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SPIDERS ASSOCIATED WITH DWELLINGS IN MICHIGAN WITH SPECIAL EMPHASIS ON THE PREDATORY BEHAVIOR OF *CHIRICANTHIUM INCLUSUM* HENTZ (ARANEAE:CLUBIONIDAE).

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SPIDERS ASSOCIATED WITH DWELLINGS IN MICHIGAN WITH SPECIAL EMPHASIS ON THE PREDATORY BEHAVIOR OF *CHIRICANTHIUM INCLUSUM* HENTZ (ARANEAE:CLUBIONIDAE)

By

Harry David Vail III

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ABSTRACT

SPIDERS ASSOCIATED WITH DWELLINGS IN MICHIGAN
WITH SPECIAL EMPHASIS ON THE PREDATORY
BEHAVIOR OF *CHIRICANTHIUM INCLUSUM*
HENTZ (ARANEAE:CLUBIONIDAE)

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Of the more than 371 species of spiders reported from Michigan, 106 (28.5%) were captured from dwellings. Twelve species were found to represent 51.5% of the 1147 specimens captured. These species were from six families, three web spinners and three non-web spinners. Analysis indicated that the spider numbers fluctuated during a calendar year to produce two distinct peaks. One peak was generally larger and termed the major peak, with the smaller peak termed the minor peak.

The two peaks were observed during the spring and fall with a period of decreasing numbers of animals during the summer and winter. The majority of the 12 species exhibited spring major peaks and fall minor peaks with reduced numbers during the summer months. Examination of the individual species indicated that the mature females and immature forms were dominant during the majority of the year. Mature males were in low numbers during

the spring and summer and disappeared completely during the fall, winter and early spring months.

Spider bites confirmed during the study occurred during those periods when both the spiders and humans were about in greatest numbers. Though considered as serious by the individual, the bites were diagnosed as not serious by medical doctors, producing slight local swelling and an itching sensation which persisted for only a few days.

The survey of buildings at the local level revealed that the most common species were the same as those found during the state wide survey. Seven species accounted for more than 60% of the 3346 specimens captured. These seven species were from four families representing two web spinners and two non-web spinners. The same peak phenomena were observed in all three building types and the same relationships between males, females and immatures.

There appeared to be no affect exerted by the building type on the species composition, but an effect was noticed on the relative densities of the individual species.

The three weather parameters measured indicated that the outside temperature exerted a force on the spiders causing an increase in numbers found indoors. The inside temperature and the relative humidity allowed the animals to survive once the move was made.

Harry David Vail III

The predation studies on Chiricanthium inclusum Hentz indicated that short contact distances coupled with random search patterns necessitated traveling in excess of one half mile by mature male specimens. Mature females and immature forms traveled proportionally less. These nocturnal animals were found to use and re-use resting cells depending on the prey density and the distances traveled from the previously constructed cell when the light levels suppassed 10 to 12 foot candles. The prey preferred by these animals were soft bodied with a high moisture content and low mobility.

Prey sizes selected by the animals could be altered by the hunger state of the animals and the sizes of the prospective prey. The numbers of prey eaten was not as flexible. When the animals were satiated, the number of prey present had no effect on the number killed. Animals that were hunger stressed would eat until apparently satiated and then would not attack and kill further. Increases in prey densities served to reduce the time to initial capture as did the increase in the numbers of predators. These spiders did not exhibit cannabalism in the test chambers or in the rearing chambers as long as the food levels were maintained at levels above starvation. There was a distinct avoidance reaction by the animals towards one another even when the densities were quite high.

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INTRODUCTION

Spiders, since time immemorial, have held a special place in man's mind as an animal to be feared and/or destroyed. Evidence for these beliefs are legend. For example, a Mediterranean dance called the Tarantela was thought to offset the effects of the bite of an aggressive lycosid spider native to the region, but for which the tarantula has been named and blamed. Another example is the small black spider the Indians of California called "The one with long black fingers that causes sickness," more commonly known as the Black Widow. Or perhaps the childrens nursery rhyme, "Little Miss Muffet," which can be traced to a 19th century incident recorded by an English physician and father regarding an incident involving his daughter.

Most of the existing information about the occurance of spiders within dwellings is generally found scattered in the locality portions of species descriptions. Bits of such information can be found in Kaston (1948), Levi (1955,1957,1959,1962,1963,1966,1968,1972), Chamberlain (1933), Dondale (1961), Gertsch (1949) and countless others. There has been little or no work done to ascribe particular species of spiders to particular types of dwellings at particular times of the year. Spiders discovered within structures are generally destroyed and/or removed with little regard to the place they hold in the ecological community.

Predatory behavior, as described by Holling (1959), has been applied to a variety of invertebrate predators, including spiders in particular, by Turnbull (1960,1964), Haynes (1966), Loughton, Derry and West (1963) and Dabrowska-Prot (1966,1968,1970). Studies involving spider predation as a portion of a larger study were conducted by Eberhard (1967), Gardner (1965), Levi (1968), Lovell (1915), Moulder *et al*. (1970) and Peck and Whitcomb (1970). The majority of these studies were observations of spiders that constructed a capture web and waited for prey to come to them or spiders that are visually stimulated and hunt with both eyesight and agility.

The aspect of foraging that considered either traveling of the spider or moving of the web has been investigated in the Lycosidae by Turnbull (1966) and Hollander (1967). Turnbull (1964) described the movements of the web location of *Achaeranea tepidariorum* (Koch) in response to varying prey densities.

A project was proposed to assess associations of spider within human dwellings, with the aim of developing an understanding of the niches spiders have in the animal world as part of the biological community and as sources of biological control of insect pests of man.

The study was divided in three main parts: first, to determine, on a state-wide level, the species of spiders that are found within dwellings during the year; second, to determine on a local level the quantitative aspects of both resident and migratory spider populations through the year as related to building type and season of the year; and third, to characterize the predatory behavior of one particular species (*Chiricanthium inclusum* Hentz) and determine its effects on the resident prey population.

MATERIALS AND METHODS

State-wide Study

The extensive portion of the study was to sample Michigan as efficiently as possible without expending unnecessary time and effort traveling. A method of collecting was proposed in which the County Extension Agents throughout the state were asked to participate. In February, 1972, a letter outlining the proposed project was drafted and sent to the 83 County Agents. Included in the letter was a sample of the data sheet to be completed for each specimen collected and a two dram, neoprene stoppered glass vial which contained 70% ethyl alcohol and a number to designate the county and the specimen. Return of an enclosed addressed card with the introductory letter acknowledged willingness of the agent to participate. Of the 83 county agents contacted, 67 agreed to participate and 53 sent in specimens. Immediately upon receipt of the card, a set of 12 vials and data sheets, correspondingly numbered, were forwarded to the agent. As each set of vials was returned, another was forwarded with the next set of 12 ascending numbers and data sheets.

Data requested included date of collection, type and location of the dwelling from which the spider was taken, actual location within the dwelling, if the spider was found in or near a web and if a bite could be associated with the specimen. A sample of the letter and the data sheet is provided in Appendix A.

As soon as spiders began arriving, they were identified to species and data were assembled on the numbers and species of spiders collected from each county. Then a phylogenetic listing was made with numbers of individuals in each species and sex, including the number of immatures. The data was divided into monthly totals to determine the effects of seasonal changes on the populations present as well as the influence of the building type on the species collected.

At the completion of the sampling period, the data for the 12 species received most often were analyzed for the months in which they were collected, sex ratios present and building types in which they were most frequently found. The results of this listing will be provided for the County Agents in the form of an Extension Bulletin that will be useful in determining the spider fauna in dwellings.

One of the objectives of the study was to monitor the incidence of spider bites that could be traced definitely to a given species. The procedure was for the individual to submit the spider to a Michigan State University

Extension office and have a medical doctor examine the bite. The doctor would provide a written description of the symptoms, reactions and prescribed treatments administered to the patient. Of the vast potential for arthropod bites throughout the summer months, very few were actually attributed to spiders.

Local Quantitative Study

During January, 1972, several attempts were made to contact both city and county agencies in order to establish a regular sampling program in buildings owned and managed by them. When this failed, the housing authority for the University was contacted and permission obtained to use buildings owned by the University, provided collecting activities did not interfere with their operation. Thirteen buildings were selected from around the campus for a one year study.

Beginning in February, 1972, a sampling project was initiated to determine what effects collecting and removal of spiders on a bi-weekly basis would have on the resident populations for a period of one month. Three samples were taken during the month long period and the results were examined using a Chi-Square test. The test showed that sampling with removal did not significantly alter the resident populations when done at intervals of two weeks or longer. Thus a regular biweekly sampling program was started in March, 1972, and ended in March, 1973.

The data sheets used were modified from the original, with the following additional data being recorded: temperatures inside and outside the buildings and relative humidity inside, all taken with an Atkins Thermistor Psychrometer, Model 3Z02B. Specimens were collected, numbered in accordance with data sheets, then brought to the laboratory for identification. The specimens of C. inclusum collected were kept alive in rearing vials (See Predator Rearing Section) for future experimentation. The other specimens were killed, placed in numbered vials and stored for identification at a future date.

From the data collected, monthly changes in spider populations were noted as well as changes in the measured weather parameters, in an attempt to relate weather changes with noticeable changes in the spider populations. Throughout the study, particular attention was placed on C. inclusum.

Predatory Behavior of Chiricanthium inclusum Hentz

Predator

Chiricanthium inclusum was first described by Hentz in 1875. The general biology was discussed by Peck and Whitcomb (1970). Included in their study were descriptions of the life cycle, mating behavior, mean stadium for each instar, general food preferences and the effects of several environmental parameters on development and general biology.

Rearing

Beginning in the fall of 1971, specimens of _C. inclusum_ were collected from buildings on campus and returned alive to the laboratory. Each animal was placed in a 20 dram shell vial stoppered with non-absorbent cotton. Various types of food were offered and after several familiarization periods by the spiders, one was selected, based on acceptance by the spiders and the ease in which the prey could be maintained in the laboratory. Since the spiders were collected in buildings having relatively stable temperatures, they were maintained in the laboratory at room temperature during the winter and spring. As the outdoor temperature increased during the spring and summer, accompanied with a marked rise in the relative humidity, the animals were moved to a controlled temperature room where the temperature was maintained within a range of 70-75 degrees F. Additional specimens were collected and kept both as experimental animals and as sources of egg supply to raise future experimental animals.

Initially, several methods were tried to keep the moisture levels sufficient to maintain the animals. Though Peck and Whitcomb (1970) stated that the normal ranges of relative humidity have no effect on the animals' health, observations tended to indicate that the animals began to lose their ability as hunters when the temperature and relative humidity increased more than 20 units above that to which they were accustomed. In a pilot study to determine the amount of humidity change needed to alter the hunting behavior of the spider, it was noted that when the humidity was raised over 20 percent above that to which the animals were accustomed, the distances traveled decreased by as much as 20 percent and the number of prey animals eaten decreased by up to 33 percent.

Moist pieces of paper were placed in the rearing vials, but they dried out rapidly and needed continuous attention. Absorbent cotton was tried, but the residues from the spider meals as well as the fecal materials remained moist in the small chambers and resulted in mold and contamination. A method reported by Peck (1970) was tried using a tube with both ends removed and stoppered with cotton for easier cleaning. These tubes were stored in a horizontal manner and required a considerable amount of laboratory space. This method was rejected owing to the lack of storage space. Also, C. inclusum was able to burrow between the cotton and the glass container side and escape. Therefore, only one open end was considered an advantage in reducing the numbers of spiders escaping.

Feeding regimens for maintaining the animals were established at three to five medium sized Tribolium confusum larvae per day. This number was determined by feeding the adult spiders an arbitrary amount, waiting for 24 hours, counting the number of uneaten larvae, halving this number and subtracting it from the original number and giving this amount to the spiders the next meal. When the spiders ate those placed in the chambers without leaving one or two animals uneaten or unattacked, this number was given as the daily ration. The tendency of C. inclusum was not to attack every prey animal placed in the container, and therefore several might be found in the bottom of the container depending on the hunger levels of the particular spider.

Prey

Several types of prey organisms were tried as a source of food and, after some experimentation, T. confusum was determined as the best one to be used. According to Peck and Whitcomb (1970), the more varied the diet, the better the animals grew and matured. According to their results, a wide variety of animals were introduced to the spiders and after 24 hours the results of their eating or rejecting the prey was compared with the acceptance of Drosophila melanogaster as a test food. According to Dondale (personel communication) spiders need a period of several days to become accustomed to a newly introduced prey species. Therefore, the testing of prey species was conducted for two weeks in order that one be chosen that was easy to rear in the laboratory, was preferred by the spiders and was of such a form that similar types could be expected to be found within dwellings.

The types of prey tested were adult fruit flies, D. melanogaster; Ants, Formicidae; Milkweed bugs, Oncopeltus fasciatus; Cockroaches, Blatta sp. and Periplaneta sp.; the yellow mealworm, Tenebrio molitor; and the confused flour beetle, Tribolium confusum.

The fruit fly varieties tried were both winged and wingless. Their mobility did not permit the spiders to capture them and so as a potential experimental prey were rejected.

Ants were noticed in all the buildings investigated as well as the Natural Science Building. When the ants were placed in a rearing chamber as food for C. inclusum, the spider became very agitated, and if the number of ants exceeded three or four, they often killed the spider. There was never a time when the spiders were observed eating ants. Several times during the rearing of egg masses, the ants got into the rearing chambers and carried off eggs or young spiderlings.

Milkweed bugs were tried because of their ease in rearing, but the spiders would not eat either the adults or the smaller nymphs. The rejection of Milkweed bugs could be based on several factors: a hard exoskeleton, a possible taste or odor objection, or perhaps the size of the more mature specimens.

One of the few animals observed in the dark were cockroaches. Several species, including the adults and nymphs were tried with the same results as with the Milkweed bugs. The hard carapace and the speed and agility seemed to deter the spiders in their attack.

Mealworms, ranging in size from five to twenty millimeters, were used with varying degrees of success. The adult male spiders were able to kill and eat most of the medium and all of the smaller specimens, but the thick integument and active thrashing of the prey would often deter even the most persistent spider. Smaller adults and immature spiders often were dislodged and would give up the attack.

Flour beetles were tried with the highest degree of success. The adult beetles were not readily accepted due to the hard carapace. The preferred forms were the larvae which were attacked and eaten by all sexes and stages of spiders. Because of the soft bodies of the larvae, there were few parts left when the spider had finished eating. The larvae averaged 63-75% moisture by weight. When these animals were the only food sources, they were divided into three size classes by inspection:

small, less than four mm.; medium, four to eight mm.; large, greater than eight mm. The soft bodies, apparent high moisture content and lack of mobility proved them to be good food sources.

Rearing the Prey

Several one quart jars filled with enriched white flour were inoculated with 25-30 adult beetles and left to reproduce at room temperature. As one culture was maturing, another was begun with adults from the previous culture. To obtain food for the spiders, a portion of the flour was poured onto a wire screen of 60 meshes per inch and the flour sifted. The larvae were sorted, the appropriate size removed for food and the rest returned to the stock culture. When the cultures began to indicate effects of crowding, cannabalism, reduced number of larvae, and many beetles along the side of the jar, the culture was discarded and another begun.

Peck and Whitcomb (1970) in their experiments with food preferences, gave the spiders a wide variety of prey organisms from several Phyla and Classes of animals. The preferred organisms were the soft bodied forms, particularly larval forms. Their data agrees with the results of this study.

Apparatus

Rearing Chambers.--The rearing chambers were 20 dram glass shell vials, stoppered with non-absorbent cotton and stored vertically in racks.

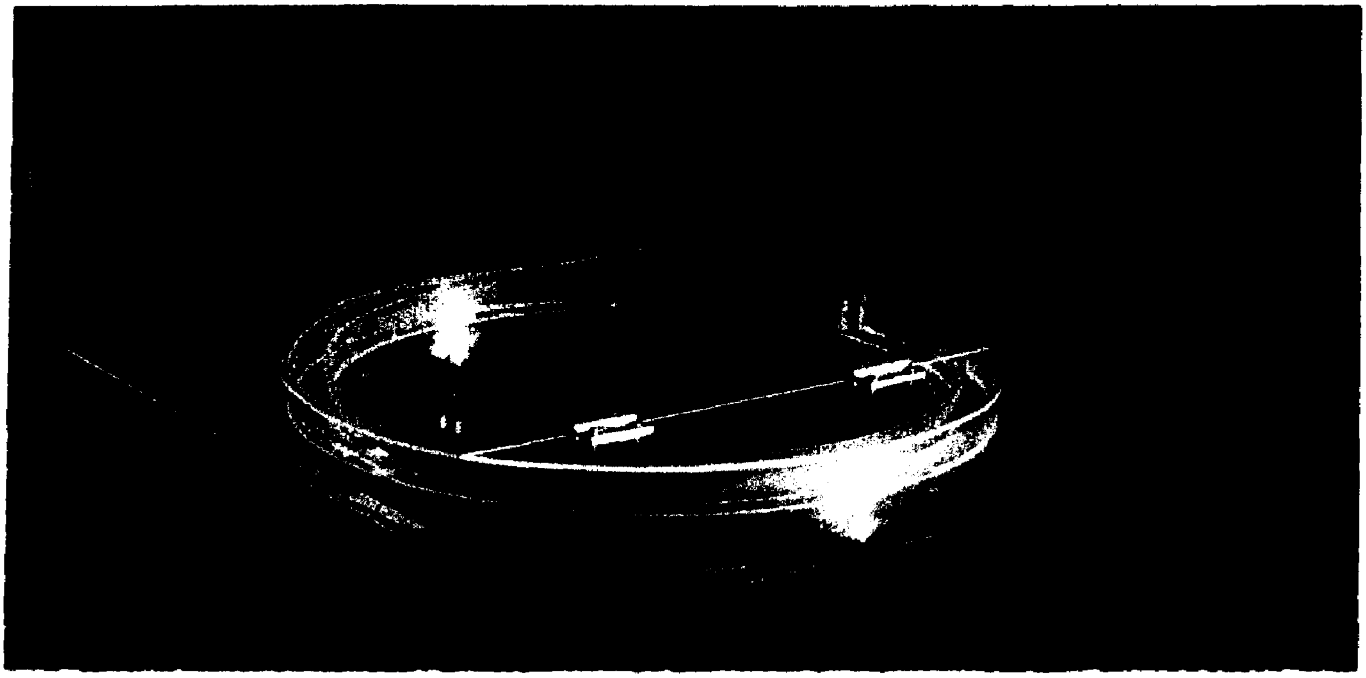
Experimental Chambers.--Two types of experimental chambers were used, one for measuring foraging, distances traveled and the other for observing hunting behavior.

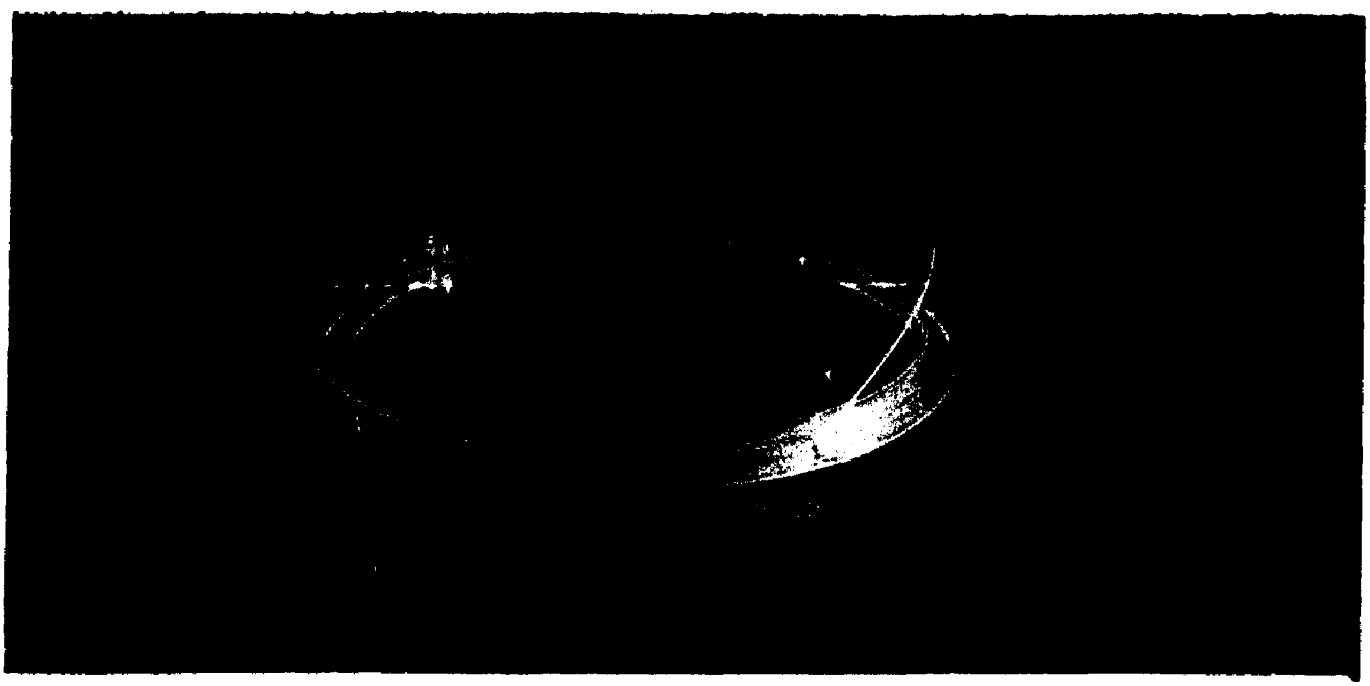
A. The chamber used to measure foraging distances was a clear plexiglass circular track 48 inches in diameter (Plate 1).

B. The chambers for observing hunting behavior were three glass aquaria and a screened cage.

Type of cage	Length	Width	Height	Surface area	Ratio
Glass	8.5 in.	5.5 in.	6.5 in.	292 square in. 2.02 square ft.	1
Glass	14 in.	8.0 in.	10.0 in.	664 square in. 4.61 square ft.	2
Glass	20 in.	10.0 in	12.0 in.	1120 square in. 7.8 square ft.	4
Screen cage	6.6 ft.	6.6 ft.	6.0 ft.	31,104 square in. 216 square ft.	32

Plate 1.--Circular track used to determine distances traveled by experimental spiders.





Lighting.--The rearing chambers were placed in a constant temperature room at 70-74 degrees F and maintained on a 14:10 light cycle (14 hours of light and 10 hours of dark) to approximate the normal daylight cycle occuring during the spring, summer and early fall of the year. Before any experiments were begun, all newly captured animals were placed in the light room for a minimum of 72 hours to acclimate them to the experimental light cycle.

Experimental Design

The predatory behavior of *C. inclusum* Hentz exhibited several basic behavioral attributes which will be examined before the actual predator-prey activities are evaluated.

Peck and Whitcomb (1970) stated that *C. inclusum* Hentz is a nocturnal predator that does not see well during its normal hunting period. On the basis of their observations, *C. inclusum* Hentz located its prey by touching it with the extended front legs while moving in a forward direction. To determine what the critical distance is between the predator and prey before the attack, five males, five females and five medium sized immatures were selected and placed one at a time in the five gallon tanks. Small larval forms of *T. molitor* were placed in the tank at various distances from the rearing chambers containing the spiders. The test was repeated twice for each specimen and the results compared for the significant distances needed to detect prey. Prey detection, or the detection of any object in the path of the spider, was considered as an action not related to searching; i.e., pausing with the front legs extended, tapping the encountered object, an avoidance reaction, or a direct attack.

To determine the necessary level of light to initiate hunting response, five individuals of each sex and five medium sized immatures, with two replications each, were placed in a two gallon tank and measurements made of the available light by use of a Wilson Illumination meter model 756 with a quartz filter. When the animals began their hunting activities, the light intensity was recorded in foot candles. To determine the effects of hunger, the same experiment was run again following 72 hours of starvation.

Following the results of Peck and Whitcomb (1970) regarding relative humidity, an evaluation of the moisture content of their food was made to determine if prey moisture content affected the spiders well being. Fifteen spiders of each sex and 15 medium sized immatures were placed in the constant temperature room at approximately 72 degrees F. The purpose of the test was to determine the moisture requirements necessary to maintain healthy spiders in an environment approximating that found in buildings. Having determined the approximate moisture content of the prey, a feeding regimen was established so that five of each type of animal were fed what had been determined (See Predator Rearing Section) as a normal meal every three, seven and 10 days. During that time, no water was provided to the spiders. The relative humidity was maintained at approximately 45% with the test being run for six weeks. The numbers of animals dying were analyzed by sex, maturity, and feeding regimens.

A study was conducted to determine if the search patterns of the spider were random. Three spiders of each sex and three medium sized immatures were placed in the six by six foot screen cage one at a time and left to acclimate for 24 hours. When the individual spiders emerged after dark to begin their search activities, a 25 watt red light was used to observe and tabulate their movements.

The spiders were allowed to wander at will and whenever they turned one way or the other from the direction they were going, a "1" was tabulated for a left turn and a "2" was tabulated for a right turn. The spiders were permitted to make 40 turns for each run. Three replications were made for each animal. In order to determine the effects of locating prey on the search pattern, prey were positioned in such a manner that the spider came upon the prey in as natural a manner as possible. After allowing the spider to feed, the experiment was repeated for 40 more turns, with three replications. The effects of starvation on the search patterns were determined by starving the spiders for 48 hours and repeating the above experiments.

The results were tested using the Wald-Walfowitz Runs Test, outlined in Conover (1971) and Bradley (1968). The observations consisted of two types, "1" and "2" or "a" and "b." The assumptions are (1) the samples are random, (2) they are mutually independent of each other, and (3) they are continuous. The null hypothesis predicts that the process that generates the sequence is random. The alternative hypothesis is that the variables in the sequence are dependent on other random variables, or they are distributed differently from each other. The test statistic equals the number of runs of like elements, called "T." The "T" value is compared with values in a table prepared by Swed and Eisenhart (1943). For values of "a" or "b" greater than 20, the formula is

$$W_\alpha \cong \frac{2ab}{a+b} + 1 + x_\alpha \sqrt{\frac{2ab(2ab-a-b)}{(a+b)^2\ (a+b-1)}}$$

where x = the quantile values in a standard normal random variable. "T" greater than W signifies acceptance of the null hypothesis.

At the outset of the study, an attempt was made to census the _C. inclusum_ population within a building by tabulating the number of resting cells found. This proved unreliable because the spiders may use the same resting cell more than once, or may build two in one 24 hour period. Therefore, an experiment was devised to test if spiders returned to one cell or, if not, what caused the abandoment of the old cell. Beginning in February, 1972, the resting cells in the basement and first floor of the Natural Science Building were tabulated, the spiders collected and the resting cells removed. The spiders that were used in the test were either adults or penultimate instar animals. They were marked with watercolor paint and released in the same areas in which they were collected. After 24 hours, a new census was made of the marked spiders, and the location of the resting cells recorded. For the next two weeks, a daily count was made of the marked spiders and the location of the resting cells.

At the same time as the above experiment was in progress a series of tests were run in the laboratory to determine what effect hunting area size had on the return to the established resting cells. Five spiders of each sex and five medium sized immatures were placed individually in two gallon chambers and observed for five days under established feeding regimes. The number that returned to the original cells and those that did not were recorded. The same procedure was repeated in five gallon and 10 gallon chambers and the 6' x 6' x 6' screened cages. A series of similar experiments were conducted on two levels of predator starvation levels, 48 and 72 hours without food.

Prey size and its effects on hunting success when associated with predator hunger levels was investigated. Three size classes, designated small, medium and large, were selected from the prey animals. The small and medium size classes were selected from T. confusum stocks and the large size class was selected from T. molitor stocks. The results of this study were analyzed from three aspects: sex of the spider, hunger levels of the spiders, and prey size, using a two way analysis of variance at three hunger levels as outlined in Sokal and Rohlf (1969).

Throughout the study the degree of cannabalism in this species of spider was noted. Whenever spiders were mentioned in the literature, a section was always allowed to cover aspects of one spider feeding on the same or different species. Peck and Whitcomb (1970) stated that the incidence of cannabalism among C. inclusum was the highest among the early instars and decreased markedly in the adult stages. Their experiments were conducted in small glass rearing chambers which affected the normal activities of the spiders. Even the notorious Black Widow is not as cannabalistic if she is offered a choice of food (Gertsch 1949).

The next two portions of the study have to do with the effectiveness of the predator at various prey densities and the distances traveled under various hunger regimes. The hunger regimes were satiated, one, two, three, four and five days without food. The individual spiders were placed in the circular test chamber and observed under the red 25 watt light for a full hunting period of 10 hours. The number of complete circuits around the track were tabulated for each animal and the distances calculated. To be sure that the wandering was not a desire to escape, food was introduced at various times on several sample tests.

The final portion of the study considered the density of prey in relation to the success of the spider in locating food. This was accomplished by increasing hunting area size and varying prey densities to approach the potential prey densities in the natural environment as opposed to the laboratory situation. The prey densities varied from a high of one prey per 14.6 square inches to a low of one prey per 180 square feet. Within each of the experimental chambers, prey were placed in a random manner at densities of one, two, four, eight and 20 animals per search area. The random placement of prey was determined by marking off the surface area of the chamber into one inch squares, numbering them in a consecutive manner and locating the squares to hold prey by drawing random numbers from a random numbers table. The animals were fastened to the side of the chambers with small pieces of masking tape.

At the same time that the prey density portion of the study was being conducted, the effects of intraspecific non-prey organisms on hunting success was determined by increasing the number of the number of predators from one to two and then to four within the same area. Each set of experiments was run for males. There were five sets of three replications each. The results were analyzed using a three by three factorial design in examining the effects of search area size, prey density, predator density and the inherent interactions.

RESULTS

State-wide Survey

The 1147 spider specimens taken from inside buldings throughout the state represent 16 families, 65 genera and 196 species (Table 1). Appendix B contains the numerical code developed for the spiders collected during this study. Figure 1 illustrates the 53 counties in which the county agents participated. The numbers in each county indicate the total number of specimens collected in that particular county. Appendix B lists the specimens received from each county in alphabetical order with the county code as used by the Michigan State Extension Service.

Of the 16 families, nine were web spinners and seven were non-web spinners. Web spinning families were represented by the Theridiidae, Pholcidae, Araneidae, Linyphiidae, Scytodidae, Agelenidae,Tetragnathidae, Dictynidae and the Amaurobiidae. The non-web spinning families were represented by the Erigonidae, Salticidae, Gnaphosidae, Pisauridae, Clubionidae, Thomisidae and the Lycosidae. Drew and Sauer (unpublished data) credit Michigan with 23 families of spiders which contain 153 genera and 371 species. The state-wide survey represnted 69.5% of the potential families, 42.4% of the potential genera

TABLE 1.--Taxonomic Listing of Spiders Received from the State-wide Survey.

Theridiidae	Steatoda	borealis
	"	triangulosa
	"	altera
	"	grosa
		sp.
	Theridion	murarium
	Crustulian	stricta
	Unknown	sp.
	Achaeranea	tepidariorum
	Latrodectus	mactans
	"	variolus
Erigonidae	Hypselistes	florens
	Erigone	sp.
	Unknown	sp.
Dictynidae	Dictyna	sublata
	"	sp.
Salticidae	Phidippus	audax
	"	regius
	Salticus	scenicus
	Sitticus	palustris
	"	floridanus
	"	pubescens
	Eris	marginatus
	Metaphidippus	sp.
	Maevia	inclemens
	Habrocestum	pulex
	Metacyrba	undata
	Icius	sp.
	Unknown	sp.
Pholcidae	Pholcus	phalangoides
	Spermophora	meridionalis
Gnaphosidae	Zelotes	subterraneus
	"	hentzi
	Herpyllus	ecclesiasticus
	Gnaphosa	muscorum
	"	sp.
	Drassylus	nigar
	"	depresus
	Geodrasus	sp.
	Drassodes	sp.
Pisauridae	Dolomedes	tenebrosus
	"	sexpunctatus
	Pisaurina	mira
	"	sp.

TABLE 1.--(continued).

Araneidae	*Araneus*	*cornutus*
	"	*sericatus*
	"	*diadematus*
	"	*marmoreus*
	"	*cavatica*
	"	*undata*
	"	*diadema*
	"	*dumetorum*
	"	*pegnia*
	"	sp.
	Argiope	*argentata*
		aurantia
	Neoscona	*minima*
	Conepeira	*juniperi*
	Araniella	*displicata*
	Gea	*heptagon*
Clubionidae	*Chiricanthium*	*inclusum*
	"	*mildei*
	"	sp.
	Castaneira	*descripta*
		trilineata
	Clubiona	*abbotti*
	"	*obesa*
	"	sp.
	Trachelas	*ruber*
	"	*tranquillas*
	"	sp.
	Agroeca	*ornata*
Thomisidae	*Misumena*	*yatia*
	"	sp.
	Philodromis	*pernix*
	"	*rufus*
	"	*placidus*
	"	*vulgaris*
	"	*washita*
	"	*aureolus*
	"	*praelustris*
	"	sp.
	Xysticus	*elegans*
	"	*ferox*
	"	*funestus*
	"	*lucosta*
	"	*acquiescens*
	"	sp.
	Coriarachne	sp.
	Misumenops	*oblongus*
	"	*speratus*
	"	sp.

TABLE 1.--(continued).

	Tibellus	oblongus
	"	maritimus
	Thanatus	formicinus
	Unknown	sp.
Linyphiidae	Pityohyphantes	phrygianus
	"	costatus
	Lepthyphantes	nebulosus
	Linyphia	marginata
	"	sp.
	Bathyphantes	pallida
	Drapetisca	sp.
	Unknown	sp.
Scytodidae	Scytodes	thoracica
Agelenidae	Tegenaria	domestica
	Agelenopsis	pennsylvanica
	"	potteri
	"	sp.
	Coras	medicinalis
	"	juvenalis
	"	sp.
	Circurina	pallida
	"	sp.
	Cybaeus	sp.
	Wadotes	calcaratus
Lycosidae	Lycosa	aspersa
	"	avida
	"	praetensis
	"	helluo
	"	punctulata
	"	gulosa
	"	carolinensis
	"	frondicola
	"	moesta
	"	sp.
	Pardosa	milvina
	"	moesta
	"	distincta
	"	modica
	"	sp.
	Trochosa	terricola
	"	sp.
	Pirata	insularis
	"	sp.
	Geolycosa	missouriensis
Tetragnathidae	Tetragnatha	laboriosa
Amaurobiidae	Amaurobius	bennetti
	Callioplus	tibialis
		sp.

TABLE 1.--(continued).

Non-spiders	Opiliones Chelodnethida	Phalangiidae

and 28.5% of the potential species recorded in the State of Michigan.

Many of the parameters outlined in the materials and methods section regarding habitat type and house type were very difficult to quantify in this portion of the study. Over 94% of the animals returned were from wooden, single family dwellings located in a suburban or rural setting. Thus the other catagories were very poorly represented and could not be analyzed as effectively.

The weather parameter available for all the counties with a degree of reliability was temperature. Figure 2 presents the variation in air temperature during the study period, with the numbers of specimens received as a percentage of the total for the state. For a period of four months, May through August, spider numbers were inversely related to temperature. For the remaining eight months, both curves approximate each other closely. During this period as the temperature increased, so did the numbers of spiders received, and as the temperature decreased, so did the spider numbers.

Figure 1.--Map of Michigan showing counties in which agents participated in state-wide survey and numbers of specimens received from each county.

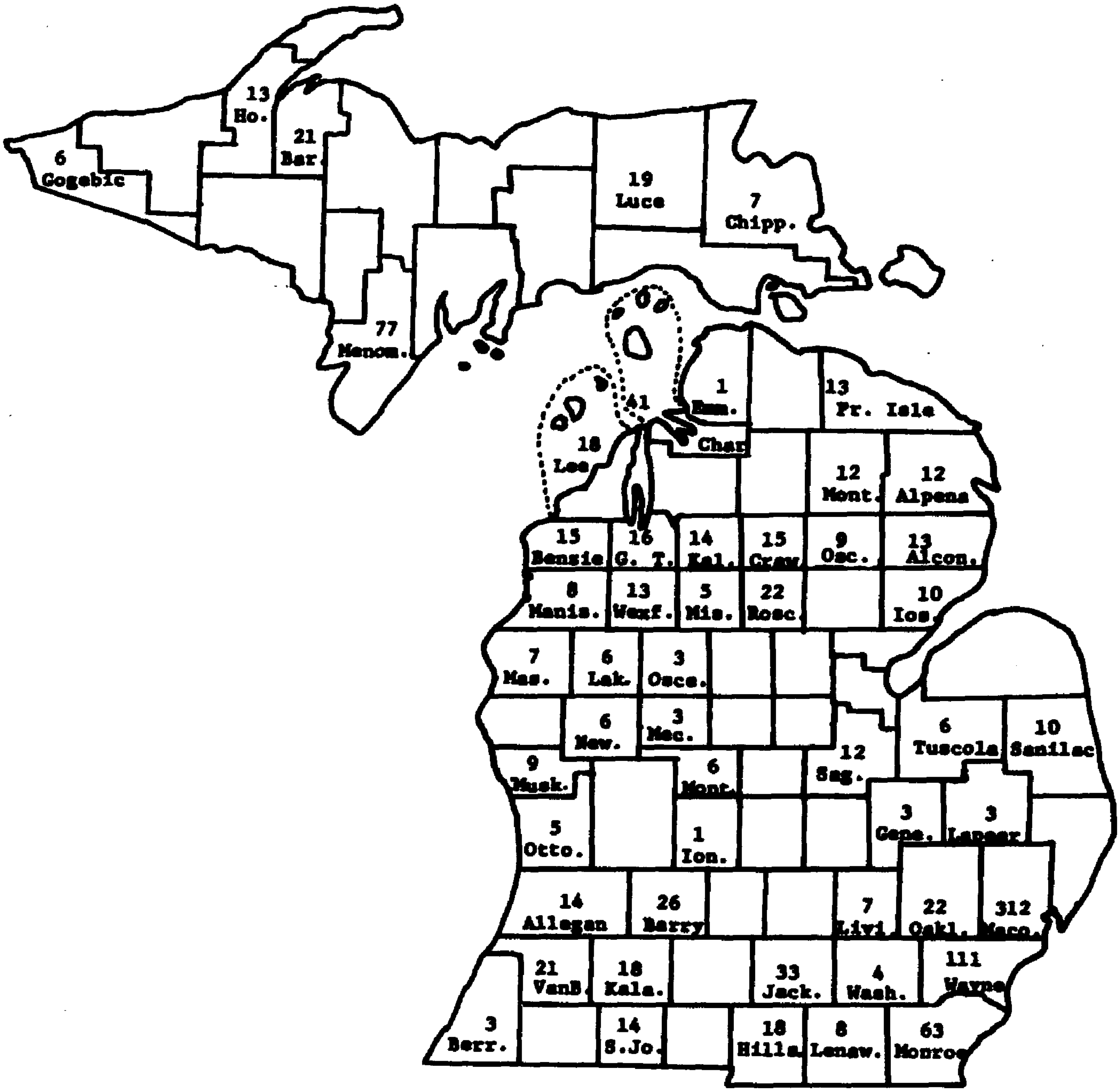
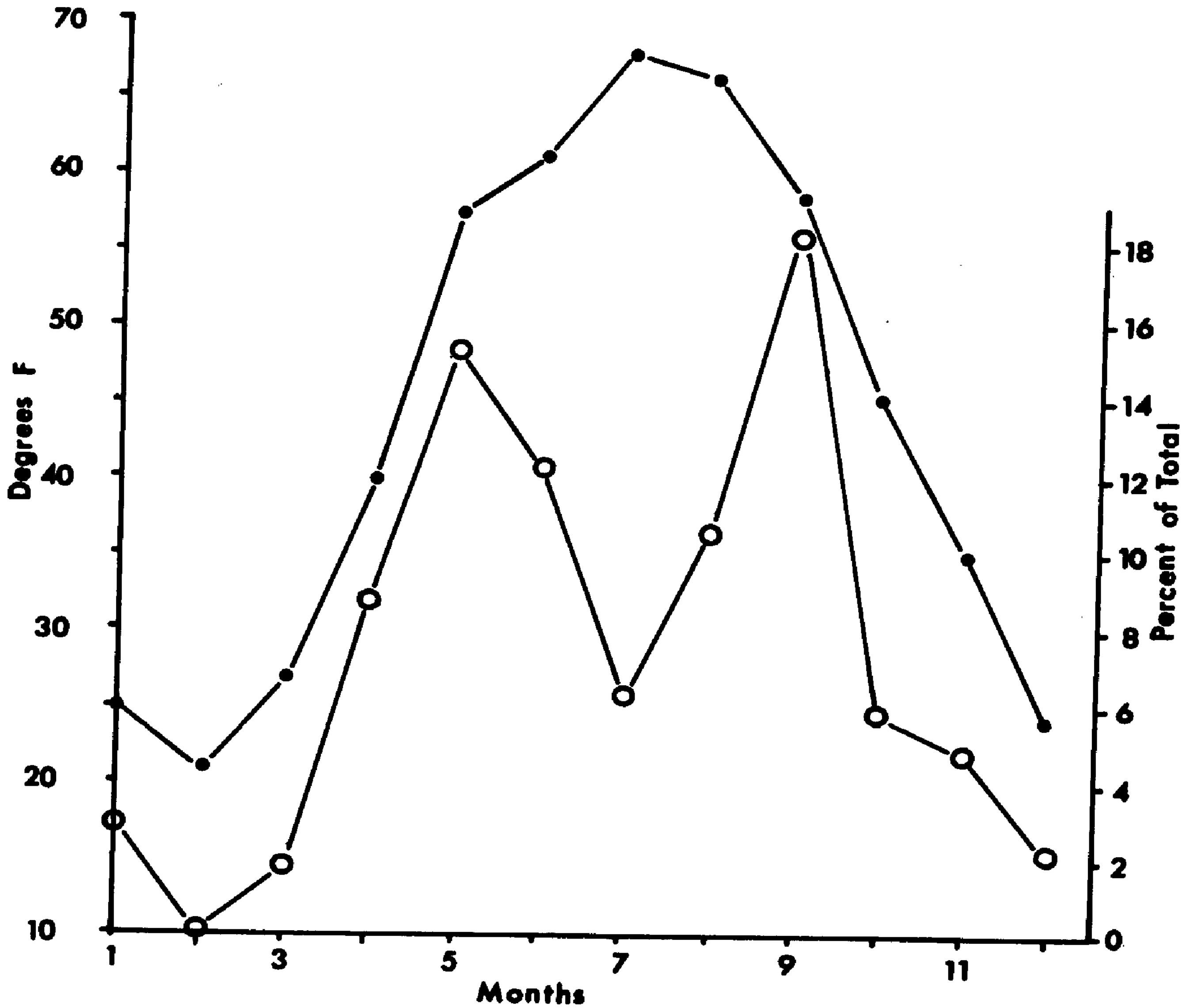

13
Ho.
21
Bar.
6
Gogebic
19
Luce
7
Chipp.
77
Menom.
41
1
Emm.
13
Pr. Isle
18
Lee
Char
12
Mont.
12
Alpena
15
Benzie
16
G. T.
14
Kal.
15
Craw
9
Osc.
13
Alcon.
8
Manis.
13
Wexf.
5
Mis.
22
Rosc
10
Ios.
7
Mas.
6
Lak.
3
Osce.
6
New.
3
Mec.
6
Tuscola
10
Sanilac
9
Musk.
6
Mont.
12
Sag.
5
Otto.
1
Ion.
3
Gene.
3
Lapeer
14
Allegan
26
Barry
7
Livi.
22
Oakl.
312
Maco.
21
VanB
18
Kala.
33
Jack.
4
Wash.
111
Wayne
3
Berr.
14
S.Jo
18
Hills.
8
Lenaw.
63
Monroe

Figure 2.--Mean monthly temperatures compared with percentages of spiders sent in by county agents.

Air temperature

Animals as a percentage of total number (N).


70
60
50
40
30
20
10
Degrees F
18
16
14
12
10
8
6
4
2
0
Percent of Total
1
3
5
7
9
11
Months

The months in which spider numbers were directly related to temperature were also the months in which the most specimens were received. In May, 175 specimens or 15.25% of the total were collected and in September, 212 specimens or 18.6% of the total were collected. When the mean temperature for the state was at a high of 68 degrees F., the number of spiders was at a low value (75 or 6.4% of the total) for this four month period.

In order that the large numbers of spiders collected could be analyzed in a meaningful manner, the species representing more than 50% of the total were analyzed in detail. This decision was made on the basis that many county agents did not collect sufficient numbers of animals to make a valid analysis either by county total or by species in each county.

The 12 species selected on the basis of numbers can be found on Table 2. Included are the totals for each species as well as the percentage of the total numbers and the percentage of the total for the 12 species. The 12 species listed represent 591 specimens and 51.5% of the total for this portion of the study.

When the 12 species are considered on an individual basis, two main patterns appear. Figure 3 displays the species through the sampling period as actual numbers of specimens received and the makeup by sex and maturity level.

The two patterns are the peaks which appear in both April-May and September-October. There is generally one peak larger than the other, labeled the major peak. The second pattern is that the major peak may occur either during the spring or during the fall.

On the basis of the above observed patterns, the 12 species were separated into spring major and fall major species. The spring major peak species are *Tegenaria domestica*, *Steatoda borealis*, *Chiricanthium inclusum*, *Phidippus audax*, and *Salticus scenicus*. Thus species having fall major peaks are *Achaeranea tepidariorum*, *Aranea sericatus*, *Agelenopsis potteri*, *Trachelas tranquillas*, *Herpyllus acclesiasticus* and *Agelenopsis pennsylvanica*.

Of the spring major peak species, there was only one true web spinner, *Steatoda borealis*. When the fall major peak species were examined, there were two, *Achaeranea tepidariorum* and *Aranea sericatus*.

When the percentages of males to females were examined, there were more females than males and immatures combined. The ratios for the individual species (Table 3) ranged from a low of 12 males to 10 females for *S. scenicus* to a high of two males to 73 females in *A. sericatus*.

When the sex ratios are compared with the major peak data, there is no significant differences between sex ratios from spring peak through fall peak. Any peak can

TABLE 2.--Twelve Most Frequently Received Species From State-Wide Survey

Species	No.	% of Total	% of Top 12
Tegenaria domestica	108	9.5	18.2
Achaeranea tepidariorum	90	7.9	15.2
Aranea sericatus	73	6.4	12.3
Agelenopsis potteri	53	4.6	8.9
Steatoda borealis	47	4.1	7.9
Chiricanthium inclusum	47	4.1	7.9
Phidippus audax	43	3.7	7.3
Steatoda triangulosa	38	3.5	6.8
Salticus scenicus	29	2.5	4.9
Trachelas tranquillas	25	2.2	4.2
Herpyllus ecclesiasticus	24	2.0	4.0
Agelenopsis pennsylvanica	22	1.9	3.7
TOTAL	591	51.5%	100.0

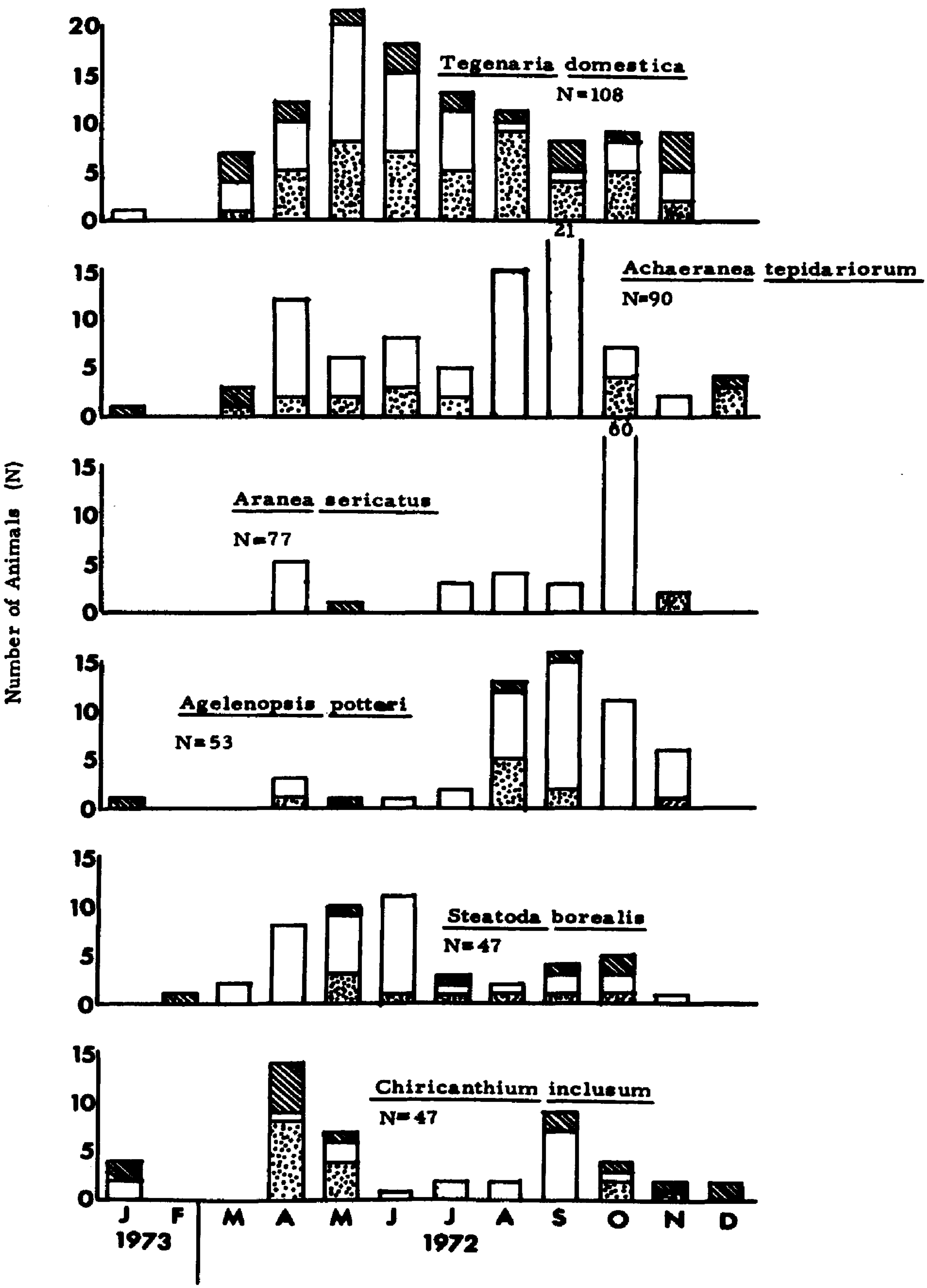
The number of specimens reported for each of the 12 most numerous species

Figure 3.--Numbers of spiders broken down by sex and maturity level by the month for state-wide survey.

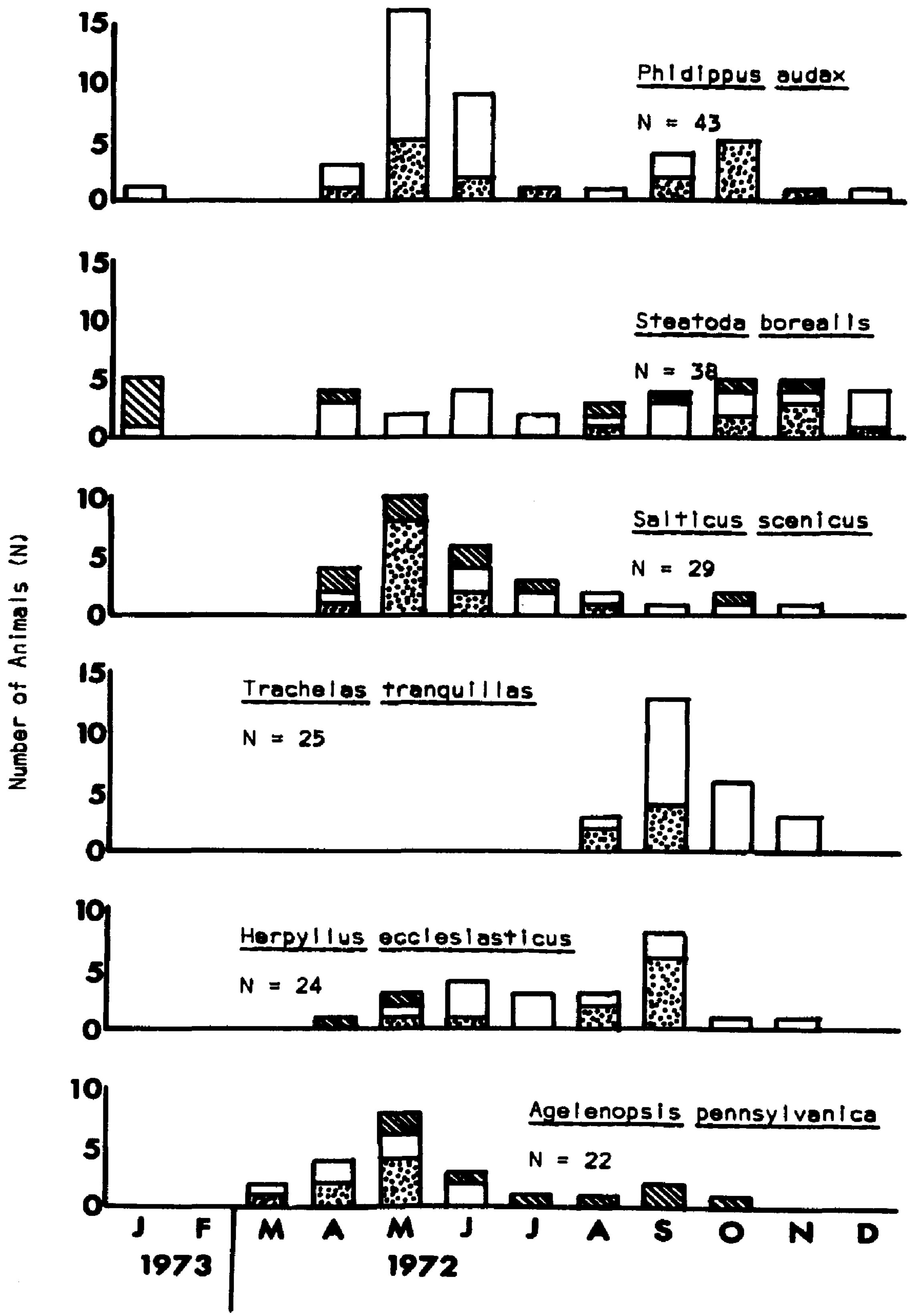
= Female

= Male

= Immatures



Number of Animals (N)
Tegenaria domestica
N=108
21
Achaeranea tepidariorum
N=90
60
Aranea sericatus
N=77
Agelenopsis potteri
N=53
Steatoda borealis
N=47
Chiricanthium inclusum
N=47
0
5
10
15
20
J F M A M J J A S O N D
1973
1972



Phidippus audax
N = 43
Steatoda borealis
N = 38
Salticus scenicus
N = 29
Trachelas tranquillas
N = 25
Herpyllus ecclesiasticus
N = 24
Agelenopsis pennsylvanica
N = 22
Number of Animals (N)
15
10
5
0
J F M A M J J A S O N D
1973
1972

TABLE 3.--Number of Individuals Per Sex in the Top Twelve Species.

Species	♂	♀	Imm.	Total
Tegenaria domestica	46 42.5	42 38.9	20 18.5	108 18.3%
Achaeranca tepidariorum	17 18.9	69 76.5	4 4.5	90 15.2%
Aranea sericatus	2 2.6	74 96.0	1 1.4	77 13.0%
Agelenopsis potteri	9 17.0	40 75.5	4 7.5	53 8.9%
Steatoda borealis	8 17.0	33 70.0	6 13.0	47 7.9%
Chiricanthium inclusum	15 32.0	18 38.3	14 29.7	47 7.9%
Phidippus audax	17 39.5	26 60.5	0 0	43 7.3%
Steatoda triangulosa	7 18.4	22 58.0	9 23.6	38 6.4%
Salticus scenicus	12 41.5	10 34.5	7 24.0	29 4.9%
Trachelas tranquillas	6 24.0	19 76.0	0 0	25 4.2%
Herpyllus ecclesiasticus	10 41.7	12 50.0	2 8.3	24 4.1%
Agelenopsis pennsylvanica	7 31.8	7 31.8	8 36.4	22 3.7%
Totals %	156 26.4	372 62.9	75 12.1	591

The bottom row of figures associated with each species represents percentages of males, females and immatures of each species total.

be examined and the major peak, whether spring or fall, will consist primarily of females. Only S. triangulosa and A. pennsylvanica are represented by having immatures as the dominant group.

In examining the most frequently occurring species the top nine are found within dwellings through more than 10 months of the year. These species over winter either as penultimate instars or as mature females.

Spider bite data was collected in conjunction with the State-wide study and produced a total of 18 suspected bites. The frequency of bites was plotted over the year long survey and the bites occurred at two peak periods during the year. The first peak occurred during May which is the month when the spider population is the highest, and accounted for eight bites. August, the second peak of the year for the spider populations, was also the second peak in number of six bites reported.

These two periods coincide with several factors important to man. First, spiders are at their peak densities during these two months and secondly, people are out and active during these months, placing themselves in close contact with potential pests.

Of the 18 suspected bites, only four were confirmed by capturing the animals during the biting and having a medical doctor confirm the bite and describe the symptoms and treatments. Of the four, two were _C. inclusum_, another was a pisaurid and the third was an unknown species not collected or seen by me but which accounted for possible complications leading to the death of a senior citizen.

Of the two _C. inclusum_ bites, one was on the naval of a woman and caused an itching sensation and a small red weal which persisted for several days. The treatment prescribed was penicillin and a bee sting antivenom. The second bite was on the finger of a woman sleeping in bed, who awoke following a sharp stinging sensation. The same symptoms were reported and similar treatment prescribed. The symptoms described for bites coincide with the data reported by Furnam and Reeves (1957). Their data comes from one suspected bite reported in the California Medical Journal from a study done on spider bite venom.

The third confirmed bite was made by a mature female _Dolomedes tenebrosus_, of the family Pisauridae. The bite was on the buttock of a woman and caused a red weal and severe itching which persisted for several days. Following treatment with penicillin, the itching and the weal subsuded, with no side effects.

The final confirmed bite was reported by a youngster who saw the spider bite his grandfather. The spider bit the man while he was working on a woodpile near a stream. The spider was killed and the man taken to a local hospital. The man had a history of heart trouble and was in his mid-seventies, so the death cannot be attributed directly to the spider bite, but the venom may have caused complications. From the description given by the grandson and the nearness to water, there is reason to suspect that the spider was a member of the family Pisauridae, though it could have been from the family Lycosidae as both families contain large dark spider species.

Local Quantitative Study

The sampling at the local level produced 3346 spider specimens representing 12 Families, 32 Genera and 57 Species. Appendix B provides the numerical code used for both the state-wide and local studies. Each building type will be presented separately with the appropriate weather parameters.

Table 4 contains the species found in the local survey, representing 625 specimens from 12 families, 32 genera and 56 species or 18% of the total for the study. The animals were taken from two metal quanset-hut structures containing 1950 square feet of surface area each or 3900 square feet total. This gives 0.127 animals per square foot per year or 0.0635 animals per square foot per year per building. There were six web spinning families and six non-web spinning families. The web spinning families were the Theridiidae, Pholcidae, Araneidae, Dictynidae, Linyphiidae and Agelenidae. Non-web spinning families were represented by the Erigonidae, Salticidae, Gnaphosidae, Thomosidae, Clubionidae and the Lycosidae.

Weather parameters, Figure 4, are shown with the percentage of spiders collected each month. The outside temperature does not follow the inside temperature closely, but there are similar trends observable between the two. The outside temperatures ranged from a low of 26 degrees F in December to a high of 82 degrees F in August, while the temperature inside the building ranged from a low of 67 degrees F in March to a high of 80 degrees F in August. Relative humidity ranged from a low of 46% in February to a high of 85% in August.

The total spider population varied with two peaks, similar to those observed in the state-wide survey. The spring major peak occurred in April and the minor peak occurred in August. The major peak accounted for approximately 19% of the total and the minor peak accounted for 11%.

To facilitate the handling of the data, the same method used in the state-wide survey was used here. The five species representing the most frequently encountered animals were *Steatoda triangulosa*, *Achaeranea tepidariorum*, *Chiricanthium inclusum*, *Steatoda borealis* and *Tegenaria domestica*, representing 450 specimens or 72.0% of the 625 total. These five species represent four web spinners and one non-web spinner, *Chiricanthium inclusum*.

TABLE 4.--Taxonomic Listing Local Spider Survey.

Family	Genus	Species
Theridiidae	Steatoda	borealis
	"	triangulosa
	"	grossa
	Crustulina	stricta
	Achaeranea	tepidariorum
	Unknown	sp.
Dictynidae	Dictyna	sublata
	"	sp.
Salticidae	Phidippus	audax
	Sitticus	palustris
	"	floridanus
	"	pubescens
	Salticus	scenicus
	Metaphidippus	sp.
	Maevia	inclemens
	Metacyrba	undata
Pholcidae	Pholcus	phalangeides
	Spermophora	meridionalis
Gnaphosidae	Herpyllus	ecclesiasticus
	Zelotes	subterraneus
	Gnaphesa	muscorum
		sp.
	Drassylus	niger
	"	depressus
	Drassodes	sp.
Araneidae	Aranea	cornutus
	"	sericatus
	"	diadematus
	"	cavatica
	"	undata
	"	diadema
	"	dumetorum
	"	sp.
	Argiope	argentata

TABLE 4.--Continued.

Family	Genus	Species
Clubionidae	Chiricanthium	inclusum
	"	mildei
	"	sp.
	Castaneira	descripta
	"	trilineata
	Clubiona	abbotti
	"	obesa
	"	sp.
	Trachelas	ruber
	"	tranquillas
	"	sp.
Thomisidae	Misumena	vatia
	Philodromis	pernix
	"	rufus
	"	placidus
	"	vulgaris
	"	sp.
	Xysticus	elegans
	"	ferox
	"	funestus
	Misumenops	oblongus
	"	sp.
	Unknown	sp.
Linyphiidae	Linyphia	marginata
	"	sp.
	Unknown	sp.
Scytodidae	Scytodes	thoracica
Agelenidae	Tegenaria	domestica
	Agelenopsis	pennsylvanica
	"	potteri
	"	sp.
	Coras	medicinalis
		juvinalis
	Wadotes	calcaratus
Lycosidae	Lycosa	avida
		helluo
		punctulata
		moesta
		sp.

Figure 4.--Temperatures both inside and outside metal buildings with relative humidity inside buildings compared with monthly changes in spider numbers captured.

······· Inside temperature
—— - —— Outside temperature
------- Relative humidity
———— Percent of spiders occurring each month

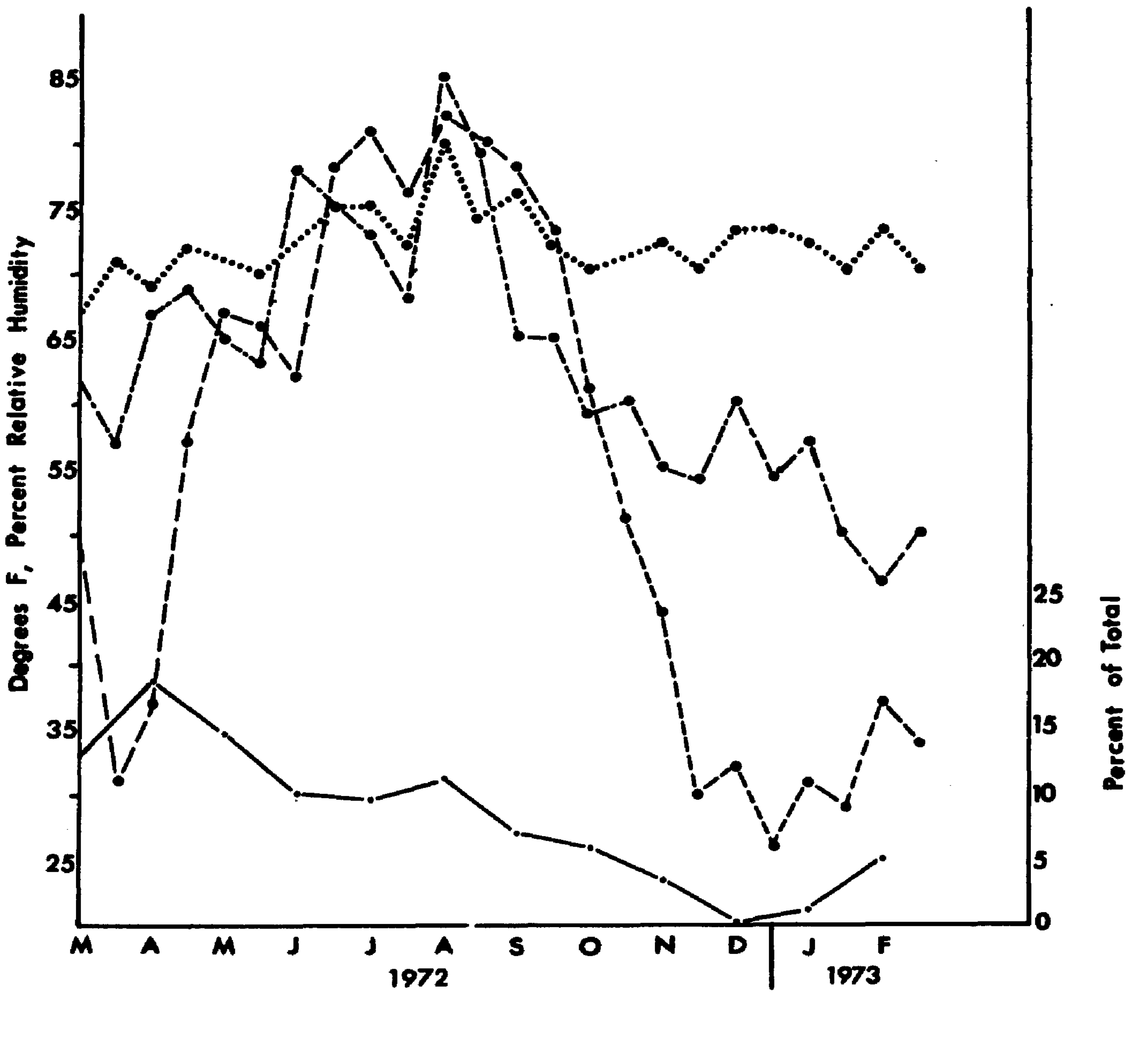

Degrees F, Percent Relative Humidity
85
75
65
55
45
35
25
Percent of Total
25
20
15
10
5
0
M A M J J A S O N D J F
1972
1973

Figure 5 represents the monthly breakdown for each species by number of animals and sex proportions. The two peak phenomenon was again present but not to the extent as found in the state-wide survey. The most numerous species, Achaeranea tepidariorum, had one major peak in May and then gradually decreased in frequency from a high of 12 specimens to a low of zero in December. Females again proved to be the most numerous, with immatures a very close second (Table 5).

Steatoda triangulosa, a tangled web spinner, of which 133 specimens were captured during the survey, displayed a spring peak composed mainly of females. During April, May and June, females and immature forms were captured but no mature males were captured. The preponderence of specimens captured during the early spring were mature females, tapering off in numbers through the fall. From the middle of the summer through late summer, the numbers of immature specimens increased as the numbers of mature specimens decreased.

Chiricanthium inclusum, a wandering or vagabond spider, was captured throughout the year, with the majority of the specimens being females. Immature forms were captured throughout the year, with a peak coming in spring and decreasing through the early summer. The mature specimens, both male and female, followed the same general pattern but

Figure 5.--Proportional breakdown by sex and maturity level of most frequently each of the top twelve species.

= Females

= Males

= Immatures

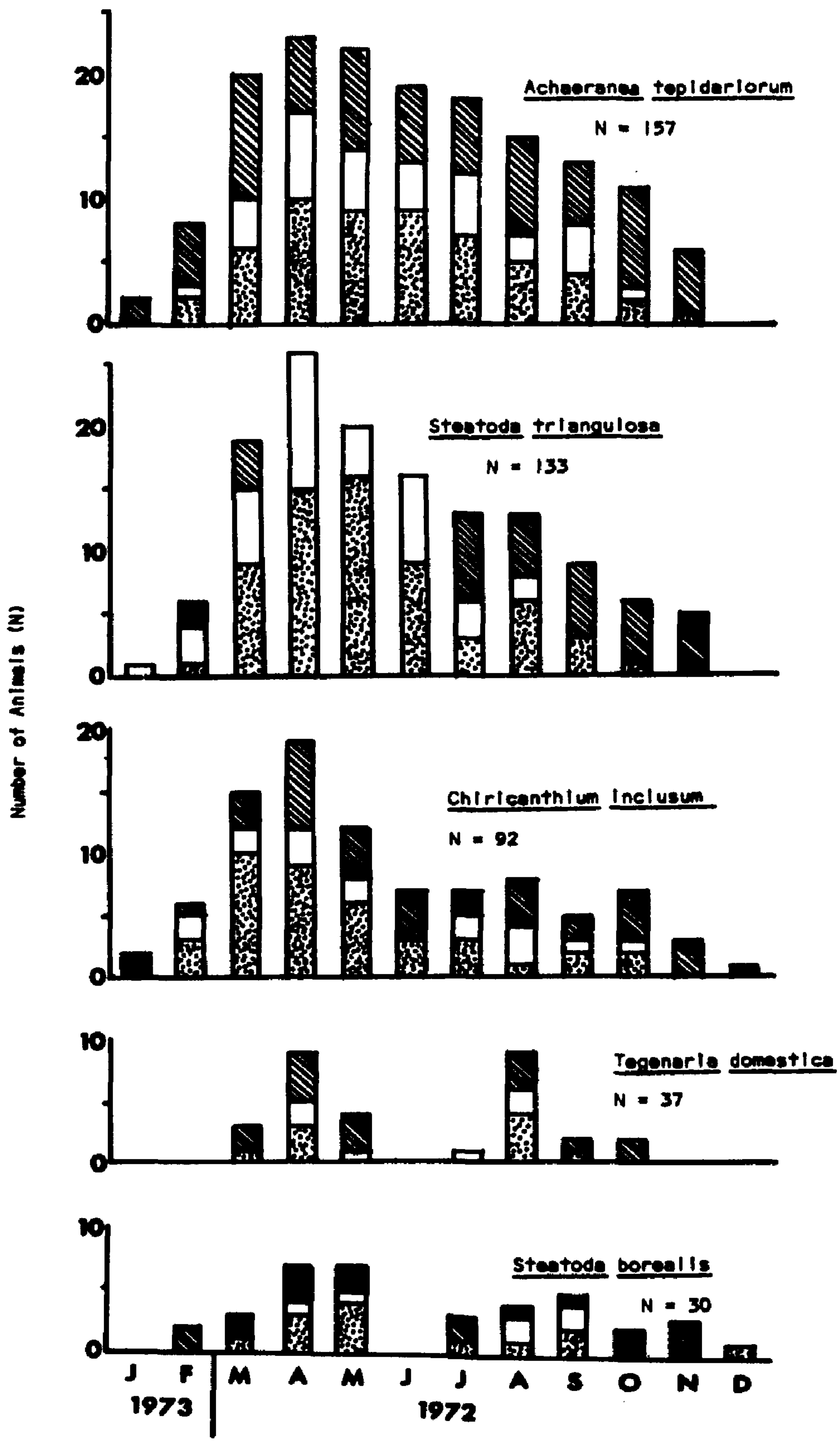

Number of Animals (N)
Achaeranea tepidariorum
N = 157
Steatoda triangulosa
N = 133
Chiricanthium inclusum
N = 92
Tegenaria domestica
N = 37
Steatoda borealis
N = 30
0
10
20
J F M A M J J A S O N D
1973
1972

TABLE 5.--Sex Breakdown for Five Species Most Frequently Captured in Metal Buildings

Species	Females	Males	Immatures	Sum
A. tepidariorum	55 35%	33 21%	33 44%	157 34.9%
S. triangulosa	63 47%	37 28%	34 25%	133 29.6%
C. inclusum	39 42%	16 17%	37 41%	92 20.4%
T. domestica	13 35%	6 16%	18 49%	37 8.2%
S. borealis	9 30%	5 17%	16 53%	30 6.7%
	180 40%	97 21%	179 39%	450

Totals and percentages for the top five species captured in the two metal buildings.

with many fewer specimens. The males were captured in much lower numbers than either the females or the immatures.

Steatoda borealis, another tangled web spinner, was taken only during seven months of the year. The majority of the specimens were immatures, with mature males taken only during April, July and August in low numbers. The same pattern of numerical increase and decrease was noticed though in a smaller scale regarding males, females and immatures. The immatures were the first captured in the early spring, followed by a few matures then and an increase in the numbers of immatures through the fall.

Tegenaria domestica, a funnel web spinner, was collected during all but three months of the year. The major peak occurred during April and May, with the minor peak occurring during August. Females were dominant in numbers through the study, with the immature forms captured less frequently and the males captured in the lowest numbers.

When the local study was analyzed from the viewpoint of animals per square foot (Table 6) several factors became apparent regarding the effects of building type on resident spider populations. The results are presented by building type. In each of the appropriate sections, evaluations were made of the similarities and differences between buildings regarding the numbers of animals per 100 square feet both by building type and species of spider. To facilitate the evaluation, three periods were selected during the study for detailed analysis. The three periods were the months of the major peak, the minor peak and the month during the summer when the spider densities were lowest.

The major peak came during April, accounting for 114 specimens from the five most numerous species collected. The densities ranged from a high of 0.46 animals per 100 square feet for _Achaeranea tepidariorum_ to a low of 0.04 animals per 100 square feet for both _Steatoda borealis_ and _Tegenaria domestica_. _Chiricanthium inclusum_, the third most frequently encountered species, occurred in densities of 0.22 animals per 100 square feet.

August was the minor peak month with a total of 53 specimens ranging in densities from a high of 0.41 for _Achaeranea tepidariorum_ to a low of 0.03 animals per 100 square feet for _Tegenaria domestica_. _Chiricanthium inclusum_ had a density of 0.09 per 100 square feet.

The month of the summer high temperature was July when the temperature reached 81 degrees F. and during which 57 specimens were captured. _Achaeranea tepidariorum_, again was the most dense with 0.36 animals per 100 square feet. _Tegenaria domestica_ was low with a value of 0.0005 animals per 100 square feet. _Chiricanthium inclusum_ had a density of 0.08 animals per 100 square feet.

The values of the majority of the species changed as expected from one sample period to another. As the temperature changed, so did the animal densities. The two species, _Steatoda borealis_ and _Tegenaria domestica_ did not alter their densities in moving from the spring major peak to the summer low density, but did change when moving to the fall minor peak.

When the weather parameters are considered with the spider populations found within the metal buildings, several points became clear. First, the temperature inside the buildings seemed to have little effect on either causing invasion by spiders or maintaining the populations once inside. The main effect of the inside temperature was that of allowing the spiders to survive once they made the move in. The spider population follows the changes in outside temperature and percent relative humidity.

Wooden Building

There were 462 specimens taken representing 12 families, 32 genera and 56 species, or 13.8% of the total study. The building sampled was a single story office building located on the Michigan State University campus, containing 1125 square feet. This represented 0.409 animals per square foot per year.

Figure 6 displays the weather parameters plotted against the monthly spider catch.

TABLE 6.--Numbers of Spiders per 100 Square Feet in Two Metal Buildings. Metal Buildings 1950 Sq. ft. each, 3800 Sq. ft. total.

Species	Major Peak April		Minor Peak August		Summer Low Peak	
	1 #/Mo.	2 #/100 sq. ft.	1 #/Mo.	2 #/100 sq. ft.	1 #/Mo.	2 #/100 sq. ft.
A. tepidariorum	35	0.44	17.85	0.23	17	0.22
S. triangulosa	36	0.46	24	0.31	28	0.36
C. inclusum	17	0.22	7.0	0.09	6.0	0.08
S. borealis	3	0.04	3.0	0.04	0.3	0.004
T. domestica	3	0.04	2.0	0.03	0.4	0.0005

1-The total number of animals taken per month.

2-The number of individuals per 100 square feet of available surface search area during the sample period.

The same families were captured in the wooden building as those found in the metal ones. Therefore the ratio of web spinners to non-web spinners was the same, 6 web spinning families to 6 non-web spinners.

The inside temperature, ranged from a high of 73 to a low of 68, and did not seem to have any correlation with the numbers of spiders captured. The two parameters which seemed to follow the spider number changes were the relative humidity and the outside temperature. The relative humidity values moved in opposite directions from March to September, then began to move in a similar direction, ranging from a high of 79% to a low of 45%. The outside temperatures moved in the same manner. The time that the spider numbers and the outside temperatures came into close association was during the fall of the year.

The spiders captured showed two definite peaks in frequency, one during April with 15.5% of the total and another lesser fall peak in September, with 10% of the total.

When the most frequently captured species were examined on an individual basis (Figure 7), several facts became evident. There were seven species making up 282 specimens or 61% of the total. The species found most frequently in the wooden buildings were the same as in the metal buildings with the addition of _Agelenopsis potteri_ and _Phidippus audax_. The ratio of web spinning species to

Figure 6.--Temperatures both inside and outside wooden building and relative humidity inside building compared with monthly changes in spider numbers captured.

......	Inside temperature
—— - ——	Outside temperature
— — — —	Relative humidity
————	Percent of spiders occurring each month

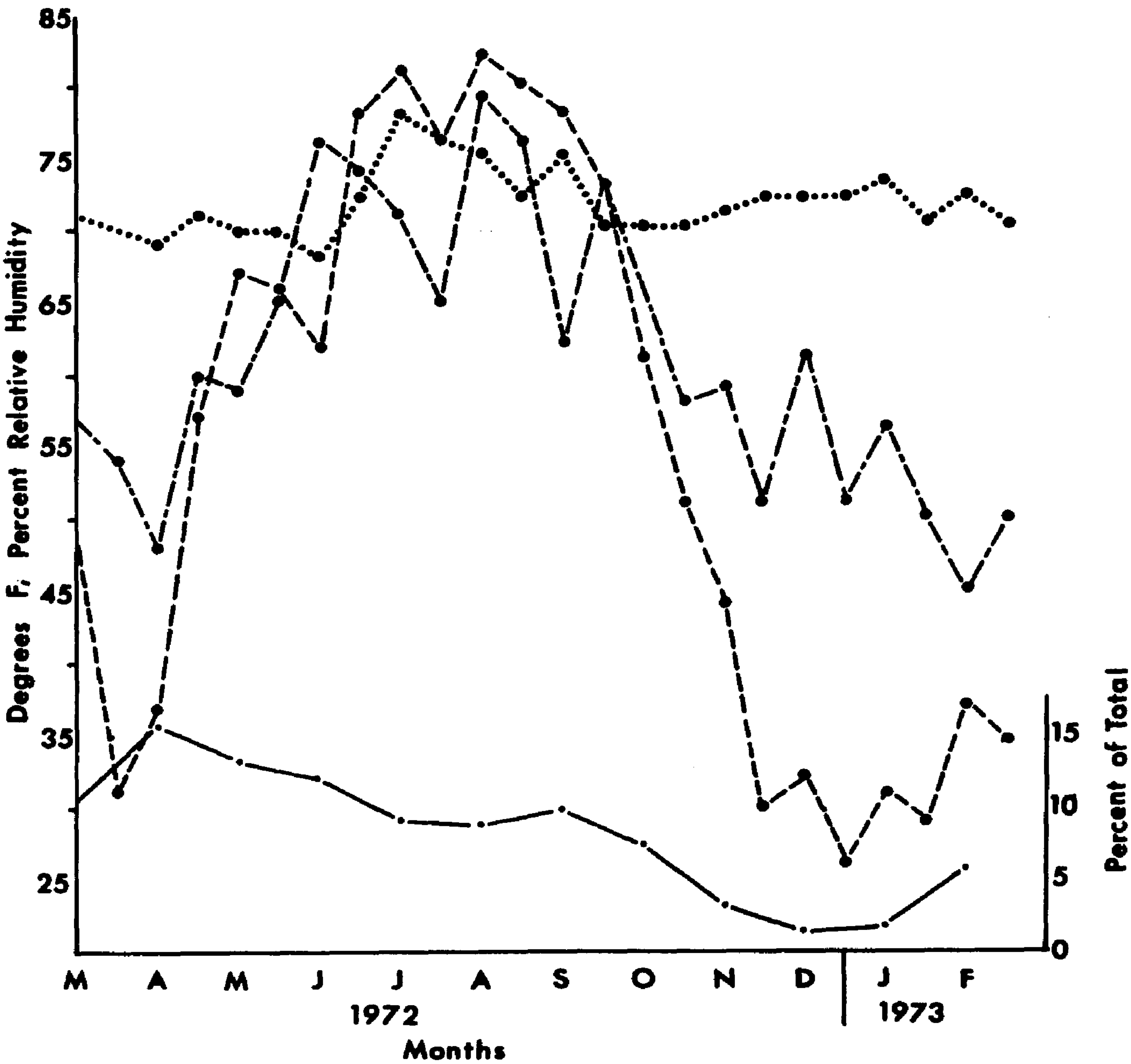
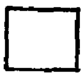
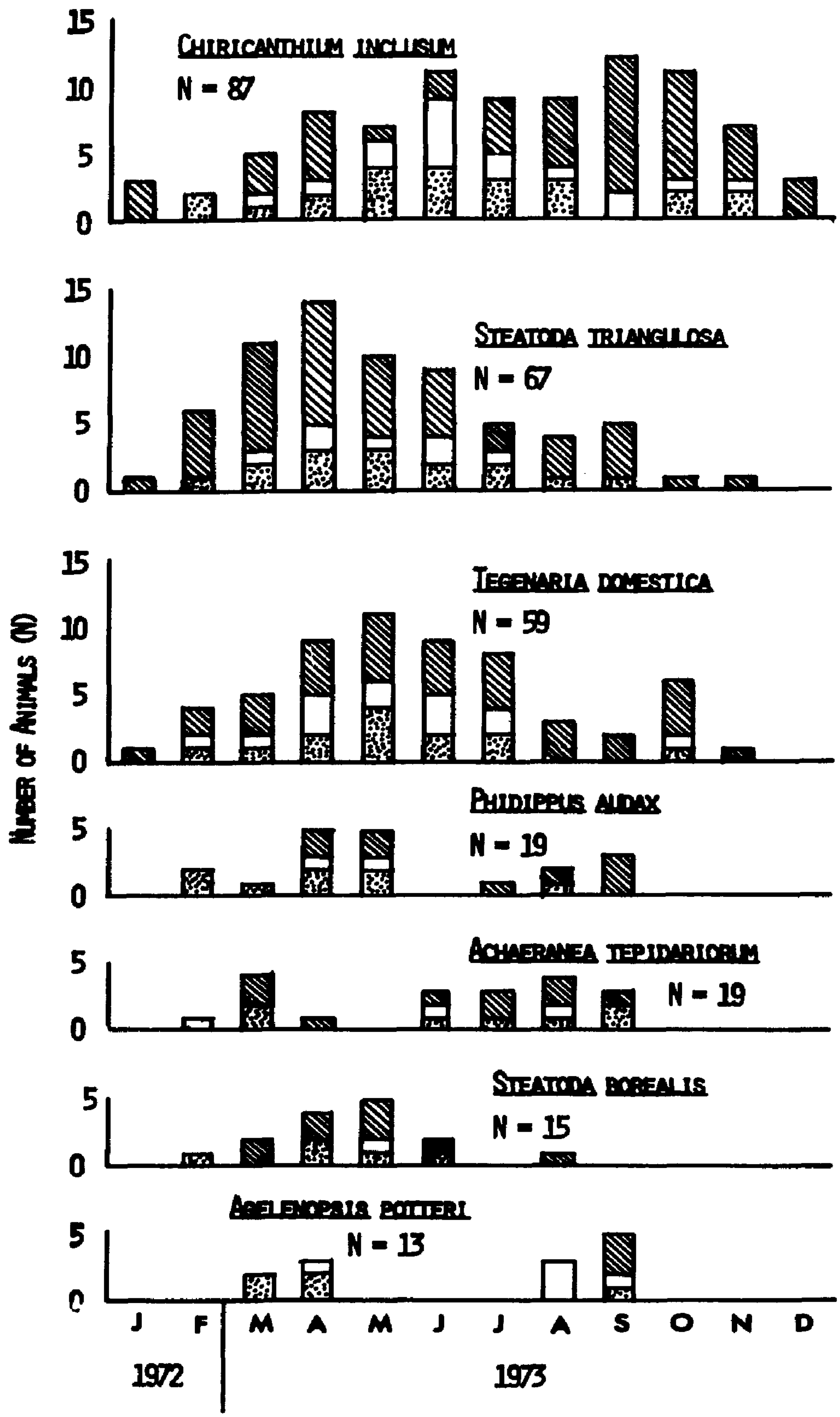

85
75
65
55
45
35
25
Degrees F, Percent Relative Humidity
15
10
5
0
Percent of Total
M
A
M
J
J
A
S
O
N
D
J
F
1972
1973
Months

Figure 7.--Proportional breakdown by sex and maturity level of most frequently captured species in wooden building.

 = Female

 = Male

 = Immatures


Chiricanthium inclusum
N = 87
Steatoda triangulosa
N = 67
Tegenaria domestica
N = 59
Phidippus audax
N = 19
Achaeranea tepidariorum
N = 19
Steatoda borealis
N = 15
Agelenopsis potteri
N = 13
Number of Animals (N)
15
10
5
0
J
F
M
A
M
J
J
A
S
O
N
D
1972
1973

non-web spinning species is five web spinners to two non-web spinners, a higher percentage than found in the metal buildings.

The three most frequently encountered species of the above seven were collected throughout the year with the exception of December. Chiricanthium inclusum, had a major peak in late September-early October and a series of lesser spring peaks in January, April and June. Steatoda triangulosa had a major peak in April and Tegenaria domestica peaked in May. The minor peaks were in September for Steatoda triangulosa and October for Tegenaria domestica.

The next three most frequently captured species, Phidippus audax, Achaeranea tepidariorum and Steatoda borealis occurred for six to seven months of the year. P. audax and A. tepidariorum occurred most frequently during April, May and June, while S. borealis was found mainly during May.

Agelenopsis potteri, while occurring only during three months of the year, produced two definite peaks, one in April and one in September.

As with the previous spider populations from metal buildings, the most numerous stage was the immature, followed by mature females (Table 7). Mature males, though few in number, appeared in both spring and fall peaks.

TABLE 7.--Sex Breakdown for Seven Species Most Frequently Captured in Wooden Building.

Species	Females	Males	Immatures	Sum
C. inclusum	23 27%	15 17%	49 56%	87 36.8%
S. triangulosa	15 22%	7 11%	45 67%	67 23.8%
T. domestica	13 22%	13 22%	33 56%	59 20.9%
P. audax	8 42%	2 11%	9 47%	19 6.7%
A. tepidariorum	7 37%	3 16%	9 47%	19 6.7%
S. borealis	5 33%	1 7%	9 60%	15 5.3%
A. potteri	5 39%	5 39%	3 22%	13 4.6%
TOTAL	76 27%	45 16%	159 56%	282

Totals for each species and maturity level for the top seven species.

Spiders present in the wooden building had distinct differences in both order and frequencies of species when compared with the populations found in the metal buildings. _Steatoda triangulaosa_ became the most frequently encountered species with a density of 0.40 animals per 100 square feet, as opposed to 0.44 animals per 100 square feet in the metal buildings, where it was the second most dense species. _Chiricanthium inclusum_ became the second most frequently encountered species with a density of 0.31 animals per 100 square feet, as opposed to 0.22 in the metal buildings. The lowest density was exhibited by _Agelenopsis potteri_ at 0.01 animals per 100 square feet, as opposed to 0.04 animals for _Tegenaria domestica_ (Table 8).

The minor peak, which occurred in September, proved _Chiricanthium inclusum_ to be the most dense with 0.47 animals per 100 square feet, with _S. triangulosa_ second with 0.13 animals per 100 square feet. _Steatoda borealis_, though found throughout the rest of the year, was not captured during this sample period.

When the densities were considered at both the major and the minor peak periods, the densities of all species considered decreased except _C. inclusum_ which advanced to a high of 0.47 animals per 100 square feet. The same patterns were seen when the densities during the summer low density period was considered. All species decreased in densities except _T. domestica_, which increased by 0.03 animals per 100 square feet.

TABLE 8.--Numbers of Spiders per 100 Square Feet in Wooden Building. Wooden Building 1125 Square Feet.

Species	Major Peak April		Minor Peak		Summer Low	
	1 #/Mo.	2 #/100 sq. ft.	1 #/Mo.	2 #/100 sq. ft.	1 #/Mo.	2 #/100 sq. ft.
C. inclusum	7.0	0.31	10.6	0.47	4.4	0.19
S. triangulosa	9.0	0.40	3.0	0.13	2.7	0.12
T. domestica	5.0	0.22	1.2	0.05	1.8	0.08
P. audax	0.95	0.04	0.2	0.01	0.2	0.01
A. tepidariorum	0.20	0.01	0.6	0.03	0.2	0.01
S. borealis	0.60	0.03	0.0	0.0	0.3	0.013
A. potteri	0.20	0.01	0.6	0.03	0.7	0.31

1-The total number of animals taken per month

2-The number of individuals per 100 square feet of available surface search area.

Brick Buildings

There were 10 brick buildings, with 10,200 square feet of surface area on two floors plus a partial basement in each in which 2154 specimens were collected. This total gave 0.0211 animals per 100 square feet of surface area per building per year. The total number of animals produced an average number of 215 per building for the twelve month sampling period. The species list for the buildings can be found on Table 4. The ratio of web spinning families to non-web spinning families was 6:6, the same as for the metal and wooden buildings.

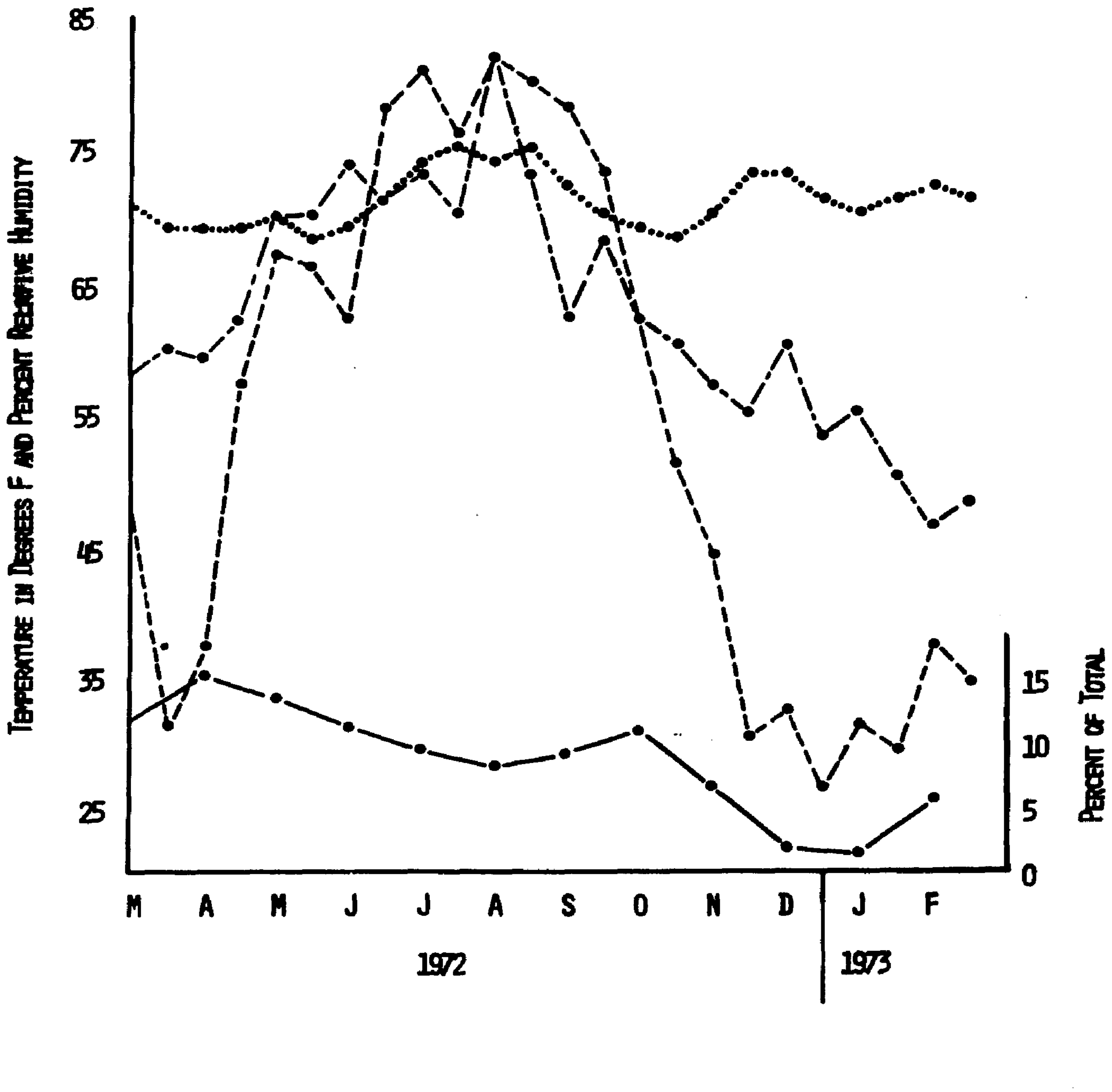
Weather data, Figure 8, displayed a pattern seen in the two previous building types. The spider numbers were at their peak in the spring, decreased to a summer low and then had a small fall peak, followed by a steady decrease into the winter. All three peaks occurred during the same months in all three building types. The outside temperatures remained the same from one building type to another, while the inside temperature and relative humidity changed in a similar manner to that of the previous building types. The temperature inside varied from a low of 68 degrees F during May and October and attained a high of 75 degrees F during July and August. The relative humidity ranged from a low of 46 percent in February to a high of 82 percent in August. The trend observed in the two previous

Figure 8.--Temperatures inside and outside brick buildings and relative humidity inside buildings compared with monthly changes in spider numbers captured.

——————— Inside Temperature

------- Outside Temperature

— - — Relative Humidity
Percentages of Spiders Captured



Temperature in Degrees F and Percent Relative Humidity
85
75
65
55
45
35
25
Percent of Total
15
10
5
0
M A M J J A S O N D J F
1972
1973

building types regarding the changes in the population as effected by changes in the weather parameters was again observed here.

From April until the end of September the weather parameters and the spider populations moved in opposite directions. As the temperature increased, the spider densities decreased. In October, the outside temperature began to decrease as did the number of spiders captured. From September on through the spring, generally April, the spider populations responded directly to changes in the outside temperatures and relative humidities. The temperatures inside the buildings, though not directly affecting the immigration rate, seemed to allow the animals to survive once the move inside had been made.

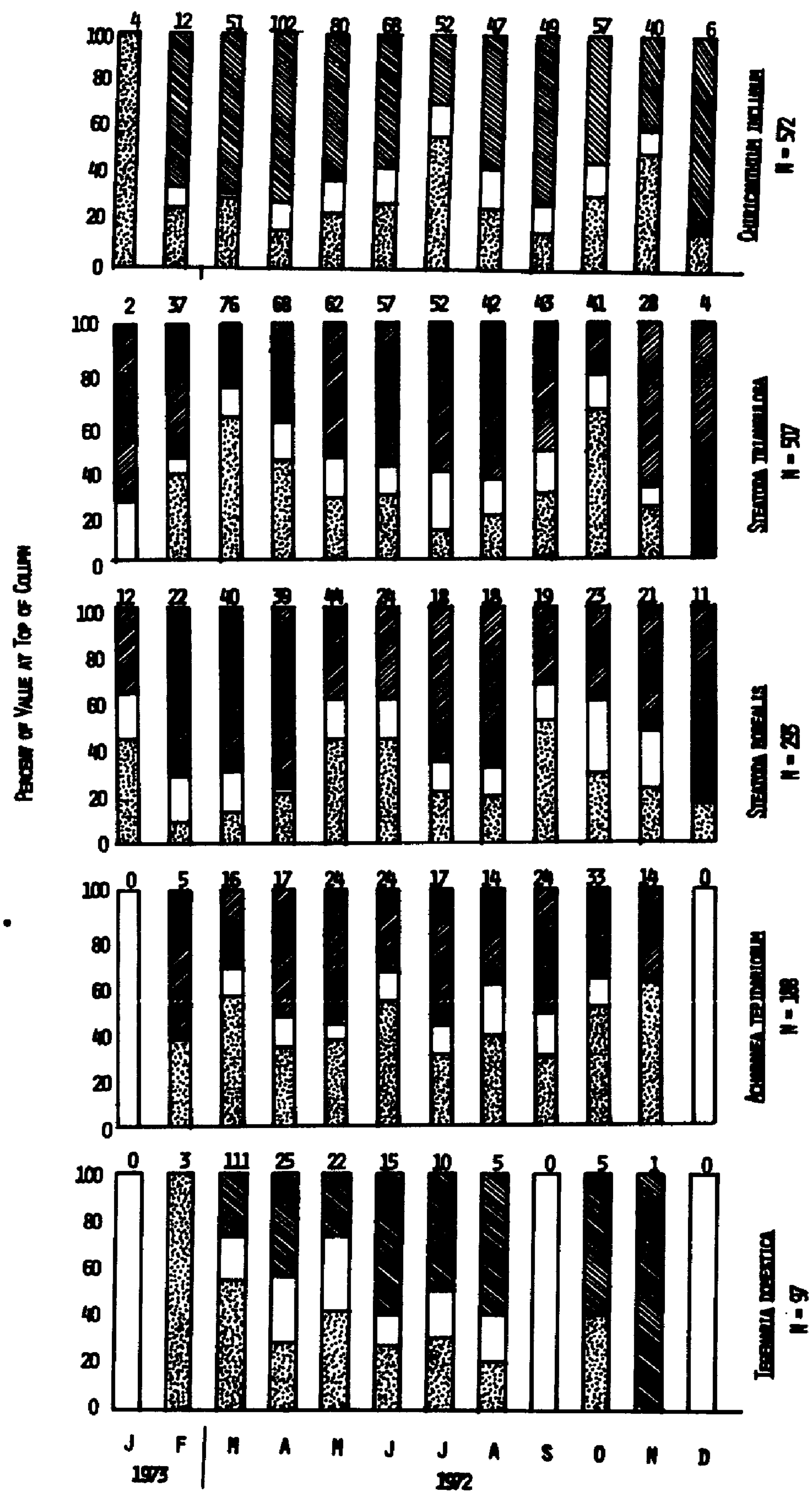
The five most frequently captured species produced a total of 1657 specimens or 76.9 percent of the total taken from the brick buildings. The most numerous species was C. inclusum (Figure 9) with 572 specimens or 26.8% of the total collected or 34.6% of the five most numerous species. A major peak was observed during April followed by a minor peak during October. Throughout the major portion of the year, immatures were the dominant group collected, with the majority of these being collected during February and the months of April through August. Females were dominant during March and October indicating that there may be more than one generation per year.

Figure 9.--Percentages of total numbers of spiders collected from five most numerous species from brick buildings.

= Female

= Male

= Immatures


Percent of Value at Top of Column
Chiracanthium inclusum
N = 572
Steatoda triangulosa
N = 507
Steatoda borealis
N = 295
Achaearanea tepidariorum
N = 188
Tegenaria domestica
N = 97
J F M A M J J A S O N D
1973
1972

S. triangulosa, of which 507 specimens were captured, was a species that appeared in all of the previous buildings. The 507 animals represent 23.6% of the total for the study and 30.6% of the top five species. Throughout the study this species had the immatures stages as the most numerous of all, followed by the famales and then the males (Table 9). The major peak was in March with a minor peak in September. The spring peak was primarily females, followed by immatures and then males, the trend observed for the entire study. The fall minor peak was evenly divided between females and immatures, with 205 of the total being males. From April through the fall, the majority of the animals captured were immatures, making up as much as 62% of the monthly total. This number decreased steadily until September when the immatures and females were evenly divided. This even relationship can be attributed to the mortality amongst the immature forms.

S. borealis, another tangled web spinner, occurred in lower numbers but was found within dwellings throughout the year as opposed to the other two more numerous species. Major peaks occurred during two months, March with 40 specimens and May with 44 specimens. The minor peak occurred during October with 23 specimens.

The two major peaks were not similar in their sex ratios. The first peak occurred during March and consisted of all three stages, evenly distributed. The second peak which occurred during May was 68% immatures, 20% females and 12% males. The fall minor peak occurred during September and consisted of 77% immatures, 20% females and 3% males. Figure 9 gives the proportions for this portion of the study. Even during the middle of the winter, from November through February there were large numbers of immatures and females captured. There were only eleven mature males captured during this period, including November during which there were none collected.

A. tepidariorum, a web spinning member of the family Theridiidae, was captured during 10 months of the year, excluding December and January, during which no specimens were captured. The major peak occurred during the month of October, accounting for 33 of the 188 specimens captured for the species. Fifty-four percent of the October total were females, 14 percent males and 32 percent immatures. The minor peak occurred during May and June, accounting for 48 of the 188 total specimens. Immatures here accounted for 12 percent of the total, or 20 animals.

T. domestica, a funnel web spinner belonging to the family Agelenidae, was only captured during eight months of the year, with 97 animals captured. The major peak occurred in April when 25 specimens were captured, where 44 percent were immatures, 28 percent were females and 28 per cent males. The minor peak occurred in October when only

TABLE 9.--Sex Breakdown for Five Most Frequently Captured Species in Brick Buildings.

Species	Females	Males	Immatures	Sums
C. inclusum	159 29%	75 14%	338 57%	572 35%
S. triangulosa	173 34%	71 14%	263 52%	507 31%
S. borealis	81 28%	48 16%	163 56%	293 18%
A. tepidariorum	77 41%	23 12%	88 47%	188 11%
T. domestica	32 33%	21 22%	44 45%	97 5%
TOTALS	522 32%	238 14%	876 54%	1657

The totals and breakdowns by sex and maturity levels as percentages of the total for the species. Also the percentage of the total for the brick buildings.

five specimens were captured, two females and three immatures. The sex ratios for the brick buildings, Table 9, indicate that immature forms account for almost half of the specimens captured, 45 percent immatures, 33 percent females and 22 percent males.

Brick buildings were the most numerous structures sampled but consistently had the lowest numbers of animals (Table 10). The differences in densities of animals often differed by a factor of 10 to 100 times lower than densities of the same species in the other two building types. During the major peak, *C. inclusum* was the most frequently

TABLE 10.--Numbers of Spiders per 100 Square Feet in 10 Brick Buildings. Brick Buildings 10,200 square feet each, 102,000 square feet total.

Species	Major Peak		Minor Peak		Summer Low	
	1 #/Mo.	2 #/100 ft.	1 #/Mo.	2 #/100 ft.	1 #/Mo.	2 #/100 ft.
C. inclusum	102.96	0.05	63	0.03	51.48	0.025
S. triangulosa	70.98	0.036	41	0.02	45.63	0.22
S. borealis	32.23	0.015	23	0.01	14.65	0.007
A. tepidariorum	15.04	0.007	28	0.01	13.85	0.007
T. domestica	24.25	0.012	5	0.002	4.85	0.003

1-The total number of animals taken per month.

2-The number of individuals per 100 square feet of available search area.

encountered species with a density of 0.05 animals per 100 square feet of surface area. _T. domestica_, though never frequently encountered when compared to the other species and building types, had a density of 0.012 animals per 100 square feet.

The minor peak dropped _C. inclusum_ to a value of 0.03 animals per 100 square feet. _T. domestica_, with a low value from the major peak, dropped to 0.002 animals per 100 square feet.

The summer period during which the spider population was lowest, which occurred during August, was when _C. inclusum_ dropped in density to 0.025 animals per 100 square feet of surface area. This value was 0.005 below that for the density during the minor peak period. _T. domestica_, the animal with the lowest density in both the metal and wooden buildings was also the least dense in the brick buildings. The density was 0.012 animals per 100 square feet during the major peak and 0.002 animals per 100 square feet during the minor peak. The period during the summer when the spider population was lowest was during August when the density of _A. domestica_ was 0.003 animals per 100 square feet, 0.001 animals higher than the minor peak density.

Predatory Behavior

Prey Contact Distance

Peck and Whitcomb (1970) state that C. inclusum located prey through physical contact with the extended forelegs while traveling in a forward direction. The results of this portion of the study agree with their investigation. When the spiders were exposed to prey at various distances and their attack responses were noted, the critical distance was between 0.5 cm. and 1.0 cm. When the spiders were exposed to prey at distances greater than 1.0 cm., the response by matures and immatures alike was identical to the nonexistance of prey situation.

Effects of Light on Hunting Behavior

The results of this study indicate that light has a very negative effect on the tendencies of the spiders to wander about. Satiated spiders, particularly mature males and females, do not usually hunt when the light levels advance above eight foot candles. Figure 10 shows that the acitivity curves for males and females do not differ significantly. The curve for the immatures indicates that they are active in low light levels as well as levels higher than those tolerated by the adult spiders.

The effects of starvation increased the apparent tolerance levels of all classes of spiders towards light.

The numbers of animals hunting in the lower light levels does not increase noticeably from the fed animals, but at higher levels a noticeable increase in activity takes place. Mature male spiders, even though starved, followed the same patterns as the satiated spiders except that they were active at higher light levels. Mature females increase their hunting activities from a high of eight foot candles in satiated animals to 12 foot candles in starved animals. Immatures were noticed to be more active in higher light levels even when satiated and display the same tendencies when starved. These animals were found outside their resting cells and actively hunting even when the light levels exceeded 12 foot candles.

Under normal feeding conditions, hunting behavior could not be elicited unless the light levels were lower than four to six foot candles. The degree of drop in the response curve was steepest from four to the eight foot candle level in the satiated animals. When the starved animals were examined, the curves were quite different. The steep parts of the curve were extended to the eight to 12 foot candle level. The effects of starvation can force the animals out of their resting cells and assume a hunting behavior.

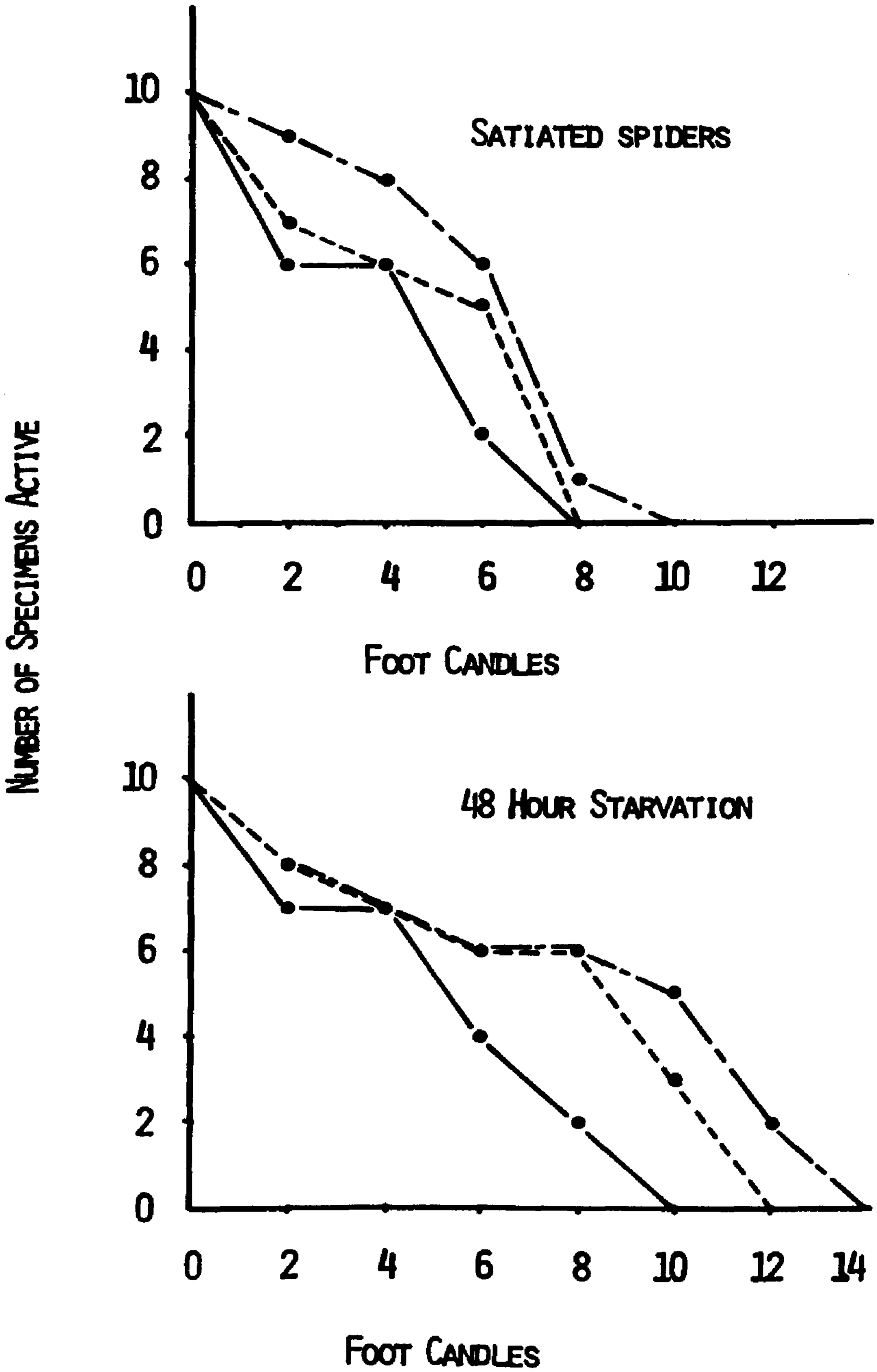
During broad daylight, three things could activate the spiders: first, a severe hunger level; second, the

Figure 10.--Numbers of spiders remaining active before and after starvation observed at different foot candle levels.

- - - - - = Female

——— = Male

— - —— = Immatures



Number of Specimens Active
10
8
6
4
2
0
Satiated spiders
0
2
4
6
8
10
12
Foot Candles
10
8
6
4
2
0
48 Hour Starvation
0
2
4
6
8
10
12
14
Foot Candles

active searching for a mate by either the males or females; and third, the disturbance of a resting cell such that the animal is forced to vacate it. The response to the resting cell disturbance was to flee the source of disturbance, move about for a short time searching for another hiding place and becoming quiescent when the disturbance ceased or a hiding place was found.

C. inclusum reacts in a negative phototropic manner. The spiders seem to be able to detect the movement of shadows when they are active in subdued light. When an object moved between the light source and the animal caused a shadow to move across the animal, an evasive response was elicited.

Prey Moisture Content

Prey moisture, an often overlooked portion of the ecology of spiders and other animals, has been shown to have certain effects on maintaining the normal condition of spiders. Assuming that spiders which overwinter and remain active in dwellings have little access to water supplies and assuming the relative humidity within heated buildings was fairly low, spiders which are able to survive must have an alternate source of moisture.

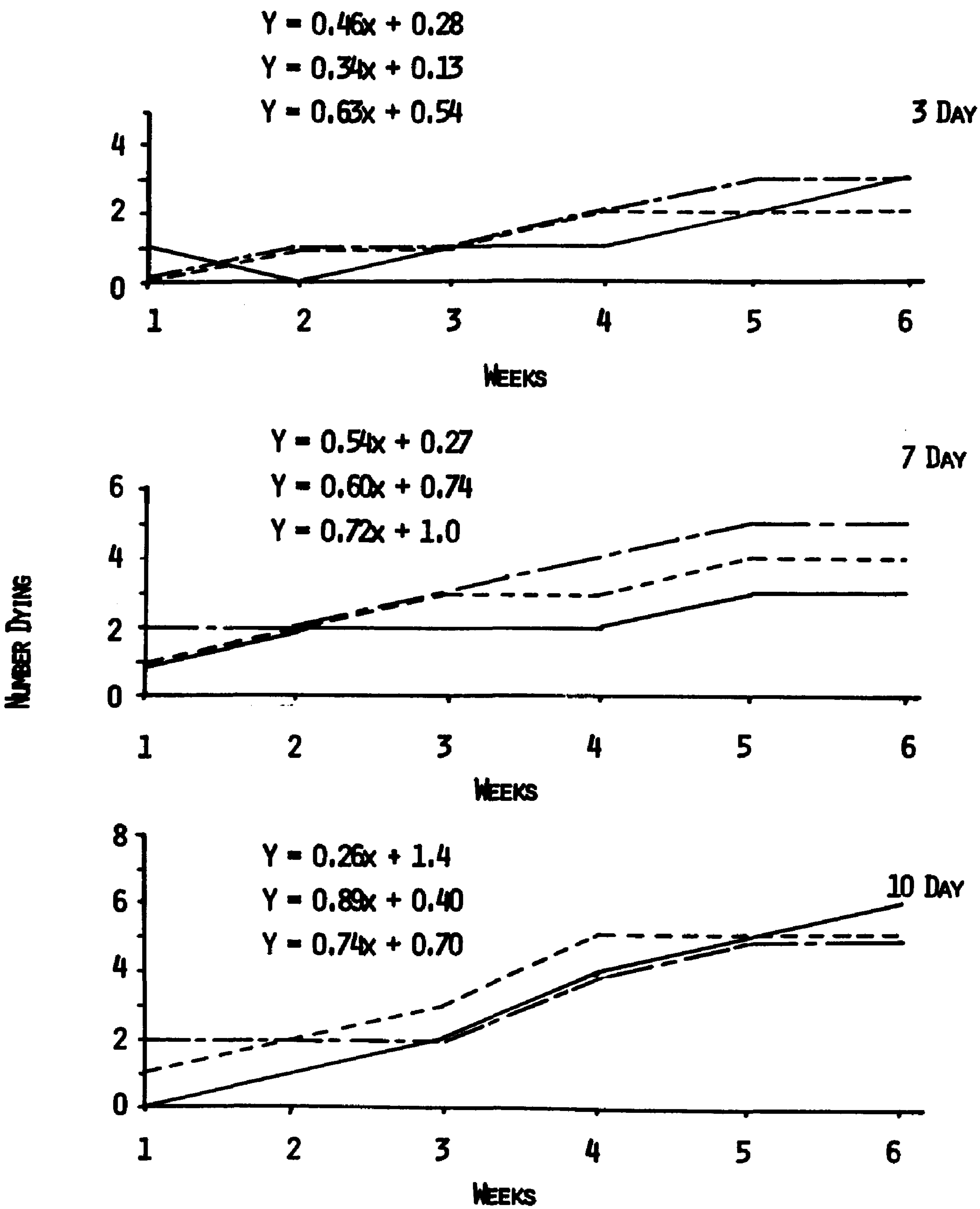
Throughout this study, no water was given to the animals in any form except that which they were able to obtain from their food sources. Figure 11 shows the number

Figure 11.--Three graphs showing the number of individuals dying for each of three hunger stress periods.

- - - - - = Female

———— = Male

—— - —— = Immatures



Y = 0.46x + 0.28
Y = 0.34x + 0.13
Y = 0.63x + 0.54
3 DAY
4
2
0
1
2
3
4
5
6
WEEKS
Y = 0.54x + 0.27
Y = 0.60x + 0.74
Y = 0.72x + 1.0
7 DAY
6
4
2
0
1
2
3
4
5
6
WEEKS
NUMBER DYING
8
6
4
2
0
Y = 0.26x + 1.4
Y = 0.89x + 0.40
Y = 0.74x + 0.70
10 DAY
1
2
3
4
5
6
WEEKS

of animals lost for the three degrees of stress for each sex and the immature specimens.

Beginning with the three day stress period the slopes for males, females and immatures are presented. Regression analysis showed that the equations were not significantly different at the 0.05 level even though the equations were different in both slope and intercept. When the individual slopes were examined, the mature females had the lowest slope, followed by the mature males and then the immatures.

When the seven day feeding schedule was examined, the immature animals again were found to be the most susceptable to the effects of moisture loss. They were followed by the females and then the males. The slopes provided by the three equations again proved to be nonsignificant at the 0.05 level, but were significantly different at the 0.1 level. The three slopes placed the females between the immatures and males this time, indicating an increased response to lower moisture levels.

When the 10 day stress period was examined, the mature males had the steepest slope, 1.26, while the females had a line equation with a slope of 0.89. The immature forms did not alter their responses much in moving from a slope of 0.72 to 0.74.

Following the last two feeding regimens, males died in greater numbers with the reduced moisture levels. When the slope differences are compared between the three day and the seven day regime, there was a difference in slopes of 0.08. But when the 10 day regimen was compared with the seven day regimen, the difference was 0.72.

Females showed less severe responses to reduced moisture but there was an increased loss due to mortality for each increase in time between feedings. The females in going from the three day feeding regime to the seven day regime changed in slope from 0.34 to a slope of 0.60, a net change of 0.26. In moving to the 10 day schedule, the net change was 0.29 in going from a slope of 0.60 to a slope of 0.89.

The immature animals exhibited the least amount of change in slope when they were examined under the three periods of stress. The net changes in slope in moving from the three to seven and seven to 10 day stress periods were 0.09 to 0.02, respectively.

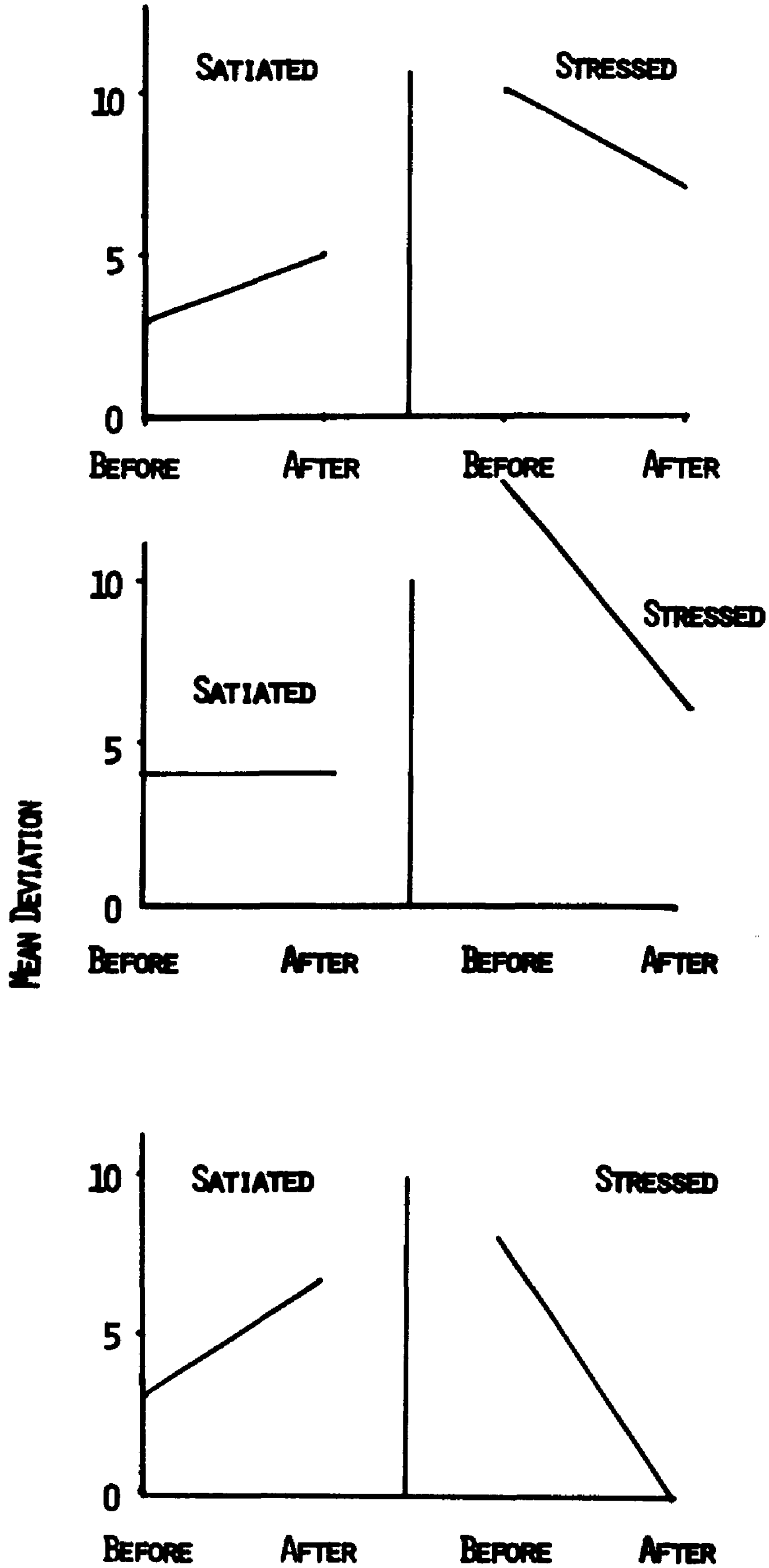
Data from Peck and Whitcomb (1970) and this study indicate that the spiders can live for at least a period of three weeks without food. When water is withheld the animals seldom live longer than three to five days.

Search Patterns

The analysis of data indicated that the search patterns of *C. inclusum* males, females and immatures were random. When the animals were tested before and after food capture, the results indicated that the feeding altered the search patterns slightly, but they remained random. This difference was best illustrated with the mean values plotted for each condition and number of turns. Assuming the mean value for each of the three runs to be 20, the values for each run above or below 20 were tabulated. The values for both left and right turns were added together and averaged. The resulting value was plotted for each sex both before and after food capture and before and after 48 hours of hunger stress (Figure 12). In each case, the values following starvation were much more varied, indicating a change in behavior following hunger stress.

The degree of change in the deviation from the mean number of turns was greatest in the mature females, less in the mature males and there was no change in the immatures specimens. Following the 48 hour starvation period, all three classes of spiders increased their deviations from the mean value of 20 turns. The greatest amount of change was noticed in the immatures which had a change of nine, followed by the mature males with a change of seven and then the females with a change of five. Following food capture and feeding, the deviation decreased in all three classes tested. The most severe change occurred in the females where the deviation dropped by eight, followed by the immatures with a change of seven and the males with a change of three.

Figure 12.--Graph showing deviation from mean value of 20 turns during random search pattern investigation.


SATIATED
STRESSED
10
5
0
BEFORE
AFTER
BEFORE
AFTER
STRESSED
10
SATIATED
5
0
MEAN DEVIATION
BEFORE
AFTER
BEFORE
AFTER
10
SATIATED
STRESSED
5
0
BEFORE
AFTER
BEFORE
AFTER

The results of this portion of the study indicate though the search patterns were random in nature, there were slight changes in the degree of randomness associated with changes in the hunger stress applied to the animals. Under hunger stress the spiders' search patterns became slightly less random. After the animals captured food and were allowed to feed, the amount of deviation from the mean value was observed to decrease.

<u>Resting Cell Study</u>

Part one of the study showed that there was an increase of five resting cells from the initiation of the study through the 14 day period.

When the analysis of part one of this portion of the study was completed, the data indicated that the method of counting resting cells to determine the number of spiders present would not give reliable results. On day one of the study 14 resting cells were observed to contain spiders. On day fourteen there were 19 resting cells, a net gain of five cells, or a 36 percent increase. There was a net loss in the number of spiders of four, leaving 10 animals and 19 cells.

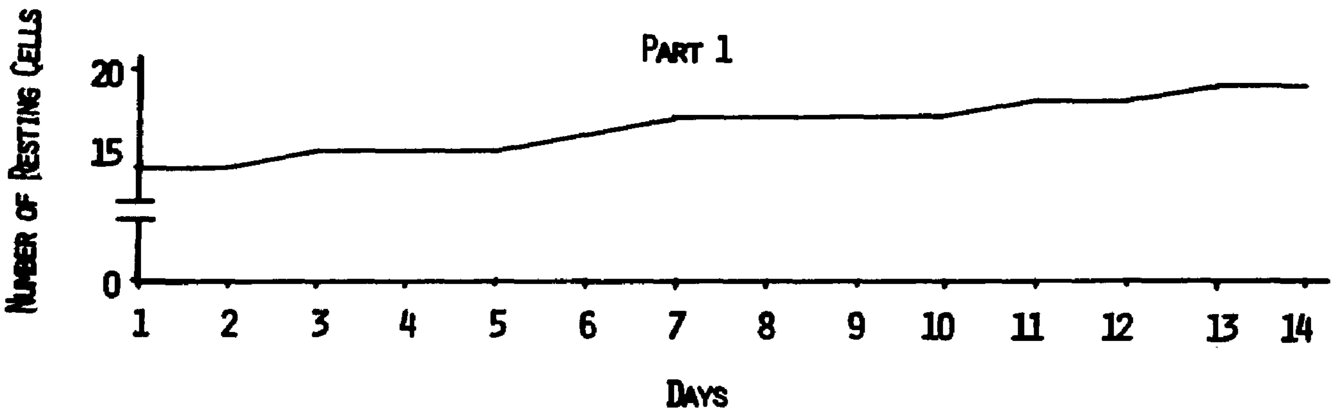
The second portion of the study was designed to determine the length of residency in the original cells and the increase in cells built. On day one 14 cells were tabulated and marked. On day two, three old cells

Figure 13.--Part 1: Original number of resting cells found with increase over two week period.

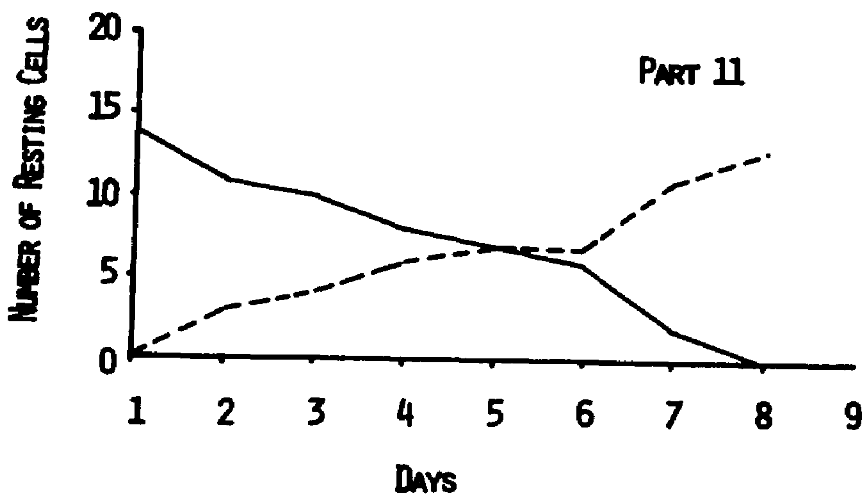
Part 2: Changes in resting cell occupancy and new cell construction rate.

——— Number of original cells used and reused.

– – – – Number of new cells constructed over time.



Part 1
Number of Resting Cells
20
15
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Days



Part 11
Number of Resting Cells
20
15
10
5
0
1
2
3
4
5
6
7
8
9
Days

were abandoned and three new cells were constructed. By the fifth day of the study there were as many old cells as there were new cells. On the eighth day all of the original 14 cells had been abandoned and there were 15 new cells constructed since the original tabulation. The net change in the number of marked spiders during this portion of the study changed from 14 on day one to nine on day eight. This was a loss of five or 36 percent.

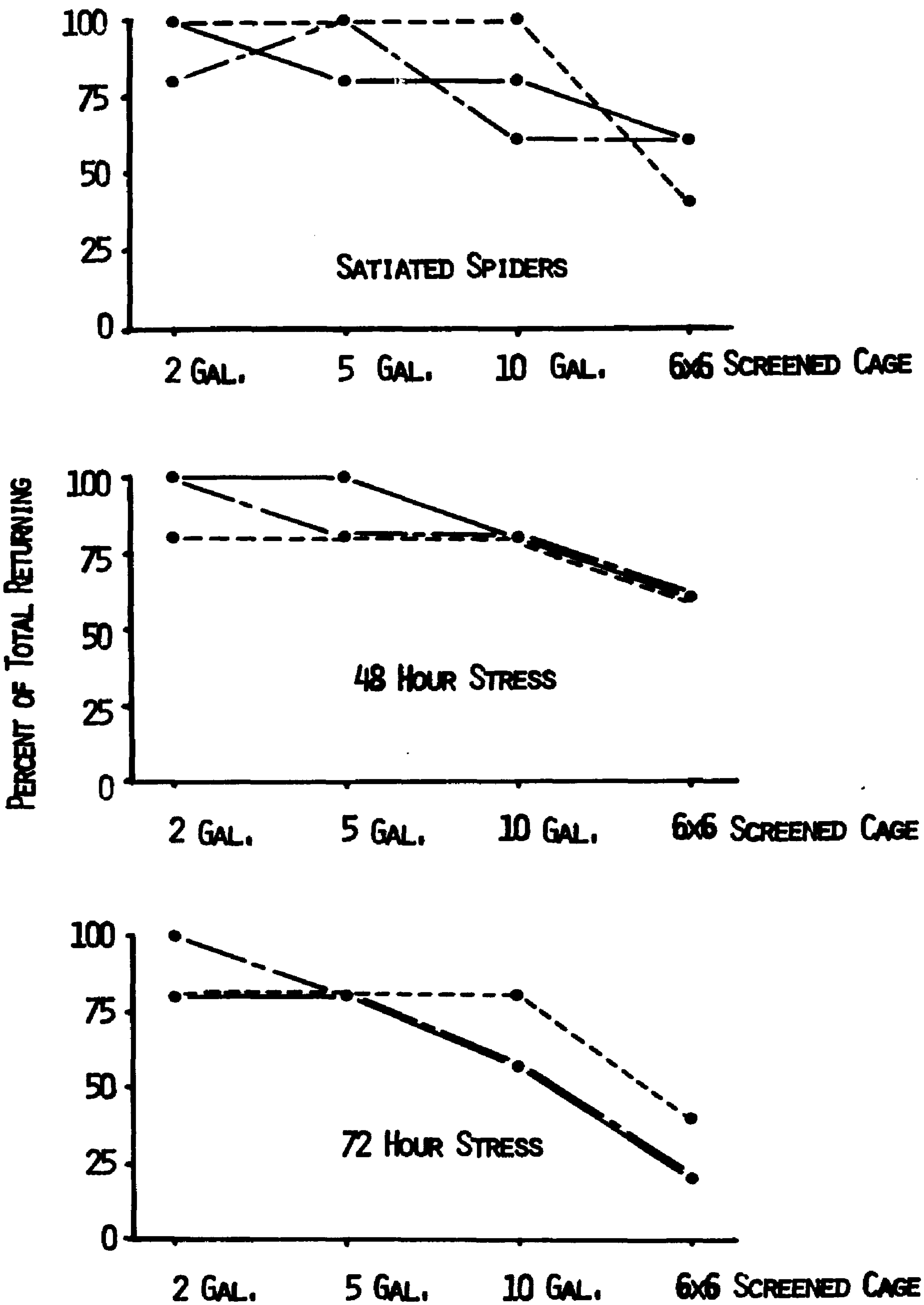
Part three of the study involved the effects of search area size on the number of spiders returning to the original resting cells. The return rate was also tested against several periods of hunger stress (Figure 14). Beginning with satiated animals, all three classes tested returned to the original cells an average of 95% of the time. This occurred in both the two and five gallon test chambers. When the tests were carried out in the 10 gallon aquarium, the females returned 100% of the time. Males returned 80% of the time and the immatures returned 60% of the time. When the six by six by six foot screened cage was used, the percentages were lower. The females dropped to 40%, the males and the immatures dropped to a 60% return rate.

The size of the aquarium seemed to affect the percentage of animals returning to the original cells. The next factor tested was the effect of hunger. Following 48 hours of starvation, the same tests were run again. This

Figure 14.--Three graphs showing number of spiders returning to resting cells in different sized search areas.

X axis denotes search area size.
Y axis denotes percent returning to the resting cell.

——— Males
— — — — Females
—— – —— Immatures



100
75
50
25
0
Satiated Spiders
2 Gal.
5 Gal.
10 Gal.
6x6 Screened Cage
Percent of Total Returning
100
75
50
25
0
48 Hour Stress
2 Gal.
5 Gal.
10 Gal.
6x6 Screened Cage
100
75
50
25
0
72 Hour Stress
2 Gal.
5 Gal.
10 Gal.
6x6 Screened Cage

time the females returned only 80% of the time in the two gallon aquarium. The males returned 100% of the time in the five gallon aquarium, while the females and the immatures returned 80% of the time. When the 10 gallon aquarium was used all three classes of spiders returned 80% of the time. The six by six by six foot screened cage had all three spider classes returning at the rate of 60%.

Before the effects of hunger were tested on the return rate, the responses of individual spiders were apt to vary considerably. Following the application of hunger, the animals all acted in a similar manner.

When severe hunger stress was applied to the test animals, the aquarium size had a direct effect on the percentage of animals returning to the resting cells. When the animals were starved for 72 hours, there was a noticable effect on the numbers of animals of each sex and maturity level returning to the resting cells. Immatures were the only animals returning to the resting cells 100% of the time in the two gallon aquarium. Both males and females returned at the rate of 80%. When the aquarium size was increased to five gallons, all three classes of spiders returned at the rate of 80%. In the 10 gallon aquarium the females remained at the 80% return rate while the males and immatures decreased to a 60% return rate.

At 72 hours of hunger stress in the six by six by six foot screened cage, the females return rate dropped to

40%, identical to that for the satiated females. Males and immatures dropped to a 20% rate.

The overall effect appears to be that aquarium size, when considered alone, exerts a moderate effect on the abandonment of resting cells. When a starvation alone is considered, beginning with the two gallon universe over three starvation regimens, no change takes place in the numbers of animals abandoning their resting cells. When the five gallon squarium is considered, little change is noticed until the 72 hour hunger stress is reached, at which point all three classes of animals are at a return rate of 75%. In the 10 gallon aquarium the effects of starvation begin to be apparent. Satiated animals are somewhat more erratic in their activities than those in the smaller aquarium but by 48 hours of hunger stress, all the original resting cells have been abandoned at the rate of 20%. At 72 hours of stress the abandonment rate had dropped to 40% except for the males. When the screened cage was used, satiated and 48 hour stresses animals were not significantly different, but by 72 hours the abandonment rate was 75%.

The overall effect was that the greater the hunger stress and the further the animals had to travel in locating and capturing food, the less likely the animals were to return to the resting cell most recently constructed.

Effects of Prey Size

The prey sizes were selected at a percentage of prey body weight to that of the spider. The small size was 1/2 or less than the body weight of the spider, the medium size was greater than 1/2 but less than the body weight of the spider, and the large size was greater than the body weight of the spider. The statistical data can be found in Appendix C. Figure 15 displays the results in the three starvation experiments.

Spiders starved for 24 hours had a marked preference for specific size classes. The effects of spider sex and maturity level were also significant but at a lower significance level. Mature males tended to attack all size classes with more frequency than the females and immatures. Females followed the same selection pattern but at 10% lower rate of ingestion. Immatures began at the same level as the females, but decreased at a greater rate. At this level of starvation, the effects of prey size was significant at the .005 level, while sex of the predator was significant at the .05 level.

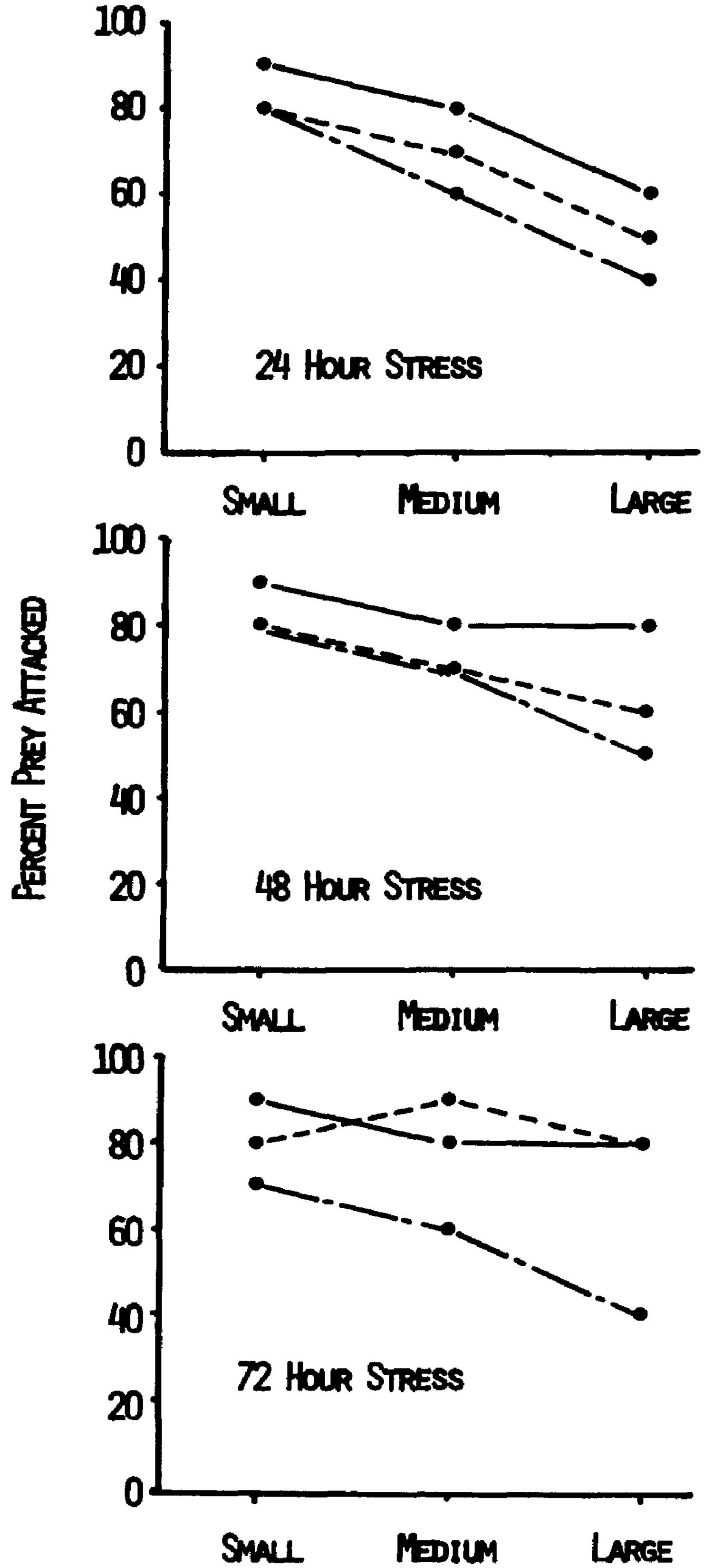
When the spiders were subjected to 48 hour starvation stress, the noticable change in prey size attacked was significant. The males did not change their attack rates for the small and medium size classes but when the large size class of prey was introduced, the attack rate

Figure 15.--Percent attack rates for three classes of spiders under three hunger stress regimes.

- - - - = Female

——— = Male

—— - — = Immatures



Percent Prey Attacked
100
80
60
40
20
0
24 Hour Stress
Small
Medium
Large
48 Hour Stress
72 Hour Stress

increased from 60% to 80%. An increase was also noted in the females, where the increase was from 50% to 60%. The immature spiders increased their attack rates from 40% to 50%. These results indicate that the spiders will increase their attack rates with an increase in hunger stress regardless of sex or maturity level.

The effects of hunger on the size of prey attacked increased when the stress reached 72 hours. The most noticeable increase occurred among the mature females. There was no difference when the small prey size was offered, but when the medium sized prey was offered, the attack rate increased from 70% to 90%. When the large sized prey was offered, the attack rate increased from 60% to 80%. When the immature spiders were examined, their attack rate decreased to that of the 24 hour stress period.

When the results of the entire investigation were considered, there was an increase in the size of prey attacked and eaten associated with an increase in hunger stress. This increase affected the mature specimens to a greater degree than the immature specimens. The statistical analysis indicated that the effects of the sex of the spider attacking the prey was barely significant at the 0.1 level. The size class of the prey proved to be non-significant at the 0.1 level. This indicates that the predators would attack almost any size class with minimal selection.

The interactions between the sex of the spider and the prey size proved to be barely significant at the 0.1 level.

Distances Traveled Study

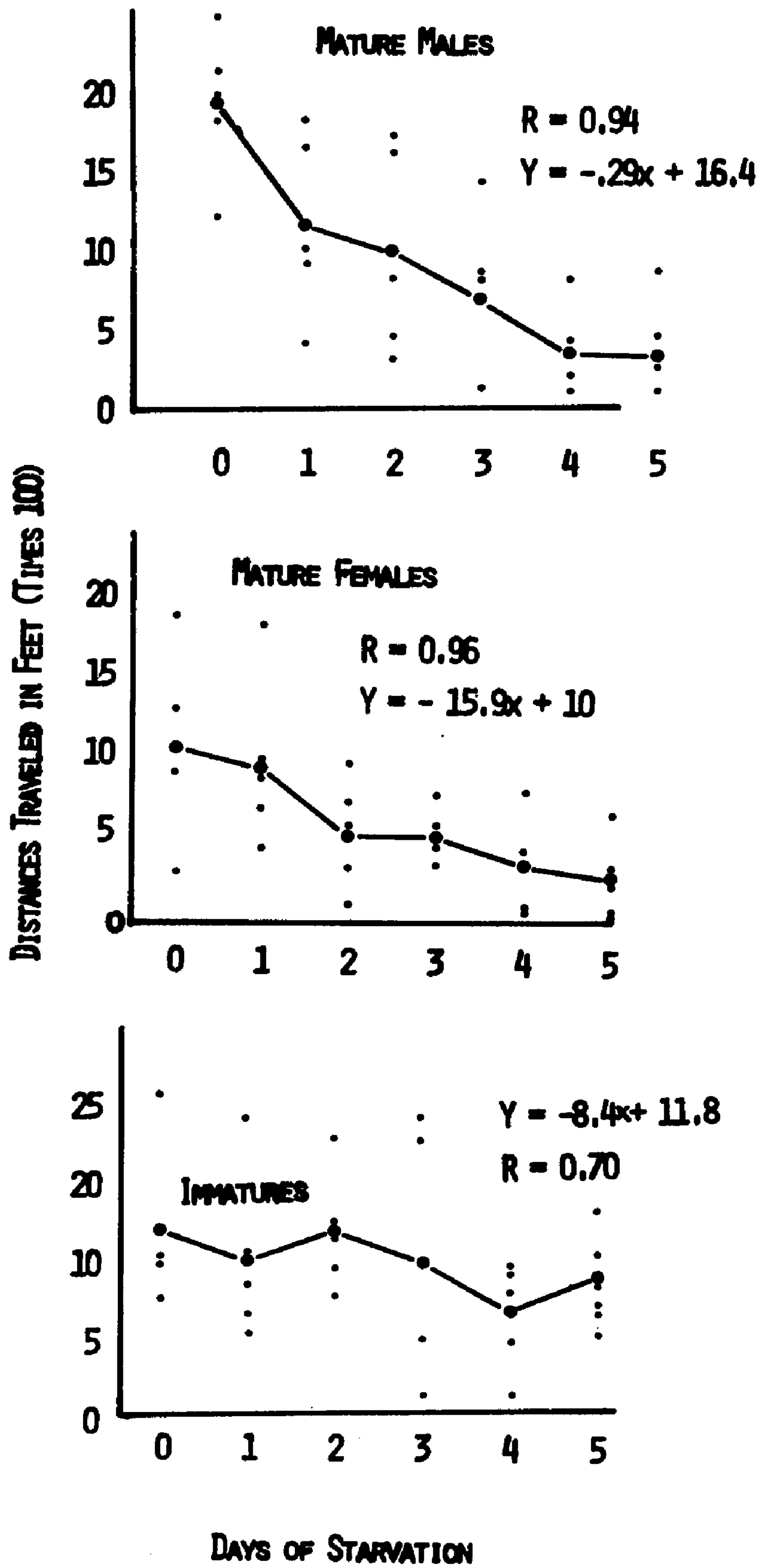
The distances that *C. inclusum* travels during a foraging period has been shown to be related to sex of the spider, maturity of the spider and to what extent it has been stressed by hunger. Mature male *C. inclusum* specimens have been shown to wander in excess of 2400 feet during a 10 hour foraging period. The mean value for the animals tested was 1940 feet during the same length of time (Figure 16). As the stress of hunger was applied to the animals, a steady decrease in the distances traveled was noted. As the stress increased from satiated spiders to those without food for five days, the distances decreased in a regular manner. When the mean values for each stress period were plotted and a regression line fitted, the equation for the line was $Y = -2.91X + 16.39$. In looking at the mean values of the distances traveled at the individual stress periods, it can be seen from Figure 17 that from the fourth day of stress onward, the minimum distances had apparently reached a minimum. The slope of the line is approximately zero. The correlation coefficient between starvation and distance traveled is quite high at 0.943. The coefficient of determination was 0.889, again quite high.

Figure 16.--Distances traveled by three classes of spiders under six hunger stress regimes. Y axis denotes distances traveled in feet, multiplied by 100. X axis denotes six regimes.

r = The Correlation Coefficient.

r^2 = The Coefficient of Determination.

Y = The equation for the line represented by the six mean values of the feeding regimes.



MATURE MALES
R = 0.94
Y = -.29x + 16.4
MATURE FEMALES
R = 0.96
Y = - 15.9x + 10
IMMATURES
Y = -8.4x+ 11.8
R = 0.70
DISTANCES TRAVELED IN FEET (TIMES 100)
DAYS OF STARVATION

The mature females had a maximum distance traveled equal to 1925 feet, somewhat less than the mature males. The mean value for satiated females was 1125 feet, which decreased through the individual stress periods to a low of 270 feet after five days without food. As can be seen from Figure 17, the range of distances for the females is wider at the more satiated levels and then decreases when the hunger stress is increased. The equation for the line representing the plot of the mean distances traveled is $Y = -1.59X + 10.05$. The coefficient of correlation between the distances traveled and the hunger stress effects was 0.963, higher than that for the mature males. The coefficient of determination was 0.928. Both these values are very high and indicate a close relationship between distances traveled and the effects of hunger stress.

The immature specimens displayed a less direct response to the effects of hunger stress. The distances traveled through the stress periods were not consistant. The correlation coefficient was lower than either the males or the females at 0.704. The coefficient of determination was also lower at 0.496. The mean distances at each of the stress periods did not produce the decreasing slope of the males and females. The equation for the line was $Y = -.84X + 11.83$. The responses of the immatures to stress proved to be less predictable.

When the investigation is considered in its entirety, the mature males have the more direct response to hunger stress, followed by the mature females and then the immature specimens. When the correlations between stress and distances traveled are examined, the females have the most direct response followed by the males and then by the immatures.

Prey Density Study

These experiments were designed to determine the effects of both prey and predator densities on the ability of the predators to capture prey. The design of the experiment was to manipulate prey densities within four search areas of increasing size. As explained in the methods section, each area was tested using one predator at each of five prey densities. As a result there were several redundancies in prey densities as the area sizes were increased. Therefore, specific densities were selected from different area sizes to give a series of prey densities which would increase in an approximate geometric manner. Table 11 gives the values for the situations including one, two and four predators per search area. From inspection of the table, the prey densities roughly double from one animal per 14.8 square inches to a low of one prey per 2960 square inches in eight density changes.

Operating under the assumption that these spiders hunt in a random manner, with a known increase in prey density there should be a corresponding decrease in predation time for a corresponding decrease in available search area. As the time to capture prey changed from the high to the low density, a straight line relationship developed. Figure 18 gives the curve and the equation for the data. The equation for the line is $Y = 0.83X + 62$, with a correlation coefficient of 0.848. The high correlation coefficient supports the contention that a straight line relationship exists between search time and prey density.

The question arises that if there is a 1:1 relationship between the search time and the prey density, should not the slope of the line be 1.0 instead of 0.83? One explanation for this difference is that the majority of the tests were run in the small tanks where the possibility of encountering prey would be increased with a reduction in search time.

When the stress of increased predator numbers was considered, several patterns emerged regarding changes in slope and intercept of the equations. When the predators were increased from one to two per search area, the assumption was that the slope of the line would decrease by one half. This assumption was made on the basis of zero cannabalism. From the results of previous observations, cannabalism among adults was practically non-existant. With

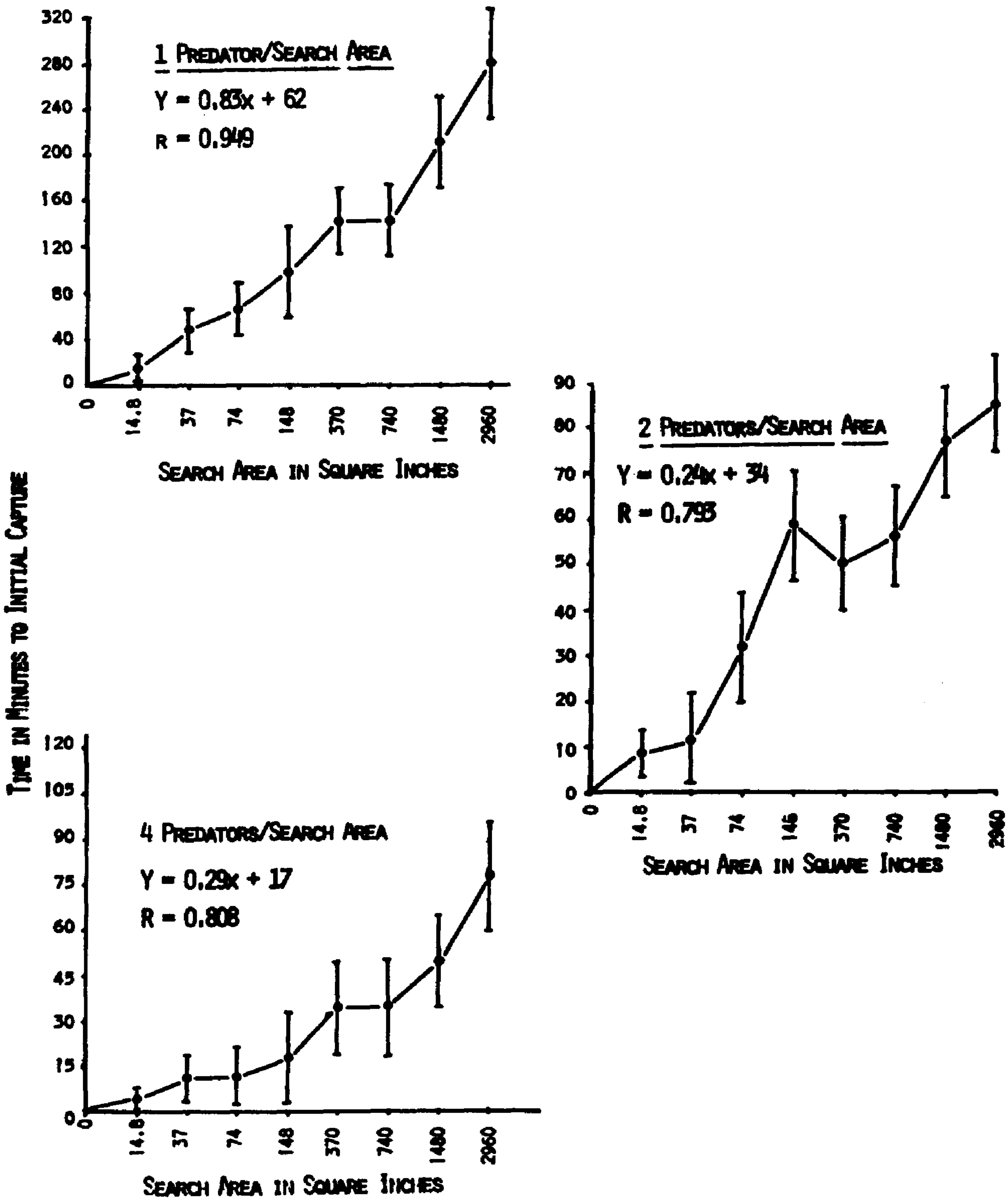
TABLE 11.--Time to Initial Capture for Predators in Different Densities and Prey in Different Densities.

Tank Size	Surface Area	Time to Capture in minutes
1 Predator/Universe		
10 gal; 1:1	2960	285
10 gal; 2:1	1480	215
5 gal; 1:1	740	145
5 gal; 2:1	370	145
2 gal; 2:1	148	105
2 gal; 4:1	74	62
5 gal; 20:1	37	48
2 gal; 20:1	14.8	15
2 Predators/Universe		
10 gal; 1:1	2960	93
10 gal; 2:1	1480	85
5 gal; 1:1	740	60
5 gal; 2:1	370	55
2 gal; 2:1	148	65
2 gal; 4:1	74	35
5 gal; 20:1	37	12
2 gal; 20:1	14.8	10
4 Predators/Universe		
10 gal; 1:1	2960	78
10 gal; 2:1	1480	108
5 gal; 1:1	740	35
5 gal; 2:1	370	35
2 gal; 2:1	148	18
2 gal; 4:1	74	12
5 gal; 20:1	37	12
2 Gal; 20:1	14.8	5

Figure 17.--The three predator densities over available searching area at different prey densities.

r = The Correlation Coefficient.

Y = The equation for the line representing the plotted points.


1 Predator/Search Area
Y = 0.83x + 62
R = 0.949
2 Predators/Search Area
Y = 0.24x + 34
R = 0.793
4 Predators/Search Area
Y = 0.29x + 17
R = 0.808
Time in Minutes to Initial Capture
Search Area in Square Inches
0
14.8
37
74
148
370
740
1480
2960

zero cannabalism and two predators per search area, the data produced a line with the equation of $Y = 0.237X + 34.57$. This does not meet the assumption of a 50% reduction in the slope of the line.

The interesting point, however, is that when the number of predators was increased from two to four, the equation of the line was $Y = 0.287X + 16.99$. The slope of this line was very near the slope of the line for the two predator case. The difference between the two equations was in the Y intercept, in which the four predator case had an intercept very nearly that for the two predator case. When the two equations were plotted together, the apparent difference was that the two predator case operates at a slower rate.

When the correlation coefficients were examined, they were found to differ by only 0.015, which is a small difference in light of the sample sizes and the number of replications.

When the entire density study is considered, C. inclusum apparently behaves in a predictable manner when predator densities exceed two per search area. When the densities fluctuated between one and two predators per search area, apparent behavioral acitvities tended to render the spiders unpredictable.

DISCUSSION

Examination of the spider species found within dwellings in Michigan during the local survey indicated that there were many species of spiders able to invade dwellings and to occur there for varying periods throughout a calendar year. However, when the quantitative aspects of the spider species were examined, there was a reduction in the numbers of species containing large numbers of individuals through the year. The species were ranked in order of the number of individuals captured by building type in descending order. The species making up 50% or more of the total numbers of animals were examined in detail to determine changes in the density and population structures throughout a calendar year. In conjunction with the animal survey, three environmental parameters were measured at the same time as the spider survey.

The parameters measured were the temperature inside the buildings, the percent relative humidity inside the buildings and the temperature outside the building. The parameters were related to the spider populations in several ways. The initial effect of the temperatures was whether they were the cause of the increase in spider numbers or whether they were responsible for the continued existance of the animals within the particular dwelling.

The outside temperature, though not a direct influence on the spiders once the move was made inside, was used as a measure of the degree of movement evidenced by the spiders. As the temperature increased in the spring, so did the numbers of spiders. The change was from a low of 32 degrees during December when there were 27 spiders captured. As the temperature increased in the spring months from the minimum, so did the number of spiders. There seemed to be no absolute temperature when the spiders began their movement indoors or outdoors. The changes were gradual in both temperature and the numbers of spiders captured. The upward changes in both temperature and spider density continued until April when the spider densities began to decrease. This change in direction continued until August when another change in density took place. During October the directions of the curves again coincided and continued so until the end of the study.

The two parameters that helped maintain the spider populations during the periods of adverse conditions were the temperature inside the dwellings and the relative humidity. The latter seemed to move in the same directions as the outside temperature but without the same degree of change. When the relative humidity and the temperatures inside the buildings were considered at the same time, there appeared to be an environment more suitable for the continued habitation by the spiders.

The results of this portion of the study indicate that the temperature outside affects the spiders to the extent that they either must escape to a more protected area or die. The two parameters inside the buildings allow those spiders that have made the move the opportunity to survive in an active state unless some factor present indoors kills or removes them or their food supply.

The fact that spiders were found in the characteristic two peak pattern can be explained in several ways. The life cycles of many spiders follow the pattern of mating and the laying of eggs in the spring and early summer, overwintering as penultimate instars with maturation and mating in the spring again (Gertsch 1949, Comstock 1948, Dondale 1961). This cycle, when considered in a numerical sense, can account for population fluctuations in the following ways. In the spring there is an increase in both numbers of animals as they emerge from the winter estivation coupled with the high degree of mobility associated with the active searching for mates by the mature spiders. These facts are all associated with the favorable conditions found during the spring and early summer.

As the numbers of immatures increased during the summer and early fall there was a drop in the numbers of both mature males and mature females captured. Moulder et al. (1970) have found that there is an increase in the numbers of immature animals in the months of May and December. The increase during May can be explained as due to the numbers of animals newly hatched and their increased mobility. The increase during the month of December is harder to explain as the winter months were usually the poorest in numbers of animals captured. My data indicated that the two peaks were composed mainly of immature specimens and mature females. The spring peak being mostly mature females and the fall peak was mainly immature specimens.

The absolute numbers of immatures were found to remain relatively constant during the latter months of the year. When the numbers were considered as percentage values of the totals for each month, the immatures seemed to increase in number. This was due to the gradual decrease in number of both males and females. These results confirmed the hypothesis based on the understanding of spider life cycles.

When the three building types were considered with the most frequently captured species, the same patterns emerged. The major peak occurred in April consisting mostly of females and immatures. The population was reduced during the summer months, increased to a lesser peak during the fall and decreased to the low period of the year during the winter months. The five species most dominant in the metal buildings, the seven in the wooden building and the five in the brick buildings all followed the same pattern, that of spring major peaks followed by summer low densities and a smaller peak in the fall followed by a reduction in numbers to almost zero.

The densities of spiders on a square foot basis were examined to assess the actual numbers of animals at specific times during the year. The three time periods selected were the spring major peak, the summer low density period and the fall minor peak period. The densities per 100 square feet indicate that there were only two species out of the many frequently captured that provide the most animals. The top two species, though not the same in all three building types, were within the four most frequently captured species. The top three species in all three building types were composed of two web spinners to one wandering or non-web spinning species.

C. inclusum, the species of concern throughout the study, was captured in densities varying 0.05 animals per 100 square feet in the brick buildings to a high of 0.3 animals per 100 square feet in the wooden building. The two metal buildings had a density of 0.22 animals per 100 square feet. When these values are compared with the species most frequently captured during the study, S. triangulosa, which had a density of 0.40 in the wooden building and 0.44 in the two metal buildings, it was found that these two species were always present during almost the entire year and the proportions of males to immatures to females held relatively constant.

When considering the third most frequently captured species on down to the least frequent of the detailed ones, the densities were smaller by a factor of from 2 to 45 times. The least frequently captured species in both the metal and brick buildings was T. domestica, with S. borealis in both the metal and wooden buildings.

When the remaining two periods were examined, the same order within the species was retained. In other words the placement of the species in order of densities was the same from one sampling period to another within a particular building type.

Size of the spiders was at first suspected as a potential means of explaining the make up of the populations with particular dwellings. The hypothesis being that the smaller more inconspicuous species would attract less attention and thus be less susceptable to predation or removal by humans. Of the three most frequently captured species within the three building types none can be considered as small spiders. C. inclusum ranges up to three-quarters of an inch as a mature animal, while T. domestica approaches the same dimension, with S. triangulosa, a slightly smaller spider at one-half inch.

An interesting point regarding the movement of spiders into dwellings is that even though the sampling method used called for removal of all possible specimens, there were always more spiders being captured even during the winter months. This indicates that even though there was a good possibility that all specimens were not captured, enough were removed each time so that similar populations could not become established between sampling periods, excluding invasion. This indicates that there must be a continual movement of spiders into dwellings throughout the year, including the winter months. This constancy of numbers would also indicate that the prey densities will support only that number of animals so that there would not be a large number of animals similar to the spring and fall densities. There apparently is no concerted effort by the spiders to move indoors, but the move indoors does allow those that make it to extend their survival beyond that of those remaining outdoors.

The conclusions of this portion of the study are that only a very few species, in most cases from five to seven, are able to maintain themselves within dwellings over time. Of this number, three make up the majority of specimens captured in the ratio of two web spinners to one non-web spinner. When the effects of building type was considered, there was no apparent effect, as the species were the same from one building type to another. The only differences were in the order of frequencies of the most common species. The environmental parameters appeared to have only a slight effect on the spider numbers once the move had been made indoors. The outside temperature effect was that of a driving force causing the spiders to move and also aid in the maturation process.

The results of the state-wide survey reinforce the conclusions drawn from the local quantitative survey. There were 12 species captured that made up more than 50% of the total number of specimens. Seven of this number were common to the three building type species list from the local survey. The remaining five species were *A. sericatus*, *S. scenicus*, *T. tranquillas*, *H. ecclesiasticus* and *A. pennsylvanica*. Of this number, there was only one new family added. This was the Gnaphosidae which contains the species *H. ecclesiasticus*. *T. tranquillas* belongs to the family Clubionidae as does *C. inclusum*. *A. sericatus* has been eliminated from the discussion because there was only one time when the specimens were captured and turned in. This represented 70 of the 73 specimens which were captured in one day from a warehouse in Detroit. This sample tended to bias the sample and the results of that portion of the study.

The differences between the two studies were significant only when the relative frequencies of the species were considered. In the local survey, the most frequently captured species in one building type were not the most frequent in the next. The same principle held true for a comparison between the state wide and local surveys. The most frequently captured species in the state-wide survey was from first through third in the local survey. When the entire study was considered, the fact that the top seven species in the local survey were the top seven species in the state-wide survey, the conclusion that only a few species were able to invade buildings successfully was reinforced.

The results of the predation study, when combined with the results of the Peck and Whitcomb study, give a more detailed view of the basic biology and behavior traits of the spider as found in the state of Michigan.

C. inclusum, a clubionid wandering spider, has been shown in the past to have a single generation per year when found in the natural habitat. However, the results of this study and the results of the two surveys indicate that there is a possibility that two generations are possible when the spiders remain indoors through the winter. This is evidenced by the fact that matures were found late in the season as well as immature forms. If only one generation was to found, there would be distinct times when the mature forms would dominate and other times when the immatures would be dominant. There is enough overlap in the occurance of both matures and immatures that the two generation per year or at least an overlap of two generations idea can be considered.

The behavior associated with food location and capture is presented and discussed as follows:

Adult and immature specimens of _C_. _inclusum_ have been tested and found to require a contact distance of less than 0.5 cm. before prey can be located under normal hunting conditions. When this small contact distance is coupled with habit of the animals to hunt during the night hours an interesting behavior pattern becomes apparent. The more light that was applied to the animals, the less the hunting activity was observed. The mature forms were less likely to be hunting when the light levels exceeded eight foot candles than when the light levels were below eight foot candles. Immature specimens were observed hunting in slightly higher levels. This tendency on the part of the immature forms to be a little less predictable also held true when the stress of starvation was applied to the spiders and the experiment repeated. After 48 hours of hunger stress, the mature specimens were found hunting in light levels up to 12 foot candles. Again the immatures were found hunting in slightly higher levels. There is no apparent reason except that they have not yet learned that higher light levels may lead to higher predation levels. The differences between the sexes of the mature specimens is also difficult to explain. Mature males were consistently the animals found in the lowest light levels. Females were always found in slightly higher levels, with the immature forms found hunting in the highest light levels. This relationship was first observed during this set of investigations and was noticed to be true for many of the subsequent investigations involving adult and immature animals.

When the animals were considered within buildings the ability to obtain moisture became a question that needed answering. The question asked was whether or not the animals would be able to maintain themselves on a diet of prey organisms with no water. And if so, how long between feedings would the animals be able to stay active and healthy. The results of this study, though not as significant statistically as was hoped, have shown that there is a relationship between survival of the animals and the frequency of feeding. Because there was no water introduced at any time, the only source of moisture was that obtained from the food. Two pilot studies were run initially to determine the length of time needed for the spiders to die strictly from the effects of starvation, and whether or not the animals would be able to survive on a diet of dried prey. The first study indicated that the animals were unable to survive longer than 10 days when all sources of food were withheld. This held for all three groups of animals, mature males, females and immatures alike. As the animals will only attack living prey, as stated in Kaston (1948), Gertsch (1949), Chamberlain (1933), Dondale (1961), they were shown not to be able to survive for any length of time on dry or freshly killed prey with low moisture content.

By deduction then, if the only moisture present was found in the prey animals, then the prey animals must contain adequate amounts of moisture to support the animals. Peck and Whitcomb (1970) state that C. inclusum was shown to prefer prey forms that were generally large, slow moving and had high moisture content ratios to body weight. This date confirms my findings, and so the animals can be shown to acquire much of their moisture requirements for the prey they eat and not necessarily from outside sources.

Having poor eyesight and thus a small prey contact distance, coupled with a moisture requirement of three to five days, the hunting strategy would have to be a successful one for the animals to survive. The search patterns were tested and found to be random in manner for both the matures and the immatures. The degree of randomness changed from one sex to another and from one stress level to another. This difference in significance level, though slight, was enough to indicate that the animals were effected in their search patterns by hunger and the sex and degree of maturity exhibited.

When the animals were considered as wandering foragers, the degree of residency in any given area would be dependent on the nearness of potential prey to the resting cell and whether the resting cells were of real importance in the hunting strategy of the spider. The results of the first two studies regarding return to previously constructed resting cells indicated that the resting cells were reoccupied as many as two to three nights in succession. The cells were not occupied for periods longer than eight days. When the search areas were not greater than 4.6 square feet in area, the return rates were above 80%. When the search area increased to near 8 square feet, the return rates declined to an average of 75%, falling off to near 60% when the search area exceeded 216 square feet. Above 216 square feet the return rates would be expected to continue to drop when related to prey densitiy.

When the effects of hunger stress were applied to the animals, the return rates did not change significantly until 72 hours of stress. The greatest numbers of spiders not returning to the previously constructed resting cell was when the animals were stressed for 72 hours and the search area was 216 square feet. These results conclude that the resting cell was used repeatedly when the search area was small and prey capture was successful. As the search area increased in size, the time to capture success decreased and so did the return rate. The resting cells are therefore used repeatedly in high prey densities and abandoned in areas of low prey densities.

Prey size selection was proven to be a characteristic that could be altered through the effects of hunger. When the spiders were in a satiated condition, they exhibited definite preferences for specific sizes of prey. These preferences also were shown to vary from one sex to another and from mature to immature animals. The effects of hunger stress were also exhibited from one group to another. From the hunger studies, it can be stated that the mature males attack a more diverse prey size range than the females and the immatures. The females are the most severely affected by hunger stress in that they can be influenced to take more diverse prey sizes based on the degree of hunger applied. The immature forms on the other hand are relatively static in their response to hunger stress. Hunger stress was shown to lower the barriers of both mature and immature specimens.

Prey size can be related to hunger and the sex and maturity of the animals considered. From this point of view, prey size selection is a variable that is constantly changing with the hunger state of the spider and the maturity level of the spiders.

C. inclusum was shown to be worthy of the name wandering or vagabond spider. The distances traveled were large for both mature and immature forms and consistent from one search period to another. The distances traveled varied from one animal to another but were consistent enough within the sex or maturity level that ranges could be predicted when the sex and hunger levels were known.

The relationship between sex, hunger level and distances traveled was direct, linear and negative. The more the spiders were stressed by hunger the shorter the distances traveled. Males were shown to travel further than females and immature forms traveled the shortest distance of all. The opposite was found to be true of satiated animals.

Under satiated conditions, the energy levels and endurance levels remained high. The distances were near the maximum for the sex and maturity level of the particular animal. This assumption was less reliable when the immature forms were considered. The immatures were shown to be less predictable in their responses to stress.

The predator-prey studies established the fact that the successful capture of prey by *C. inclusum* was related in a direct manner to prey density. Because of the hunting patterns of the spider, the density and placement of the prey should have little effect on capture success. This is so due to the short contact distance of the spider. When the short contact distance is coupled with the random search pattern, each prey has an equal chance of being encountered, assuming random spacing and placement.

The change in time to capture one prey in varying prey densities was shown to be a straight line relationship when there was one predator per search area. The straight line relationship held for medium to high densities but when very low densities were encountered, the time to capture varied from five hours to more than one 10 hour hunting period. These results differ from these given by Holling (1959) in his disc equation for invertebrate predators. His equation gives a type 2 response curve, which is a negatively increasing slope to a plateau. One explanation for this difference is that the biology of the spider affects the predatory behavior.

The spider, though an active predator, does not behave in the same manner as those reported by Haynes and Sisojevic (1966), Turnbull (1966), Dondale (1970). *C. inclusum* does not continue to attack and kill prey after the initial prey has been captured. After the capture, the prey is eaten and then the search is continued until the next contact is made, or the searching period is interrupted by daylight or satiation.

The same relationship between capture time and prey density held constant even when the number of predators was increased. The correlation coefficient, however, decreased in value, indicating that the relationship was not as definite. The increase from one predator to two altered the equation for the relationship between the capture time and prey density such that the search time was reduced. In changing the predator density to four predators, the changes in the relationship evidenced by the change in the equation, indicated an even stronger effect of one predator on another by a more reduced search time. Because no cannabalism was seen or the evidence of it detected, the changes in the response equations can be considered to be the effect of the positive interaction between the spiders.

In summary, the results of this study indicate that C. inclusum has a range including both the upper and lower peninsula of Michigan. There is evidence that there may be as many as two generations per year when considered within dwellings in Michigan. The mature females usually outnumber the mature males, and the immatures. There were two periods during the year when the populations within dwellings exhibit peak densities. These two periods were April and October. The effect of the spiders on resident prey populations has been shown to be related directly to the density of the spiders. This is because the spiders do not kill and eat large numbers of prey but kill and eat only that amount which satiates them in areas of high prey density or those prey animals that can be captured in one hunting period, if satiation is not reached.

When the prey density is low, the number of new resting cells constructed will increase to one per hunting period. After spending the daylight hours in the cell, the spider begins its search and constructs another cell the following morning. In areas of high prey density, the resting cell may be used again the following day, depending on how far the animals have to wander from the cell in search of prey.

The effects on the human population were shown to be slight except for two short periods during the year when the potential for harmful interaction is reased. Bites, when they occurred were few in number and were the cause of only short term ill effects.

C. inclusum can be considered as a potential source of biological control only on a limited bases because of the basic biology of the animal. The spider can therefore be considered as a resident species which has limited effect on either prey organisms or the human inhabitants.

APPENDICES

APPENDIX A

Introductory Letter and Data Sheet

COOPERATIVE EXTENSION SERVICE

MICHIGAN STATE UNIVERSITY · EAST LANSING · MICHIGAN 48823

AND U.S. DEPARTMENT OF AGRICULTURE COOPERATING

Entomology
Natural Science Building

February 23, 1972

Dear County Extension Director:

You are already aware of my responsibilities as Survey Entomologist, because it includes the preparation of the "Insect Alerts" newsletter which enters your mailbox each week from April to September. You may not know, however, of my interest in spiders and my extension responsibilities for spiders occurring in dwellings.

Many county extension staff members have asked for literature that would allow them to readily identify a majority of the spider specimens submitted to their offices. Public health officials, pest control operators, medical doctors and others also have need for such literature. I plan to produce an extension bulletin that will serve this need among extension staff and the other professional groups above.

First, however, I need more reliable information on the kinds of spiders that occur in Michigan dwellings, their relative abundance, and association of suspected spider bite cases with the creature that actually caused the bite. To gather some of this information I would like to conduct an extensive one-year survey of spiders in dwellings throughout the state, and I invite your cooperation in this survey.

You are, of course, under no obligation to participate. However, if you feel that there is a need for an extension bulletin on spiders, your contribution would help make it a more accurate and complete bulletin.

If you or another staff member in your county office is willing to cooperate, I would like you to save all of the spider specimens that you receive during a one-year period (April 1, 1972-March 31, 1973). I will provide you with a set of pre-numbered, alcohol-filled vials and pre-numbered forms on which to record the necessary information. A copy of the form is enclosed, and you can see that it is very brief and simple to complete. I will also provide you with a mailing container in which to periodically ship me a group of vials. In addition, I would like to be notified each time a suspected spider bite is reported. I will attempt to personally follow up each one of these reports.

If you are willing to participate in this survey, please reply by March 15 with the enclosed card. I will then ship you a set of vials and forms before April 1. Thank you for any attention which you may give to my request.

Sincerely,

Richard J. Sauer

Richard J. Sauer
Extension Entomology Specialist
and Survey Entomologist

SPIDER INFORMATION SHEET

R. J. Sauer
Dept. of Entomology
MSU

Spider No.: ____________________
(Match this no. with no. in vial)
County: ____________________

Collected by: ____________________

Date: ____________________

Spider was found: Inside of a building ____________________

Outside of a building ____________________
(If you check outside please make some notes on habitat such as host plant or substrate under "additional notes below).

Check one blank in each of the following nine categories on which you may have information:

1. AREA:
   ________Urban
   ________Suburban
   ________Rural

2. STATUS OF BUILDING:
   ________In Use
   ________Abandoned

3. CONDITION:
   ________Heated
   ________Unheated

4. CONSTRUCTION:
   ________Single story with basement
   ________Single story without basement
   ________Multistory with basement
   ________Multistory without basement

5. EXTERIOR:
   ________Brick
   ________Wood
   ________Aluminum or Vinyl Siding
   ________Other (Specify)

6. USE:

Residential

________Single-family dwelling
________Multi-family dwelling

Farm

________Barn
________Silo
________Shed
________Other (specify)

Commercial

________Factory (Manufact.)
________Retail (non-food) or Business
________Retail food (grocery store)
________Food serving (restaurant)
________Food processing (dairy, commercial bakery, etc.)

7. SPIDER LOCATION IN BUILDING:
   ________Basement
   ________Bathroom
   ________Attic
   ________Closet
   ________Kitchen
   ________Other (specify)

8. PRESENCE OF WEB:
   ________Found in web
   ________Webbing evident nearby
   ________No web

9. SPIDER BITE?
   ________Bite reported
   ________No bite reported

Additional Notes (optional):

APPENDIX B

Number of Spiders Sent by County Agents

TABLE APPENDIX B.1.--Spiders Turned in by County Agents.

County	Code No.	Spiders	County	Code No.	Spiders	County	Code No.	Spiders
Alcona	01	13	Iosco	35	10	Montmorency	60	12
Allegan	03	14	Kalamazoo	39	33	Muskegon	61	9
Baraga	07	21	Kalkaska	40	14	Oakland	63	22
Barry	08	26	Lake	43	6	Osceola	67	3
Bay	09	10	Lapeer	44	3	Oscoda	68	9
Benzie	10	15	Leelanau	45	18	Ottawa	70	5
Berrien	11	3	Lenawee	46	8	Presque Isle	71	13
Charlevoix	15	41	Livingston	47	7	Roscommon	72	22
Chippewa	17	7	Luce	48	19	Saginaw	73	12
Crawford	20	15	Macomb	50	312	St. Joseph	75	14
Emmet	24	1	Manistee	51	8	Sanilac	76	10
Genesee	25	3	Mason	53	7	Tuscola	79	6
Gogebic	27	6	Mecosta	54	3	Van Buren	80	21
Gr. Traverse	28	16	Menominee	55	77	Washtenaw	81	4
Hillsdale	30	18	Missaukee	57	5	Wayne	82	111
Houghton	31	13	Monroe	58	63	Wexford	83	13
Ionia	34	1	Montcalm	59	6			
						TOTAL	53	1147

APPENDIX C

Statistics for Size Class Study, Distance Study and Predator Prey Study

TABLE APPENDIX C.1.--Size Class Study.

	♂	♀	Imm.	$\overline{X}$		Aov.	df	M.S.	F	
Sm.	9	8	8	8.3		Col.	2	4.222	9.48*	
Md.	8	7	6	7.0	24 Hour	Row	2	16.889	37.95***	
Lg.	6	5	4	5.0	Starvation	Error	4	0.445		
X	7.7	6.6	6.0			Total	8	21.556		
Sm.	9	8	8	8.3		Col.	2	4.666	3.39	N.S.
Md.	8	7	7	7.3	48 Hour	Row	2	5.999	4.49	✓
Lg.	8	6	5	6.3	Starvation	Error	4	1.335		
X	8.3	7.0	6.6			Total	8	12.000		
Sm.	9	8	7	8.0		Col.	2	14.222	4.56	P>0.1
Md.	8	9	6	7.7	72 Hour	Row	2	2.889	<1.0	N.S.
Lg.	8	8	4	6.9	Starvation	Error	4	3.112		
X	8.3	8.3	5.7			Total	8	20.223		

Significance Levels 0.10 ✓
0.05 *
0.01 **
0.005 ***

TABLE APPENDIX C.2.--Distance Study, AOV Table.

Factor	df	M.S.	F		Factors
A	2	2,415,367	11.97	****	A = Sexes; ♂ , ♀ , Imm.
B	5	4,502,551	22.3	****	
C	1	57,553	<1	N.S.	B = Starvation Levels
AB	10	456,381	2.26	*	
AC	2	191,219	<1.	N.S.	C = Before + After
BC	5	177,826	<1.	N.S.	Capture of Food
ABC	10	2,981,545	14.7	****	
J	144	201.866			

Significance Levels .05 *
.01 **
.005 ***
.001 ****
N.S. Non Significant

TABLE APPENDIX C.3.--Analysis of Variance for Universe Size, Prey Density and Predator Density Study.

Factor	df	SS	MS	F	Significance
A	2	77.389	38.695	19	***
B	4	107.386	26.847	13.4	***
C	2	228.881	114.441	57	****
AB	8	24.140	3.018	1.41	P<.25
AC	4	210.334	52.584	24.51	****
BC	8	104.816	13.102	61.08	****
ABC	16	407.166	25.448	11.86	****
J	180	386.850	2.145		

Factor A = Universe Size

Factor B = Prey Density

Factor C = Predator Density

Significance Levels .05 = *
.01 = **
.005 = ***
.001 = ****

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