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LIFE-CYCLE AND ECOLOGICAL IMPACT OF *POLISTES VERSICOLOR*
VERSICOLOR (OLIVIER) (HYMENOPTERA: VESPIDAE), AN INTRODUCED
PREDATORY WASP ON THE GALÁPAGOS ISLANDS, ECUADOR

by

Christine Parent, B.Sc.

A thesis submitted to the
Faculty of Graduate Studies and Research
in partial fulfillment of
the requirements for the degree of

Master of Science

Department of Biology

Carleton University

Ottawa, Ontario

April 25, 2000

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Life-cycle and ecological impact of *Polistes versicolor*
versicolor (Olivier) (Hymenoptera: Vespidae), an introduced
predatory wasp on the Galápagos Islands, Ecuador

submitted by Christine Parent, B.Sc.
in partial fulfillment of the requirements for
the degree of Master of Science

Thesis Supervisor

Chair, Department of Biology

Carleton University

April 27, 2000

Abstract

This study investigated the ecology (especially the life cycle) of *Polistes versicolor*, an introduced predatory wasp on the Galápagos Islands. Emphasis was given to the impact it might have on naturally occurring insects and insect-feeding birds of the Galápagos Islands.

The data suggest that *Polistes versicolor* is a food semi-specialist, feeding on various terrestrial invertebrates, but predominantly on lepidoptera larvae.

Study of the colony cycle revealed that air temperature was significantly related with the number of active colonies. However, it could not be established if *P. versicolor* has a seasonally synchronized cycle.

The predation pressure of *P. versicolor* on the insect fauna was estimated to range between 17 and 154.52 g/ha/day of prey insect tissue.

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Introduction

The prediction of community theory stating that communities should be saturated with species at levels determined by environmental conditions is a controversial one. There is growing evidence that local community saturation depends on the local environmental conditions (Ricklefs, 1990). According to this idea of biotic saturation, invasions of continental ecosystems by newly introduced species should be very seldom followed by the total exclusion (or extirpation) of established native competitors. Introduced species should not be able to easily invade an intact community, especially on continents, because available niches are usually already filled by locally adapted species. According to the same principle of biotic saturation, island systems should be more vulnerable because they are normally less saturated or the native species are less competitive.

It is now well known that many ecosystems have been altered by the establishment of newly introduced species on many tropical islands. The archipelago of Hawaii has been

the recipient of numerous examples (Howarth, 1985). Generally, the most important effects related to the introduction of alien species seem to originate in the processes of predation and habitat modification. There are many examples of change in island ecosystems worldwide following their invasion by introduced plants and vertebrates (Carlquist, 1974). However, studies examining examples of problems related to the introduction of invertebrate species to an island ecosystem are uncommon.

The Galápagos Islands form a province of the country of Ecuador. They are located 960 km off the west coast of the South American continent and lie on the equator. There are about 30 named islands, and many more small rocks and islets (Figure 1). The oceanic isolation of the archipelago, its recent origin (it is not more than 3.5 million years old), and climate have promoted speciation in plant and animal groups, conferring upon them a uniqueness that is now recognized world-wide. The best known illustration of this is provided by Darwin's Finches. From a single ancestral colonization, under the influence of selection and isolation, the finch populations have

diverged into 13 different species through the process of adaptive radiation (Lack, 1947; Grant, 1986). Although less spectacular, the evolution of some groups of invertebrates has resulted in the formation of several species swarms; the bulimid land snails are an example (Coppoio, 1984) as well as the species of the beetle genus *Stomion* (Finston and Peck, 1997).

At least 712 of the 1822 identified insect species inhabiting Galápagos are endemic (Peck et al., 1998). Therefore, the total insect fauna of the Galápagos Islands presents a relatively high level of endemism of about 40%. Some orders show even higher levels of endemism; for example about 67% of the coleopterans that are found in the Galápagos cannot be encountered anywhere else in the world.

As are all other oceanic islands, the Galápagos are (by definition) isolated, and have never been connected to other land masses. The proportions of the species represented in various animal groups do not correspond to their proportions as observed on continents (Thornton, 1971). On Galápagos, this phenomenon of an unbalanced or disharmonic fauna is expressed primarily through the over-

representation of reptiles compared to mammals and amphibians. In terms of the representation of each order, the insect fauna of Galápagos is unbalanced as well (Peck et al., 1998). The ability of all organisms to reach the islands depends on their respective dispersal and survival abilities. Once a potential colonist arrives, the successful establishment of a species in the ecosystem depends on the ecology of this species, its specific niche, its ecological adaptability, and the presence or absence of potential competitors and predators. Due to the natural variations in colonization ability among insect groups, some insect orders that flourish in various regions of the South American continent are not well represented or are totally absent from the Galápagos Islands.

With the first arrival of humans on the Galápagos Islands (probably by Europeans in 1535), some insect species that could not possibly have reached the islands by themselves were accidentally introduced to the Galápagos, and humans have since then continuously contributed to the arrival and spread of introduced insect species.

In addition to its high level of endemism, the Galápagos Archipelago is notable because it is the world's most pristine, best preserved and protected, tropical oceanic island ecosystem. More than 95% of the land area is protected by the Galápagos National Park, but this unfortunately does not prevent the constant arrival of new introduced organisms to the islands. New organisms reach the islands continuously, and the rate of accumulation of introduced insects closely parallels the increase in both the population of human residents and the number of tourist visits per year (Peck et al., 1998).

A new quarantine and cargo inspection program has been in effect in the Galápagos since summer 1999. This will hopefully contribute to a decrease of insect introductions to the islands, and the inter-island mixing of insect populations. Among the 1822 recognized insect species composing the invertebrate fauna of the Galápagos Archipelago, 292 were most probably accidentally introduced to the Islands by human activity. The great majority of these introduced insects are plant-feeders, and they probably reached the islands when their host plants were

intentionally introduced (Peck et al., 1998). Until now, it seems that most introduced insect species have had a neutral effect on Galápagos ecosystems. However, six species of introduced insects were able to invade and alter natural habitats. In some cases, the invading insects have reduced some endemic invertebrate populations (Lubin, 1984), and they even have out-competed and extirpated other populations in some cases.

As has been observed in numerous regions throughout the world, social insects (especially ants) have been extremely successful invaders. They can expose different native biotas to massive threats (Howarth, 1985; Wojeik, 1994; Moller, 1996; Beggs et al., 1998). In Galápagos, 4 out of the 6 introduced insect species that have been recognized as harmful are social insects: two ant species, *Wasmannia auropunctata* Roger and *Solenopsis geminata* (F.), as well as two vespid wasps, *Brachygastra lecheguana* (Latreille) and *Polistes versicolor versicolor* (Olivier).

The vespid wasp *Polistes versicolor* (Figure 2) was first reported on Galápagos in 1988. It was probably introduced on a cargo-ship with fruits such as bananas

(Abedrabbo, 1991). Since then, the wasps have spread to almost all the islands of the archipelago. After an increase in individual numbers in 1991, particularly on Floreana Island where it was first introduced, the populations seem to have decreased and to have reached a plateau at lower numbers. However, *Polistes versicolor* still has the potential to invade new islands and habitats. This aggressive wasp species has demonstrated a great ability in dispersal by active flight or by taking advantage of the constantly growing inter-island sea transport.

These wasps are voracious predators on insect larvae, and this predation pressure might impact the native insect fauna of the Galápagos Islands. Moreover, these wasps might be in competition for this food resource with other insectivorous species (Table 1). For example, some endemic insectivorous birds such as Darwin's finches feed their nestlings with insect larvae (Grant, 1986), and others are strict insectivores. It is known that populations of ground finches are limited by the food supply during the dry season. The biomass of *Geospiza scandens* and *G. fortis*

declined precipitously in parallel with the decrease in food supply (mostly seeds) during the extended dry season of 1977 (Grant, 1986). The survival of the ground finches is thus related to the amount of food available. It is reasonable to suppose that the success of adults in fledging their nestlings is also related to the availability of insect food for them.

The first attempt to measure the distribution and density of *Polistes versicolor* was made in 1992/1993 on Floreana and Santa Cruz Islands (Lasso, 1997). Furthermore, since 1997, there has been a monthly monitoring program on Santa Cruz Island, which is presently conducted by the Program of Invertebrates of the Charles Darwin Research Station (CDRS). However, it has been difficult to quantify the impact these predatory wasps have on the Galápagos biota. A first step in determining if *Polistes versicolor* constitutes a major threat to the critical balance of the complex ecosystems found on the archipelago is to measure its impact on the biota. This question is one focus of this thesis.

Furthermore, various authors have looked at the influence of abiotic factors such as air temperature, precipitation levels, humidity, etc., on the annual cycle and population dynamics of *Polistes* spp. Among them, Yamane (1986) has concluded that these factors had only a minor influence on colonies at equatorial latitudes. The data previously gathered by the monitoring program of the CDRS showed that at least air temperature and amount of precipitation are correlated with the distribution of *Polistes versicolor* on two of the major islands of Galápagos (Roque-Albedo, pers. comm.).

Likewise, the life cycle of *Polistes* spp. can be limited by the presence of predators. In addition to birds, and mammals, *Polistes* spp. are susceptible to predation by other insects such as ants and lepidoptera (Yamane, 1996). In the Galápagos, one lepidopteran was recently identified as a potential predator of *Polistes versicolor*. Indeed, *Taygete sphecophila* (Gelechiidae, first described as belonging in the genus *Epitheatis*) is a moth that presumably feeds on the wasp larvae. In the first description of the morphological characters of the species

by Meyrick (1936), it was mentioned that *Epithectis* (now *Taygete*) *sphecophila* was found in the pupal stage enclosed in cells of the wasp *Polistes canadiensis* in Central America. Since then, no information has been published on the biology of this moth, or on its predation on *Polistes* spp.

The general objective of the present study was to gather more information on the life cycle and ecology of the vespid wasp *Polistes versicolor*, so that any impact it might have on the native biota of the Galápagos Islands can be better understood. A possible management goal is to ultimately reduce or eliminate the wasp.

First, the distribution and density of this species was determined on two of the major islands of the Galápagos Archipelago: Santa Cruz and Floreana Islands. Then, the foraging behavior of *Polistes versicolor* was observed to subsequently quantify the impact these predatory wasps might have on the Galápagos biota. Lastly, the population dynamics were investigated, so that any influence which selected abiotic and biotic factors might have on the colonies could be established.

Methods

Study Area

The field work in this study was conducted on Santa Cruz and Floreana Islands, Galápagos Islands in Ecuador (Figure 1). The work on Santa Cruz Island was mainly done in and near the Charles Darwin Research Station (CDRS) in Puerto Ayora (Figure 3), a small town located on the south coast of the island at 5-30 m above sea level. Major climatic conditions recorded at the CDRS for 1999 are given in Table 2.

Both Floreana and Santa Cruz Islands have six major vegetation zones. These vegetation zones arise due to a precipitation and temperature gradient which is controlled by island elevation and wind direction (Figure 4). The first is the littoral zone, a narrow coastal belt which has as its upper limit the border of the highest tides. The composition of the vegetation in this zone depends strongly on the plants' ability to tolerate salt.

The littoral zone is then followed by the arid zone, and it may comprise the remaining land area of some of the

smaller islands, such as Baltra and Santa Fé Islands. The arid zone may rise to 120 m on the south side of the islands, and up to 300 m on the north side. Most of the field work in this study was conducted within this zone. The vegetation is predominantly composed of arborescent *Jasminocereus* and *Opuntia* cacti, and seasonally deciduous trees in the genera *Prosopis*, *Acacia*, and *Bursera*, which were in leaf at the time the fieldwork was conducted.

The third vegetation zone, the transition zone, receives more moisture, and is characterized by the presence of evergreen plants. This large zone bears more numerous and taller trees than in the arid zone, and it is mainly composed of species in the genera *Pisonia*, *Psidium*, and *Piscidia*.

The next higher zone is the humid forest zone, also called *Scalesia* zone. This zone, as its name implies, is dominated by the arborescent composite *Scalesia* and a thick and rich undergrowth. The range of the *Scalesia* zone is from about 180 m to 550 m.

The next zone is the *Miconia* or evergreen shrub zone. Replacing the *Scalesia* zone at elevations of about 400 m,

it also signalizes the beginning of a trend to decreased rainfall with increased elevation.

Lastly, the pampa or fern-sedge zone starts around 525-550 m in elevation and rises to the top of the mountains of the highest islands of the archipelago. At this elevation, native woody vegetation is notable in its absence. The summits are mostly covered with sedges and bracken fern.

The climate experienced on the Galápagos Islands is unusually dry for the tropics. The year is divided into two main seasons. From January to June, also known as the warm/wet season, the air temperature is warmer and the generally clear skies are shadowed on occasions by heavy rain showers. From June to December, during the cool/dry or garúa season, the air temperature drops, and although the sky is cloudy most of the time, rainfall is scarce at low altitude, but the higher vegetation zones are almost constantly wet.

Distribution and density of *P. versicolor* nests

In order to determine the distribution and the density of *P. versicolor* nests, various study sites were chosen at random in all of the different vegetational zones found on Santa Cruz and Floreana Islands (Figures 3 and 5). In each vegetational zone, a varying number of quadrats of 10m X 10m were established, and the number of active and inactive nests of *P. versicolor* were counted. Nests were found by systematically searching all the study sites, looking for their presence in every tree and shrub. I recorded the island and the vegetation zone, the number of nest cells, the stage of development the nest was in, the height the nest was built in the tree, the tree species, the presence of signs of moth predation by *Taygete sphecophila*, and the presence of other *P. versicolor* nests around each nest. All nests were in one of the three possible development stages. The first stage, the pre-emergence stage, starts with the foundation of a new nest, and ends with the emergence of the first adult wasp in that nest. The pre-emergence stage is followed by the enlargement stage which is characterized by the growth in individual numbers of the wasp colony. The

enlargement stage reaches its end when the first male wasps are produced. This signals the beginning of the reproduction stage which ends when the colony disassembles. The presence of *T. sphecophila* in the nests could be determined two ways. First, in order to lay its eggs in a wasp nest, *T. sphecophila* pierces small holes on the back of the nests, and these were clearly distinguishable. Second, when the adult moths emerged from the capped cells of the wasp pupae, they always make distinctive breaches in the cells.

Methods of Observation and experimentation

The observational data were gathered mainly in the field in and near the CDRS during the period from April to August 1999. During the course of this study, I made extensive field observations on colonies of *P. versicolor* on their nesting habits, foraging habits, population dynamics, and activities of adult wasps on and outside the nest.

Nesting habits

All the nests found in the study area in the arid zone of Santa Cruz Island were numbered according to the order in which they were found. A total of 69 nests were observed in and near the study area over the five months of fieldwork.

For each nest found on Santa Cruz and Floreana Islands, I recorded the tree species or human structure on which it was built, the height, the developmental stage it was in, and the presence of signs of moth predation. Whenever it was possible, the number of adults, pupae, larvae, and eggs was counted or estimated when the nest was too far away. In case the nest was abandoned, it was collected and measured in terms of width, length, number of cells, and the length of its petiole. All the abandoned nests that showed signs of moth predation were put in an isolation box, so that any moth individuals left in the nest could be subsequently identified.

Foraging habits

Foraging behavior of *P. versicolor* was studied at the nest entrance, where returning foragers were collected. For three *P. versicolor* colonies found in the arid zone of Santa Cruz Island (B18, B22, B23), all returning foragers which did not carry any prey were collected over a period of nine hours (from 0730 until 1700, with half an hour break at 1200). A total of 52 wasps belonging to the three different colonies found in the arid zone of Santa Cruz Island were captured over a period of three days (one day per colony), and put in a killing jar. The wasps were then dissected in the laboratory. The crop content was examined visually for evidence of solid chewed prey (indicated by the presence of small flesh particles in the crop). If the crop contents were liquid, they were tested with a Diastix[®] reagent strip having a sensitivity to glucose of at least 4-7 mmol/L. The liquid crop content of the wasp was considered as being water if the glucose test was negative, and as being nectar if the test was positive. Moreover, during the same period of time, 49 returning foragers from different colonies located in the arid zone of Santa Cruz Island

carrying a visible prey load were collected. The prey items were identified at the level of insect order and life stage and their fresh and dry weight were recorded.

In addition to prey items that are carried externally in their mandibles, *P. versicolor* wasps sometimes also carry wood fiber for nest construction. The returning foragers for four different colonies in the arid zone of Santa Cruz Island were observed for six days, from 0730 until 1700 (with half an hour break at 1200). The foragers' loads were determined visually, and recorded as prey, fiber, or other if the wasp was carrying no visible load.

Foraging range

Yellow sheets of paper were glued on the underside of transparent plastic pans (14 X 21 cm). These were used as pan traps and were then filled with a sucrose solution (1:1 water/sugar), and placed at 50 m intervals along equidistant radians having as a starting point one of four different *P. versicolor* colonies (B27, B31, B33, B34) located in the arid zone of Santa Cruz Island (Figure 6). All wasps were previously marked with a dot of permanent

textile paint on the dorsal side of the thorax. The four different colonies were marked with four different colors, so that the wasps could be subsequently identified as belonging to a given colony. The pan traps were set for a period of three consecutive days for each of the four colonies respectively at the end of July and beginning of August 1999.

Population dynamics

Data on the survival of brood and adults of *P. versicolor* were gathered from one nest (A20) that was observed during most of its development stages. Nest maps were drawn daily for this colony. The number of adults, pupae, larvae, eggs, and empty cells were recorded every day, as well as any other change in the colony. These observations were made during the evening or early in the morning, when flight activity was nonexistent.

All active colonies of *P. versicolor* found in or near the CDRS and the town of Puerto Ayora were observed once a week. A nest map was drawn for each nest, recording the number of eggs, larvae, pupae, adults, and empty cells.

Measure of abiotic and biotic environmental factors

Abiotic factors

The air temperature, hours of sunlight, and amount of precipitation were all measured daily at the Meteorological Station of the CDRS from January to December 1999. Multiple regression was used to analyse the data; using as dependent variable the number of active nests, and as independent variables the air temperature, the number of sunlight hours, and the amount of precipitation.

Biotic Factors

P. versicolor wasps use mostly lepidopteran larvae as a food source for their own developing larvae, but they also use beetle larvae, spiders and other terrestrial invertebrates. In order to determine the importance and influence of the quantity of available food to the wasps, a measure of food abundance had to be established. For the purpose of this study, the group of 13 Sphingidae moth species occurring on Santa Cruz Island was chosen as a proxy of the seasonal abundance of the Lepidoptera fauna as

a whole. A light trap (mercury vapor and UV) was set up twice a week near the CDRS on Santa Cruz Island, at about 20 m above sea level. The light was installed just before sunset at 1800, and all adult Sphingidae individuals coming to the light trap from 2200 until sunrise at 0600 were recorded, marked and then released.

Results

Description of *Polistes versicolor* colonies

Nests in all development stages were found during the experimental period, from March to August 1999. The nests in the first stage, the pre-emergence stage, were small (1.20 cm wide X 1.81 cm long in average), and were composed of few cells (average of 11.23 cells). A total of 97 nests was found at the pre-emergence stage, and 43 of them were active at the moment they were found. The following stage, the enlargement stage, was also well represented in the nest population with a total of 247 nests found, and 46.2% of them were active. The nests in that stage had mean dimension of 20.57 cm wide and 29.92 cm long. Only one nest was found to be in the last stage, the reproduction stage, during this fieldwork period. The colonies of *Polistes versicolor* in this study were founded by one to five foundresses, with an average of 2.05 foundresses per nests. The productivity of one *P. versicolor* colony, colony #A20, was measured, and it produced 222 adults out of 427 eggs. The colony attained its maximum size of 248 cells with 36

adults on July 6. The number of cells in nests in the enlargement stage ranged from 12 to 251, with an average of 100 cells per nest. The nests were all supported by a single petiole, which was a few millimeters long, 5.5 mm in average. The nests were built in trees, shrubs, and on different human-made structures (Table 3). All the nests that were found in inhabited areas were built on human-made structures. *P. versicolor* attached their nests on various types of material: wood, plastic, cement, iron, etc. The height at which *P. versicolor* built their nests ranged from 0.2 m to 9.5 m from the ground. More than 85% of the nests are found between 1.5 and 3.5 meters (Figure 7).

Distribution and density

Polistes versicolor wasps were observed in great numbers, both on Santa Cruz and Floreana Islands. Although nests were found in all the vegetation zones of both Islands, their densities varied greatly. In 1999 (and 1992), no active colonies were found in the study sites of the littoral zone on Floreana Island, whereas the littoral zone presented the highest density on Santa Cruz Island.

The highest density of active nests on Floreana Island in 1999 was measured in the humid zone. On the other hand, Santa Cruz Island had a very low density of active colonies in the transition and humid zones. The increasing density of active colonies with increasing altitude on Floreana Island is totally opposite to the gradient of nest densities on Santa Cruz Island, which decreases with altitude (Figure 8). The densities of active nests measured on both islands were in the same ranges as the densities that were recorded in 1992-1993. The only outlier is the nest density that was measured in the littoral zone on Santa Cruz Island in October-November 1992, which is more than twice as large as the second greatest nest density (Table 4).

Foraging activity

Polistes versicolor was observed in the field foraging for four types of different resources. Wasps were observed collecting fiber from the vegetation, waste paper, and less often from wooden structures, to use as building material

for their nests. The wasp removes thin layers of fiber, forms a small pellet, and carries it in its mandibles back to the nest. Sometimes, the same individual wasps were observed coming back to the same fiber source more than once.

P. versicolor wasps were also seen at different sources of water, including brackish water. Again, some foragers sometimes were making the nest-water source trip more than once.

In addition, wasps were observed on flowers, collecting nectar. *P. versicolor* not only collected nectar from a wide variety of plant species, but they also collected the honeydew of aphids. *P. versicolor* was also observed collecting the extra nectary secretions of *Maytenus octogona* shrubs. Once back at the nest, the returning foragers often shared their loads of nectar or water with one or more wasps.

In addition to water and nectar, the wasps also need a protein source to feed their larvae. *P. versicolor* was often observed in the field searching for prey, mainly insect larvae. Once the prey was found and killed, the wasp

dissected it, removing undesired parts such as the head and legs. The wasp could then chew it and swallow it to bring it back to the nest in its crop. In other cases, the wasp simply carried the prey pieces back to the nest in its mandibles. Once back at the nest, the returning foragers distributed their prey load to one or more larvae.

The flesh loads that were carried in the mandibles of returning foragers were examined to determine the type of prey they collected. A list of prey items is presented in Table 5. Caterpillars accounted for the largest proportion of prey (46%).

Returning foragers either carried solids in their mandibles or their mandibles were empty and liquid or chewed particles were present in their crops. No foragers that were collected had both empty mandibles and an empty crop. Foragers with solid loads were carrying fiber for building the nest or flesh to feed the larvae. Foragers with liquid were carrying nectar or water, or flesh particles of prey in their crops. No incoming foragers were observed with a mixed load of fiber and flesh in their mandibles. However, it is possible that some carriers were

transporting a load both in their mandibles and in the crop, but this was not verified in the present study. A total of 49 prey loads were collected from four different colonies, with a mean fresh weight of 17.46 mg, standard error of 1.49. The smallest prey load was 8.2 mg fresh weight. The largest prey load was 33.5 mg fresh weight, and this was carried on two different occasions. This represents 46% of the average fresh weight of 10 returning foragers.

Liquid in the crop was clear and colorless in the case of nectar and water. On the other hand, small flesh particles carried in the crop could be distinguished and were often accompanied by a colored liquid. Of the 52 foragers returning to the nest with empty mandibles, 52% were carrying water in their crop, 35% were carrying nectar, and 13% were carrying flesh particles of prey (Table 6).

The proportions of returning foragers carrying prey, fiber, or crop loads are presented in Table 7. The number of crop loads can be divided according to the proportions of different types of loads given in Table 6. This

illustrates the proportion of each type of resource that is brought back to the nest (Figure 9). Water was the type of resource that was brought back on the greatest number of occasions. It was then followed by prey, and nectar about evenly, and then fiber loads.

Of the 140 wasps (from four different colonies) that were caught in pan traps over a period of three days, 91.4% were caught within 200 m of their nest, and only 8.5% were at a distance of 250 m up to 300m (Figure 10).

Growth of colonies

Figure 11 shows the development of nest #A20. The nest size (total number of cells), as well as the number of individuals in each development stage of the wasp life cycle increased steadily from the beginning of April to the end of June. At that point, the colony stopped its growth and even decreased slightly in size and individual numbers. This pattern closely parallels the seasonal change in air temperature as demonstrated in Figure 12. The cells no longer all contained eggs, and there was a higher level of mortality in eggs and larvae.

Colony cycle

The number of newly founded colonies (PEM stage) of *P. versicolor* appears to decrease as the warm/wet season is replaced by the cold/dry season. In parallel, the number of colonies in the enlargement stage also decreases (Figure 13). The maximum number of active colonies (40) was measured during the second week of May. As the air temperature went down, the total number of active colonies decreased and it attained its minimum (16) at the end of August when the temperature was at its lowest. At that time, numerous nests were abandoned, and no new colonies were established. As Figure 14 indicates, the mean number of occupied cells per nest increased continuously until the first week of June, and it then decreased gradually until the end of the observational period at the end of August. In a very similar fashion, the mean number of pupae per nest increased until it reached its peak at the end of May, and it then decreased steeply until it reached a plateau at the end of June (Figure 14). The analysis of the abiotic factors resulted in a multiple regression with $R^2 = 0.561$, with no independent variable having a significant partial

regression coefficient. This situation most probably indicates a high degree of correlation between two of the independent variables. Indeed, a Pearson correlation coefficient of 0.730 ($p < 0.01$) was found between the number of sunlight hours and air temperature. The stepwise analysis of the data resulted in the removal of the number of sunlight hours and the amount of precipitation from the equation, so that only the air temperature remains with a significant ($p < 0.001$) regression coefficient.

The increase of *P. versicolor* nest size (measured as the number of occupied cells per nest) seems to follow the increase in number of adult Sphingidae captured at night (Figure 15). The sequence of events begun with the first major rainfall of the wet season, which started on March 3. During the next two days, more than 25% of the total rainfall amount reported for the whole year 1999 was recorded at the Meteorological Station of the CDRS. More rainfalls, although less important, were recorded in the following months. This first major rainfall at the beginning of March triggered a period of new plant growth, as symbolized in Figure 15. In addition, an explosion of

emerging plant-eating insects was occurring at about the same time, starting a few days after the first major rainfall. Sphingidae adults emerged from their pupal stage, and started to reproduce in a few days. The life cycle of the Sphingidae, hypothesized in Figure 15, is based on a period of ca. 30 days from egg to the last larval instar. This corresponds to the life-cycle duration of one of the Sphingidae species present on Galápagos, *Manduca sexta*, as measured in laboratory at 26 °C with abundant food available (Bell and Joachim, 1976; Bell et al., 1975). This corresponds to conditions found at the beginning of the wet season on Galápagos Islands. The period of time when the egg, larval, and pupal stages were predominant was inferred from the curve of adult Sphingidae captured per night. As seen in Figure 15, the presence of moths in the larval stage (caterpillars) coincided with the period of growth in *P. versicolor* colonies.

It must be mentioned that the variation in number of adult Sphingidae captured per night could be related to certain factors. Since the moths were attracted with UV and mercury vapor lights, the phase of the moon had an

influence on the number of individuals coming to the lights, with lower numbers captured during the full moon than during the new moon phase (Figure 16). In addition, the decline of adult Sphingidae can be related significantly to the decrease in night air temperature, as demonstrated in Figure 17.

Predation pressure

The predation pressure of *Polistes versicolor* upon the terrestrial invertebrate fauna of the Galápagos Islands can be estimated from the foraging frequency of the wasp foragers, the weight of the prey loads that are brought back to the nest, and the density of active nests (Figure 8). *Polistes versicolor* foragers brought back an average of 29.5 prey loads per colony of 120-150 larvae per day (Figure 9). The average fresh weight of the prey loads was 17.46 mg, so that 515.07 mg of fresh prey was brought the nest per day for a typical colony of 120-150 larvae. Table 8 presents the predation pressure values for selected active nest densities.

Infestation by brood predators

Taygete sphecophila is a predatory moth species that was present in great numbers in nests of *P. versicolor*. The presence of *T. sphecophila* in the nests could be determined because the moths left evidences of their presence on the nest. In order to lay its eggs in a wasp nest, *T. sphecophila* pierces small holes on the back of the nests, and these were clearly distinguishable. Moreover, when the adult moths emerged from the capped cells of the wasp pupae, they always make distinctive breaches in the cells. The proportion of nests that showed signs of the presence of the moth in the different vegetation zones of both Santa Cruz and Floreana Islands are given in Table 9. Signs of infestation of *T. sphecophila* could be observed on both active and inactive *P. versicolor* nests.

In general, nests that were in the enlargement stage were more susceptible to *T. sphecophila* predation than nests in the pre-emergence stage. Moreover, it appears that nests that were built on human-made structures, thus in inhabited areas of both islands, were less susceptible to *T. sphecophila* than nests built on trees or shrubs in

vegetated areas. On Santa Cruz Island, the presence of *T. sphecophila* was limited to *P. versicolor* nests found in the arid zone. On the other hand, more than 50% of the nests in enlargement stage found in transition and humid zones of Floreana Island presented signs of *T. sphecophila*.

T. sphecophila individuals were found in seven of the 22 nests that were put in isolation boxes because they showed signs of moth infestation. A total of 42 individuals (adults) were found, and 11 individuals was the largest number found in one single nest. In some nests from which no *T. sphecophila* individuals could be isolated, the presence of *T. sphecophila* pupa cases was noted, confirming its presence.

Predation

Ant species such as *Wasmannia auropunctata* were found on nine occasions on active *P. versicolor* nests. These ants are probably predators of *P. versicolor*, and are attracted by the high protein content of the nest. These ants were found in abandoned nests as well, although most of these nests consisted only of empty cells.

Spiders were occasionally found in abandoned nests, but never in active nests.

Other possible predators on the wasps are some insectivorous birds, including some Darwin's Finches, rats, or mice. They were never observed in action in the field, but what was left of 11 destroyed nests suggests that birds were probably responsible for their destruction. It seems that this kind of destruction was often following nest invasion by *Taygete sphecophila*. Eight of the 11 nests apparently destroyed by birds presented signs of the presence of *Taygete sphecophila*.

Discussion

Description of the colonies

I found that the number of foundresses per colony of *P. versicolor* obtained in the present study varies between one and five. This is comparable with the numbers Giannotti and Mansur (1993) obtained for the same species in southeastern Brazil.

In the littoral and arid zones on both Floreana and Santa Cruz Islands, an important proportion of *P. versicolor* nests were built under roof overhangs or other human-made structures (24% of nests in the arid zone of Santa Cruz Island and 87% of nests in the arid zone of Floreana Island). This result indicates that *P. versicolor* probably takes advantage of the protection from adverse weather and predators provided by these structures, as was previously suggested by Reed and Vinson (1979). *P. versicolor* used *Cordia lutea* frequently in the littoral zone on Floreana Island. However, in the littoral zone on Santa Cruz Island, *Bursea graveolens* was found to support 36% of the nests compared to 17% for *Cordia lutea*. In the

arid zone of both islands, *Acacia macracantha* was the plant species most occupied by *P. versicolor* nests, except for the human-made structures. The petiole of most of the nests built on branches of *A. macracantha* was constructed directly on a thorn of the tree. *P. versicolor* possibly uses the thorns as additional support because they might increase the strength of the petioles supporting the nests. Other plant species with thorns, such as *Opuntia echios* and *Parkinsonia aculeata* are used by *P. versicolor* to build their nests, but in lower proportion. In the transition and humid zones of both islands, *Zanthoxylum fagara* was the plant species mostly used by *P. versicolor*. This might however reflect the predominance of this plant species (the higher proportion available) in the study sites of these two zones.

Nest distribution and density

The average monthly density of *P. versicolor* wasp nests on the island of Floreana did not change significantly since it was first measured in 1992/1993. Additionally, the density of active wasp nests found in the

littoral zone of the island was significantly greater in May 1992 compared to June-July 1992 and July 1999. This suggests that the populations of active nests decreased significantly in both years as a response to seasonal change, probably related to climatic conditions.

Puerto Ayora, on Santa Cruz Island, is the largest human population center on the Galápagos Archipelago. Numerous nests were found underneath roof overhangs of houses and other structures in the village. On the other hand, active nest density in the littoral and arid zones of Floreana Island was measured in the absence of an important urban area. In fact, the largest village on Floreana Island is composed of about 15 houses, not comparable to the nearly 10,000 human inhabitants in Puerto Ayora. The fact that only one wasp nest (inactive) was found in the littoral zone of Floreana Island could be related to the difference in urban development of the two islands. Indeed, mainland South-American populations of *P. versicolor* are often more numerous in and around urban areas than in natural vegetated habitats (Ramos and Diniz, 1993). Across its wide geographical range, from Costa Rica to Southern

Argentina, *P. versicolor* seems to prefer dry-forest habitat (Richards, 1978). This again suggests that *P. versicolor* wasps probably take advantage of the protection that artificial structures such as buildings might offer from adverse weather and predators. Thus, although the general development of urban areas reduces the availability of natural habitats, *P. versicolor* probably benefits from it.

An inventory of *P. versicolor* densities in littoral and arid zones of other major islands would be a way to verify this hypothesis.

At the time that the *P. versicolor* nest densities were measured on Santa Cruz and Floreana Islands (mid-July 1999), the cool/dry (garúa) season had already begun. The garúa season is accompanied by large amounts of moisture at high elevations, particularly on the southern slope of the higher islands. The study sites on Santa Cruz Island were all located on the southern slope of the island, so that the study sites in the transition and humid zones were experiencing wet conditions when they were surveyed. On the other hand, the majority of the study sites located in the transition and humid zones on Floreana Island were on the

northern slope of the island. Here, the weather was dryer than on Santa Cruz Island, and since *P. versicolor* wasps seem to prefer dryer areas, it was expected that one would encounter a higher density of their active nests in the transition and humid zones of Floreana Island.

Although the sample sizes are not large enough to clearly separate the vegetation zones according to *P. versicolor* active nest density, the data suggest that *P. versicolor* does have preferences regarding available nesting locations. The results confirm the idea of Ramos and Diniz (1993), that *P. versicolor* seems to prefer dryer habitats, and builds its nest preferentially on artificial structures when possible.

Foraging activity

P. versicolor workers normally forage for fresh water for themselves and to carry to the nest. However, certain foragers were observed at brackish water sources, particularly on hot and dry days. Brackish waters can be classified according to salt content (%S). Redeke's classification, which has been widely accepted, describes

brackish water as having from 0.21% to 30% salt content (Ramane and Schlieper, 1971). It seems that *P. versicolor* wasps are able to use brackish water to satisfy their water needs, and that this is something that they were apparently not accustomed to do upon their initial arrival in the islands (Roque-Albedo, pers. comm.; Lasso, 1997). However, the wasps were generally observed in greater numbers at fresh water sources than at brackish water sources. This might also explain in part their greater abundance in and near inhabited areas, where rainwater is collected for human needs.

The prey loads (Table 4) of *P. versicolor* indicated that these wasps are semi-specialist predators. They use mostly caterpillars, but they will also accept a wide variety of other invertebrates. This might reflect a preference for caterpillars, or it might reflect what prey are available or most easily found by the workers. One could verify this by sampling the insect fauna at various times of the year, and look at the relative proportion of different insect species. The range of weights of the prey loads that foragers can bring back to their nests

corresponds to what other vespidae wasps can carry. The flesh load that *Paravespula germanica* workers can carry may be up to 50% or more of their weight, and that the loads of *Paravespula vulgaris* workers could be up to 58 % of their body weight (Archer, 1997). On the other hand, other authors found that *Vespa orientalis* foragers could carry loads heavier than their own weight (Archer 1997). The size of the flesh loads the wasp workers carry depends in part on the size of the smallest prey that are available.

In the field, I never observed *P. versicolor* foragers carrying more than one prey item at the time. If the prey was too large for the wasp, it could cut it into pieces and carry it in two or more trips, but no foragers were observed returning to the nest with two or more prey items at one time.

The great majority of workers forage within 200 m of their nests. However, one must bear in mind that the experimental design used in the present study might have underestimated the foraging range of *P. versicolor*. The foragers might have been caught further away from the nest if they did not come across the pantraps located near the

nest. Nevertheless, *P. versicolor* on the Galápagos Islands has a foraging range comparable to that of other wasp species. The shortest distance was measured both by Suzuki (1978) and Kasuya (1980) for *Polistes chinensis*, and it was about 20 meters. The largest foraging distance measured for a *Polistes* wasp species was 102 m, and was for *Polistes metricus* (Dew and Michener, 1978). Other genera of vespid wasps have an even greater foraging range. For example *Vespula mandarinia* normally forages within 1 km of its nest, but it has been observed foraging at a distance of 8 km (Matsuura and Yamane, 1990).

Colony growth and colony life-cycle

The growth of *P. versicolor* colony #A20 was certainly influenced by temperature (Figure 12). This is in agreement with Yamane (1971) who demonstrated that wasp colony growth could be affected by environmental factors.

The multiple regression analysis of the data from this study demonstrates that the colony cycle of *P. versicolor* is significantly related with air temperature. The nest population decreased during the cool/dry season, as

temperature decreased. These results contradict Yamane (1996), who states that the air temperature and other climatic factors have minor if any impact on the length and pattern of the nesting period of *Polistes* wasps at low altitudes, and in equatorial zones. However, Yamane recognizes that the seasonal change in air temperature (among various climatic factors) is possibly the most effective climatic factor in limiting the length of colony life cycle at medium and high latitudes, and high altitudes. The climate on the Galápagos Islands is not a typical equatorial climate, it is much drier and colder than the climate on the continent at the same altitude and latitude. This is probably why the results given in the present study are the opposite of Yamane's conclusions.

The present study was not carried over a period of time of sufficient length to clearly establish if *P. versicolor* colonies have a seasonally synchronized life cycle on the Galápagos Islands. Data on the abundance of active nests throughout the whole year would be necessary to reveal the complete picture on the annual life cycle. Nevertheless, the particularly long and severe dry season

on Galápagos would suggest that *P. versicolor* has a seasonally synchronized colony cycle. The herbivorous insects (wasp prey) of the Galápagos Islands are dependent on the appearance of leaves on trees and shrubs following the first rainfall at the beginning of the wet season. The wasps then are dependent on the presence of insect prey, especially caterpillars. For this reason, it would be expected that *P. versicolor* colony establishment and growth would be at about the same time, when food is increasing in abundance (Figure 15).

Gobbi and Zucchi (1980) found no correlation between season and the colonial cycle of *P. versicolor* in Southern Brazil. However, they concluded that the colonies are directly influenced by climatic conditions. On the other hand, Ramos and Diniz (1993) challenged these results by stating that *P. versicolor* had a seasonal cycle, and that it was similar to that of other wasp species in southern Brazil. According to Ramos and Diniz's study, *P. versicolor* colonies are most abundant during the dry season (from June to September), and they are almost absent during the wet season (from November to February). The seasonal variation

in precipitation is what regulates the colony cycle of *P. versicolor* in southern Brazil.

Predation pressure

A quantification of the predation pressure of *P. versicolor* (Table 7) reveals the impact that these wasps have on the terrestrial invertebrate fauna of Galápagos. The invertebrates eaten each day by wasps are ones that are no longer available for other insectivorous animals such as Darwin's ground finches. Clapperton (1999) estimated a range of predation pressure of 31 to 957 g/ha/season for the Asian paper wasp (*Polistes chinensis antennalis*). The nest densities of those wasps varied from 20 to 210 nests/ha. The Asian paper wasp is considered to be a pest in New Zealand, and it is widely encountered in their shrubland areas.

Colony duration of *P. versicolor* was measured for 10 colonies in Southern Brazil, and it varied between 79 and 155 days (Gobbi and Zucchi, 1985). The predation pressure which *P. versicolor* has on the invertebrate fauna of the Galápagos Islands can be estimated from the predation

pressure values for each vegetation zone on Santa Cruz Island (Table 7). Assuming that *P. versicolor* has an active season of 122 days in Galápagos (which would be a relatively short season for *P. versicolor* compared to its active season in Brazil), this would result in a predation pressure ranging from 2.1 to 18.9 kg/ha/season, depending on the vegetation zone.

The ground finches of Galápagos feed their nestlings with insect larvae. Before the arrival of *P. versicolor* on the archipelago, food abundance was already a limiting factor for insectivorous finch populations (Grant, 1986). The different finch populations were in strong competition for food resources then, and now that a new voracious competitor has been introduced, competition for food resources is certainly more intense. There are some reasons to believe that the recent decline in mangrove finch populations (*Cactospiza heliobates*), the rarest of Darwin's finches, is at least partly due to the presence of *P. versicolor* as new competitor in the ecosystem (Grant and Grant, 1997).

Nest infestation by brood predators

As are many other wasps (Nelson, 1968), *Polistes* wasps are vulnerable to predation by different insects. Yamane (1996) presented a list of 11 moth species that are known to infest nests of up to 7 different *Polistes* species. In Galápagos, only one species of brood predator has been found to present (*Taygete sphecophila*). It was most probably accidentally introduced after the arrival of *P. versicolor* on the Galápagos Islands. *Taygete sphecophila* larvae prey upon the pupae of *P. versicolor*. After the first signs of infestation become apparent (when the first adults *T. sphecophila* emerge from an infested nest) it takes only a few weeks or sometimes only a few days before another predator takes advantage of the weakened colony to destroy it. Another possible scenario is that the adult *P. versicolor* simply abandon their nest after infestation. No nests that showed signs of *T. sphecophila* presence could be observed for a long period of time. Such nests were always destroyed or abandoned at one time or another before the end of its life-cycle.

Although other predators such as ants, birds, rats and mice probably destroyed nests during the observational period, these do not represent a high proportion of the mortality for *P. versicolor* colonies. No active colonies were found to be completely destroyed by ants. Few colonies were attacked by birds, rats, or mice (11 in total), and most that were attacked (8 nests) already presented signs of infestation by *Taygete sphecophila*. However, no colonies were found that had survived a bird, rat, or mouse attack.

Conclusions

It is well known that the life cycle of *Polistes* is flexible in response to different climatic and ecological factors (Yamane, 1996). In particular, *P. versicolor* has demonstrated a great ability to adapt its life-cycle habits to the conditions on the Galápagos Islands. The foragers have found in the flora and invertebrate fauna all they need to survive, and establish themselves on the islands. The climatic factors such as air temperature, and ecological factors such as infestation by *Taygete sphecophila* represent constraints to the colony development of *P. versicolor* on the Galápagos Islands. However, this vespid wasp could adapt to these new conditions, and it is now part of the permanent fauna of the islands.

The climate of the Galápagos Archipelago not only varies within the year, but it also varies considerably from one year to another. The presence of *P. versicolor* in the ecosystem might not be harmful to the community in years of high food abundance, when the wet/warm season brings about more rainfall than usual. However, during the drier years to come, the Galápagos fauna, particularly the

native insect populations and insectivorous finch populations will most probably suffer from the presence of this newly introduced voracious insect predator. It is known that ground finch survival declines with the decrease in food supply, particularly during especially severe dry seasons or during years when there is no wet season. With the presence of *P. versicolor* in the community, the situation can only be more difficult for the finches. By using part of the same food supply (insect larvae) during the wet season, the wasps reduce even more the food resources that are already scarce.

The importance of the impact of *P. versicolor* on the Galápagos fauna can be now better comprehended. The information gained in this study about the effect of the biotic and abiotic constraints should now be exploited in order to restrain the continued establishment of *P. versicolor*, and to control its populations, before it occasions irreversible damage to the Galápagos biotas. The possibility of using *T. sphecophila* as a biological control agent against *P. versicolor* has to be evaluated. First, more information on the biology of this moth has to be

gathered. It has been demonstrated that *P. versicolor* prefers drier habitats, and urban areas. Controlling wasp populations in urban areas is more readily accessible to the human inhabitants of the Galápagos Islands. However, people should learn how to effectively destroy the colonies in order to have a significant effect on the wasp populations.

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Table 1.- Landbirds and reptiles occurring on the Galápagos Islands that are known to feed on insects and other terrestrial invertebrates. Sources: 1: Jackson (1993); 2: Franklin et al. (1979); 3: Rosenberg et al. (1990); 4: Grant & Grant (1979); 5: Grant (1986); 6: Werner (1978).

Species	Strict insectivore	Generalist feeder which includes insects in its diet
LANDBIRDS:		
<i>Tyto punctissima</i>		✓
Barn owl ¹		
<i>Asio flammeus</i>		✓
Short-eared owl ¹		
<i>Lateralus spilonotus</i>	✓	
Galápagos rail ²		
<i>Neocrex erythrops</i>		✓
Paint-billed crake ¹		
<i>Zenaida galapagoensis</i>		✓
Galápagos dove ¹		
<i>Coccyzus melacoryphus</i>	✓	
Dark-billed cuckoo ¹		
<i>Crotophaga ani</i>	✓	
Smooth-billed ani ³	✓	
<i>Pyrocephalus rubinus</i>	✓	
Vermilion flycatcher ¹	✓	
<i>Myiarchus magnirostris</i>		
Large billed flycatcher ¹	✓	
<i>Nesomimus parvulus</i>		✓
Galápagos mockingbird ⁴		
<i>N. macdonaldi</i>		✓
Hood mockingbird ⁴		
<i>N. melanotis</i>		✓
Chatam mockingbird ⁴		
<i>N. trifasciatus</i>		✓
Charles mockingbird ⁴		
<i>Dendroica petechia</i>	✓	
Yellow warbler ¹		
<i>Geospiza magnirostris</i>		✓
Large ground finch ⁵		

Table 1.- Continued.

Species	Strict insectivore	Generalist feeder which includes insects in its diet
<i>G. fortis</i>		✓
Medium ground finch ⁵		
<i>G. fuliginosa</i>		✓
Small ground finch ⁵		
<i>G. scandens</i>		✓
Cactus ground finch ⁵		
<i>G. conirostris</i>		✓
Large cactus ground finch ⁵		
<i>Camarhynchus psittacula</i>	✓	
Large tree finch ⁵		
<i>C. pauper</i>	✓	
Medium tree finch ⁵		
<i>C. parvulus</i>	✓	
Small tree finch ⁵		
<i>C. pallidus</i>	✓	
Woodpecker finch ⁵		
<i>C. heliobates</i>	✓	
Mangrove finch ⁵		
<i>Platyspiza crassirostris</i>	✓	
Vegetarian finch ⁵		
<i>Certhidea olivacea</i>	✓	
Warbler finch ⁵		
REPTILES:		
Snakes		
<i>Philodryas bisedrialis</i> ¹		✓
<i>Alsophis slevini</i> ¹		✓
<i>A. dorsalis</i> ¹		✓
Leaf-toed geckoes		
<i>Phyllodactylus leei</i> ¹	✓	
<i>P. gilberti</i> ¹	✓	
<i>P. barringtonensis</i> ¹	✓	
<i>P. galapagoensis</i> ¹	✓	
<i>P. bauri</i> ¹	✓	
<i>P. tuberculosus</i> ¹	✓	
<i>P. reissi</i> ¹	✓	

Table 1.- Continued.

Species	Strict insectivore	Generalist feeder which includes insects in its diet
<i>Gonatodes caudiscutatus</i> ⁱ	✓	
<i>Lepidodactylus lugubris</i> ⁱ	✓	
Lava lizards		
<i>Tropidurus grayi</i> ^e	✓	
<i>T. bivittatus</i> ^e	✓	
<i>T. pacificus</i> ^e	✓	
<i>T. habellii</i> ^e	✓	
<i>T. delanosis</i> ^e	✓	
<i>T. albemarlensis</i> ^e	✓	
<i>T. duncanensis</i> ^e	✓	
Land Iguana		
<i>Conolophus subcristatus</i> ⁱ		✓
<i>C. pallidus</i> ⁱ		✓

Table 2.- Climatic conditions as measured at the Charles Darwin Meteorological Station, Bahía Academia, Puerto Ayora, Santa Cruz Island, Galápagos Islands (January-December 1999).

Month	Daily Air Temperature (°C)			Precipitation (mm)
	Minimum	Mean	Maximum	
January	20.6	22.9	25.0	6.5
February	21.7	23.6	24.9	11.4
March	23.3	24.9	26.0	47.0
April	21.9	24.2	26.6	8.1
May	23.2	23.9	25.1	3.0
June	21.1	22.2	23.2	3.8
July	19.9	21.2	22.6	6.1
August	19.8	20.8	21.8	13.5
September	19.8	20.6	21.8	6.9
October	20.2	21.6	22.5	21.0
November	19.7	21.1	22.4	3.0
December	21.1	22.1	23.3	12.9
Mean	21.0	22.4	23.8	11.9

Table 3.- Comparison of utilization of support structures for nests of *Polistes versicolor* in different vegetation zones on Santa Cruz and Floreana Islands.

Vegetation Zone	Nest Support	Island			
		Santa Cruz		Floreana	
Littoral	<i>Avicennia germinans</i>	1	4%	0	0%
	<i>Conocarpus erecta</i>	3	13%	0	0%
	<i>Cordia lutea</i>	4	17%	2	100%
	<i>Croton scouleri</i>	3	13%	0	0%
	<i>Bursera graveolens</i>	9	36%	0	0%
	<i>Laguncularia racemosa</i>	2	8%	0	0%
	<i>Maytenus octogona</i>	1	4%	0	0%
	<i>Rhizophora mangle</i>	2	8%	0	0%
Arid	<i>Acacia macracantha</i>	60	57%	9	8%
	<i>Cordia lutea</i>	8	8%	3	3%
	<i>Lantana camara</i>	1	1%	0	0%
	<i>Opuntia echios</i>	7	7%	2	2%
	<i>Parkinsonia aculeata</i>	4	4%	0	0%
	<i>Prosopis juliflora</i>	0	0%	1	1%
	human-made structure	25	24%	101	87%
Transition	<i>Cordia lutea</i>	0	0%	1	5%
	<i>Croton scouleri</i>	1	20%	6	32%
	<i>Opuntia echios</i>	0	0%	3	16%
	<i>Tournefortia pubescens</i>	1	20%	0	0%
	<i>Zanthoxylum fagara</i>	3	60%	9	47%
Humid	<i>Citrus limon</i>	0	0%	8	18%
	<i>Cordia lutea</i>	0	0%	1	2%
	<i>Croton scouleri</i>	0	0%	11	25%
	<i>Lantana camara</i>	1	25%	0	0%
	<i>Prosopis juliflora</i>	0	0%	2	5%
	<i>Scaevola pedunculata</i>	1	25%	0	0%
	<i>Zanthoxylum fagara</i>	2	50%	22	50%
Total		139		181	

Table 4.- Comparison of density of active colonies of *Polistes versicolor* on Santa Cruz and Floreana Islands (A and B), as measured in 1992/1993 and 1999. The numbers of sites that were explored are in parentheses. Data in columns *marked are from Lasso (1997).

A: Santa Cruz Island

Active nest density (nests/100m ²)			
Vegetation Zone	Oct-Nov 1992*	Jan-Feb 1993*	Jul 1999
Littoral	14.67 (2)	2.50 (2)	3.00 (3)
Arid	2.25 (4)	1.08 (4)	2.33 (5)
Transition	1.92 (4)	0.25 (4)	0.33 (3)
Humid	0.00 (4)	0.00 (4)	0.67 (4)

B: Floreana Island

Active nest density (nests/100m ²)			
Vegetation Zone	Oct-Nov 1992*	Jan-Feb 1993*	Jul 1999
Littoral	0.00 (2)	1.75 (2)	0.00 (3)
Arid	3.67 (3)	3.00 (3)	1.40 (5)
Transition	7.83 (2)	2.30 (2)	2.67 (3)
Humid	4.06 (10)	2.41 (10)	4.75 (8)

Table 5.- Relative abundance of categories of prey items in flesh loads of returning foragers. Months of collecting: April and May.

Prey	Number of loads
<i>Insects:</i>	
Coleoptera	8
Diptera (adults)	3
Hemiptera	2
Lepidoptera (larvae)	46
<i>Other invertebrates:</i>	
Araneae	16
Gastropoda	3
Unknown	22
Total number of loads	100

Table 6.- Proportion of different types of loads found in the crop of all foragers returning to their nest with empty mandibles. All nests had between 120-150 larvae on the first day of experimentation (Nests B13, B14, B19). Months of experimentation: April to June.

Colony	Chewed Prey	Nectar	Water	Total
B13	2	4	7	13
B14	3	7	11	21
B19	2	7	9	18
Total	7	18	27	52
Percentage	13%	35%	52%	100%

Table 7.- Proportions of the different types of loads (visually identified) that foragers brought back to their nest. The load of every returning forager was recorded as prey, fiber, or other if the wasp was carrying no visible load. All nests had between 120-150 larvae on the first day of experimentation. Nests: B21, B22, B23, B25.

Colony	B21		
Date	Fiber	Prey	Other
19-Apr	6	20	90
26-Apr	9	25	88
17-May	7	19	95
24-May	8	22	82
14-Jun	8	22	91
21-Jun	11	21	80
Total	49	129	526
Mean	8.17	21.50	87.67

Colony	B23		
Date	Fiber	Prey	Other
21-Apr	4	15	80
28-Apr	9	21	72
19-May	2	16	69
26-May	4	11	75
16-Jun	2	18	65
23-Jun	5	16	74
Total	26	97	435
Mean	4.33	16.17	72.50

Colony	B22		
Date	Fiber	Prey	Other
20-Apr	4	18	84
27-Apr	6	17	80
18-May	8	15	72
25-May	5	20	81
15-Jun	7	18	94
22-Jun	7	13	74
Total	37	101	485
Mean	6.17	16.83	80.83

Colony	B25		
Date	Fiber	Prey	Other
22-Apr	8	22	91
29-Apr	8	18	94
20-May	7	19	87
27-May	5	22	80
17-Jun	8	24	89
24-Jun	7	20	89
Total	43	125	530
Mean	7.17	20.83	88.33

Table 8.- Predation pressure of *Polistes versicolor* on the terrestrial invertebrate fauna (grams of fresh prey brought back to their nests per hectare per day) in different vegetation zones on Santa Cruz Island.

Vegetation Zone	Active nest density (nests/100m ²)	Predation pressure g/ha/day
Littoral	3.00	154.52
Arid	2.33	120.01
Transition	0.33	17.00
Humid	0.67	34.51

Table 9.- Proportion (as percentage) of active *Polistes versicolor* nests that presented signs of moth predation (*Taygete sphecophila*) in the different vegetation zones of Santa Cruz and Floreana Islands. PEM = nests in pre-emergence stage; ENL = nests in enlargement stage. Numbers in parentheses are the sample sizes.

Nests built on vegetation (n = 206):

Vegetation zone	Santa Cruz Island				Floreana Island			
	PEM		ENL		PEM		ENL	
Littoral	0	(6)	0	(24)	0	(0)	0	(1)
Arid	4.2	(24)	24.6	(61)	14.3	(7)	22.2	(9)
Transition	0	(0)	0	(5)	0	(0)	63.2	(19)
Humid	0	(1)	0	(3)	0	(0)	58.7	(46)

Nests built on human-made structures (n = 139):

Vegetation zone	Santa Cruz Island				Floreana Island			
	PEM		ENL		PEM		ENL	
Littoral	0	(0)	0	(0)	0	(0)	0	(0)
Arid	3.7	(27)	8.3	(12)	9.1	(33)	11.9	(67)
Transition	0	(0)	0	(0)	0	(0)	0	(0)
Humid	0	(0)	0	(0)	0	(0)	0	(0)

Figure 1.- The islands of the Galápagos Archipelago,
Ecuador.

Figure 2.- *Polistes versicolor*.

Figure 3.- Santa Cruz Island and the study sites.

Figure 4.- Major vegetation zones found on the higher Galápagos Islands (adapted from Peck and Kukalová-Peck, 1990). The zone gradient is under the influence of elevation and moisture, which is related to the prevailing winds.

Figure 5.- Floreana Island and the study sites.

Figure 6.- Arrangement of transects of yellow pan traps from a central nest used to determine the foraging range of *Polistes versicolor*.

Figure 7.- Frequency histogram of height at which *Polistes*
versicolor built their nests.

Figure 8.- Density of active colonies of *Polistes*
versicolor in the vegetation zones on Santa Cruz and
Floreana Islands. Errors bars are SE.

Figure 9.- Mean daily foraging effort (worker round trips/colony of 120-150 larvae/day) for 4 *Polistes versicolor* colonies from the arid zone on Santa Cruz Island. Error bars are SE.

Figure 10.- Foraging range of *Polistes versicolor*: capture frequency at increasing distances from the nests. Total number of wasps = 140.

Figure 11.- Colony development of *Polistes versicolor* nest
#A20.

Figure 12.- Number of adult *Polistes versicolor* in nest #A20 and mean daily air temperature as measured at Bahía Academia, Puerto Ayora, Santa Cruz Island, Galápagos Islands.

Figure 13.- Number of active *Polistes versicolor* nests over a period of five months, from April to August 1999. PEM = pre-emergence stage; ENL = enlargement stage.

Figure 14.- Population of pupae and mean size of colonies of *Polistes versicolor* during a five month period (April-August 1999).

Figure 15.- Sequence of events leading to the growth of *P. versicolor* colonies (filled circles). The first important rainfall of the wet season occurred on March 3, as indicated by the arrow on the X-axis. This major rainfall triggered a period of new plant growth (illustrated by a hypothetical band), which starts usually a few days following the rainfall. In addition, the rainfall triggered an explosion in number of plant-eating insects. Here, this is illustrated by the increase in number of Sphingidae adults captured at night (open circles). The period of time when the egg, larval, and pupal stages were present were inferred from the captured adult Sphingidae curve. The dotted lines are the hypothetical continuation of the curves, which were fitted by eye from the data.

Figure 16.- The influence of the moon phase on the number of adult Sphingidae individuals captured per night.

Figure 17.- The influence of mean air temperature of the night on the number of adult Sphingidae individuals captured per night.

Appendix 1.- Climatic conditions as measured at the meteorological station of the CDRS, Bahía Academia, Puerto Ayora, Santa Cruz Island, Galápagos Islands, Ecuador.

FECHA dd/mm/aa	Tnp. Aire a la sombra SECA °C						Tnp. Aire Sombr Húmeda°C			Tnp. °C Mar	Precipitación (mm)				Sol Media
	6:00	12:0	18:0	Media	Min.	Máx.	6:00	12:00	18:00		6:0	12:0	18:0	Sum a	
01-Jan-99	22.0	27.0	23.8	24.3	21.5	27.7	21.8	24.8	23.5	22.0	2.0	0.0	0.0	0.5	6.2
02-Jan-99	22.5	26.5	24.2	24.4	22.5	27.5	22.2	25.0	24.0	22.6	0.5	0.0	0.0	0.5	5
03-Jan-99	22.0	27.0	24.8	24.6	22.0	27.4	21.7	25.4	24.2	22.0	0.5	0.0	0.0	0.0	10.7
04-Jan-99	21.0	22.3	24.5	22.6	21.0	27.3	20.9	20.5	24.0	22.6	0.0	0.0	0.0	0.0	7.7
05-Jan-99	23.0	27.4	24.3	24.9	23.0	27.7	22.6	25.8	24.2	23.1	0.0	0.0	0.0	5.5	5.2
06-Jan-99	23.0	27.2	24.5	24.9	22.5	27.5	23.0	25.4	23.8	23.5	5.5	0.0	0.0	0.0	6.0
07-Jan-99	23.0	26.9			22.0	27.8	22.8	25.9		23.3	0.0	0.0	0.0	0.0	9.3
08-Jan-99	22.5	25.6	24.5	24.2	22.5	26.4	22.2	24.8	24.2	23.0	0.0	0.0	0.0	0.0	0.0
09-Jan-99	23.2	27.0	24.6	24.9	23.0	27.2	22.5	25.2	24.0	23.5	0.0	0.0	0.0	0.0	4.8
10-Jan-99	20.8	26.4	24.8	24.0	20.5	27.4	20.6	25.3	23.5	23.3	0.0	0.0	0.0	0.0	8.5
11-Jan-99	23.2	26.6	25	24.9	22.5	27.5	22.2	24.5	23.6	24	0.0	0.0	0.0	0.0	10.8
12-Jan-99	23.9	27.2	24.8	25.3	23	28.2	22.7	25.2	23.6	24.6	0.0	0.0	0.0	0.0	5.4
13-Jan-99	23.5	27.3	25.9	25.6	23.5	28	22.9	25.2	24	24.7	0.0	0.0	0.0	0.0	10.3
14-Jan-99	23.5	27.4	25.2	25.4	22	28.2	22.7	25.8	24.6	24.7	0.0	0.0	0.0	0.0	9.8
15-Jan-99	23.6	27.2	24.3	25.0	23.5	27.3	22.8	25.8	23.5	25	0.0	0.0	0.0	0.0	10.5
16-Jan-99	22.5	26.5	24.2	24.4	22	27.4	22	25.2	23.6	24	0.0	0.0	0.0	0.0	5.7
17-Jan-99	20.5	26.2	23.9	23.5	20.5	26.6	20.5	24.8	23.4	23.2	0.0	0.0	0.0	0.0	10.6
18-Jan-99	21	26	23.2	23.4	21	26.2	20.8	23.8	22.5	22.5	0.0	0.0	0.0	0.0	9.7
19-Jan-99	20.5	26	23.5	23.3	19.5	26.8	20.2	24.6	23.4	20.6	0.0	0.0	0.0	0.0	10.8
20-Jan-99	18.6	26.2	23.6	22.8	18.5	26.5	18.4	24.5	23.4	21.5	0.0	0.0	0.0	0.0	9.7
21-Jan-99	21.4	26.2	24.2	23.9	21	26.8	21.1	25.4	23.8	21.7	0.0	0.0	0.0	0.0	9.4
22-Jan-99	22	25.8	24	23.9	21.5	27	21.8	24.3	24	21.8	0.0	0.0	0.0	0.0	6.5
23-Jan-99	19.6	27	23.5	23.4	19.6	27.2	19	25.4	23.2	21.5	0.0	0.0	0.0	0.0	9.0
24-Jan-99	21.2	26.5	23.5	23.7	20	27	20.8	25.3	23	21.2	0.0	0.0	0.0	0.0	4.3
25-Jan-99	22.2	27	24.5	24.6	22.2	27.1	21.8	24.8	24.4	22.5	0.0	0.0	0.0	0.0	8.9
26-Jan-99	22.1	25.1	23.9	23.7	21.7	27.1	21.9	23.2	22.8	22.5	0.0	0.0	0.0	0.0	2.9
27-Jan-99	22	27.1	24	24.4	21.5	27.4	21.8	24.7	23.4	22.4	0.0	0.0	0.0	0.0	7.6
28-Jan-99	19.8	26.4	24.5	23.6	19.6	27.5	19.6	24.4	23.5	22.9	0.0	0.0	0.0	0.0	10.0
29-Jan-99	21.9	26	24.3	24.1	21	27.2	21.4	23.6	23	22.9	0.0	0.0	0.0	0.0	10.4
30-Jan-99	22	27.2	24.4	24.5	22	27.9	21.8	25	23.4	23.1	0.0	0.0	0.0	0.0	9.5
31-Jan-99	24	27	24.8	25.3	20.5	27.5	20.2	25.5	24.3	22.7	0.0	0.0	0.0	0.0	10.5
01-Feb-99											0.0				
MEAN	22.0	26.5	24.3	24.3	21.5		21.5	24.8	23.7	22.9	6.5	0.0	0.0	6.5	7.9

Appendix 1.- continued.

FECHA dd/mm/aa	Tmp. Aire a la sombra SECA °C						Tmp. Aire Sombr Húmeda°C			Tmp. °C Mar	Precipitación (mm)				Sol Media
	6:00	12:0	18:0	Media	Min	Máx.	6:00	12:00	18:00		6:0	12:0	18:0	Sum a	
01-Feb-99	22.7	27.6	25.4	25.2	21.0	28.4	22.2	26.2	23.4	23.5	0.0	0.0	0.0	0.0	6.8
02-Feb-99	22.8	27.8	25.4	25.3	22.4	28.5	22.6	26.1	25.4	22.6	0.0	0.0	0.0	0.0	8.5
03-Feb-99	23.2	28.4	25.6	25.7	22.5	28.7	23.0	26.1	25.5	23.5	0.0	0.0	0.0	0.0	8.3
04-Feb-99	22.2	26.8	25.1	24.7	22.5	28.4	22.0	25.3	24.4	23.0	0.0	0.0	0.0	0.0	10.8
05-Feb-99	21.6	26.2	24.6	24.1	21.5	28.3	21.4	24.8	24.2	23.0	0.0	0.0	0.0	0.0	10.5
06-Feb-99	21.4	27.2	25.0	24.5	21.0	28.4	21.0	25.4	23.2	22.2	0.0	0.0	0.0	0.0	10.1
07-Feb-99	22.4	26.8	25.2	24.8	22.0	28.4	22.2	25.5	24.4	21.7	0.0	0.0	0.0	0.0	10.9
08-Feb-99	22.5	26.6	24.8	24.6	22.5	27.7	22.3	24.9	24.6	22.0	0.0	0.0	0.0	0.0	10.7
09-Feb-99	20.5	26.6	25.8	24.3	20.0	27.9	20.2	25.8	25.4	22.1	0.0	0.0	0.0	0.0	11.3
10-Feb-99	22.6	26.8	25.4	24.9	22.4	28.3	22.1	25.0	24.1	23.6	0.0	0.0	0.0	0.0	9.2
11-Feb-99	22.2	25.8	25.2	24.4	22.2	28.4	21.7	24.2	23.9	22.7	0.0	0.0	0.0	4.5	2.8
12-Feb-99	22.6	27.8	25.0	25.1	22.5	28.8	22.4	25.2	24.2	23.6	4.5	0.0	0.0	0.0	5.6
13-Feb-99	23.7	28.4	25.4	25.8	23.5	30.2	23.1	24.8	24.4	23.9	0.0	0.0	0.0	0.0	4.6
14-Feb-99	23.6	28.1	25.2	25.6	23.5	28.6	22.8	25.4	24.2	24.5	0.0	0.0	0.0	1.2	3.7
15-Feb-99	23.6	26.4	24.4	24.8	23.5	28.6	23.0	24.4	23.8	24.1	1.2	0.0	0.0	0.0	2.1
16-Feb-99	23.5	29.6	24.7	25.9	23.5	29.6	22.9	25.9	23.7	24.3	0.0	0.0	0.0	0.0	7.1
17-Feb-99	23.2	29.8	26.0	26.3	23.2	30.0	22.7	25.4	24.8	23.8	0.0	0.0	0.0	0.0	11.3
18-Feb-99	22.7	28.7	25.8	25.7	22.5	29.6	22.0	25.8	24.7	23.6	0.0	0.0	0.0	0.5	8.9
19-Feb-99	22.1	27.5	26.0	25.2	22.0	28.9	22.1	25.1	25.0	23.1	0.5	0.0	0.0	0.0	7.0
20-Feb-99	24.1	28.2	22.9	25.1	24.0	28.8	23.7	25.6	21.7	24.2	0.0	0.0	2.4	3.0	5.4
21-Feb-99	22.1	29.2	26.4	25.9	22.0	29.5	22.0	26.2	25.5	23.9	0.6	0.0	0.0	0.0	10.1
22-Feb-99	23.4	29.3	26.2	26.3	23.4	30.1	23.2	25.8	24.7	24.8	0.0	0.0	0.0	0.0	10.5
23-Feb-99	23.3	29.8	26.5	26.5	23.3	30.0	23.0	25.4	24.9	24.6	0.0	0.0	0.0	0.0	11.1
24-Feb-99	21.5	27.0	27.0	25.2	21.5	30.2	21.3	25.4	25.2	23.9	0.0	0.0	2.2	2.2	7.3
25-Feb-99	21.2	28.0	29.4	26.2	21.0	31.0	21.0	25.8	25.6	24.1	0.0	0.0	0.0	0.0	7.4
26-Feb-99	21.8	29.9	27.2	26.3	21.2	29.6	21.4	27.8	25.4	24.0	0.0	0.0	0.0	0.0	10.5
27-Feb-99	22.2	28.2	28.2	26.2	22.2	29.6	21.8	25.7	25.8	24.9	0.0	0.0	0.0	0.0	10.0
28-Feb-99	23.7	29.2	26.4	26.4	23.7	31.6	23.3	26.9	25.1	24.8	0.0	0.0	0.0	0.0	9.3
01-Mar-99											0.0				
MEAN	22.6	27.9	25.7	25.4	22.4	29.1	22.2	25.6	24.5	23.6	6.8	0.0	4.6	11.4	8.3

Appendix 1.- continued.

FECHA dd/mm/aa	Tmp. Aire a la sombra SECA °C						Tmp. Aire Sombr Húmeda °C			Tmp. °C Mar	Precipitación (mm)				Sol Media
	6:00	12:00	18:00	Media	Min	Máx.	6:00	12:00	18:00		6:00	12:00	18:00	Suma	
01-Mar-99	22.3	28.8	26.7	25.9	22.3	31.0	21.9	26.1	25.7	24.5	0.00	0.00	0.00	0.0	5.8
02-Mar-99	23.5	30.0	27.2	26.9	23.5	30.6	23.3	27.0	25.8	25.0	0.00	0.00	0.00	0.0	10.9
03-Mar-99	22.4	28.3	26.4	25.7	22.4	29.9	22.1	26.6	25.5	25.9	0.00	0.00	20.20	27.0	5.2
04-Mar-99	23.0	27.2	27.1	25.8	23.0	31.8	22.9	25.7	25.9	25.7	6.80	0.00	0.00	11.5	2.6
05-Mar-99	23.5	30.9	27.1	27.2	23.5	31.5	23.5	27.5	25.5	25.9	###	0.00	0.00	0.0	9.7
06-Mar-99	22.1	31.6	27.5	27.1	22.1	32.5	21.9	25.8	27.0	25.7	0.00	0.00	0.00	0.0	11.0
07-Mar-99	22.9	31.8	26.2	27.0	22.9	33.5	22.4	28.3	25.8	24.6	0.00	0.00	0.00	0.0	9.8
08-Mar-99	21.3	28.4	26.7	25.5		29.7	20.8	25.7	25.7	24.2	0.00	0.00	0.00	0.0	10.1
09-Mar-99	22.6	29.4	27.5	26.5	22.5	30.4	22.4	26.4	26.2	26.0	0.00	0.00	0.00	0.0	10.3
10-Mar-99	22.4	28.6	27.4	26.1	22.5	31.6	22.2	26.0	27.2	25.5	0.00	0.00	0.00	0.0	8.8
11-Mar-99	22.8	28.4	27.5	26.2	23.0	31.9	22.6	26.1	25.3	25.4	0.00	0.00	0.00	0.0	10.8
12-Mar-99	23.5	28.0	27.0	26.2	23.5	32.9	23.1	25.5	24.0	23.9	0.00	0.00	0.00	0.0	10.6
13-Mar-99	23.2	29.2	27.4	26.6	23.2	32.0	22.8	28.3	26.2	25.0	0.00	0.00	0.00	0.0	10.6
14-Mar-99	22.0	29.5	26.7	26.1	22.0	30.2	21.4	28.5	25.2	25.0	0.00	0.00	0.00	0.0	4.6
15-Mar-99	22.2	29.4	26.7	26.1	22.2	30.0	22.0	26.8	25.5	24.6	0.00	0.00	0.00	0.0	9.6
16-Mar-99	23.2	28.4	24.8	25.5	23.2	28.8	23.0	26.6	24.8	25.0	0.00	0.00	7.40	8.4	5.6
17-Mar-99	24.4	28.6	26.6	26.5	24.3	29.1	24.3	26.8	25.7	25.6	1.00	0.00	0.00	0.0	9.8
18-Mar-99	22.0	28.4	26.8	25.7	22.0	29.6	21.8	27.0	26.0	24.0	0.00	0.00	0.00	0.0	9.8
19-Mar-99	22.2	28.9	25.0	25.4	22.2	30.2	22.0	26.8	25.0	24.5	0.00	0.00	0.00	0.0	8.3
20-Mar-99	22.2	27.9	26.4	25.5	22.2	28.8	22.1	26.1	25.6	25.3	0.00	0.00	0.10	0.1	0.9
21-Mar-99	22.9	27.4	27.7	26.0	21.5	30.1	22.8	25.2	26.2	24.7	0.00	0.00	0.00	0.0	1.8
22-Mar-99	24.2	29.8	27.2	27.1	24.0	32.3	24.0	27.2	25.2	24.7	0.00	0.00	0.00	0.0	8.9
23-Mar-99	22.6	28.4	26.8	25.9	22.5	31.7	22.4	25.7	25.1	25.0	0.00	0.00	0.00	0.0	10.1
24-Mar-99	24.8	32.3	27.6	28.2		32.6	24.1	27.6	25.6	25.0	0.00	0.00	0.00	0.0	9.5
25-Mar-99	23.3	31.4	27.4	27.4	23.3	31.5	22.9	26.7	26.1	24.3	0.00	0.00	0.00	0.0	10.3
26-Mar-99	22.7	29.0	26.8	26.2	22.5	29.5	22.3	26.6	25.9	24.2	0.00	0.00	0.00	0.0	9.0
27-Mar-99	23.3	29.4	27.0	26.6	23.3	30.3	23.0	27.1	26.0	24.8	0.00	0.00	0.00	0.0	8.5
28-Mar-99	23.5	28.3	25.8	25.9	23.5	29.9	23.1	26.0	25.2	25.2	0.00	0.00	0.00	0.0	2.8
29-Mar-99	22.4	28.9	26.8	26.0	22.4	29.7	22.2	26.4	26.7	25.0	0.00	0.00	0.00	0.0	9.7
30-Mar-99	23.1	29.6	26.7	26.5	22.9	29.9	22.9	26.8	26.3	23.3	0.00	0.00	0.00	0.0	9.4
31-Mar-99	24.1	30.0	27.2	27.1	24.1	30.2	23.9	27.8	25.8	25.7	0.00	0.00	0.00	0.0	9.4
01-Apr-99											0.00				
MEAN	22.9	29.2	26.8	26.3	22.8	30.8	22.6	26.7	25.7	24.9	19.3	0.0	27.7	47.0	8.2

Appendix 1.- continued.

FECHA dd/mm/aa	Tmp. Aire a la sombra SECA °C						Tmp. Aire Somb Húmeda °C			Tmp. °C Mar	Precipitación (mm)				Sol Media
	6:00	12:00	18:00	Media	Min	Máx.	6:00	12:00	18:00		6:00	12:00	18:00	Suma	
01-Apr-99	23.2	29.2	27.2	26.5	23.2	30.0	23.1	26.4	26.4	25.7	0.0	0.0	0.0	0.0	9.4
02-Apr-99	24.2	31.3	27.1	27.5	24.2	32.0	23.8	27.2	26.0	26.6	0.0	0.0	0.0	0.0	8.1
03-Apr-99	22.4	30.0	25.6	26.0	21.8	30.0	22.0	26.8	25.2	26.4	0.0	0.0	1.4	0.0	4.2
04-Apr-99	23.2	28.0	25.4	25.5	22.4	29.6	23.0	26.6	25.0	26.2	2.9	0.0	0.2	4.3	3.1
05-Apr-99	23.6	27.2	25.6	25.5	23.0	29.0	23.2	25.2	24.8	26.1	2.6	0.0	0.0	2.8	5.4
06-Apr-99	21.8	27.8	25.2	24.9	21.5	28.2	21.6	25.2	24.0	25.9	0.1	0.0	0.0	0.1	1.2
07-Apr-99	22.0	27.2	25.0	24.7	21.0	28.0	21.8	25.0	24.0	26.0	0.0	0.0	0.0	0.0	10.0
08-Apr-99	22.0	26.6	24.8	24.5	21.8	28.0	21.8	24.2	24.0	25.1	0.0	0.0	0.0	0.0	9.5
09-Apr-99	23.2	27.2	24.8	25.1	21.5	27.6	22.8	25.0	24.2	24.9	0.0	0.0	0.0	0.0	10.1
10-Apr-99	23.0	27.1	24.7	24.9	21.0		22.8	25.4	24.5	24.9	0.0	0.0	0.0	0.0	10.5
11-Apr-99	23.0	26.8	24.6	24.8	21.5	27.4	22.4	25.2	24.2	25.1	0.1	0.5	0.0	0.1	8.1
12-Apr-99	24.0	26.2	24.4	24.9	21.5	27.2	23.4	24.8	23.6	25.0	0.0	0.0	0.0	0.5	6.1
13-Apr-99	23.3	27.6	25.1	25.3	21.3	28.1	23.0	25.8	24.4	24.3	0.0	0.0	0.0	0.0	4.5
14-Apr-99	23.6	27.0	24.5	25.0	23.0	27.8	23.3	25.6	23.8	23.3	0.3	0.0	0.0	0.3	8.6
15-Apr-99	22.7	26.0	24.5	24.4	22.3	27.6	22.4	24.1	23.4	23.6	0.0	0.0	0.0	0.0	6.9
16-Apr-99	22.4	27.2	24.2	24.6	22.0	27.4	22.0	25.2	23.3	23.5	0.0	0.0	0.0	0.0	7.2
17-Apr-99	20.4	27.0	24.5	24.0	20.0	27.5	20.1	24.7	24.0	21.9	0.0	0.0	0.0	0.0	9.1
18-Apr-99	21.0	27.8	24.9	24.6	20.5	28.2	20.8	25.6	24.0	23.6	0.0	0.0	0.0	0.0	8.8
19-Apr-99	23.2	28.0	25.0	25.4	22.7	28.6	22.8	26.2	24.4	24.4	0.0	0.0	0.0	0.0	9.8
20-Apr-99	23.7	27.6	24.2	25.2	23.6	28.4	23.3	25.6	23.4	24.3	0.0	0.0	0.0	0.0	7.7
21-Apr-99	23.3	27.2	24.4	25.0	23.0	27.8	23.0	25.4	24.1	23.9	0.0	0.0	0.0	0.0	7.5
22-Apr-99	22.9	25.0	24.7	24.2	22.3	27.5	22.3	23.9	24.4	22.3	0.0	0.0	0.0	0.0	8.8
23-Apr-99	22.0	26.5	24.0	24.2	21.7	27.3	21.8	25.2	23.2	22.0	0.0	0.0	0.0	0.0	6.7
24-Apr-99	22.5	26.6	25.0	24.7	21.9	27.2	22.1	25.2	24.6	22.3	0.0	0.0	0.0	0.0	9.6
25-Apr-99	22.3	27.4	24.0	24.6	22.0	27.8	22.0	25.6	23.4	22.8	0.0	0.0	0.0	0.0	6.5
26-Apr-99	22.9	25.4	23.9	24.1	22.6	26.9	22.6	24.4	23.3	22.9	0.0	0.0	0.0	0.0	2.4
27-Apr-99	20.8	27.0	24.0	23.9	20.7	27.2	20.6	25.4	23.6	23.0	0.0	0.0	0.0	0.0	2.4
28-Apr-99	20.8	25.8	23.6	23.4	20.5	26.7	20.6	24.2	23.2	22.9	0.0	0.0	0.0	0.0	2.4
29-Apr-99	19.9	26.4	23.6	23.3	19.8	27.2	19.8	24.6	22.9	22.7	0.0	0.0	0.0	0.0	2.4
30-Apr-99	20.8	26.6	23.6	23.7	20.0	27.2	20.4	24.8	22.8	23.0	0.0	0.0	0.0	0.0	2.4
01-May-99											0.0				
MEAN	22.5	27.2	24.7	24.8	21.8	28.0	22.2	25.3	24.1	24.2	6.0	0.5	1.6	8.1	6.6

Appendix 1.- continued.

FECHA dd/mm/aa	Tmp. Aire a la sombra SECA °C						Tmp. Aire Sombr Húmeda °C			Tmp. °C Mar	Precipitación (mm)				Sol Media
	6:00	12:00	18:00	Media	Min	Máx.	6:00	12:00	18:00		6:00	12:00	18:00	Suma	
01-May-99	20.8	26.6	24.0	23.8	20.5	27.2	20.6	24.7	23.4	23.3	0.0	0.0	0.0	0.0	8.3
02-May-99	23.1	26.2	23.7	24.3	22.9	27.6	22.6	25.0	23.2	24.0	0.0	0.0	0.0	0.0	4.8
03-May-99	21.1	26.9	23.8	23.9	21.0	26.2	20.0	25.1	22.9	24.0	0.0	0.0	0.0	0.0	8.3
04-May-99	23.1	24.4	23.9	23.8	21.0	25.6	22.2	22.2	23.5	24.1	0.0	0.0	0.0	0.0	3.3
05-May-99	22.0	26.4	23.5	24.0	21.8	27.0	21.9	24.5	22.8	23.2	0.0	0.0	0.0	0.0	10.6
06-May-99	22.5	26.4	23.7	24.2	21.0	27.0	22.0	24.2	23.2	23.5	0.0	0.0	0.0	0.0	7.8
07-May-99	23.0	26.5	24.0	24.5	23.0	27.2	22.4	24.9	23.6	23.3	0.0	0.0	0.0	0.0	8.7
08-May-99	23.6	26.9	24.2	24.9	23.4	26.4	23.1	24.8	23.5	23.7	0.0	0.0	0.0	0.0	6.9
09-May-99	21.5	26.5	24.4	24.1	21.0	27.6	21.2	25.0	24.2	23.7	0.0	0.0	0.0	0.0	6.4
10-May-99	23.7	27.6	24.7	25.3	23.3	27.6	23.3	25.4	23.7	24.2	0.0	0.0	0.0	0.0	6.4
11-May-99	21.6	28.8	24.8	25.1	21.0	28.8	21.4	25.4	23.6	24.2	0.0	0.0	0.0	0.0	7.1
12-May-99	24.2	28.4	25.4	26.0	23.5	28.9	23.7	26.6	24.8	25.1	0.0	0.0	0.0	2.0	7.1
13-May-99	23.6	26.4	24.4	24.8	23.3	26.9	23.3	24.6	23.6	25.0	2.0	0.0	0.0	0.0	4.5
14-May-99	23.3	25.4	24.0	24.2	22.8	25.8	22.8	24.0	23.2	24.5	0.0	0.0	0.0	0.0	1
15-May-99	23.2	26.4	24.4	24.7	23.0	27.4	23.0	24.8	23.3	24.5	0.0	0.0	0.0	0.0	8.5
16-May-99	23.7	27.9	24.4	25.3	23.0	28.2	23.2	25.8	23.8	24.7	0.0	0.0	0.0	0.0	8.5
17-May-99	23.7	27.8	24.4	25.3	23.2	28.6	23.2	25.8	23.8	24.6	0.0	0.0	0.0	0.0	8.4
18-May-99	22.2	27.2	24.2	24.5	22.0	28.0	22.0	25.4	23.8	24.2	0.0	0.0	0.0	0.0	9.2
19-May-99	21.4	26.9	23.8	24.0	21.0	28.2	21.2	24.5	23.1	24.2	0.0	0.0	0.0	0.0	9.9
20-May-99	21.4	27.8	24.6	24.6	21.0	27.8	21.2	25.4	24.0	23.8	0.0	0.0	0.0	0.0	4.7
21-May-99	23.3	27.9	24.6	25.3	23.3	28.2	23.0	25.8	24.0	23.9	0.0	0.0	0.0	0.0	8
22-May-99	22.0	27.2	23.6	24.3	21.8	27.6	21.8	25.6	23.0	23.7	0.0	0.0	0.0	0.0	9.3
23-May-99	20.3	26.6	24.2	23.7	20.1	27.9	20.0	24.8	23.6	23.3	0.0	0.0	0.0	0.0	8.3
24-May-99	22.7	28.0	24.7	25.1	22.4	28.4	22.4	26.0	24.2	23.9	0.0	0.0	0.0	0.0	5
25-May-99	23.7	26.2	24.6	24.8	23.5	28.4	23.1	24.8	23.8	23.8	0.0	0.0	0.0	0.0	9.2
26-May-99	23.6	27.2	24.5	25.1	23.3	26.8	23.3	24.7	24.2	23.4	0.0	0.0	0.0	0.0	1.4
27-May-99	22.4	26.8	24.4	24.5	22.2	27.6	22.4	25.7	24.0	23.5	0.0	0.0	0.0	0.0	6.2
28-May-99	23.7	26.4	24.8	25.0	23.7	27.8	23.4	25.2	24.3	24.2	0.0	0.0	0.0	0.0	2.2
29-May-99	23.4	26.5	24.5	24.8	22.9	27.8	22.9	25.2	23.9	23.5	0.0	0.0	0.0	0.0	4
30-May-99	23.2	23.9	24.0	23.7	23.0	27.7	22.8	23.6	23.8	23.4	0.0	0.5	0.0	1.0	0.4
31-May-99	22.8	25.8	23.7	24.1	22.6	26.6	22.6	24.7	23.4	23.3	0.5	0.0	0.0	0.0	0.7
01-Jun-99											0.0				
MEAN	22.7	26.8	24.3	24.6	22.3	27.5	22.3	25.0	23.7	23.9	2.5	0.5	0.0	3.0	6.3

Appendix 1.- continued.

FECHA dd/mm/aa	Tmp. Aire a la sombra SECA °C						Tmp. Aire Sombr Húmeda °C			Tmp. °C Mar	Precipitación (mm)				Sol Media
	6:00	12:00	18:00	Media	Min	Máx.	6:00	12:00	18:00		6:00	12:00	18:00	Suma	
01-Jun-99	22.8	27.0	24.0	24.6	22.4	27.4	22.4	25.4	23.6	22.8	0.00	0.00	0.00	0.00	2.5
02-Jun-99	22.8	25.8	24.0	24.2	22.3	26.3	22.4	23.8	23.4	23.2	0.00	0.00	0.00	0.10	4.8
03-Jun-99	20.7	25.5	23.8	23.3	20.4	26.4	20.4	24.0	23.5	22.4	0.10	0.00	0.00	0.00	5.1
04-Jun-99	21.4	24.8	23.2	23.1	21.0	25.4	21.1	23.8	23.0	21.9	0.00	0.00	0.20	0.20	0.8
05-Jun-99	22.6	26.0	23.8	24.1	22.4	26.4	22.4	25.2	23.4	22.4	0.00	0.00	0.00	0.80	2.5
06-Jun-99	22.0	25.4	23.8	23.7	21.5	26.4	21.9	24.4	23.4	22.5	0.80	0.00	0.00	0.00	1.2
07-Jun-99	22.3	23.6	23.4	23.1	22.0	26.0	22.1	23.2	22.7	22.4	0.00	0.00	0.00	0.00	0.6
08-Jun-99	22.2	26.4	23.0	23.9	21.0	27.0	21.8	24.6	22.6	22.6	0.00	0.00	0.00	0.00	8.6
09-Jun-99	21.8	24.2	22.4	22.8	21.4	25.8	21.4	23.0	22.1	22.6	0.00	0.00	0.00	0.00	3.3
10-Jun-99	22.0	24.8	23.2	23.3	21.7	25.9	21.8	23.4	22.6	22.7	0.00	0.00	0.00	1.20	3.7
11-Jun-99	21.4	25.0	23.1	23.2	21.0	25.4	21.2	23.6	22.6	22.4	1.20	0.00	0.00	0.00	4.2
12-Jun-99	21.8	24.2	23.1	23.0	21.0	25.4	21.6	23.2	22.8	22.6	0.00	0.00	0.00	0.60	2.1
13-Jun-99	22.0	24.8	23.0	23.3	21.5	26.1	21.8	23.6	22.8	22.3	0.60	0.00	0.00	0.00	1.9
14-Jun-99	21.6	25.6	22.8	23.3	21.4	26.0	21.4	24.1	22.6	22.3	0.00	0.00	0.00	0.00	5.9
15-Jun-99	21.4	25.0	22.8	23.1	21.2	25.4	21.2	23.8	22.4	22.3	0.00	0.00	0.00	0.00	1.7
16-Jun-99	19.8	25.2	22.6	22.5	19.0	25.7	19.4	23.8	22.2	21.7	0.00	0.00	0.00	0.00	2
17-Jun-99	21.4	24.6	23.1	23.0	21.0	25.8	21.2	23.9	22.6	22.0	0.00	0.00	0.00	0.10	8.1
18-Jun-99	22.0	24.9	22.8	23.2	21.0	26.3	21.7	23.6	22.6	22.4	0.10	0.00	0.00	0.00	3.3
19-Jun-99	21.6	24.0	22.6	22.7	21.4	25.2	21.4	22.6	22.0	22.2	0.00	0.00	0.00	0.00	6.7
20-Jun-99	21.2	24.2	22.4	22.6	20.9	25.4	20.9	22.6	21.8	21.8	0.00	0.00	0.00	0.00	0.6
21-Jun-99	21.3	24.0	22.6	22.6	20.5	25.3	20.6	22.4	22.0	21.9	0.00	0.00	0.00	0.00	1.1
22-Jun-99	20.8	25.2	22.6	22.9	19.8	25.6	20.6	23.2	21.6	22.0	0.00	0.00	0.00	0.00	7.6
23-Jun-99	19.2	24.8	22.5	22.2	18.9	25.6	19.0	23.1	21.8	21.6	0.00	0.00	0.00	0.00	7.3
24-Jun-99	19.4	24.6	22.7	22.2	18.8	26.4	19.3	23.4	22.2	21.6	0.00	0.00	0.00	0.00	10.6
25-Jun-99	21.4	25.0	22.4	22.9	19.8	25.6	21.2	23.4	22.3	21.9	0.00	0.30	0.00	0.80	6.1
26-Jun-99	21.6	25.1	23.0	23.2	19.9	25.5	21.4	23.8	22.1	22.0	0.50	0.00	0.00	0.00	1.5
27-Jun-99	21.7	25.1	23.2	23.3	19.8	25.8	21.3	23.4	22.4	22.1	0.00	0.00	0.00	0.00	0
28-Jun-99	22.1	25.7	22.6	23.5	21.0	26.1	21.2	24.2	21.0	22.3	0.00	0.00	0.00	0.00	4.3
29-Jun-99	22.7	23.6	22.4	22.9	21.1	24.3	21.1	22.0	21.1	22.1	0.00	0.00	0.00	0.00	1.7
30-Jun-99	19.6	24.0	22.6	22.1	19.0	25.3	19.4	22.4	21.4	22.3	0.00	0.00	0.00	0.00	7.6
01-Jul-99											0.00				
MEAN	21.5	24.9	23.0	23.1	20.8	25.8	21.2	23.6	22.4	22.2	3.3	0.3	0.2	3.8	3.9

Appendix 1.- continued.

FECHA dd/mm/aa	Tmp. Aire a la sombra SECA °C						Tmp. Aire Sombr Húmeda °C			Tmp. °C Mar	Precipitación (mm)				Sol Media
	6:00	12:00	18:00	Media	Min	Máx.	6:00	12:00	18:00		6:00	12:00	18:00	Suma	
01-Jul-99	22	25.8	22.8	23.5	20.2	26.0	20.8	23.4	21.4	22.4	0.0	0.0	0.0	0.00	8.2
02-Jul-99	18.7	25.2	22.8	22.2	18	26	18.5	22.8	21.6	22.1	0.0	0.0	0.0	0.00	8.2
03-Jul-99	19.9	24.0	22.8	22.2	19	25.0	19.6	22.3	22	22.4	0.0	0.0	0.0	0.20	2.3
04-Jul-99	20.3	25.4	22.6	22.8	19.6	26.4	20.1	23.6	21.8	22.5	0.2	0.0	0.0	0.60	4.5
05-Jul-99	21.1	25.4	22.7	23.1	19.9	26.4	20.8	23.6	21.8	22.4	0.6	0.0	0.0	0.00	4.8
06-Jul-99	21.8	23.4	22.7	22.6	20.0	24.4	21.4	22	21.6	22.6	0.0	0.1	0.0	0.10	0.2
07-Jul-99	22	24	22.8	22.9	20.5	24.9	21.2	22.6	22	21.8	0.0	0.0	0.0	0.00	0.0
08-Jul-99	21.3	25	22	22.8	20.2	25.4	20.9	23.0	21.2	22.1	0.0	0.0	0.0	0.00	1.8
09-Jul-99	21.3	24.4	21.8	22.5	20.3	24.6	21	23.0	21.6	22.4	0.0	0.0	0.0	0.30	0.1
10-Jul-99	20.6	23	21.4	21.7	19.0	24.8	20.4	22.2	20.8	22.1	0.3	0.0	0.2	0.60	0.9
11-Jul-99	20.6	23.8	20.7	21.7	20.0	24.2	20.3	22.4	20.5	21.8	0.4	0.0	0.0	0.00	1.5
12-Jul-99	20.8	23	21.5	21.8	19.9	23.7	19.9	21.8	20.8	21.4	0.0	0.0	0.0	0.00	0.1
13-Jul-99	20.8	24	21.8	22.2	20.2	24.2	20.2	22.1	20.9	21.0	0.0	0.0	0.0	0.00	1.4
14-Jul-99	20.7	23.2	21.2	21.7	18.5	24.6	20	21.6	20.5	21.1	0.0	0.0	0.0	0.50	2.6
15-Jul-99	20.4	23.5	21.4	21.8	20	25	19.6	21	20	21.1	0.5	0.5	0.0	0.50	4.0
16-Jul-99	19.6	24.6	21.4	21.9	19.4	25.2	19.4	22	20.4	21.0	0.0	0.0	0.0	0.00	5.3
17-Jul-99	20.7	23.6	21.4	21.9	20.5	25.0	20	21.6	20.4	21.3	0.0	0.0	0.0	0.00	3.6
18-Jul-99	20.6	22.7	20.2	21.2	20.5	23.9	20.0	21.5	19.3	21.5	0.0	0.0	0.0	0.70	1.5
19-Jul-99	20	22.2	21.2	21.1	19.8	22.6	19.4	20.5	19.8	21.2	0.7	0.0	0.0	0.00	0.0
20-Jul-99	20.6	23.1	21	21.6	20.3	23.7	19.2	21.5	19.8	20.9	0.0	0.3	0.0	0.30	0.7
21-Jul-99	20.5	22.4	21	21.3	20.3	23.1	19.8	20.2	19.9	20.2	0.0	0.0	0.0	0.00	1.1
22-Jul-99	19.8	22.4	20.8	21	19.5	23.7	19	21	19.8	20.8	0.0	0.0	0.0	0.10	3.1
23-Jul-99	19.6	21.2	19.9	20.2	19.2	22.4	19.2	20.2	19.7	20.7	0.1	0.0	0.4	1.00	0.2
24-Jul-99	19.6	21.4	19.8	20.3	19.2	22.4	19.1	20.8	19.5	19.9	0.6	0.1	0.2	0.60	0.0
25-Jul-99	19.5	22.3	20.1	20.6	19.2	22.8	19.2	21.2	19.8	20.1	0.3	0.0	0.0	0.60	0.1
26-Jul-99	19.4	21.6	20.2	20.4	19.2	22.9	19.2	20.4	19.4	20.6	0.6	0.0	0.0	0.00	0.1
27-Jul-99	19.6	23.1	20.7	21.1	19.5	23.2	18.9	20.8	19.8	20.5	0.0	0.0	0.0	0.00	0.1
28-Jul-99	20	22.3	20.2	20.8	19.8	24	19	20.7	19.3	20.4	0.0	0.0	0.0	0.00	0.1
29-Jul-99	19.4	21.5	20.6	20.5	19.2	23.0	18.8	20.1	20.2	20.2	0.0	0.0	0.0	0.00	0.1
30-Jul-99	19.4	21.3	20.9	20.5	19.2	23.2	19.2	20.2	20.4	19.9	0.0	0.0	0.0	0.00	0.1
31-Jul-99	19.6	23	20.6	21.1	19.5	23.2	19	21.3	19.8	20.0	0.0	0.0	0.0	0.00	5.6
01-Aug-99											0.0				
MEAN	20.3	23.3	21.3	21.6	19.7	24.2	19.8	21.7	20.5	21.2	4.3	1.0	0.8	6.1	2.0

Appendix 1.- continued.

FECHA dd/mm/aa	Tmp. Aire a la sombra SECA °C						Tmp. Aire Sombr Húmeda °C			Tmp. °C Mar	Precipitación (mm)				Sol Media
	6:00	12:00	18:00	Media	Min	Máx.	6:00	12:00	18:00		6:00	12:00	18:00	Suma	
01-Aug-99	19.7	22.5	20.6	20.9	19.2	23.2	19.2	21.1	20.0	20.1	0.00	0.00	0.00	1.00	1.5
02-Aug-99	20.0	20.9	20.2	20.4	19.0	21.7	19.0	20.4	19.8	19.8	1.00	0.40	0.00	1.00	0.6
03-Aug-99	19.0	21.6	20.0	20.2	18.8	22.1	18.8	20.6	20.0	19.8	0.60	0.20	0.10	0.30	0.3
04-Aug-99	20.4	23.0	20.7	21.4	19.4	23.2	19.4	21.3	19.2	20.6	0.00	0.00	0.00	0.00	0.7
05-Aug-99	20.2	22.5	21.0	21.2	18.2	23.6	19.4	19.9	19.6	20.7	0.00	0.00	0.00	0.00	0.2
06-Aug-99	20.2	21.4	21.0	20.9	18.4	23.8	19.5	20.4	19.7	20.6	0.00	0.00	0.00	1.90	5.3
07-Aug-99	20.4	21.9	21.8	21.4	19.2	22.4	19.6	20.3	19.9	21.0	1.90	0.00	0.00	0.40	3.6
08-Aug-99	20.2	21.2	20.2	20.5	19.0	22.4	19.0	20.4	19.3	20.8	0.40	0.00	0.00	0.00	0.4
09-Aug-99	19.5	22.8	20.8	21.0	19.0	23.6	18.8	21.0	20.0	21.4	0.00	0.50	0.00	0.50	3.2
10-Aug-99	20.6	22.2	21.2	21.3	20.4	23.6	19.6	21.4	20.3	21.8	0.00	0.50	0.00	3.10	0.0
11-Aug-99	20.3	22.6	21.2	21.4	20.0	23.2	20.1	21.6	20.4	21.5	2.60	0.00	0.00	0.10	0.2
12-Aug-99	20.4	22.2	20.7	21.1	20.0	23.2	19.8	20.9	20.2	21.5	0.10	0.00	0.00	0.00	0.0
13-Aug-99	20.5	22.2	20.8	21.2	20.4	23.3	20.0	20.8	20.0	21.5	0.00	0.00	0.00	0.60	0.5
14-Aug-99	19.8	22.8	20.8	21.1	19.3	23.6	18.9	21.0	19.6	21.4	0.60	0.00	0.00	0.00	3.8
15-Aug-99	19.6	22.8	20.8	21.1	19.0	23.6	19.0	21.0	20.0	20.6	0.00	0.00	0.00	0.00	0.0
16-Aug-99	19.9	23.0	20.2	21.0	19.8	23.8	19.0	21.2	19.4	20.5	0.00	0.00	0.00	0.00	5.2
17-Aug-99	18.8	21.5	20.4	20.2	18.6	22.9	18.6	20.3	20.2	20.1	0.00	0.00	0.10	0.10	2.0
18-Aug-99	19.3	23.1	20.5	21.0	19.0	23.4	18.9	21.7	20.0	20.1	0.00	0.40	0.00	0.80	2.9
19-Aug-99	19.4	22.0	20.2	20.5	19.2	23.4	19.0	20.8	19.7	20.5	0.40	0.00	0.00	0.00	2.2
20-Aug-99	20.5	23.2	21.2	21.6	19.2	24.2	19.0	21.0	20.0	20.1	0.00	0.00	0.00	0.00	3.5
21-Aug-99	20.4	21.6	20.0	20.7	19.5	24.2	19.2	20.5	19.4	20.0	0.00	0.30	0.20	0.50	1.5
22-Aug-99	20.6	22.6	20.5	21.2	20.4	24.4	20.0	20.8	19.6	20.0	0.00	0.60	0.00	0.60	1.1
23-Aug-99	19.4	20.4	20.2	20.0	19.0	24.4	18.6	19.4	18.6		0.00	0.00	0.00	0.10	0.0
24-Aug-99	18.8	21.2	20.5	20.2	18.4	22.4	18.4	19.8	19.1		0.10	0.00	0.00	0.00	1.7
25-Aug-99	20.2	19.5	20.0	19.9	18.9	22.6	18.9	19.2	19.0		0.00	0.00	0.40	0.90	0.6
26-Aug-99	19.3	23.6	20.4	21.1	17.9	23.8	18.8	21.4	20.0		0.50	0.00	0.00	0.00	5.8
27-Aug-99	19.4	23.4	20.6	21.1	19.0	23.5	19.2	21.6	19.6	21.2	0.00	0.00	0.00	0.40	1.0
28-Aug-99	19.8	21.0	20.2	20.3	19.0	23.2	19.2	20.0	19.4	21.3	0.40	0.20	0.00	0.60	2.0
29-Aug-99	19.9	20.4	20.1	20.1	19.1	23.0	19.1	19.8	19.2	21.1	0.40	0.20	0.00	0.60	1.5
30-Aug-99	19.1	20.8	20.2	20.0	18.1	22.4	18.2	19.4	19.3	21.3	0.40	0.00	0.00	0.00	1.4
31-Aug-99	19.3	22.4	20.4	20.7	18.3	22.4	18.6	20.4	19.1	21.2	0.00	0.00	0.00	0.00	1.6
01-Sep-99											0.20				
MEAN	19.8	22.0	20.6	20.8	19.1	23.2	19.1	20.6	19.7	20.8	9.6	3.3	0.8	13.5	1.8

Appendix 1.- continued.

FECHA dd/mm/aa	Tmp. Aire a la sombra SECA °C						Tmp. Aire Sombr Húmeda°C			Tmp. °C Mar	Precipitación (mm)				Sol Media
	6:00	12:00	18:00	Media	Min	Máx.	6:00	12:00	18:00		6:00	12:00	18:00	Suma	
01-Sep-99	18.7	20.6	20.2	19.8	18.3	22.6	18.4	19.6	19.0	20.9	0.20	0.10	0.00	0.10	5.2
02-Sep-99	19.0	22.8	19.2	20.3	18.4		18.4	21.2	18.8	20.3	0.00	0.00	0.00	0.00	1.4
03-Sep-99	18.8	21.8	20.1	20.2	18.3		18.3	20.2	19.0	20.4	0.00	0.00	0.00	0.10	6.1
04-Sep-99	18.3	22.2	20.2	20.2	18.0		18.0	20.8	19.6	20.4	0.10	0.00	0.00	0.60	4
05-Sep-99	18.4	21.6	20.0	20.0	18.0	25.0	18.1	20.7	19.4	20.3	0.60	0.00	0.00	0.10	0.5
06-Sep-99	19.1	21.8	19.7	20.2	18.8	23.5	18.8	20.2	19.0	20.6	0.10	0.00	0.00	0.60	0.7
07-Sep-99	18.6	20.8	19.4	19.6	18.4	21.5	18.4	19.9	18.9	20.3	0.60	0.00	0.00	0.30	0.3
08-Sep-99	19.0	20.4	19.6	19.7	18.6	21.1	18.6	19.7	18.7	20.3	0.30	0.30	0.00	0.30	0.1
09-Sep-99	19.4	22.3	20.0	20.6	18.2	22.5	18.6	20.3	18.8	20.1	0.00	0.00	0.00	0.40	1.4
10-Sep-99	18.8	21.6	19.8	20.1	18.2	23.1	18.2	20.4	18.8	20.2	0.40	0.10	0.00	0.10	4.1
11-Sep-99	19.1	22.2	19.3	20.2	18.0	23.0	18.3	20.2	18.4	20.4	0.00	0.00	0.00	0.30	4.7
12-Sep-99	18.4	21.8	20.2	20.1	18.2	23.5	18.2	20.4	19.4	20.3	0.30	0.00	0.00	0.00	4.1
13-Sep-99	18.8	21.6	19.8	20.1	18.0	22.5	18.4	20.2	18.8	20.5	0.00	0.00	0.00	1.00	0.5
14-Sep-99	18.6	22.8	20.0	20.5	18.0	22.5	18.4	20.8	19.8	20.0	1.00	0.00	0.00	0.40	1
15-Sep-99	18.4	21.2	19.4	19.7	17.0	22.5	18.2	20.2	19.0	20.0	0.40	0.20	0.00	0.50	5.6
16-Sep-99	18.0	22.4	19.4	19.9	17.4	23.0	17.8	21.0	18.8	19.8	0.30	0.00	0.00	0.10	7
17-Sep-99	19.2	20.6	20.2	20.0		23.0	18.2	19.4	18.0	19.8	0.10	0.00	0.00	0.00	2
18-Sep-99	19.4	22.0	20.2	20.5	19.0	23.0	18.2	20.4	19.2	20.0	0.00	0.00	0.00	0.00	2.5
19-Sep-99	19.2	22.0	20.4	20.5	19.0	23.0	18.2	21.0	19.4	20.0	0.00	0.00	0.00	0.00	1
20-Sep-99	19.2	23.0	20.2	20.8	18.0		19.0	21.2	19.4	20.2	0.00	0.00	0.00	0.00	1.1
21-Sep-99	20.0	22.0	20.4	20.8	18.5	22.0	19.2	20.4	19.4	20.4	0.00	0.00	0.00	0.00	0.4
22-Sep-99	18.8	22.2	20.8	20.6	18.5	23.5	18.6	20.6	19.6	20.2	0.00	0.00	0.00	0.00	5.5
23-Sep-99	20.4	23.6	21.0	21.7	20.0	24.0	19.6	21.8	20.2	20.8	0.00	0.00	0.00	0.30	6
24-Sep-99	19.8	23.4	20.8	21.3	19.3	24.0	19.6	21.8	20.4	21.2	0.30	0.00	0.00	0.40	1.9
25-Sep-99	19.5	23.2	21.1	21.3	19.0	24.0	19.4	21.6	20.2	21.2	0.40	0.00	0.00	0.50	4.5
26-Sep-99	20.0	23.2	20.4	21.2	19.3	23.5	19.8	21.6	19.8	21.8	0.50	0.00	0.00	0.70	1.8
27-Sep-99	19.6	22.6	21.0	21.1	19.0	23.0	19.2	21.2	19.8	21.7	0.70	0.00	0.00	0.00	1.9
28-Sep-99	20.4	23.2	20.6	21.4	20.0	24.0	19.0	21.0	19.8	21.5	0.00	0.00	0.00	0.00	5.3
29-Sep-99	20.2	23.8	21.0	21.7	19.5	24.0	19.6	21.1	20.0	21.4	0.00	0.00	0.00	0.00	3.5
30-Sep-99	20.6	22.8	20.4	21.3	19.5	23.5	19.6	20.7	19.2	21.6	0.00	0.00	0.10	0.10	1.2
01-Oct-99															
MEAN	19.2	22.2	20.2	20.5	18.6	23.1	18.7	20.7	19.3	20.6	6.1	0.7	0.1	6.9	2.8

Appendix 1.- continued.

FECHA dd/mm/aa	Tmp. Aire a la sombra SECA °C						Tmp. Aire Sombr Húmeda °C			Tmp. °C Mar	Precipitación (mm)				Sol Media
	6:00	12:00	18:00	Media	Min	Máx.	6:00	12:00	18:00		6:00	12:00	18:00	Suma	
01-Oct-99	19.4	21.8	20.2	20.5	19.0	23.5	19.1	20.8	19.6	21.3	0.00	0.00	0.00	0.00	1.1
02-Oct-99	20.2	21.6	20.6	20.8	19.5	23.3	19.2	20.4	19.6	21.3	0.00	0.00	0.00	0.00	0.5
03-Oct-99	19.6	23.0	21.0	21.2	19.3	24.3	19.1	20.2	20.0	21.3	0.00	0.00	0.00	0.00	2.5
04-Oct-99	20.4	24.0	21.0	21.8	19.3	24.0	19.6	22.2	20.4	21.1	0.00	0.00	0.00	0.01	4.6
05-Oct-99	20.2	22.2	20.4	20.9	19.6	23.0	19.6	21.2	20.0	21.5	0.01	0.00	0.00	0.80	0.1
06-Oct-99	18.9	22.9	20.4	20.7	18.6	23.5	18.9	21.6	20.0	20.7	0.80	0.00	0.00	2.50	5.3
07-Oct-99	19.4	22.2	20.2	20.6	19.0	23.5	19.1	20.0	19.6	20.9	2.50	0.00	0.00	0.20	2.6
08-Oct-99	19.4	20.3	20.0	19.9	18.5	21.5	19.0	19.9	19.4	20.6	0.20	0.00	0.00	0.00	0.1
09-Oct-99	19.4	21.3	20.4	20.4	19.0	22.5	18.8	20.1	19.6	20.2	0.00	0.00	0.00	0.00	1.8
10-Oct-99	19.6	23.1	20.8	21.2	19.0	23.1	19.2	21.6	20.0	20.4	0.00	0.00	0.00	0.60	4.5
11-Oct-99	19.4	22.0	20.6	20.7	19.0	23.0	19.0	20.8	19.8	21.0	0.60	0.05	0.00	0.15	1
12-Oct-99	19.4	22.3	20.8	20.8	19.0	22.6	19.0	21.0	19.4	21.1	0.10	0.00	0.00	0.00	0.1
13-Oct-99	20.4	23.4	21.6	21.8	19.5	25.0	19.6	21.2	20.8	21.4	0.00	0.00	0.00	0.00	1.8
14-Oct-99	21.1	21.8	21.6	21.5	20.6	25.0	20.4	20.8	20.6	21.6	0.00	0.00	0.00	0.00	0
15-Oct-99	21.0	24.6	21.8	22.5	20.5	25.0	20.6	22.8	21.0	21.9	0.00	0.00	0.00	0.90	3.9
16-Oct-99	20.6	22.8	21.2	21.5	20.0	24.0	20.2	21.9	20.4	22.5	0.90	0.00	0.00	1.70	0.5
17-Oct-99	19.9	21.1	20.2	20.4	19.0	22.4	19.7	20.8	20.0	22.0	1.70	1.60	1.20	3.40	0.9
18-Oct-99	20.6	23.3	21.4	21.8	19.9	24.3	20.0	21.8	20.6	22.1	0.60	0.00	0.00	0.30	3.2
19-Oct-99	20.4	23.3	21.0	21.6	19.5	24.0	20.0	22.0	20.2	22.2	0.30	0.00	0.00	0.70	0.9
20-Oct-99	19.6	23.6	21.2	21.5	19.3	24.0	19.3	22.2	20.2	21.9	0.70	0.00	0.00	0.00	4.6
21-Oct-99	19.0	23.0	21.4	21.1	19.0	23.5	19.0	21.8	20.8	22.0	0.00	0.00	0.00	1.40	1.3
22-Oct-99	19.4	24.1	21.6	21.7	19.0		19.2	22.2	19.4	22.2	1.40	0.00	0.00	0.40	1.3
23-Oct-99	20.2	23.2	21.2	21.5	19.0	24.1	18.1	21.4	20.6	22.1	0.40	0.00	0.00	0.01	2.4
24-Oct-99	19.6	23.8	21.4	21.6	19.3	24.1	19.6	22.2	21.0	21.4	0.01	0.80	0.00	2.80	5
25-Oct-99	20.1	22.6	21.4	21.4	19.6	23.6	19.8	21.4	20.4	21.8	2.00	0.00	0.00	0.30	5.2
26-Oct-99	20.1	23.8	21.8	21.9	19.6	25.0	19.8	22.2	20.4	22.0	0.30	0.00	0.00	0.00	4.9
27-Oct-99	20.8	23.8	21.8	22.1	20.5	24.5	20.0	22.2	21.0	22.1	0.00	0.00	0.00	4.80	4.3
28-Oct-99	20.2	23.6	20.8	21.5	19.5	24.9	20.0	21.8	20.6	22.5	4.80	0.00	0.01	0.01	2.2
29-Oct-99	21.3	23.8	21.8	22.3	20.5	24.9	20.0	21.8	20.6	22.4	0.00	0.00	0.00	0.00	1.2
30-Oct-99	20.8	24.8	22.4	22.7	19.5	26.0	20.2	22.4	20.8	22.2	0.00	0.00	0.00	0.00	2.4
31-Oct-99	21.4	24.4	22.4	22.7	20.0	26.2	20.1	22.6	21.0	22.3	0.00	0.00	0.00	0.00	0.7
01-Nov-99											0.00				
MEAN	20.1	23.0	21.1	21.4	19.4	23.9	19.5	21.5	20.3	21.6	17.3	2.5	1.2	21.0	2

Appendix 1.- continued.

FECHA dd/mm/aa	Tmp. Aire a la sombra SECA °C						Tmp. Aire Sombr Húmeda °C			Tmp. °C Mar	Precipitación (mm)				Sol Media
	6:00	12:00	18:00	Media	Min	Máx.	6:00	12:00	18:00		6:00	12:00	18:00	Suma	
01-Nov-99	21.4	24.6	21.6	22.5	21.0	25.5	19.8	22.6	20.2	22.3	0.00	0.00	0.00	0.00	3.8
02-Nov-99	19.2	23.8	21.6	21.5	18.7	25.0	19.0	22.4	21.0	21.9	0.00	0.00	0.00	0.00	6.1
03-Nov-99	20.8	23.9	20.8	21.8	20.5	25.0	20.0	22.1	20.4	21.8	0.00	0.00	0.00	0.00	4.2
04-Nov-99	20.4	22.8	21.4	21.5	20.3	23.9	20.0	21.8	20.8	21.8	0.00	1.00	0.00	1.00	0.2
05-Nov-99	20.8	23.4	21.4	21.9	20.5	23.5	20.6	22.4	20.8	21.6	0.00	0.00	0.00	1.00	0.1
06-Nov-99	20.6	23.6	21.4	21.9	19.8	24.3	20.2	22.2	20.6	21.8	1.00	0.00	0.00	0.60	2.1
07-Nov-99	19.6	22.8	21.2	21.2	19.2	24.3	19.2	21.2	20.6	21.5	0.60	0.00	0.00	0.00	0.1
08-Nov-99	20.2	23.6	20.8	21.5	19.0	24.5	19.9	22.4	20.2	20.3	0.00	0.00	0.00	0.20	5
09-Nov-99	20.6	23.4	21.2	21.7	19.5	23.9	19.8	21.8	20.0	20.9	0.20	0.00	0.00	0.20	3
10-Nov-99	20.6	23.4	21.2	21.7	19.5	23.9	19.8	21.8	20.6	20.9	0.20	0.00	0.00	0.00	1.9
11-Nov-99		23.8	21.6			25.0	20.1	22.2	21.4	19.9	0.00	0.00	0.00	0.00	9.3
12-Nov-99	19.0	24.0	21.6	21.5	17.5	25.1	18.8	21.8	21.2	19.7	0.00	0.00	0.00	0.00	8.8
13-Nov-99	18.4		21.2		16.4	25.0	18.2		20.8	20.4	0.00	0.00	0.00	0.00	7.2
14-Nov-99	18.4		22.0		17.0	25.5	18.0		21.0	20.3	0.00		0.00	0.00	0
15-Nov-99	21.9	24.4	22.0	22.8	22.5	25.0	20.8	22.2	20.8	21.5	0.00	0.00	0.00	0.00	0
16-Nov-99	20.4	24.6	22.2	22.4	19.6	23.5	20.0	22.3	20.6	21.5	0.00	0.00	0.00	0.00	0
17-Nov-99	20.7	24.8	22.2	22.6	19.5		20.0	22.4	20.4	21.8	0.50	0.10	0.00	0.00	1.1
18-Nov-99	20.8	23.0	21.6	21.8	19.5		20.2	21.7	20.4	22.2	0.00	0.00	0.00	0.00	0.7
19-Nov-99	21.4	23.8	21.8	22.3	15.5	21.2	20.2	21.8	20.2	21.5	0.00	0.00	0.00	0.00	8.4
20-Nov-99	21.0	24.2	21.6	22.3	20.5		20.0	22.6	21.0	21.7	0.00	0.00	0.00	0.00	3.9
21-Nov-99	20.6	23.6	21.4	21.9	19.0	25.5	20.4	22.2	20.4	22.4	0.00	0.00	0.00	0.00	7
22-Nov-99	20.7	24.6	21.4	22.2	20.0	25.0	20.0	22.8	20.7	21.5	0.00	0.00	0.00	0.00	4.4
23-Nov-99	20.2	23.4	21.3	21.6	20.5	24.0	20.1	22.2	21.0	21.5	0.00	0.00	0.00	0.00	4.1
24-Nov-99	20.3	24.3	21.4	22.0	20.0	25.1	20.0	20.1	20.7	20.9	0.00	0.00	0.00	0.00	7.4
25-Nov-99	18.4	24.2			17.5		18.4	22.7		20.1	0.00	0.00	0.00	0.00	6.7
26-Nov-99	19.2	25.2	21.4	21.9	18.0	25.5	18.8	22.8	21.2	20.2	0.00	0.00	0.00	0.00	9.9
27-Nov-99	20.4	23.6	21.6	21.9	20.3	25.0	20.2	22.0	21.2	20.9	0.00	0.00	0.00	0.00	5.2
28-Nov-99	20.6	24.6	21.4	22.2	20.0	25.5	20.1	22.8	20.8	20.2	0.00	0.00	0.00	0.00	6.2
29-Nov-99	18.1	23.8	21.6	21.2	17.2	25.0	17.9	21.0	21.0	20.0	0.00	0.00	0.00	0.00	9.8
30-Nov-99	20.9	25.2	22.2	22.8	19.5		20.2	23.0	21.4	21.3	0.00	0.00	0.00	0.00	8.3
01-Dec-99											0.00				
MEAN	20.2	23.9	21.5	21.9	19.2	24.6	19.7	22.1	20.7	21.1	2.5	1.1	0.0	3.0	4

Appendix 1.- continued.

FECHA dd/mm/aa	Tmp. Aire a la sombra SECA °C						Tmp. Aire Somb. Húmeda °C			Tmp. °C Mar	Precipitación (mm)				Sol Media
	6:00	12:00	18:00	Media	Min	Máx.	6:00	12:00	18:00		6:00	12:00	18:00	Suma	
01-Dec-99	20.8	23.6	22.2	22.2	20.5	25.0	20.4	22.0	21.0	21.8	0.00	1.00	0.00	1.00	4.7
02-Dec-99	21.4	24.6	22.4	22.8	21.0	26.3	21.0	23.0	21.6	21.6	0.00	0.00	0.00	0.00	4.3
03-Dec-99	21.3	25.2	22.2	22.9	21.0	25.7	20.8	23.4	21.1	22.1	0.00	0.00	0.00	0.40	4.8
04-Dec-99	21.5	23.1	22.2	22.3	21.2	24.6	21.4	21.8	21.6	21.4	0.40	0.00	0.00	0.00	3.5
05-Dec-99	21.7	23.7	22.2	22.5	21.5	24.2	21.3	22.4	21.6	22.7	0.00	0.00	0.00	2.80	0.6
06-Dec-99	21.3	22.0	22.1	21.8	20.4	23.3	21.2	21.8	21.6	22.3	2.80	0.00	0.50	2.00	0
07-Dec-99	21.6	25.7	22.4	23.2	21.3	26.1	21.2	24.4	22.0	22.2	1.50	0.00	0.00	1.00	1.5
08-Dec-99	20.6	25.6	22.3	22.8	20.3	26.2	20.6	24.1	21.9	21.8	1.00	0.00	0.00	0.80	5.8
09-Dec-99	21.3	24.3	22.5	22.7	21.0	25.5	21.2	23.4	22.0	21.8	0.80	0.00	0.00	0.00	6
10-Dec-99		26.0	22.8		21.0	26.4	21.4	24.6	22.4	22.0	0.00	0.00	0.00	0.00	5.9
11-Dec-99	21.8	25.4	22.6	23.3	21.8	26.0	21.4	24.4	21.9	22.3	0.00	0.00	0.00	0.00	0.3
12-Dec-99	19.4	23.6			19.2	25.2	19.4	22.6	21.6	21.8	0.00	0.00	0.00	0.00	3.1
13-Dec-99	20.0	23.6	22.6	22.1	20.0	25.0	19.7	22.2	21.8	21.1	0.00	0.00	0.00	0.00	1.7
14-Dec-99		25.3	22.6		20.7	26.1	22.0	23.4	22.1	21.9	0.00	0.00	0.00	0.00	3.8
15-Dec-99	21.8	24.2	22.8	22.9	21.6	25.6	21.5	23.4	22.3	21.7	0.00	0.00	0.00	0.00	0.7
16-Dec-99	21.0	25.4	22.5	23.0	21.0	25.8	20.9	23.6	22.0	21.3	0.00	0.00	0.00	0.00	5.3
17-Dec-99	21.2	25.6	22.7	23.2	20.9	26.5	20.8	24.0	22.3	21.9	0.00	0.00	0.00	0.40	5.9
18-Dec-99	21.2	25.0	22.5	22.9	21.0	25.7	21.1	23.8	22.0	21.6	0.40	0.00	0.00	3.80	4.4
19-Dec-99	21.5	24.5	22.8	22.9	20.1	26.0	20.6	23.2	22.0	21.4	3.80	0.00	0.00	0.00	3.6
20-Dec-99	21.0	26.0	22.5	23.2	20.6	26.5	21.0	24.0	22.3	21.6	0.00	0.00	0.00	0.00	2.4
21-Dec-99	20.0	24.9	23.2	22.7	19.5	26.3	19.8	23.9	22.6	22.3	0.00	0.00	0.00	0.00	2.7
22-Dec-99	20.4	25.6	23.2	23.1	20.0	26.6	20.2	24.2	23.0	22.1	0.00	0.00	0.00	0.00	9.3
23-Dec-99	22.0	25.9	23.4	23.8	21.5	26.8	21.8	24.4	23.1	22.8	0.00	0.00	0.00	0.00	10.1
24-Dec-99	21.9	26.0	23.8	23.9	21.5	26.9	21.8	24.3	23.6	22.6	0.00	0.00	0.00	0.00	5.2
25-Dec-99	21.8	25.9	22.6	23.4	20.8	26.2	21.6	24.4	21.8	22.7	0.00	0.00	0.00	0.00	9.4
26-Dec-99	22.0	25.4	24.0	23.8	20.8	27.0	21.2	24.2	23.8	21.9	0.00	0.00	0.00	0.00	2.7
27-Dec-99	23.0	26.6	23.8	24.5	22.5	27.1	22.6	24.8	22.8	22.8	0.00	0.00	0.00	0.00	1.2
28-Dec-99	20.6	24.9	23.8	23.1	20.0	25.9	20.2	23.8	23.1	22.0	0.00	0.00	0.00	0.00	5.2
29-Dec-99	22.8	26.0	23.5	24.1	22.0	27.5	22.2	24.4	22.8	23.3	0.00	0.00	0.00	0.70	1.6
30-Dec-99	22.4	26.2	23.6	24.1	22.4	27.5	22.0	24.4	22.8	23.0	0.70	0.00	0.00	0.00	9
31-Dec-99	22.8	26.6	23.4	24.3	22.6	27.0	22.0	25.2	22.6	23.0	0.00	0.00	0.00	0.00	10.9
01-Jan-00											0.00				
MEAN	21.4	25.0	22.8	23.1	21.0	26.0	21.1	23.7	22.2	22.1	11.4	1.0	0.5	12.9	4.4

Appendix 2.- Location, structure and size of *Polistes versicolor* nests.

no.	Island	Vegetation zone	Stage	Activity	Adults	Pupae	Cells
1 SC		Littoral	PEM	X	13	6	89
2 SC		Littoral	ENL		0	28	92
3 SC		Littoral	PEM		0	0	17
4 SC		Littoral	ENL		0	3	16
5 SC		Littoral	ENL	X	21	2	82
6 SC		Littoral	ENL		0	8	72
7 SC		Littoral	ENL		0	5	43
8 SC		Littoral	ENL		0	11	82
9 SC		Littoral	ENL		0	5	18
10 SC		Littoral	ENL		0	0	12
11 SC		Littoral	ENL		0	0	7
12 SC		Littoral	ENL		0	4	26
13 SC		Littoral	ENL		0	0	28
14 SC		Littoral	ENL	X	31	0	184
15 SC		Littoral	PEM		0	3	102
16 SC		Littoral	ENL		0	0	71
17 SC		Littoral	ENL	X	9	1	64
18 SC		Littoral	ENL		0	0	8
19 SC		Littoral	ENL		0	8	46
20 SC		Littoral	ENL	X	8	2	85
21 SC		Littoral	ENL	X	16	3	98
22 SC		Littoral	ENL		0	5	51
23 SC		Littoral	PEM		0	5	43
24 SC		Littoral	ENL	X	8	4	78
25 SC		Littoral	ENL	X	6	0	46
26 SC		Littoral	ENL		0	1	8
27 SC		Littoral	PEM		0	0	7
28 SC		Littoral	ENL	X	11	5	105
29 SC		Littoral	PEM		0	8	87
30 SC		Arid	PEM	X	3	0	14
31 SC		Arid	ENL	X	6	4	20
32 SC		Arid	ENL	X	3	3	52
33 SC		Arid	PEM		0	0	4
34 SC		Arid	PEM		0	0	6
35 SC		Arid	PEM		0	0	10
36 SC		Arid	PEM		0	0	9
37 SC		Arid	ENL		0	18	114
38 SC		Arid	ENL		0	12	101

Appendix 2.- Location, structure and size of *Polistes versicolor* nests.

no.	Island	Vegetation zone	Stage	Activity	Adults	Pupae	Cells
39 SC		Arid	ENL		0	0	26
40 SC		Arid	ENL	X	10	36	114
41 SC		Arid	PEM		0	0	4
42 SC		Arid	PEM		0	0	8
43 SC		Arid	ENL		0	4	26
44 SC		Arid	PEM		0	0	10
45 SC		Arid	ENL	X	4	6	34
46 SC		Arid	ENL		0	47	145
47 SC		Arid	ENL		0	11	167
48 SC		Arid	PEM	X	1	1	17
49 SC		Arid	ENL		0	9	123
50 SC		Arid	ENL		0	0	18
51 SC		Arid	ENL		0	1	46
52 SC		Arid	ENL	X	3	1	21
53 SC		Arid	ENL	X	2	3	110
54 SC		Arid	PEM		0	0	20
55 SC		Arid	ENL		0	2	35
56 SC		Arid	ENL		0	41	122
57 SC		Arid	ENL		0	15	135
58 SC		Arid	ENL		0	6	59
59 SC		Arid	PEM		0	0	19
60 SC		Arid	ENL		0	5	27
61 SC		Arid	ENL		0	15	112
62 SC		Arid	ENL	X	3	0	11
63 SC		Arid	ENL	X	3	10	35
64 SC		Arid	ENL	X	3	8	30
65 SC		Arid	ENL	X	4	11	95
66 SC		Arid	ENL	X	5	4	16
67 SC		Arid	ENL		0	3	33
68 SC		Arid	ENL		0	0	26
69 SC		Arid	ENL		0	11	152
70 SC		Arid	ENL		0	0	53
71 SC		Arid	ENL		0	0	29
72 SC		Arid	ENL		0	31	124
73 SC		Arid	ENL		0	12	75
74 SC		Arid	ENL		0	11	88
75 SC		Arid	ENL		0	36	150
76 SC		Arid	ENL	X	12	5	54

Appendix 2.- Continued.

		Vegetation		Activity	Adults	Pupae	Cells
no.	Island	zone	Stage				
77	SC	Arid	PEM	X	5	2	26
78	SC	Arid	ENL		0	24	78
79	SC	Arid	ENL		0	13	52
80	SC	Arid	ENL	X	22	11	105
81	SC	Arid	ENL		0	21	86
82	SC	Arid	PEM		0	2	12
83	SC	Arid	ENL		0	0	9
84	SC	Arid	ENL		0	0	26
85	SC	Arid	PEM		0	8	38
86	SC	Arid	ENL	X	15	6	88
87	SC	Arid	ENL		0	0	21
88	SC	Arid	PEM		0	0	18
89	SC	Arid	PEM		0	2	44
90	SC	Arid	PEM	X	5	0	50
91	SC	Arid	PEM	X	18	0	81
92	SC	Arid	ENL		0	7	71
93	SC	Arid	ENL		0	0	7
94	SC	Arid	ENL		0	17	81
95	SC	Arid	ENL	X	22	6	123
96	SC	Arid	PEM		0	0	5
97	SC	Arid	ENL	X	15	40	205
98	SC	Arid	ENL	X	7	7	31
99	SC	Arid	ENL	X	3	6	31
100	SC	Arid	ENL	X	4	8	28
101	SC	Arid	ENL	X	7	33	140
102	SC	Arid	ENL	X	7	21	112
103	SC	Arid	ENL	X	3	9	48
104	SC	Arid	PEM	X	1	0	7
105	SC	Arid	PEM	X	2	0	12
106	SC	Arid	PEM	X	2	0	7
107	SC	Arid	ENL	X	5	3	27
108	SC	Arid	ENL	X	8	13	46
109	SC	Arid	ENL	X	7	10	60
110	SC	Arid	ENL	X	8	0	64
111	SC	Arid	PEM	X	3	0	27
112	SC	Arid	ENL	X	11	6	43
113	SC	Arid	ENL	X	6	5	35
114	SC	Arid	ENL	X	5	6	33
115	SC	Arid	ENL	X	5	6	31
116	SC	Arid	PEM		0	0	12
117	SC	Arid	ENL	X	3	1	30

Appendix 2.- Continued.

		Vegetation		Activity	Adults	Pupae	Cells
no.	Island	zone	Stage				
118	SC	Arid	ENL	X	2	1	34
119	SC	Arid	PEM		0	1	14
120	SC	Arid	ENL	X	3	11	37
121	SC	Arid	ENL		0	3	41
122	SC	Arid	PEM	X	2	0	12
123	SC	Arid	PEM	X	2	0	14
124	SC	Arid	PEM	X	2	0	7
125	SC	Arid	ENL	X	2	8	21
126	SC	Arid	PEM	X	1	0	12
127	SC	Arid	ENL	X	23	19	84
128	SC	Arid	PEM	X	3	0	19
129	SC	Arid	PEM	X	2	0	10
130	SC	Arid	ENL	X	5	0	45
131	SC	Arid	PEM	X	4	3	22
132	SC	Arid	ENL	X	7	3	50
133	SC	Arid	PEM	X	2	0	12
134	SC	Arid	PEM	X	2	0	17
135	SC	Arid	ENL	X	5	4	35
136	SC	Arid	ENL	X	11	15	117
137	SC	Arid	PEM	X	1	0	10
138	SC	Arid	PEM	X	1	0	9
139	SC	Arid	PEM	X	1	0	19
140	SC	Arid	PEM	X	1	0	8
141	SC	Arid	PEM	X	1	0	7
142	SC	Arid	PEM	X	1	0	4
143	SC	Arid	PEM	X	2	0	15
144	SC	Arid	PEM	X	1	0	1
145	SC	Arid	PEM	X	1	0	8
146	SC	Arid	PEM	X	1	0	5
147	SC	Arid	PEM	X	3	0	7
148	SC	Arid	PEM	X	1	0	2
149	SC	Arid	PEM	X	1	0	10
150	SC	Arid	PEM	X	5	0	10
151	SC	Arid	PEM	X	2	0	8
152	SC	Arid	PEM	X	3	0	9
153	SC	Arid	PEM	X	2	0	12
154	SC	Transition	ENL		0	4	26
155	SC	Transition	ENL	X	18	8	145
156	SC	Transition	ENL		0	16	56
157	SC	Transition	ENL		0	24	93
158	SC	Transition	ENL		0	0	81

Appendix 2.- Continued.

no.	Island	Vegetation		Activity	Adults	Pupae	Cells
		zone	Stage				
159	SC	Humid	PEM		0	12	72
160	SC	Humid	ENL	X	34	9	211
161	SC	Humid	ENL		0	15	44
162	SC	Humid	ENL	X	5	2	25
163	FL	Littoral	ENL		0	0	49
164	FL	Arid	ENL	X	5	6	46
165	FL	Arid	ENL		0	19	102
166	FL	Arid	REP		0	4	13
167	FL	Arid	ENL		0	3	91
168	FL	Arid	ENL	X	9	0	22
169	FL	Arid	PEM	X	1	12	95
170	FL	Arid	ENL		0	1	28
171	FL	Arid	ENL		0	8	46
172	FL	Arid	PEM		0	0	14
173	FL	Arid	ENL	X	3	9	63
174	FL	Arid	PEM	X	2	0	7
175	FL	Arid	PEM		0	0	15
176	FL	Arid	ENL		0	1	34
177	FL	Arid	ENL	X	6	12	92
178	FL	Arid	PEM		0	0	14
179	FL	Arid	PEM		0	0	12
180	FL	Arid	ENL		0	0	29
181	FL	Arid	PEM		0	0	14
182	FL	Arid	PEM	X	3	0	14
183	FL	Arid	ENL		0	8	67
184	FL	Arid	ENL		0	15	99
185	FL	Arid	REP		0	2	12
186	FL	Arid	ENL		0	5	84
187	FL	Arid	ENL	X	8	2	23
188	FL	Arid	PEM	X	2	13	104
189	FL	Arid	ENL		0	2	35
190	FL	Arid	ENL		0	3	52
191	FL	Arid	PEM		0	2	21
192	FL	Arid	ENL	X	6	10	74
193	FL	Arid	PEM	X	2	0	7
194	FL	Arid	PEM		0	0	13
195	FL	Arid	ENL		0	2	33
196	FL	Arid	ENL	X	8	13	87
197	FL	Arid	PEM		0	0	13
198	FL	Arid	PEM		0	1	11
199	FL	Arid	ENL		0	4	32

Appendix 2.- Continued.

no.	Island	Vegetation		Activity	Adults	Pupae	Cells
		zone	Stage				
200 FL	Arid		PEM		0	2	12
201 FL	Arid		ENL		0	4	93
202 FL	Arid		PEM		0	0	17
203 FL	Arid		PEM		0	1	12
204 FL	Arid		ENL		0	0	36
205 FL	Arid		PEM	X	2	2	32
206 FL	Arid		ENL		0	4	42
207 FL	Arid		ENL	X	8	13	40
208 FL	Arid		PEM		0	1	16
209 FL	Arid		ENL	X	4	1	10
210 FL	Arid		ENL		0	14	117
211 FL	Arid		PEM		0	0	13
212 FL	Arid		ENL		0	2	38
213 FL	Arid		ENL		0	0	20
214 FL	Arid		PEM	X	1	0	7
215 FL	Arid		PEM		0	0	7
216 FL	Arid		ENL		0	0	30
217 FL	Arid		ENL		0	2	25
218 FL	Arid		ENL		0	0	53
219 FL	Arid		PEM		0	5	6
220 FL	Arid		ENL		0	3	28
221 FL	Arid		ENL		0	6	35
222 FL	Arid		ENL		0	0	15
223 FL	Arid		ENL		0	2	20
224 FL	Arid		ENL		0	0	10
225 FL	Arid		ENL		0	9	20
226 FL	Arid		ENL		0	0	12
227 FL	Arid		PEM		0	3	9
228 FL	Arid		ENL		0	0	14
229 FL	Arid		PEM		0	0	16
230 FL	Arid		ENL		0	2	24
231 FL	Arid		ENL		0	0	16
232 FL	Arid		PEM		0	0	7
233 FL	Arid		PEM		0	0	9
234 FL	Arid		ENL		0	4	31
235 FL	Arid		ENL		0	44	141
236 FL	Arid		ENL	X	5	0	16
237 FL	Arid		PEM		0	1	6
238 FL	Arid		ENL		0	5	36
239 FL	Arid		ENL		0	1	62
240 FL	Arid		ENL		0	3	25

Appendix 2.- Continued.

no.	Island	Vegetation		Activity	Adults	Pupae	Cells
		zone	Stage				
241 FL	Arid		ENL		0	2	25
242 FL	Arid		ENL		0	0	31
243 FL	Arid		ENL		0	1	11
244 FL	Arid		ENL		0	0	37
245 FL	Arid		ENL		0	0	22
246 FL	Arid		ENL		0	3	26
247 FL	Arid		ENL		0	4	26
248 FL	Arid		ENL		0	2	64
249 FL	Arid		ENL	X	6	5	31
250 FL	Arid		ENL		0	2	143
251 FL	Arid		ENL		0	3	71
252 FL	Arid		ENL		0	0	14
253 FL	Arid		PEM		0	2	9
254 FL	Arid		PEM		0	0	12
255 FL	Arid		PEM	X	2	0	5
256 FL	Arid		ENL		0	3	64
257 FL	Arid		PEM		0	2	15
258 FL	Arid		ENL	X	2	4	23
259 FL	Arid		ENL		0	6	76
260 FL	Arid		PEM		0	0	12
261 FL	Arid		ENL		0	0	36
262 FL	Arid		ENL		0	0	31
263 FL	Arid		ENL		0	6	95
264 FL	Arid		ENL		0	4	38
265 FL	Arid		ENL		0	0	27
266 FL	Arid		ENL		0	3	67
267 FL	Arid		PEM	X	2	1	13
268 FL	Arid		ENL		0	2	21
269 FL	Arid		PEM	X	3	0	6
270 FL	Arid		PEM		0	0	11
271 FL	Arid		PEM	X	2	0	5
272 FL	Arid		PEM		0	0	3
273 FL	Arid		ENL		0	0	24
274 FL	Arid		ENL		0	0	20
275 FL	Arid		ENL		0	31	142
276 FL	Arid		ENL		0	0	10
277 FL	Arid		PEM	X	4	1	8
278 FL	Arid		ENL	X	11	2	20
279 FL	Arid		ENL		0	0	19
280 FL	Arid		ENL		0	0	16
281 FL	Arid		ENL		0	12	57

Appendix 2.- Continued.

no.	Island	Vegetation		Activity	Adults	Pupae	Cells
		zone	Stage				
282 FL		Transition	ENL	X	12	23	131
283 FL		Transition	ENL		0	2	37
284 FL		Transition	ENL		0	0	49
285 FL		Transition	ENL	X	17	10	101
286 FL		Transition	ENL	X	13	11	63
287 FL		Transition	ENL		0	13	97
288 FL		Transition	ENL	X	5	6	32
289 FL		Transition	ENL	X	5	4	35
290 FL		Transition	ENL		0	12	82
291 FL		Transition	ENL		0	8	83
292 FL		Transition	ENL	X	11	11	41
293 FL		Transition	ENL		0	63	221
294 FL		Transition	ENL		0	4	52
295 FL		Transition	ENL		0	15	145
296 FL		Transition	ENL	X	8	12	102
297 FL		Transition	ENL		0	10	182
298 FL		Transition	ENL		0	83	261
299 FL		Transition	ENL	X	8	10	51
300 FL		Transition	ENL		0	0	23
301 FL		Humid	ENL	X	14	52	170
302 FL		Humid	ENL		0	44	195
303 FL		Humid	ENL		0	50	170
304 FL		Humid	ENL	X	5	66	241
305 FL		Humid	ENL	X	7	13	83
306 FL		Humid	ENL	X	7	16	73
307 FL		Humid	ENL	X	5	10	71
308 FL		Humid	ENL	X	9	11	59
309 FL		Humid	ENL	X	11	18	93
310 FL		Humid	ENL	X	5	8	47
311 FL		Humid	ENL	X	7	15	71
312 FL		Humid	ENL	X	12	22	84
313 FL		Humid	ENL	X	5	1	27
314 FL		Humid	ENL		0	3	37
315 FL		Humid	ENL	X	6	13	62
316 FL		Humid	ENL	X	4	11	104
317 FL		Humid	ENL		0	12	64
318 FL		Humid	ENL		0	15	98
319 FL		Humid	ENL	X	57	32	137
320 FL		Humid	ENL		0	0	58
321 FL		Humid	ENL	X	16	57	122
322 FL		Humid	ENL	X	60	49	163

Appendix 2.- Continued.

no.	Island	Vegetation		Activity	Adults	Pupae	Cells
		zone	Stage				
323 FL		Humid	ENL	X	27	52	137
324 FL		Humid	ENL	X	8	7	32
325 FL		Humid	ENL	X	100	60	140
326 FL		Humid	ENL	X	4	4	22
327 FL		Humid	ENL	X	5	1	27
328 FL		Humid	ENL	X	0	3	37
329 FL		Humid	ENL	X	0	0	62
330 FL		Humid	ENL	X	3	11	104
331 FL		Humid	ENL	X	2	12	64
332 FL		Humid	ENL	X	0	15	98
333 FL		Humid	ENL	X	5	4	35
334 FL		Humid	ENL	X	5	6	31
335 FL		Humid	ENL	X	0	14	86
336 FL		Humid	ENL		0	5	79
337 FL		Humid	ENL	X	11	12	44
338 FL		Humid	ENL	X	32	58	223
339 FL		Humid	ENL	X	8	3	38
340 FL		Humid	ENL	X	13	13	99
341 FL		Humid	ENL	X	26	15	114
342 FL		Humid	ENL		0	9	189
343 FL		Humid	ENL	X	45	63	248
344 FL		Humid	ENL	X	5	6	46
345 FL		Humid	ENL	X	3	4	32
346 FL		Humid	ENL	X	28	45	201

Appendix 2.- Continued.

no.	Length (cm)	Width (cm)	Petiole (cm)	Nest Support	Height (m)	Moth predation
1				<i>Croton scouleri</i>	1.90	
2				<i>Bursera graveolens</i>	2.50	
3				<i>Croton scouleri</i>	2.20	
4				<i>Croton scouleri</i>	2.10	
5				<i>Avicennia germinans</i>	2.00	
6				<i>Laguncularia racemosa</i>	1.80	
7				<i>Laguncularia racemosa</i>	1.90	
8				<i>Bursera graveolens</i>	3.10	
9				<i>Bursera graveolens</i>	2.80	
10				<i>Bursera graveolens</i>	2.50	
11				<i>Rhizophora mangle</i>	3.00	
12				<i>Rhizophora mangle</i>	2.80	
13				<i>Bursera graveolens</i>	2.40	
14				<i>Bursera graveolens</i>	2.50	
15				found on the ground		
16				found on the ground		
17				<i>Maytenus octogona</i>	2.50	
18				<i>Cordia lutea</i>	3.10	
19				<i>Cordia lutea</i>	2.40	
20				<i>Conocarpus erecta</i>	2.10	
21				<i>Bursera graveolens</i>	2.70	
22				<i>Bursera graveolens</i>	2.50	
23				<i>Bursera graveolens</i>	2.40	
24				<i>Cordia lutea</i>	2.60	
25				<i>Cordia lutea</i>	1.90	
26				found on the ground		
27				<i>Conocarpus erecta</i>	2.10	
28				<i>Conocarpus erecta</i>	2.00	
29				found on the ground		
30	1.81	1.27	0.28	<i>Acacia macracantha</i>	1.75	
31	4.24	2.84		<i>Acacia macracantha</i>	2.25	
32	4.67	2.72		<i>Acacia macracantha</i>	1.50	
33	0.76	0.56	0.53	<i>Acacia macracantha</i>	2.00	
34	1.01	0.72	0.62	<i>Acacia macracantha</i>	2.10	
35	1.2	0.84		<i>Acacia macracantha</i>	1.70	
36	1.46	0.75	0.36	<i>Acacia macracantha</i>	1.50	
37	6.23	4.5	0.32	<i>Cordia lutea</i>	2.10	X
38	6.33	3.83		found on the ground		
39	2.36	1.6	0.51	<i>Acacia macracantha</i>	2.10	X
40	8.08	3.38		<i>Acacia macracantha</i>	2.50	

Appendix 2.- Continued.

no.	Length (cm)	Width (cm)	Petiole (cm)	Nest Support	Height (m)	Moth predation
41	0.68	0.54	1.27	<i>Opuntia echios</i>	1.50	
42	1.3	0.85	0.79	<i>Opuntia echios</i>	2.00	
43	2.75	1.82		<i>Acacia macracantha</i>	3.50	X
44	1.63	1.01	0.28	<i>Acacia macracantha</i>	1.70	
45				wood structure	3.10	
46	7.1	5.35	0.45	<i>Acacia macracantha</i>	1.70	X
47	8.4	5		found on the ground		X
48	5.85	3.5	0.45	<i>Acacia macracantha</i>	2.45	
49	7.85	3.95	0.55	<i>Acacia macracantha</i>	2.50	X
50	1.95	1.65	0.6	<i>Acacia macracantha</i>	2.55	
51	4.05	2.35		found on the ground		X
52	2.5	1.95		wood structure	1.90	
53	6.5	4.95	1	<i>Opuntia echios</i>	3.20	X
54	1.9	1.45	0.55	<i>Acacia macracantha</i>	1.20	X
55	3.65	2.4	0.55	<i>Acacia macracantha</i>	2.10	X
56	6.9	4.3		found on the ground	1.60	X
57	5.65	4.65	0.45	<i>Acacia macracantha</i>	2.60	X
58	4.95	2.75	0.45	<i>Cordia lutea</i>	1.85	X
59	2.3	1.75	0.6	<i>Acacia macracantha</i>	1.65	
60	3	2.1		<i>Acacia macracantha</i>	2.15	X
61	7.15	3.55	0.45	<i>Acacia macracantha</i>	1.30	X
62				<i>Acacia macracantha</i>	2.10	
63				<i>Acacia macracantha</i>	1.90	
64				<i>Parkinsonia aculeata</i>	1.80	
65				<i>Acacia macracantha</i>	3.10	
66				<i>Parkinsonia aculeata</i>	1.40	
67				<i>Parkinsonia aculeata</i>	4.20	
68				<i>Acacia macracantha</i>	4.10	
69				<i>Acacia macracantha</i>	4.30	
70				<i>Acacia macracantha</i>	3.80	
71				<i>Acacia macracantha</i>	5.00	
72				<i>Acacia macracantha</i>	4.10	
73				<i>Acacia macracantha</i>	2.40	X
74	74.5	34.25		<i>Parkinsonia aculeata</i>	1.50	
75				found on the ground		
76				<i>Acacia macracantha</i>	2.50	
77				<i>Acacia macracantha</i>	2.40	
78				<i>Acacia macracantha</i>	3.20	
79				<i>Cordia lutea</i>	3.20	
80				<i>Acacia macracantha</i>	2.90	
81				<i>Acacia macracantha</i>	2.80	

Appendix 2.- Continued.

no.	Length (cm)	Width (cm)	Petiole (cm)	Nest Support	Height (m)	Moth predation
82				<i>Acacia macracantha</i>	1.80	
83				<i>Opuntia echios</i>	3.50	
84				<i>Opuntia echios</i>	3.70	
85				<i>Opuntia echios</i>	3.20	
86				<i>Acacia macracantha</i>	1.80	
87				<i>Acacia macracantha</i>	1.60	
88				<i>Acacia macracantha</i>	1.60	
89				<i>Cordia lutea</i>	2.40	
90				<i>Cordia lutea</i>	2.80	
91				<i>Acacia macracantha</i>	1.70	
92				<i>Acacia macracantha</i>	1.80	
93				<i>Lantana camara</i>	1.20	
94				<i>Acacia macracantha</i>	2.60	
95				<i>Acacia macracantha</i>	2.70	
96				<i>Acacia macracantha</i>	2.40	
97				<i>Acacia macracantha</i>	3.30	
98				<i>Acacia macracantha</i>	3.00	
99				<i>Acacia macracantha</i>	2.50	
100				<i>Acacia macracantha</i>	2.40	
101				<i>Acacia macracantha</i>	1.90	
102				<i>Cordia lutea</i>	1.90	
103				wood structure	1.80	
104				<i>Acacia macracantha</i>	1.40	
105				<i>Acacia macracantha</i>	2.50	
106				<i>Acacia macracantha</i>	2.40	
107				<i>Acacia macracantha</i>	2.30	
108				<i>Acacia macracantha</i>	1.90	
109				<i>Acacia macracantha</i>	2.00	
110				<i>Acacia macracantha</i>	2.40	
111				<i>Acacia macracantha</i>	1.80	
112				<i>Acacia macracantha</i>	1.90	
113				<i>Cordia lutea</i>	2.50	
114				<i>Acacia macracantha</i>	1.80	
115				<i>Acacia macracantha</i>	1.90	
116				roof	2.40	
117				roof	2.40	
118				roof	2.40	
119				roof	2.10	
120				roof	2.10	
121				roof	2.10	
122				roof	2.10	

Appendix 2.- Continued.

no.	Length (cm)	Width (cm)	Petiole (cm)	Nest Support	Height (m)	Moth predation
123				roof	3.20	
124				roof	3.20	
125				roof	3.20	
126				roof	2.70	
127				roof	2.60	
128				roof	2.70	X
129				roof	2.30	
130				roof	2.40	X
131				roof	1.80	
132				<i>Cordia lutea</i>	1.80	
133				roof	1.90	
134				roof	2.50	
135				roof	2.50	
136				roof	3.00	
137				roof	2.60	
138				roof	2.70	
139				roof	2.60	
140				roof	2.30	
141				roof	2.40	
142				roof	1.80	
143				roof	1.80	
144				roof	1.90	
145				wood structure	2.10	
146				wood structure	2.10	
147				roof	3.20	
148				wood structure	2.10	
149				<i>Opuntia echios</i>	2.40	
150				roof	2.40	
151				roof	2.50	
152				wood structure	2.50	
153				wood structure	2.40	
154				<i>Zanthoxylum fagara</i>	2.80	
155				<i>Zanthoxylum fagara</i>	2.40	
156				<i>Tournefortia pubescens</i>	2.60	
157				<i>Croton scouleri</i>	2.20	
158				<i>Zanthoxylum fagara</i>	2.10	
159				<i>Lantana camara</i>	1.40	
160				<i>Scalesia pedunculata</i>	3.50	
161				<i>Zanthoxylum fagara</i>	2.90	
162				<i>Zanthoxylum fagara</i>	3.40	
163				<i>Cordia lutea</i>	1.00	

Appendix 2.- Continued.

no.	Length (cm)	Width (cm)	Petiole (cm)	Nest Support	Height (m)	Moth predation
164				<i>Prosopis juliflora</i>	2.20	
165				<i>Acacia macracantha</i>	3.50	X
166				<i>Cordia lutea</i>	3.50	
167				<i>Acacia macracantha</i>	3.40	X
168				<i>Opuntia echios</i>	3.20	
169				<i>Acacia macracantha</i>	3.20	X
170				wood structure	3.40	
171				<i>Acacia macracantha</i>	3.20	
172				<i>Opuntia echios</i>	3.25	
173				<i>Acacia macracantha</i>	3.40	
174				<i>Cordia lutea</i>	2.10	
175				<i>Acacia macracantha</i>	2.70	
176				found on the ground	2.50	
177				<i>Acacia macracantha</i>	2.70	
178				<i>Acacia macracantha</i>	2.50	
179				<i>Acacia macracantha</i>	2.50	
180				found on the ground	3.00	
181				<i>Cordia lutea</i>	2.60	
182				roof	3.50	
183				roof	3.50	X
184				roof, wood	3.50	X
185				roof, wood	3.50	
186				roof, wood	3.40	X
187				roof, wood	3.20	
188				roof	3.20	X
189				roof, wood	3.40	
190				roof, wood	3.20	
191				roof	3.25	
192				roof	3.40	
193				roof	2.10	
194				roof	2.70	
195				on wood structure	2.50	
196				roof, wood	2.70	
197				roof	2.50	
198				roof	2.50	
199				roof	3.00	
200				roof	2.60	
201				roof	2.70	X
202				roof	2.60	
203				roof	2.70	X
204				roof	2.30	

Appendix 2.- Continued.

no.	Length (cm)	Width (cm)	Petiole (cm)	Nest Support	Height (m)	Moth predation
205				roof, wood	2.40	
206				roof	1.80	X
207				roof	1.80	
208				roof	1.90	X
209				roof, ciment	3.40	
210				roof, ciment	3.40	X
211				roof, ciment	3.40	
212				roof, ciment	3.40	X
213				roof, ciment	3.40	
214				roof, ciment	3.40	
215				roof, ciment	3.40	
216				roof, ciment	3.40	
217				roof	6.00	
218				roof, PVC	2.20	
219				roof, PVC	2.20	
220				roof, wood	6.00	
221				roof, wood	6.00	
222				roof	9.50	
223				roof	9.50	
224				roof	9.50	
225				roof	8.50	
226				roof	9.50	
227				roof	6.00	
228				roof, wood	4.60	
229				roof	2.50	
230				roof	2.50	
231				roof, wood	2.50	
232				roof, wood	2.50	
233				roof, wood	2.50	
234				roof, wood	2.50	
235				roof	3.00	
236				roof	3.00	
237				roof	3.00	
238				roof	3.00	
239				roof	3.00	
240				roof	3.00	
241				roof	3.00	
242				roof	3.00	
243				roof, wood	3.00	
244				roof, wood	3.00	
245				roof	3.00	

Appendix 2.- Continued.

no.	Length (cm)	Width (cm)	Petiole (cm)	Nest Support	Height (m)	Moth predation
246				roof	3.00	
247				roof	3.00	
248				roof	3.00	
249				roof	3.00	
250				roof, wood	9.50	
251				roof, wood	9.50	
252				roof, wood	9.50	
253				roof	9.50	
254				roof	8.00	
255				roof, wood	8.00	
256				roof	8.00	
257				roof	8.00	
258				roof	8.00	
259				roof	8.00	
260				roof	9.00	
261				roof	8.00	
262				roof	8.00	
263				roof	9.00	
264				roof	8.00	
265				roof	8.00	
266				roof	9.50	
267				roof, wood	9.50	
268				roof, wood	9.50	
269				roof	3.50	
270				roof	3.50	
271				roof	3.50	
272				roof	3.50	
273				roof	3.50	
274				roof	3.50	
275				roof, wood	5.00	X
276				roof, wood	5.00	
277				roof, wood	5.00	
278				roof	2.50	
279				roof	2.20	
280				roof, wood	2.20	
281				roof, wood	2.20	
282				<i>Croton scouleri</i>	1.20	
283				<i>Zanthoxylum fagara</i>	1.20	
284				<i>Croton scouleri</i>	1.20	X
285				<i>Zanthoxylum fagara</i>	1.40	X
286				<i>Zanthoxylum fagara</i>	2.00	X

Appendix 2.- Continued.

no.	Length (cm)	Width (cm)	Petiole (cm)	Nest Support	Height (m)	Moth predation
287				<i>Croton scouleri</i>	1.20	X
288				<i>Zanthoxylum fagara</i>	1.50	
289				<i>Croton scouleri</i>	1.20	
290				<i>Zanthoxylum fagara</i>	0.20	X
291				<i>Zanthoxylum fagara</i>	1.60	X
292				<i>Croton scouleri</i>	2.20	
293				<i>Zanthoxylum fagara</i>	2.00	X
294				<i>Prosopis juliflora</i>	2.00	X
295				<i>Zanthoxylum fagara</i>	1.50	X
296				<i>Zanthoxylum fagara</i>	1.50	X
297				<i>Prosopis juliflora</i>	1.90	X
298				<i>Croton scouleri</i>	1.00	X
299				<i>Prosopis juliflora</i>	2.20	
300				<i>Cordia lutea</i>	1.00	
301				<i>Zanthoxylum fagara</i>	1.40	X
302				<i>Zanthoxylum fagara</i>	2.10	X
303	71.1	51.35		<i>Croton scouleri</i>	1.50	X
304	80.3	64.55		<i>Croton scouleri</i>	1.10	X
305				<i>Croton scouleri</i>	1.50	X
306				<i>Zanthoxylum fagara</i>	1.20	
307				<i>Croton scouleri</i>	1.25	
308				<i>Citrus limon</i>	1.30	
309				<i>Zanthoxylum fagara</i>	1.70	
310				<i>Zanthoxylum fagara</i>	1.20	
311				<i>Zanthoxylum fagara</i>	1.40	
312				<i>Citrus limon</i>	1.55	
313				<i>Croton scouleri</i>	1.20	
314				<i>Zanthoxylum fagara</i>	1.20	
315				<i>Zanthoxylum fagara</i>	1.20	X
316				<i>Zanthoxylum fagara</i>	1.40	X
317				<i>Zanthoxylum fagara</i>	2.00	X
318				<i>Croton scouleri</i>	1.20	X
319				<i>Citrus limon</i>	1.50	
320				found on the ground		X
321				<i>Zanthoxylum fagara</i>	2.00	X
322				<i>Zanthoxylum fagara</i>	2.10	X
323				<i>Citrus limon</i>	2.80	X
324				<i>Zanthoxylum fagara</i>	1.80	X
325				<i>Zanthoxylum fagara</i>	3.20	X
326				<i>Citrus limon</i>	6.00	
327				<i>Croton scouleri</i>	1.20	

Appendix 2. - Continued.

no.	Length (cm)	Width (cm)	Petiole (cm)	Nest Support	Height (m)	Moth predation
328	30.7	29.65		<i>Zanthoxylum fagara</i>	1.20	
329	30.15	25.4		<i>Zanthoxylum fagara</i>	1.20	X
330	70.2	41.6		<i>Zanthoxylum fagara</i>	1.40	X
331	33	30		<i>Zanthoxylum fagara</i>	2.00	X
332	74.15	37.05		<i>Croton scouleri</i>	1.20	X
333				<i>Croton scouleri</i>	1.50	
334				<i>Croton scouleri</i>	1.20	
335	64.4	36.6		<i>Zanthoxylum fagara</i>	0.20	X
336	46.75	26.35		<i>Zanthoxylum fagara</i>	1.60	X
337				<i>Zanthoxylum fagara</i>	2.20	
338	89.35	61.25		<i>Zanthoxylum fagara</i>	2.00	X
339	29.05	23.75		<i>Citrus lemon</i>	2.00	X
340	68.8	32.7		<i>Citrus lemon</i>	1.50	X
341	55.8	46.45		<i>Prosopis juliflora</i>	1.50	X
342	78.25	68.75		<i>Prosopis juliflora</i>	1.90	X
343	76.4	65.25		<i>Croton scouleri</i>	1.00	X
344				<i>Citrus limon</i>	2.20	
345				<i>Cordia lutea</i>	1.00	
346				<i>Cordia lutea</i>	1.00	

Appendix 3.- Colony Development of nest #A20.

Date							New cells/individuals			
	Adults	Pupae	Larvae	Eggs	Empty Cells	Total Cells	Cells	Eggs	Larvae	Pupae
27-Apr-99	7	3	24	23	0	50				
28-Apr-99	5	3	24	24	0	51	1	1	0	0
29-Apr-99	6	5	22	26	0	53	2	3	1	3
30-Apr-99	7	7	24	25	0	56	3	5	6	4
1-May-99	6	9	22	25	0	56	0	2	2	4
2-May-99	7	8	21	28	0	57	1	3	0	1
3-May-99	6	8	28	25	0	61	4	4	7	0
4-May-99	7	9	31	24	0	64	3	4	5	2
5-May-99	7	11	28	25	0	64	0	1	0	3
6-May-99	6	13	28	23	0	64	0	0	2	2
7-May-99	8	14	28	23	0	65	1	3	3	3
8-May-99	7	14	29	23	0	66	1	1	1	0
9-May-99	9	12	32	25	0	69	3	5	3	0
10-May-99	9	13	30	30	0	73	4	5	0	2
11-May-99	8	16	31	30	0	77	4	4	4	3
12-May-99	9	18	33	29	0	80	3	4	5	3
13-May-99	7	20	34	26	0	80	0	0	3	2
14-May-99	9	20	34	30	0	84	4	6	2	2
15-May-99	10	21	33	36	0	90	6	7	1	2
16-May-99	10	21	34	41	0	96	6	7	2	1
17-May-99	11	19	32	49	0	100	4	8	0	2
18-May-99	10	23	30	50	0	103	3	3	3	4
19-May-99	9	24	31	51	0	106	3	3	2	1
20-May-99	10	23	31	57	0	111	5	6	0	0
21-May-99	11	23	31	57	0	111	0	1	1	1
22-May-99	11	22	30	62	0	114	3	5	0	1
23-May-99	11	22	34	62	0	118	4	4	4	0
24-May-99	12	25	36	60	0	121	3	4	6	4
25-May-99	11	28	35	65	0	128	7	7	2	3
26-May-99	13	24	32	72	0	128	0	7	0	3
27-May-99	12	26	39	70	0	135	7	7	9	2
28-May-99	14	26	42	75	0	143	8	10	5	2
29-May-99	16	28	40	77	0	145	2	5	3	5
30-May-99	16	33	42	78	0	153	8	9	8	4
31-May-99	17	28	45	82	0	155	2	7	4	0

Appendix 3.- Continued.

Date							New cells/individuals			
	Adu Its	Pupae	Larvae	Eggs	Empty Cells	Total Cells	Cells	Eggs	Larvae	Pupae
1-Jun-99	17	26	50	82	0	158	3	5	5	0
2-Jun-99	20	22	56	89	0	167	9	13	6	0
3-Jun-99	22	24	63	87	0	174	7	9	11	4
4-Jun-99	20	26	74	77	0	177	3	3	13	2
5-Jun-99	24	25	75	83	0	183	6	10	4	3
6-Jun-99	22	26	77	88	0	191	8	8	3	1
7-Jun-99	21	22	83	90	0	195	4	8	6	0
8-Jun-99	23	22	90	90	0	202	7	9	9	2
9-Jun-99	26	22	92	90	0	204	2	6	6	3
10-Jun-99	27	25	98	88	0	211	7	8	10	4
11-Jun-99	29	24	104	84	0	212	1	3	7	1
12-Jun-99	27	22	106	86	0	214	2	4	2	0
13-Jun-99	27	23	107	84	0	214	0	0	2	1
14-Jun-99	20	25	103	86	0	214	0	2	0	3
15-Jun-99	22	27	117	74	0	218	4	6	18	4
16-Jun-99	22	27	118	78	0	223	5	6	2	1
17-Jun-99	26	26	120	82	0	228	5	9	5	3
18-Jun-99	26	32	122	76	0	230	2	2	8	5
19-Jun-99	27	29	124	79	0	232	2	5	2	0
20-Jun-99	28	31	127	75	0	233	1	3	7	4
21-Jun-99	31	35	140	63	0	238	5	8	20	5
22-Jun-99	27	38	132	68	0	238	0	5	0	6
23-Jun-99	28	33	131	74	0	238	0	6	0	1
24-Jun-99	25	32	125	81	0	238	0	7	0	5
25-Jun-99	27	31	127	80	0	238	0	2	3	1
26-Jun-99	28	24	134	85	0	243	5	12	7	0
27-Jun-99	28	27	130	87	0	244	1	2	0	4
28-Jun-99	30	32	132	80	0	244	0	2	9	7
29-Jun-99	33	30	141	75	0	246	2	5	10	1
30-Jun-99	30	29	141	81	0	251	5	6	0	0
1-Jul-99	29	31	141	81	0	253	2	2	2	2
2-Jul-99	30	34	135	83	0	252	-1	2	0	4
3-Jul-99	32	39	132	79	0	250	-2	0	4	6
4-Jul-99	32	40	131	79	0	250	0	0	0	1
5-Jul-99	32	33	138	79	0	250	0	7	7	0

Appendix 3.- Continued.

Date							New cells/individuals			
	Adu Its	Pupae	Larvae	Eggs	Empty Cells	Total Cells	Cells	Eggs	Larvae	Pupae
6-Jul-99	36	20	149	79	0	248	-2	11	11	0
7-Jul-99	32	20	147	81	0	248	0	2	0	2
8-Jul-99	32	20	147	81	0	248	0	0	0	0
9-Jul-99	32	20	147	81	0	248	0	0	0	0
10-Jul-99	32	20	146	82	0	248	0	1	0	1
11-Jul-99	29	20	145	83	0	248	0	1	0	1
12-Jul-99	29	20	145	83	0	248	0	0	0	0
13-Jul-99	29	19	147	82	0	248	0	1	2	0
14-Jul-99	29	19	148	81	0	248	0	0	1	0
15-Jul-99	29	19	142	85	0	246	-2	0	0	3
16-Jul-99	29	19	141	86	0	246	0	1	0	1
17-Jul-99	28	18	139	89	0	246	0	3	0	1
18-Jul-99	27	18	139	89	0	246	0	0	0	0
19-Jul-99	30	20	136	90	0	246	0	3	2	3
20-Jul-99	30	18	136	92	0	246	0	2	0	0
21-Jul-99	31	18	136	86	0	240	-6	1	1	1
22-Jul-99	31	18	138	84	0	240	0	0	2	0
23-Jul-99	31	18	133	89	0	240	0	5	0	2
24-Jul-99	31	17	134	89	0	240	0	1	1	0
25-Jul-99	32	17	134	89	0	240	0	1	1	1
26-Jul-99	32	16	132	92	0	240	0	3	0	2
27-Jul-99	35	14	134	92	0	240	0	3	3	1
28-Jul-99	34	14	140	87	0	241	1	1	6	0
29-Jul-99	33	14	138	88	0	240	-1	0	0	2
30-Jul-99	32	14	138	88	0	240	0	0	0	0
31-Jul-99	33	14	138	88	0	240	0	1	1	0
1-Aug-99	33	13	139	88	0	240	0	1	1	0
2-Aug-99	33	13	138	89	0	240	0	1	0	1
3-Aug-99	32	12	136	92	0	240	0	3	0	1
4-Aug-99	31	12	135	92	0	239	-1	0	0	1
5-Aug-99	30	12	132	95	0	239	0	3	0	1
6-Aug-99	30	12	131	95	1	239	0	1	0	1
7-Aug-99	28	10	131	96	2	239	0	2	0	0
8-Aug-99	28	10	132	95	2	239	0	0	1	0
9-Aug-99	28	10	131	96	2	239	0	1	0	1

Appendix 3.- Continued.

Date							New cells/individuals			
	Adu Its	Pupae	Larvae	Eggs	Empty Cells	Total Cells	Cells	Eggs	Larvae	Pupae
10-Aug-99	28	9	131	97	2	239	0	1	0	0
11-Aug-99	27	9	131	95	3	238	-1	0	0	0
12-Aug-99	28	9	131	95	3	238	0	1	1	1
13-Aug-99	26	9	129	96	4	238	0	2	0	1
14-Aug-99	28	9	129	96	4	238	0	2	2	2
15-Aug-99	28	9	130	95	4	238	0	0	1	0
16-Aug-99	28	9	128	94	4	235	-3	0	0	1
17-Aug-99	26	8	129	94	4	235	0	1	1	0
18-Aug-99	26	5	133	93	4	235	0	3	4	0
19-Aug-99	25	5	132	93	5	235	0	1	0	0
20-Aug-99	25	5	133	92	5	235	0	0	2	0
21-Aug-99	25	5	132	92	6	235	0	1	0	1
22-Aug-99	22	5	130	94	6	235	0	2	0	1
23-Aug-99	22	5	130	94	6	235	0	0	1	0
24-Aug-99	20	5	132	92	6	235	0	0	4	0