	112.000	0.348	a
ASE	100	94.000	14.000	82.000	0.171	e
CASE	101	94.000	2.000	18.000	0.111	k
ASE	102	94.000	2.000	18.000	0.111	k
ASE	103	94.000	7.000	51.000	0.137	a
ASE	104	94.000	17.000	42.000	0.405	arm
ASE	105	94.000	18.000	54.000	0.333	a
AS	106	94.000	14.000	54.000	0.259	a
A	107	94.000	11.000	54.000	0.204	f
CAS	108	94.000	11.000	54.000	0.204	f
CASE	109	94.000	4.000	28.000	0.143	
CASE	110	94.000	14.000	72.000	0.194	
CASE	111	94.000	22.000	72.000	0.306	
CASE	112	94.000	5.000	28.000	0.179	
CASE	113	94.000	54.000	140.000	0.386	
CASE	114	94.000	6.000	66.000	0.091	
CASE	115	94.000	44.000	83.000	0.530	
CASE	116	94.000	10.000	59.000	0.169	
CASE	117	94.000	12.000	72.000	0.167	
CASE	118	94.000	20.000	72.000	0.278	
CASE	119	94.000	6.000	72.000	0.083	
CASE	120	94.000	34.000	72.000	0.472	
CASE	121	94.000	51.000	109.000	0.468	
CASE	122	94.000	18.000	109.000	0.165	
CASE	123	94.000	39.000	112.000	0.348	
CASE	124	94.000	20.000	112.000	0.179	
CASE	125	94.000	30.000	131.000	0.229	
ASE	126	94.000	18.000	109.000	0.165	
CASE	127	94.000	26.000	109.000	0.239	
ASE	128	94.000	51.000	109.000	0.468	
CASE	129	94.000	11.000	39.000	0.282	
ASE	130	94.000	14.000	109.000	0.128	
CASE	131	94.000	26.000	109.000	0.239	
ASE	132	94.000	14.000	109.000	0.128	
ASE	133	95.000	6.000	25.000	0.240	
CASE	134	95.000	4.000	28.000	0.143	
ASE	135	95.000	0.000	25.000	0.000	
ASE	136	95.000	19.000	82.000	0.232	
CASE	137	95.000	21.000	49.000	0.429	
ASE	138	95.000	21.000	51.000	0.412	
ASE	139	95.000	14.000	62.000	0.226	
ASE	140	95.000	3.000	30.000	0.100	
CASE	141	95.000	12.000	54.000	0.222	
CASE	142	95.000	13.000	54.000	0.241	
CASE	143	95.000	8.000	59.000	0.136	
CASE	144	95.000	27.000	75.000	0.360	
CASE	145	95.000	22.000	75.000	0.293	
CASE	146	95.000	19.000	62.000	0.306	
CASE	147	96.000	1.000	25.000	0.040	
CASE	148	96.000	18.000	25.000	0.720	
CASE	149	96.000	6.000	17.000	0.353	
CASE	150	96.000	15.000	28.000	0.536	
CASE	151	96.000	10.000	18.000	0.556	
CASE	152	96.000	4.000	18.000	0.222	
CASE	153	96.000	7.000	30.000	0.233	
CASE	154	96.000	15.000	30.000	0.500	
CASE	155	96.000	8.000	40.000	0.200	
CASE	156	96.000	24.000	38.000	0.632	
CASE	157	96.000	14.000	82.000	0.171	
CASE	158	96.000	35.000	82.000	0.427	
CASE	159	96.000	24.000	59.000	0.407	
CASE	160	96.000	6.000	49.000	0.122	
CASE	161	96.000	15.000	49.000	0.306	
CASE	162	97.000	44.000	140.000	0.314	

Refer to Appendix D for a list of the volunteers.

APPENDIX N: Plot of Percentage of Total Control Vs. Skin Temperature



A .NDIX O: Kurt Shubert's Results From 1989

Data for Substrates on Mosquito — Sat, Oct 7, 1989 2:28 PM

	date	exp substrate	control 1	control 2	control 3	control 4	experimental 1	experimental 2	experimental 3	experimental 4
1	5/30/89	napthalene	81.000	46.000	94.000	52.000	40.000	11.000	43.000	85.000
2	5/31/89	coil smoker	50.000	63.000	41.000	35.000	26.000	29.000	25.000	10.000
3	6/1/89	skin-so-soft	48.000	66.000	37.000	87.000	1.000	1.000	1.000	5.000
4	6/1/89	deet	58.000	58.000	39.000	39.000	1.000	0.000	1.000	0.000
5	6/3/89	citronella	52.000	69.000	52.000	67.000	44.000	58.000	18.000	60.000
6	6/3/89	ultra sound	62.000	66.000	55.000	49.000	23.000	90.000	44.000	74.000
7	6/12/89	clickers	20.000	20.000	48.000	58.000	32.000	45.000	27.000	61.000
8	6/12/89	coil smokers	18.000	22.000	42.000	24.000	2.000	10.000	13.000	8.000
9	6/12/89	skin-so-soft	18.000	22.000	42.000	24.000	2.000	0.000	2.000	3.000
10	6/13/89	ultra sound	4.000	2.000	15.000	22.000	9.000	8.000	19.000	20.000
11	6/15/89	napthalene	8.000	11.000	12.000	37.000	12.000	12.000	31.000	53.000
12	6/15/89	deet	8.000	11.000	12.000	37.000	0.000	0.000	0.000	0.000
13	6/19/89	clickers	3.000	23.000	18.000	14.000	2.000	15.000	19.000	22.000
14	6/19/89	citronella	3.000	23.000	18.000	14.000	3.000	15.000	12.000	31.000
15	6/22/89	coil smokers	13.000	17.000	24.000	16.000	0.000	0.000	1.000	1.000
16	6/22/89	baby oil	13.000	17.000	24.000	16.000	0.000	0.000	0.000	1.000
17	7/4/89	napthelene	8.000	6.000	33.000	33.000	5.000	16.000	26.000	27.000
18	7/4/89	coil smokers	8.000	6.000	33.000	33.000	3.000	11.000	22.000	20.000
19	7/4/89	baby oil	8.000	6.000	33.000	33.000	0.000	2.000	0.000	3.000
20	7/11/89	napthalene	10.000	19.000	18.000	15.000	7.000	9.000	16.000	13.000
21	7/11/89	clickers	10.000	19.000	18.000	15.000	11.000	6.000	14.000	13.000
22	7/11/89	citronella	10.000	19.000	18.000	15.000	11.000	4.000	28.000	20.000
23	7/11/89	baby oil	10.000	19.000	18.000	15.000	5.000	0.000	4.000	15.000
24	7/14/89	ultra	4.000	2.000	18.000	16.000	13.000	2.000	24.000	18.000
25	7/18/89	revenge	8.000	6.000	9.000	20.000	5.000	16.000	9.000	33.000
26			T-test	Results						
27	Product	Mean Diff.	SD Difference	T	Probability	DF				
28	Mosquito Beat	4.813	21.864	0.880	0.393	15.000				
29	Repellant Coils	16.500	9.331	7.073	0.001	15.000				
30	Skin-So-Soft	41.125	23.006	5.056	0.001	7.000				
31	Baby Oil	15.167	10.223	5.139	0.001	11.000				
32	(DEET)	48.143	41.946	3.037	0.023	6.000				
33	Citronella	4.667	13.034	1.240	0.241	11.000				
34	Bug Shield	-2.417	16.445	0.059	0.621	11.000				
35	Mosquito Hawk	-0.083	11.828	0.024	0.981	11.000				
36	Revenge	-5.000	7.703	1.298	0.285	3.000				

APPENDIX P: Advertisement in The Boston Globe

pping Bag

ASBARRO

No more dates with Mr. Mosquito

▶ Mosquitoes and other flying insects make a beeline to your body once the weather warms. But if you don't wish to slather insecticides over your arms, legs and face, the Bug Baffler is a more natural alternative.

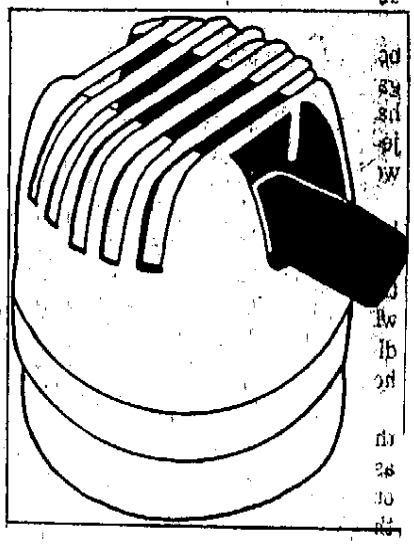
The Bug Baffler is a one-piece shirt with hood made entirely of screening material that goes over your head and torso. Its semi-rigid quality keeps it away from your face and body, yet air can pass through for comfort during the summer months.

The brainstorm of New Hampshirites Jan Merrill and Phyllis Biron, the Bug Baffler is great for camping, fishing, patio sitting or walking through the woods or fields in the evening.

"The concept grew out of self-defense," says Merrill. "My partner and I wanted to be outdoors without being eaten alive!"

The Baffler comes in children's and adult sizes and sells for $29.95. For more information and a complete list of sizes, write to Bug Baffler, PO Box 444BG, Goffstown, NH 03045.

Another way to drive 'em buggy



▶ For inside your house – for instance, your bedroom, where bugs like to congregate at night – the Skeeter Eater is a silent destroyer.

You plug the electrical unit into any standard outlet. Then you push the blue insecticide mat into the unit. Each mat lasts about eight hours; mats are sold separately in boxes of 30.

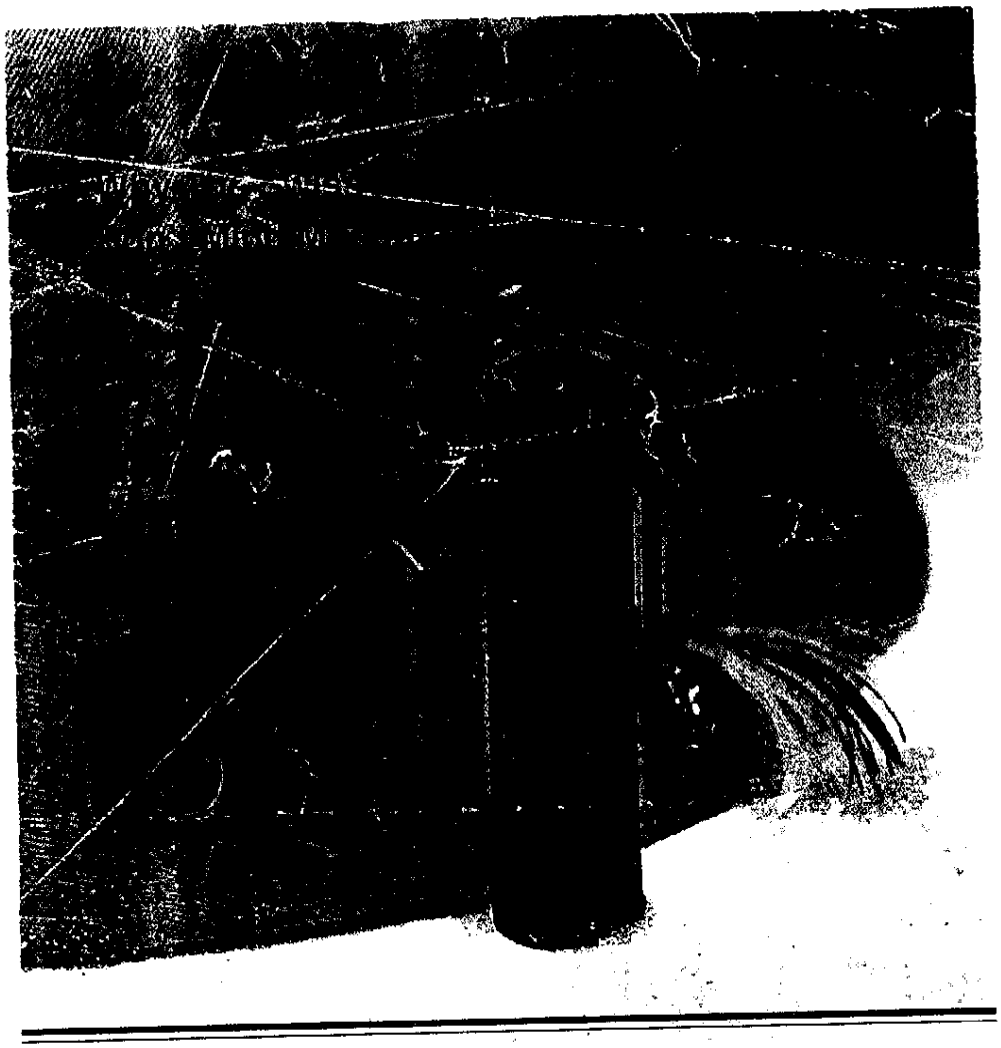
The company, LaReina Enterprises of Falmouth, also markets a portable Skeeter Eater you can use on your patio.

According to G. W. Grey, director of sales, the units also discourage sandflies and no-see-ums.

These products cost less than $10 and are available at all Christmas Tree Shops in Massachusetts.

▶ *Ron Gasbarro's Shopping Bag column appears each week in At Home. Send correspondence to The Shopping Bag, At Home section, Boston Globe, Boston, MA 02107. Please include phone number.*

APPENDIX Q: Advertisement for Electronic Device



New Swiss Bug Repellent
This electronic unit produces a high frequency sound that repels mosquitos, sand flies, gnats and black flies... they stay 6 to 8 feet away from it. Tested and proved by Swiss entomologists, effective even in marshy areas. Tiny cylinder is cigarette lighter size– fits in pocket, clips to belt, while gardening or fishing, at beach or campsite. Use on night table, dinner table, or in baby carriage, too. Barely audible buzz is harmless to people and pets. Comes with replaceable battery– wonderful outdoor equipment.

3411E Bug Repellent $16; two for $29

Money Back Guarantee with every product!

ACQUISITIONS FROM joan cook

Cook Building, 3200 S.E. 14 Avenue, Ft. Lauderdale, FL 33316 - TOLL-FREE 1-800-327-3799