Mosquitos in the Mist:
Entomology of BFREE

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One Man's Battle to Establish BFREE's First Insect Collection

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Introduction

There are more species of insects than all other forms of life combined. They inhabit almost every terrestrial habitat and even fresh and salt water. The larvae of petroleum flies live in pools of oil around California oil wells. The short circuit beetle bores into lead cables. Flies have even been found breeding in the brine vats in which human cadavers are preserved. (Stiling, 1986: p.1)

For every pound of human beings in the world, there are approximately 300 pounds of insects. Twenty five percent of all animal species are beetles. Dragonflies can fly sixty miles per hour. There may be fifty million midges in a single swarm. (Hubbell, 1993: cover leaf)

Insects are not easily observed like many larger organisms. It takes a dedicated naturalist to uncover the secrets of the hidden world of insects. Is it not exciting to think that there are millions of species of insects still undiscovered?

Although this study was largely driven by my sheer fascination with the diversity and intricacies of insects, entomology is an area of great importance. If we take the time to examine insects closely, we can learn a lot. The value of insects is becoming more and more recognized. They are an integral component of the web of life, providing food for other animals as well as shredding and decomposing organic matter that is essential in the recycling of life. Insects are also very beneficial to man in other ways. In the United States, it is estimated that insects are worth at least five billion dollars annually (Stiling, 1986: p.6). Four and a half billion of this vast sum is due to the pollination of insects. Without them we would have very few vegetables and fruits. Less clover would mean less beef and wool and cotton. We would have no coffee, tobacco, chocolate, and very few flowers. And this is just a result of pollination. Insects also give us honey, beeswax, silk, dyes, and are useful for their aesthetic value.
Without the use of the aphid proboscis in a plant stem as an anticoagulant, science would never know the rate at which nutrients are passed down the phloem. And where would our children be without the entertainment of the Mexican jumping bean?

The harmful effects of insects are also useful to study. They can be devastating to crops and also can transmit diseases to humans and livestock, including malaria, the world's chief killer of people (Stiling, 1986: p.8). The more we know about them, the more we can control the injurious effects of insects without seriously disrupting the ecology.

Aside from these beneficial and harmful impacts of insects on humans, it is important to study the insects we know little about. There are still so many insects undiscovered that could yield useful products, not to mention possible medicinal value. The area of entomology needs more attention and this must be done before the habitats are destroyed.

The pristine subtropical rain forest in the BFREE (Belize Foundation for Research and Environmental Education) area of the southern Maya Mountain region in Belize is a largely untouched natural habitat harboring countless species of insects as well as myriads of other plants and animals. The lush and also varied forest habitats of BFREE as well as its insect diversity render it the ideal place for me to study.

Very little work has been done at BFREE regarding entomology. Since the area is currently being developed into a foundation with research facilities and other accommodations, it is especially important to collect baseline data. This pre-alteration data is very useful in determining the impacts of the development of BFREE on the surrounding environment. It will help to address questions regarding the ethics of development in the area. Accurate baseline data covering 'disturbed and
undisturbed areas in the near vicinity will be very useful in the future.

To make an assessment of this information, I prepared a permanent collection of the insects I found in the BFREE area. I also attempted to determine general insect abundances by order and family. This data is also useful in the examination of seasonality in insects. There is distinct seasonality of insects (certain insects flourish at different times of the year) at BFREE (pers.comm., Marlin, 1996). Although my study is far too brief to make a good seasonality evaluation, I noticed certain trends and attempted to tie them in with climate, including temperature and rainfall.

I also examined the fascinating behaviors among insects, including symbiotic relationships, areas of insect habitation, defenses such as camouflage, poison, and mimicry, predation techniques, mating, and other interesting observations. It was exciting to study the complex social behavior of insects. The dedication, communication, and specialization of labor is amazing, and are impressive qualities that I think humans can learn a lot from. Drawing the insects was also an enjoyable component of my project. The project will also give me valuable research and collecting experience in the field.

Although this report documents much of my study and observations, as well as interesting information about the insects, by far the largest and most time consuming focus of my project was the preparation of the insect collection. As well as serving as a scientific record of insects at BFREE at this specific time, I hope it will be used as an educational display for groups and people who come to visit. Being exposed to the beauty of nature and its many awesome forms of life at a very young age is what fostered such a love for the environment in me. Many children grow up in cities or areas where they never develop an appreciation for the natural world around them. Encouraging these interests in the younger generation is crucial for protecting our earth in the long run. Wildlife is
something we can't afford to lose, especially as habitats are being destroyed so quickly. I am lucky to have the opportunity to work and study in a pristine rain forest such as the one at BFREE. My grandchildren might not be so lucky.

**Background**

The Belize Foundation for Research and Environmental Education (BFREE), founded in December of 1994, owns a 1153 acre parcel of land located along the edge of the Bladen River southeast of Forest Hill in the Toledo District of Belize. The area is also bounded by Deep River Forest Reserve, Bladen Nature Reserve, Cockscomb Basin Wildlife Sanctuary and Maya Mountain Forest Reserve [see appendix 2.]

The development of BFREE currently consists of two camps. One by the river consists of open air thatches for guests. The thatches connect via trail and old logging road to the main camp, consisting of a thatch kitchen, organic garden, and manager's house. Future development hopes to include a bunk house, wash house, private research cabins, trail systems, biogas latrine, orchard, living museum, bridge, lookout tower, and canopy walkways (Madin, 1995: p.11).

The goals of BFREE include encouraging and promoting the scientific study of the wildlife sanctuary and surrounding reserves as well as offering environmental education programs to Belizeans and students from abroad. The area of land owned by BFREE is the perfect place to fulfill these goals.

BFREE has various trails leading around its property which I used during my study, mostly old hunting trails. The area I focused on was the fifty acre piece of land in the northwest corner of
the property where the facilities are located [see appendix 3.] This area was old growth forest until 1980 when patches were cut for small scale milpa (slash and burn agriculture.) In 1983, about 40 acres were selectively logged and the area was again used for milpa for a year. Afterwards it grew in peace until logging began again in 1994 and many hardwoods were removed.

Now the forest is mostly secondary growth, including trumpet trees (*Cecropia obtusifolia*), gombolimbo (*Dendropanax arboreus*), wild tamarind (*Albizzia tomentosa*), quamwood (*Schizolobium parahybum*), prickly yellow (*Zanthoxylum mayanum*), cohune palm (*Orbignya cohune*), moho (*Hampea trilobata*), banak (*Virola koschnyi*), breadnut (*Brosimum alicastrum*), hogplum (*Spondias mombin*), warree cohune (*Astrocaryum mexicanum*), and some hardwoods. Belizeans refer to this type of forest as waha mill. I also hiked to other areas of the property which included older hardwoods and some primary growth. The terrain I worked and collected in included swamps, creeks, ponds, shady cohune ridge, lush riparian forest, grassy roads and trails, and dense jungle laden with numerous lianas and epiphytes.

The climate is subtropical, with high humidity. There is a distinct dry season lasting from February to June. In June, heavy rains mark the beginning of the rainy season. These continue through September and are followed by lighter rain from October through January. My study took place in November. [see appendix 1 for weather details]

This lush forest combined with the warm, humid climate supports vast numbers of insects.

My strong fascination with the vibrant life of the rain forest is the driving force behind my entomological study in this region. Since I was very young I've been fascinated with animals and the beauty of the natural surroundings. Living in the rain forest with the opportunity to work on a useful entomological project is the fruition of a childhood dream and hopefully the first of many
experiences in the rain forest. The variety of insects I found at BFREE was tremendous. This variety, as well as the amazing facts and characteristics of the diverse insect world enthralls me.

Methodology:

This project required a tremendous amount of work. Almost every free minute was spent hiking (in search of insects), pinning, writing, or drawing the insects.

The hikes took places at all times of day as well as night. Various collecting methods were used. A butterfly net was essential on hikes. I also used jars and small plastic collecting containers. I never traveled anywhere, even to meals, without my butterfly net and my backpack with collecting equipment. Many nice specimens were collected at strange and unexpected times.

Butterflies and moths were quickly killed with a firm pinch to the bottom of the thorax and placed in special waxed paper envelopes. The envelopes need to be kept in a rigid case to prevent bending. It took a while to develop the best technique for catching a butterfly and quickly examining it for flaws, before removing it from the net without damaging it at all.

Upon return to camp, other insects were killed in a killing jar with a layer of absorbent tissue soaked with poison and covered with plastic gauze and an airtight lid. I made several of these jars of different sizes.

Pitfall traps were placed at various locations and checked regularly. These were large tin containers that were dug into the ground with the lip at ground level and baited with either dog food, beef, fish head, or rotting fruit.
Bowls were placed at various locations and checked regularly. They were placed on stumps, on the ground, and in sunny clearings. They were baited with either sugar water, honey, or rotting fruit.

A white sheet was hung near the house with an incandescent tube light above it which was left on all night. This was checked as regularly as possible at night as well as first thing in the morning.

Sweeping the net back and forth through the grass was another collecting technique.

While collecting, I examined various habitats, including swamp, river banks, creeks, cohune ridge, road, trails, and other forest areas. One day I might be forging through the river up to my waist chasing dragonflies and butterflies, and the next day I might be hiking through dense shaded jungle, carefully turning over logs and examining each leaf, stem, tree trunk, and the ground, as well as watching the air for signs of flight.

The typical day of work began at dawn. Rising shortly after six, I washed, checked the insects that were collected the night before, recorded the temperature, and walked to the house to check the sheet. After collecting the insects on the sheet and the plants in the near vicinity, I checked the bowls and pitfall traps and went to breakfast. After breakfast I would hike, usually for three or four hours. Returning with the insects, I would put them in the killing jars and write my observations of the morning in my work journal. After lunch I would check the bowls again, record the temperature, and go on another hike. Again before dinner, I would sort out the insects I had collected and write field notes. After dinner I usually turned on the insect light and relaxed for a while, perhaps playing a little ping pong under the house, checking the sheet regularly. After this, I would take a night hike, sometimes spending two or three hours carefully scouring the trail or road.
on the way back to my thatch, or sometimes hiking one of the other trails or canoeing up the river. I recorded the temperature again before preparing the insects and going to sleep.

Often I would skip one of these morning or afternoon hikes, or simply cut it short. In place of this, I would work on pinning the insects, writing in my work journal (including records of rainfall and mosquito abundance), or drawing the insects.

The pinning and preparation of the insects was delicate and time consuming work. After being killed in the jars, the insects were removed with forceps. Some were placed in tupperware containers with moth balls and packets of desiccant to dry them out. Some were immediately pinned on styrofoam while the joints were still soft and then placed in tupperware with desiccant to dry. The legs, antennae, and sometimes wings were spread with pins and often the help of forceps. Insects that were dried before pinning were placed overnight in tupperware with a wet T-shirt to be 'relaxed'. They were then pinned as usual in the morning. For butterflies and moths, strips of index card were used to pin out the wings without damaging them. A groove was cut in the styrofoam to fit their bodies into so that their wings would not lie backwards at an angle. The strips were laid flat over each wing with pins holding tightly at each end to hold the wings in place after forceps or the ball end of a pin was used to gently coax the wing up into position.

The cases were prepared with insects in clusters by order. Pieces of styrofoam were glued to hold the pins in place. Containers with moth balls and desiccant were placed in the containers to preserve the collection for a long time. The cases were sealed along cracks and the lining of the glass with silicone gel for ultimate protection.
Results and Discussion

Insects have spectacularly evolved anatomies and life cycles. Their skeleton (cuticle in this case) is on the outside and is called an exoskeleton. This tough external armor is great protection from predation and crashing into things. As insects first colonized terrestrial habitats millions of years ago, they were faced with the problem of desiccation (drying out), especially due to their small size which increased evaporation. The exoskeleton has a waxy covering that prevents this, holding moisture in. Breathing is performed through tiny holes all over the body wall called spiracles. There is one blood circulation, but instead gas exchange takes place directly at the cells through these spiracles. As a result, the insects must stay small. In the tropics however, temperatures are higher. This allows a greater rate of gas exchange, so the insects in a subtropical place such as BFREE can get larger than insects in temperate regions.
Other typical definitions of insects include six legs (meaning spiders, ticks, mites, scorpions, millipedes and centipedes are not insects) and wings. In fact they are the only invertebrates with wings. Insects are members of class Insecta, which is a smaller part of phylum Arthropoda (including arachnids and crustaceans.) They are further classified and broken down into order, family, genus, and species.

Insects are also cold blooded, and so are greatly affected by external temperatures. This helps explain seasonality of insects. This also explains why most insects I found were either out in the heat of the day or were specialized to be nocturnal. Collecting around dawn or dusk usually was not as successful.

There are two general life cycles of insects. Some emerge from eggs as miniature adults and must moult, their exoskeleton and form a new one as they grow into adults. These include grasshoppers, mantids, cockroaches, termites, and homopterans. I observed this process once on the underside of the wooden stairs at the house. An insect had just emerged from its old exoskeleton which still stuck to the wood next to it. The body was soft and white and it waited weakly and patiently for its new armor to harden.

Most insects, however, undergo a spectacular metamorphosis. They emerge from eggs as caterpillars, maggots, grubs, or some form of larva. They feed and grow until they mature enough to pupate. Eventually they re-emerge as an adult, remarkably different in appearance. The adults do not grow and often live and feed in very different habitats from the immature larvae.

When I first arrived at BFREE, there was already a beautiful red, yellow, and black bug waiting for me. It did not take long to realize the amazing diversity of insects that live here. Although identification of species were close to impossible with my weak entomological background.
and a distinct lack of identification resource material, here is a breakdown of the insects I studied by order.

**Order Odonata: Dragonflies & Damselflies**

This ancient order dates back 300 million years. The easy distinction between dragonflies and damselflies is that dragonflies rest with their wings horizontally to the sides, and damselflies rest with their wings raised vertically. The most common types of dragonfly are skimmers and darters, both of which I observed. The darters have long slender bodies, while the skimmers have bodies shorter than the wingspan. Members of this order were very abundant in the BFREE area.

**Habitat & Collecting**

Dragonflies and damselflies are very interesting in that their immature stage is aquatic, feeding on other insects. Because of this, the adults are commonly found near water. The red skimmers were extremely common, particularly on the old logging road near the river. They patrolled up and down the road, flashing their bright red abdomens in the air as they darted in different directions with incredible agility.

Walking down the Bladen was a sure way to find these creatures. Damselflies and dragonflies of all sizes and colors played along the vegetation by the side of the river. The colors are magnificent, often bright green, blue, red, yellow, or purple.

My most impressive find of this order was a huge damselfly in the clearing by the kitchen. Its wingspan measured fifteen centimeters, and its body extended a whopping thirteen centimeters. I caught it in the net, but then had some difficulty because I had no idea how to handle it or kill it. It was my first Odonata, and I couldn't kill it the same way as a butterfly. They also bite. In my
hesitation, it got away and flew slowly to a tree deeper in the forest. I ran after it and netted it, before carrying it back to my thatch in the net, trying to keep it from beating and damaging its wings. Its size seemed to make it a very slow flyer.

Defense

The primary defense, as well as a painful bite, is speed and agility. The red skimmers were the fastest of the dragonflies or damselflies that I observed. I probably missed about thirty of them while falling into deep puddles and splashing into the river in pursuit as they masterfully eluded the sweeping rim of the net. Finally I caught one and was very excited.

Feeding

I never directly observed any predation, but made some interesting observations. I often saw dragonflies flying in large groups at dusk. Perhaps a hundred in one area would dart quickly back and forth in the air, usually in a clearing such as near the house. When I was young I had an electronic device that emitted the sound of dragonfly wings beating. It was supposed to keep away mosquitos. Because of this, and because mosquitos and other small flies are out in large numbers at dusk, I would guess that the dragonflies are feeding. They certainly dart violently back and forth as if they're chasing something.

Mating

On a few occasions I observed dragonflies and damselflies mating, connected at the tip of the abdomen. Sometimes the pairs were two completely different colors. This is very interesting because sexual dimorphism almost always exists in insects with varying size, but not usually with color. I also observed pairs flying around together with the male holding onto the head of the female
with special appendages. I think this is a preliminary component of the mating ritual.

**Order Orthoptera: Mantids, Cockroaches, Stick Insects, Grasshoppers & Crickets**

This order is very diverse. Representatives of this order were observed in great abundance at all times of day and night and in many various habitats.

The most distinguishing feature of grasshoppers and crickets is their long powerful hind legs used for jumping. By rubbing these against their wings or by rubbing just their wings together, the males produce a chirping noise.

Grasshoppers and crickets vary tremendously in size, shape, and color. Some have very short antennae, and I observed these more commonly in the day. Most of the nocturnal species have long antennae, some extending at least two or three times as long as the body. This extra length must help the nocturnal species maneuver in the dark (whiptail scorpions and other cave dwellers have this specialization for the darkness.) Sizes ranged from about one inch to six inches in length.
Habitat

Grasshoppers of many varieties were observed in large numbers, especially in the grass and low shrubs and trees along trails and roads. They are easily seen as they hop away upon disturbance or sometimes take flight in an attempt to escape. They stay fairly hidden during the day, although some species appeared to be diurnal and many can be found in the grass. With a strong headlamp, the grasshoppers are easily observed at night, usually sitting on the top or bottom of leaves on bushes or plants. It was not rare to find grasshoppers on or near the sheet at night, attracted to the light.

I did not observe as many crickets as grasshoppers. There were many small brown crickets running around the leaf litter during the day. They also enjoy grass and the underside of logs and stones. They are distinguished from grasshoppers by cerci, long conspicuous spikes at the end of the abdomen.

Defense

The color of grasshoppers is a spectacular camouflage. Some were bright green, and some various shades of brown. Some were even red or blue or yellow. Many of them perfectly mimicked leaves. The casing covering the wings is flattened and pointed upward so that from the side it looks exactly like a leaf. The detail was so immaculate that veins show on the pseudoleaf and sometimes brown areas mimicking fungal spots. One small grasshopper I found resembled a green leaf with brown spots and yellow edging along the brown, exactly like the decaying of a real leaf. I also realized that it was the exact size and shape of the piece or a leaf cut by a wee-wee ant. Perhaps this is some tightly evolved mimicry developed for protection.

Other grasshoppers resembled completely brown leaves of different shades. Perhaps they dwell on the ground among the dead leaves during the day. I only found them at night, sticking out
conspicuously on their green leafy perches.

I observed some grasshoppers during the day that appeared very brown and drab in color. They blended perfectly with the ground, but upon disturbance, took flight, displaying bright colorful wings. Some were red and some blue. Perhaps this has to do with mating, but is probably some sort of warning sign to predators.

Their other defenses include their powerful jumping legs and flight.

Feeding

I often observed grasshoppers feeding at night. They are sloppy eaters and leave ragged edges on leaves, often leaving pieces dangling off. They eat up to their own weight in food a day (Stiling, 1986: p.13). I observed one defecating on a leaf at night. It was a long laborious process. It slowly curled its abdomen downwards, pushing its curved scythe shaped ovipositor (meaning it was a female) around until it pointed forward. As it defecated a greenish slime, it very slowly and methodically dragged its abdomen along the leaf to clean itself. I would guess that this slow process is an effort to maintain camouflage. There are many predators waiting at night to see any movement. Even the dropping of faeces onto a lower leaf could mean death.

Many times at night I observed large spiders feeding on grasshoppers. I have heard these spiders called wolf spiders and also horse spiders. Often the grasshopper is larger than the spider. Sometimes I’ve seen these spiders dangling from a thread on the bottom of a leaf at night with specialized legs ready to grab any passerby. I’ve also seen them catch a grasshopper by networking the top of a leaf with sticky threads. When the grasshopper landed on the leaf, it was stuck and the spider moved in for the kill.
Mating

The chirping noise produced by the males is used to attract females. I heard these noises everywhere and at all times. At dusk and night especially these chirps can get almost deafening. Only once did I actually see grasshoppers mating. It was a pair of cherry red grasshoppers. They were beautiful and had extremely long antennae. They were connected at the tip of the abdomen with heads facing away from each other. They quickly parted as they became aware of my presence.

Cockroaches

Cockroaches of many kinds are very common around BFREE. Although they are frequent denizens of the house and thatches, they live also in the forest, feeding on organic debris.

My second insect catch of the study was a giant cockroach in the house, measuring eight centimeters long (Blaborous colosseus). Cockroaches are nocturnal and emerge from their crevices at night. They can be seen all over the thatch roofs as well as flying around lights. They manage to get into every bowl and hide under every piece of silverware. Simply moving the silverware tray, I saw a cockroach, beetle, and small scorpion clustered together.

It is hard to look under anything in the forest and not find some species of cockroach. I found quite a variety of species of all sizes. Some were reddish, some dark brown, some light brown and spotted, and some were even green. Turning dead leaves and especially searching in piles of rotten cohune pieces always yielded cockroaches.

I didn't observe any special defense, feeding, or mating. What impresses me most about cockroaches is that they can live in almost any environment, reproduce like crazy, and eat almost anything, including cardboard.
Habitat & Defense

Stick insects are masters of camouflage. All the ones I observed were brown. They resemble twigs perfectly. Sometimes they had small flat knobs on one or more legs, looking like the knob of a twig. They also have tiny bumps all over their body, giving a bark like appearance. I never saw a stick insect during the day, probably because they remain undercover with their brilliant disguise.

However at night I observed stick insects frequently as they clung to green leaves along trails and the road. I usually found them in grass and on the top and undersides of low leaves.

Another defense of stick insects (which I never observed) is that they have chemicals stored in special glands on their thorax. They spray this into the eyes of birds or other predators to deter them.

Another amazing and unusual quality of stick insects is that they can regenerate lost limbs.

Feeding

I observed a stick insect feeding, and it was eating a large green leaf. It was especially interesting since it was eating from the middle of the leaf rather than the edge like most insects.
Mating

The first time I spotted a stick insect, I was very excited. It was actually a mating pair. The male, a third of the size and much slenderer than the female, was mounted on top of her. His abdomen was curved down and had special appendages on its tip with which it grasped the female in the right position.

Mantids

I have heard from people that have been at BFREE that there are quite a few bizarre mantids there. I observed some, but I think that with a blacklight, I would have had much more success locating them, especially the larger species.

Mantids are peculiar predators. Equipped with specialized spines on their front legs, they can grasp and hold their prey while they slowly eat it alive. They have powerful mandibles and can eat heavily armoured insects. Although I have seen larger ones in the United States feeding on cicadas, the only mantids I observed at BFREE were quite small.

I observed a green mantis with red eyes that was on a cement column at night, presumably attracted to the light or to the small insects that were attracted to the light. It was about two inches long and quickly flew away as I attempted to catch it.

Another mantis I found was small and black, with a plump, squat abdomen. It was on the kitchen table at night. I caught an insect on a leaf in the day that was very bizarre. It appeared to be a mantid, but also had characteristics of a stick insect. Its long spidery legs and thin body and small head resembled a stick insect. However its front legs were raised with spikes like a praying mantis.
All the other mantids I saw were a small speckled variety. I always saw them on tree trunks, the wood beams of the thatches, or the cement posts. Sometimes at day and sometimes at night, they blend into their background perfectly. One was on a patch of green and white lichen on a tree and had taken the exact mottled color of green and white. About an inch long, they run incredibly fast along the tree trunks and are very hard to catch.

Although I never observed them eating or mating, it is interesting to note that the female often consumes the male while mating. The male continues copulating with his head removed.

**Order Hemiptera: True Bugs**

The term 'bug' doesn't really apply to any insect that's not in this order. This is my favorite order of insects, probably due to the bright colors and bizarre shapes and behaviors. The front wings distinguish this order. The basal portions are leathery and thickened, while the apical portions are membranous. The hind wings are entirely membranous.
Habitat & Feeding

I observed bugs of many varieties. They were not as abundant as some other orders of insects, but each find was very exciting. I found bugs during day and night, but perhaps more in the day. The bugs were usually found on low leaves and vegetation. With the resources I had available, my identification of the bugs was poor. I think that I found a few species of reduvid or assassin bugs. These bugs have sharp mouth parts that stab their victim and suck the juices. Some species bite people and transmit diseases such as Chaga’s disease. All bugs have specialized mouth parts for piercing and sucking. Some use them for predation, but most peacefully feed on plant sap.

Although I never observed them feeding, I noticed one of them seemed to be paying attention to a small cluster of yellow cylindrical shapes in a wet puddle on a leaf. It stayed near them as it was disturbed and hid under the leaf. I’m not sure whether it was a dropping with seeds in it which it was feeding on or whether they were its eggs. I saw these clusters on other leaves. Apparently females often stand guard over clutches of barrel shaped eggs (Stiling, 1986: p.21), so probably this is the case.

Defense

Some of the bugs I found secreted foul smelling substances. Some of these were stink bugs. These were green with a broadened thorax with horn-like protuberances. There were a few varieties, some with black and gold on their wings. For two straight nights, about ten of them were attracted to the sheet with the light. These stink bugs have a toxic defense, which can even asphyxiate themselves in a closed container.

Some bugs used camouflage as a defense, although most displayed bright colors, probably telling predators to beware of their chemical defense.
**Order Homoptera: Cicadas & Leafhoppers**

This order is often classified with hemiptera. All homoptera have four membranous wings and feed on plant sap.

Cicadas are a common inhabitant of the rain forest. However, my study was not at the right time of the year for these insects. During the dry season, cicada songs are heard all day and night (pers.comm., Marlin, 1996). Unlike the thirteen or seventeen year life cycles in northern climates, cicadas in the tropics emerge annually. The mature nymphs crawl out of the ground and up a tree trunk before the adult flies off, leaving its empty shell clinging to the trunk. I found about a dozen of these shells, mostly on trunks, but also on the underside of low leaves.

Leafhoppers are very common at BFREE. They are tiny insects usually, often hiding in grasses and on the undersides of leaves. They suck plant sap and secrete honeydew from their anus, which attracts ants, flies, and wasps. They flourished along the old logging road and the trails. A simple sweeping of the net through tall grass yielded numerous small leafhoppers. The colors are often magnificent, with bright speckles and stripes. Most of them are too small to preserve in a collection and I never observed any special behaviors.

Along with these leafhoppers were a few treehoppers. These often have an elongated spike near their head, resembling a thorn on a tree.

The most glorious and bizarre insect that BFREE area boasts is the peanut head bug, also known as alligator or lantern bug, which is also a homopteran. This magnificent specimen is an odd and noteworthy insect. Ever since seeing one of these in a collection at Chaa Creek, it has been the object of my desire. A few weeks prior to my study, a pair of these insects was observed regularly in the morning on the trunk of a prickly yellow (pers.comm., Marlin, 1996). Unfortunately during
my study, despite avid searching on every prickly tree I saw, the peanut head bug eluded me. It was a crushing defeat, but another example of seasonality.

**Order Coleoptera: Beetles**

Beetles are more abundant in species than any other group of organisms. There are more species of weevil than there are birds in the world. Beetles include the smallest insect and the largest. (Stiling, 1986: p.26)

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Habitat

I observed all different kinds of beetles in all different habitats and at day and night. Walks along trails and roads in the day often revealed small flying insects that showed themselves as colorful beetles when landed in the net. Sometimes large dark insects whizzed through at high speeds. One time I instinctively stuck up my net and luckily intercepted the hurtling shape, which turned out to be a large weevil.
Many beetles, particularly bessbugs, were found in rotting logs and decaying cohune piles. These bessbugs made a squeaking sound when I disturbed them (by rubbing toughened areas under their wings across their backs). I also found many large white larvae in rotting wood, including bessbug larvae, and presumably other species.

At night, beetles were found on leaves and sometimes attracted to lights.

**Defense & Feeding.**

The main defense of beetles is their strong shell, some of which are much thicker than others. This thick shell is a trade-off because it allows protection from being crushed by predators and crash landings, but takes away the ability for agile flight.

Feeding in beetles varies greatly. I observed small beetles feeding on the edges of leaves. I also observed small red beetles feeding on white fungus at night. I returned to the same fungus on another night and found different specimens of the same kind of beetle. Some species of beetle are fast and predatory, such as one I found running on a log with extremely quick long legs, long antennae and powerful mandibles [see title page drawing].

Weevils were the most common species of beetle I found. Their long slender snout has elbowed antennae and is used to feed on sap. I often observed them sticking these snouts into the base of flowers for the nectar. Some weevils were attracted to the rotting fruit in the bowls. I watched one actually push the bowl off the stump. It looked like it couldn't climb over the lip of the bowl which jutted outward, and so it pushed it off, knocking the fruit on the ground!

Many beetles were caught overnight in pitfall traps. Fish heads worked as well as ground beef. Dog food was very effective, yielding a couple dozen beetles each night. Most of these were similar squat round plump black beetles. Their hind legs are elongated and curved ~ackwards into
an O. They appear perfect for rolling balls of dung. These beetles also reeked of dung.

**Mating**

I only observed mating once. One night I discovered two brightly iridescent golden striated beetles on a tree trunk. One was larger and rounder than the other. I placed both in a container. Fifteen minutes later back at my thatch, the two were mating. The smaller male was mounted on the female and a long wide fleshy part extended from the rear of his shell and into her. It resembled the back of a snail.

I found a few weevils that carried tiny reddish-orange eggs on them. Some carried the eggs on their underside, while one had clusters of eggs all over its belly and around the top of its head. The clusters were so large on each side of the head, they looked like huge red eyes.

There were a few fireflies out each night, but not nearly as many as you see at the right time of the year in northern climates. Their luminescence is probably used in mating, although some females mimic patterns of other species and eat the males.

**Miscellaneous**

I found a few click beetles. These beetles can snap a joint violently in their body so that when they are on their back, they can flip up. They continue to do this until they land right side up.

I found quite a few long horned beetles. These have amazingly long antennae relative to their body and are usually striped with beautiful colors.

Another crushing defeat of the project was that I never observed any rhinoceros beetles, but again, this is an example of seasonality. I did find the shell of a very large beetle with a golden velvety back. The horns were broken off its head and maggots were festering in its shell.
**Order Diptera: The Flies**

Flies are distinguished by having only one pair of wings. The second pair is modified to short balancing sensory organs called halteres. Among all the insects at BFREE, the flies are the hardest to avoid.

**Habitat & Feeding**

Many species of flies have aquatic larval stages, while the adults are bloodsuckers. It is the females that need the protein in the blood to mature their eggs. The males feed on nectar. The biting flies at BFREE include mosquitoes, botlass (black fly), doctor flies, short jackets, and horse flies.

The mosquitoes are crafty and relentless bloodsuckers. They are very seasonal, affected greatly by rainfall. I observed many species of mosquitoes, including long legged ones with white feet, small black ones, enormous black ones, blue ones, purple ones, and large orange ones. The *anopheles*, which transmit malaria, give a painful bite and reveal their identity by sticking their abdomen vertically in the air as they suck. The mosquitoes laugh at deet and consider two layers of clothing no great challenge. The back and buttocks are a smorgasbord for the mosquitoes to feast upon when lying in a hammock. Mosquitos at BFREE are most common during November and December, and pestered me in swarms at day and night, but especially at dusk.

Some mosquitoes also carry the larva of the botfly (known locally as a beefworm.) There is much controversy over this, but somehow this larva gets into the skin of its mammalian host. Some say the botfly pins down a certain species of mosquito and lays an egg on its abdomen or proboscis. This egg is dropped onto the host when the mosquito bites, and hatches, crawling into a pore in the skin. A Mayan guide showed me what he says is the botfly. It was a medium sized fly with orange eyes. According to him, one species is orange and one is black, and there is a larger kind that lays
eggs on rotting flesh. I hit one of these flies and then saw a tiny white worm stuck to my hand, exactly like a miniature beefworm!

About four days after leaving BFREE, I was elated to feel a sharp stinging pain in my right tricep near my shoulder. I could see a small red bump, but didn't get too excited in case it was just a pimple. But the next day, the intense burning pain came back, and the doubt crept out of my mind. I had a beefworm! Now I am nurturing my beefworm, hoping to eventually pupate it into a botfly. I am not sure how long I will last however, since there seems to be more than one worm in the same hole and they keep hitting a nerve and also have caused the lymph node in my right armpit to painfully swell up.

Botflies are small black flies with an annoying bite. The larvae filter feed in mountain streams, and when I swim in some streams, I emerged covered with these tiny worms that resembled little leeches. The flies leave a nice welt, with a red dot of blood in the center. The flies often become so bloated with blood that they roll off and can't fly (hence the name bottleass).

Shortjackets were rather uncommon during my stay as well as doctor flies. Horseflies occasionally gave me a nasty bite and were usually found near water. Apparently they are more common during the dry season (pers.comm., Maclin, 1996).

Robber flies were seen noisily buzzing with fast jerky flights over dirt roads or sandy beach. These hairy flies show themselves as formidable predators with sharp mouthparts and a violent personality. I caught one on the beach by the river with orange bristles and a huge thorax which probably supplies their tremendous flying power. It brandished a long, dangerous looking mouthpart and a strange bendable black thread coming out of the end of its abdomen which forked at the end like a snake tongue. When I caught it in the net, it buzzed about with great fury.
Hover flies were quite common. They shined metallic green and blue and often hovered noisily and curiously in the air around people before a movement would cause them to hurry away at great speed.

One time I observed a large swarm of tiny flies. These densely packed insects, probably midges, were moving very slowly about fifteen feet off the ground in a clearing by the house. They emitted a barely audible high pitch buzzing. If I stamped my foot on the ground, they all jerked an inch up in response and sank back down to their original position, in a fluid synchronized fashion. I would guess that this was either a mating swarm, or some sort of protection from predation, simply by travelling in such large numbers (ensures that many survive if the swarm is attacked).

**Order Hymenoptera: Wasps, Ants & Bees**

Many of the members of Hymenoptera have highly advanced social behavior. Almost all of them also have a painful sting or bite.
**Wasps & Bees**

Wasps were fairly common in the area. Large orange wasps were making a paper nest on the underside of a heliconia leaf [see drawing above]. As the nest grew, the leaf weighed down, and appeared as if it would break off. I saw a few nests of similar size abandoned on other heliconias. Perhaps the wasps build a nest just big enough to incubate a few eggs before moving on.

My prize wasp was a huge black spider wasp with a blue sheen and yellow antennae. I often saw these take off as I approached, but could never recognize them since they moved so fast and never landed until out of sight. Finally I spotted one land and crept up before slamming the net down. These wasps paralyze tarantulas and drag them into an underground burrow. They lay an egg on it and seal the entrance. The tarantula is eaten alive in its tomb by the larva.

One night I was pestered by a species of nocturnal wasp. These wasps had white fluorescent bodies and buzzed around my headlamp as I walked to my thatch. I also found a few of them on the sheet in the morning. They were only out for two nights (seasonality).

Wasp nests were common occurrences on buildings and roofs. The paper nests are made by paper wasps. These wasps have wings that fold back over the abdomen. Most of these are social insects and feed their young chewed up insects. The mud nests are made by sphecid wasps. These wasps have a long skinny 'waist' at the front of their abdomen. Other members of this family dig burrows in sandy areas and supply their young with grasshoppers and other bugs, sealing them up similarly to the spider wasps.

I'm not sure if drunken baymen are bees or flies, but they are one of the most prevalent insects at BFREE. They are easily recognized as black, slow flying insects that drag their fat back legs behind them and flock around sugary food, especially honey. The bowls I prepared with sugar...
solution and with honey became quickly filled with a solid layer of drunken baymen. Sometimes when their nests are approached by people, they fly out in great numbers and plant themselves in hair and clothes until they are brushed out. Their haphazard flight and ability to get tangled in anything give them their name. Although they don't bite or sting, I have heard a story of a man who got too close to a nest. The baymen swarmed into his hair and before he knew it, large chunks of his hair were falling out. The baymen had chewed off his hair, perhaps as some sort of food source. He was left with bald patches on his head!

My observations of bees were rather limited. I saw some small honey bees as well as large bees that hovered noisily around wooden beams. No bees are carnivorous.

Ants

Ants are incredibly common and diverse social insects. The species of ants in the tropics far exceed those in temperate regions. They are long lived, workers often surviving for two years.

Ants don't construct cells for their larvae, but instead they are carried around by workers. Disturbing ant nests always produced a mass activity of ants, and I observed many workers carrying the white larvae and eggs quickly away to safety.

Wee-Wees

The wee-wee ants, also known as leaf cutter ants, were kings of the forest at BFREE, sharing the throne only with the termites. Some of the underground nests I found were huge, one of them twenty feet wide, and the mounds of dirt piled high into the air. The mounds were sporadically ornamented with holes from which streams of ants could almost always be seen moving hastily in and out. These ants carry a steady flow of cut up leaves back into their nest. There it is chewed up and specialized
ants coat it with saliva to catalyze the decaying process. The fungus that grows on these leaves is the food of these incredible gardeners. Observing the ants on their trails can be quite interesting. They carve trails along the forest floor that are so clear of any debris that they look manmade, and sometimes can be a foot wide. I've seen them working hard both day and night. Often I found discarded trails of cut leaves, presumably left behind when the rain hit so that the ants weren't washed away with their 'boats'.

One time I observed them on a wild papaya tree. I noticed them on the trunk, and looked for the leaf they were cutting. It was a yellow leaf that was dying and dangling off the tree. All the other leaves on the tree were healthy and green, but it was the yellow one they focused on. Usually I've seen them carrying green leaves, but they probably took advantage of this leaf because it was further along on its process of decay. The stream of ants on the trunk included workers of different sizes, which each seemed to carry a piece of leaf relative to his own size. Some of the ants seemed to get confused, and carried their leaves back in the wrong direction. Perhaps they were sent back to get a bigger piece! There were also larger ants with oversized heads and mandibles that patrolled along the edges of the path, protecting against attacks. The Mayans often use the large mandibles of these warriors to hold wounds closed, pinching off the body and leaving the head as a suture.

**Army Ants**

Army ants were not rare to see around BFREE. These nomadic ants travel in large colonies during the day, transporting their queen and larvae. They pillage and plunder the forest, ravaging and sacking all the living organisms they can handle, including large scorpions and tarantulas. At night they form huge bivouacs of ants all clinging to each other in a large living mass with the queen in the center.
These ants sometimes moved through the thatches where I slept, and occasionally cleaned out the kitchen. It is a blessing when they raid the kitchen because they leave all the food in its containers, but destroy all the roaches and scorpions and other insects that inhabit the kitchen and get in the food.

_Azteca Ants_

_Azteca_ ants have a very interesting symbiotic relationship with the bullhorn acacia. Living in the large hollow thorns of this plant, they angrily swarm out to defend the shrub against any enemy. Brushing up against these accidentally occasionally gave me a nasty bite or two. The ants have a hole in each thorn which they travel in and out through. Even if a vine grows around the acacia, the ants will chew it away. In return for this protection, the acacia supplies the ants with a sweet sap that they use for food. Some of the acacias I saw at BFREE grew high up into the canopy, although they usually remain quite low to the ground.

_Fire Ants_

Fire ants were a common and painful species to encounter. Sometimes I inadvertently placed a foot or hand too near a nest of fire ants. These small red ants swarm out of their nest when disturbed, angrily searching for whatever dares to invade their privacy. They quickly find the culprit and begin biting as soon as they touch flesh. The bite inflicts a burning pain, and they secrete an acid which irritates the skin.

_Other Ants_

Some ants are slavers, stealing the larvae from other colonies of ants and raising them as their slaves. Many ants travel alone and search for food. I observed large black ants that actually 'farm' other homopterans and induce them to secrete their liquid sugar which they feed on.
I often observed ants attacking and killing other species of ants. I observed one spider that made itself appear very much like an ant. It took close examination to realize that it was indeed a spider. The body was segmented exactly like an ant, and it was only small details on the head that gave it away. It mastered the illusion of walking and moving like an ant. Since it was a solitary spider without a web, it probably preys on ants and flies. This could allow it to blend in and appear unmenacing before it makes its kill. Perhaps it even mimics a specific species of ant which it approaches and then kills! I saw other solitary spiders that I actually observed stalking and pouncing on flies.

Order Isoptera: Termites

These insects dominate the forest and proliferate in many various habitats of BFREE. Most trees in the jungle are decorated with the brown trails of the termites. Only the hardwood trees that focus their energy into the slow growth and production of very strong, dense wood have any protection against these insects. As soon as a tree falls, the termites are quick to move in after the wood begins to grow soft. I did not find a thatch that was not riddled with termite trails and large nests up in the rafters. Even the kitchen at BFREE is not expected to last much longer, and will probably need replacing every couple years. The house is the only thing safe from termites (hopefully), and this was built with cabbage bark, one of the hardest woods available, and supported by cement posts.

Termites are similar to ants in that they have a highly specialized soldier caste for colony defense and a worker caste that is usually dominant in the colony. The colony is founded by primary reproductives, special winged termites that construct a nest and rear the first brood. As the first
workers mature from nymphs, they take over nest construction, nursing and foraging. They also feed the royal pair with special salivary secretions. The king and queen live as long as each other, because the king must fertilize each egg. The soldiers have very large heads with strong mandibles, and one species produces a fluid that repels ants, termites' natural enemy.

I observed their spherical nests everywhere, including the ground, bushes, and tree tops. Sometimes they reached six feet high and four feet across! The inside of the nest is honeycombed with chambers for the termites. Breaking open a trail reveals a stream of termites moving quickly in both directions. They construct these from wood pulp. I would guess that this protects them from easy predation, giving them some disguise as well as giving them an easy path to follow without getting lost. It also allows them to forage in darkness, and they are active all day and night. The tunnels I broke were repaired the next morning.

In order to digest the cellulose in the wood, the termites have special protozoa in their guts which help convert the pulp to glucose for them to feed on.

Order Lepidoptera: Butterflies & Moths

There are over 180,000 species of Lepidoptera known in the world. They are named after the thousands of tiny overlapping scales that cover their wings. These scales make this order the most beautiful that I observed at BFREE. Although butterflies usually fly by day and moths by night, this is not always the case and should not be used for identification. One of the best ways to distinguish them is by the antennae. Moths usually have feathery or thread-like antennae, while butterflies have skinny antennae with club shaped tips. In butterflies, the base of the hindwing is expanded and strengthened, supporting and coupling with the forewing when in flight. Moths have
a wing-coupling device consisting of bristles on the base of the hindwing that engage with a catch on the forewing. Male moths have single stout bristles, while females have a number of slender bristles. (Carter, 1992: p.11)

Habitat & Collecting

The habitats I observed were quite varied. In the grasses along trails and near the river, I commonly observed skipper butterflies. These butterflies have short wings and very stout bodies and 'skip' quickly from leaf to leaf.

While watching these skippers as well as various small moths and field butterflies in the grass, I often came to sunny openings in the canopy. These places were hot spots for beautiful butterflies of all kinds to flit through. I often observed daintily winged brightly colored orange,
yellow, red, white, and black butterflies playing in the sunlight.

The denser areas of the forest were inhabited by different species of butterflies. Except for some small orange, black, and yellow butterflies, most of these inhabitants of the shade were quite large. These included the occasional blue morpho (of which I saw only about six, although at times they can be very seasonally common (pers.comm., Martín, 1996) and the prevalent owl butterfly. The blue morphos have breathtaking iridescent blue wings and are prized for their aesthetic value. There are many farms that exploit their pupae to collectors all over the world.

There were three species of owl butterfly I observed. Most of them had large nicks and pieces out of their wings, and I never found a flawless specimen. This is probably because their large size (they are one of the largest species of butterflies) causes them to bump into things with their delicate wings and also makes them an easy target for birds. The more common species had yellow on its upper wings and a grayish blue beneath. I often saw these circling each other along the trails at all times of the day, but mostly at dusk. They also sometimes circled my headlamp at night. Because of this, I wasn't sure if they were diurnal or nocturnal. They definitely like shaded areas and never stay in large areas of sun. One night I found one perched upside down on the bottom of a leaf. I carefully grabbed it by the thorax with my fingers and examined its condition. From this experience, I surmised that they were diurnal. Usually the owl butterflies stayed well ahead of me on the trail and were aware of my presence. This butterfly was sl~eping. The butterflies around my headlamp at night must have been woken up and then attracted to the light. I found out later that they are crepuscular, meaning they are active in the day within the deep shade of the forest (Janzen, 1983: p.703). At dusk they venture into more open areas.

There was one species that I only saw once. It was a shredded specimen, and had an odd
arrangement of bluish gray fading to black. The third species was the most beautiful. It had a purplish blue upper wing, with creamy yellow beneath. These butterflies were much rarer than the first species. Although I observed a few, I never managed to catch one [see appendix 4].

The best area to search for butterflies was the river. On a sunny day, scores of colorful butterflies cruise up and down the river banks, occasionally crossing the river or stopping at flowers to feed. I took a few unplanned baths in attempts to chase these butterflies. Sandy beach was an excellent place to look, as the butterflies often like to land on the sand, perhaps feeding on the minerals and moisture. On one of my collecting trips by the river, a strong wing kicked in. The butterflies quickly disappeared, unable to fly in the gusty winds with their delicate wings.

Moths were most commonly found at night, especially attracted to the light with the sheet. Moths of all colors, mostly small, often roosted on the sheet and could still be found there in the morning. The larger moths weren't usually attracted to my feeble white light, but I found a couple nice specimens with huge eyes that reflected orange in the light, as well as a beautiful large green moth that was dead and partially eaten by ants.

Caterpillars were commonly seen at BFREE, particularly towards the end of my study, suggesting that a few months from now, there will be an increase in butterflies (seasonality). I often saw caterpillars on tree trunks, and also sometimes on leaves or on the ground. Occasionally I found a pupa on a branch or a leaf. More often I saw pupae on the rafters of thatches or underneath signs. These usually were formed from the yellow or white or orange hairs of the caterpillar.

**Why Do Moths Come to Light?**

I have heard many theories about why moths and other insects are attracted to lights at night. The first theory I heard was from my biology professor who claimed that the darkest area appeared
to be next to the light. Because the light is so bright, the area around the light appears darker in contrast
than the rest of the night, so the moth flies in this direction, and then turns around to follow the darkness again.

Another theory states that insects fly in straight lines, navigating by the parallel rays of the moon. The rays cast by the artificial light are not parallel, and so as the moth attempts to fly at a constant angle to the light source, it spirals in ever decreasing circles into the light or comes to rest where it is equally illuminated from all sides. (Stiling, 1986: p. 53)

A similar theory states that moths use distant stars as a reference when flying from one place to another. As before, the moth maintains a constant angle to this light to get to its destination. However, maintaining a constant angle to the nearby artificial light will cause the moth to circle into it (Janzen, 1983: p. 620)

Another theory states that the moth is not attracted to the light in any way, but instead is simply dazzled and disoriented by it, causing them to often fly towards them. (Carter, 1992: p.21)

**Defense**

The bright colors of many butterflies usually exist to deter predators, warning them that their meal will be poisonous. Some butterflies have developed effective camouflage on tree trunks, but usually this is accomplished more by moths. One small moth I observed was beautifully mottled with green and white and brown like the lichen on a tree. Many moths are brown or white, blending in with their background in the day. Often their hindwings which are exposed only when they fly contain the flashy colors that warn off predators. This makes sense, since they would rather remain camouflaged while dormant in the day, but need alternate protection when they are forced to fly at night. Some of them had bright orange spots on their hindwings. One moth I observed had a dark
puff ball at the tip of its abdomen. It wriggled this about a bit, and after being captured, ceased to display it. It appeared to extend many thin hairs in all directions to achieve this afro. I would guess that this is some sort of defense, making the predator think that it is something it's not.

I found a bright blue hairstreak butterfly by the river. As I approached, it took off rapidly, but landed on a nearby bush. It hung upside down there, and engaged in a very peculiar behavior. It had threadlike tails at the base of its lower wings. It perched with its wings closed and rubbed these together. It gave the appearance of the head of some insect, either the antenna or the legs being moved about. Perhaps this defense fools birds into striking at the wrong part of the butterfly or not attacking at all. Since the tails are in the rear and this butterfly flies extremely fast, it would have time to get away.

The owl butterflies have developed a very interesting defense. They land on trees and leaves with their wings closed, displaying large eye spots on the underside of each hind wing. It is believed that these spots scare away predators, who perhaps think that they are the eyes of an owl perched on the tree.

Caterpillars also possess some impressive defenses. Many are brightly colored and wear long poisonous bristles all over their body which give a nasty skin irritation to people and probably a very sore stomach to birds. Some blend in well on the trunk they are foraging on for lichen or mosses. I saw some off-white caterpillars that clustered themselves in tight circles in different spots all over a tree trunk. They remarkably resembled the light colored lichen spots that also adorned the tree. Under this disguise, they could slowly move around and feed in peace.

I also saw on a few occasions, tight trails of light brown caterpillars leading down the tree trunk. The trail was all moving very slowly in one direction, and all the caterpillars would follow
the ones in front of them as they slowly wound their way forward, grazing on moss. If gaps appeared, the caterpillars backed up to fill them in. This behavior baffled me for a while, but then I realized that I was observing a mimicry of a termite trail! Another time the caterpillars behaving in this fashion were a different color and didn't appear as much like a termite trail. I surmised that they were probably imitating one of the many skinny vines and tendrils that snake down the trunks of trees.

**Feeding**

Butterflies and moths feed on nectar which they obtain from flowers with a long proboscis, although some don't feed at all. I also observed many butterflies that appeared to be drinking water from the sand next to the river and perhaps nutrients and minerals also. Once a butterfly landed on the rotting fruit I put out. I also observed a cloud of butterflies, white, green, yellow, and orange, feeding on bird feces on the beach.

All caterpillars are gluttonous eaters. Species are usually restricted to eating a specific kind of plant, and I often saw these plants completely ravaged by caterpillars. Some caterpillars also feed on stems and roots as well as leaves.

I also observed pupae being consumed by a few spiders. Birds enjoyed waiting on a branch for small butterflies to fly too close. Ants also were quick to eat apart butterflies that died. I once left one of my specimens out for a few minutes and upon return, discovered a swarm of ants the had already chewed off an antenna and were working on a wing.

**Mating**

Butterflies and moths live only long enough to mate and lay eggs, which usually takes a few months. I only observed mating once, and the couple was oblivious to my presence. They circled
each other in the tree tops for a while, before landing on a leaf very high above the ground. One butterfly positioned itself below the other. Despite the disturbance I was causing to try and make them fly down for a closer observation, they remained unfazed. I also observed butterflies circling each other in the air, but I'm not sure if this is necessarily a part of mating or perhaps a territorial display. Sometimes I even encountered groups of about fifteen butterflies of different colors circling each other.

**Miscellaneous Insects**

A few of the insects I observed, I could not plate with the other orders, but since I found them so interesting, I will briefly mention them here.

The trashbug as I have termed it, is a curious insect that I observed several times in the kitchen. This tiny critter has front mandibles and plodded slowly around with a large mound of garbage on its back. The insect can't even be seen beneath the filth until it is flipped over. The back has many thin hairs coming out of each side that curve around and angle up to form a basket. This basket was filled with small pieces of lint and debris. I shifted the trash a bit, and it couldn't walk straight, having lost its balance. It took a few moments to readjust its load, and then ambled merrily on. An incredible disguise!

The ant lion is a member of order Neuroptera, the net-vetned insects. The adult resembles a dragonfly. The larval form is a voracious predator. They make the loose dirt around the kitchen and other areas at BFREE look like swiss cheese. I observed these fascinating insects for a while at meals. Ants wander into the conical pits dug by these insects. As they try to climb out, the antlion flicks dirt up around the edges and the avalanche makes the ant fall back to the bottom.
Finally the antlion closes its mandibles on the ant and feasts. I dug a few out with a spoon. They look strange, with soft bodies and large mandibles.

I observed a very strange species of spider that I was convinced was an insect. This spider had an elongated second pair of legs. It extended these up in front of it, exactly like the antennae of an insect. I eventually found many of these solitary spiders sitting on leaves with their peculiar legs raised. Perhaps this is a mimicry that fools certain insects into coming too close.

**Collecting in the Bush**

I was warned that the rain forest is a harsh place, not meant to be inhabited by humans. I was confident that I could handle it, and I was right, although it definitely became trying at times.

The heat and humidity is the first thing you notice in the rain forest. While I was there, the weather was not so hot, and things were beginning to cool down. The humidity is still intense and I needed to drink a lot of water to replace what I sweated off while hiking. The long clothes don't help with the heat, but they must be worn to protect against bugs and thorns.

It is not uncommon to be caught in a powerful tropical storm while collecting deep in the bush. The rain can come so quickly and unexpectedly that the trails instantly become rivers. It did not take long for my camera to break in the water and humidity of the forest, ruining many splendid photographs. I was also caught once in a huge wind storm, which brought small branches and leaves crashing all about me. I heard trees falling in the distance. I hurried back to camp, and on the way, I narrowly escaped a thirty foot cohune branch that was ripped off the tree behind me.

A machete must be carried at all times to hack through the thick vegetation. There are many vines with thorns that manage to grab and slice, and often pulled my hair out, I also drew back
bleeding hands with thorns on a few occasions as I sought the support of a tree while climbing down a slope. Many of the trees are covered with long sharp spikes. Once I managed to get a broken branch with thorns stuck on my boot and I jammed it into my other calf as I stepped forward, breaking the spines off deep in my skin.

The vines and thorns were especially troublesome when an insect took flight. Usually in pursuit of butterflies, I often sprinted through the jungle off the trail, looking at nothing but the insect. Sometimes the bush was very thick, and usually I ended up tripping on vines and landing on my face in a tangled heap as the butterfly gracefully flitted high above my head to safety. Sometimes I was stuck with thorns, and sometimes I emerged with bleeding slices from the razor sharp grass.

The animals were not a great concern as a danger for me. I occasionally worried about running right into a fer-de-lance on one of these blind pursuits into the bush, but my only encounter with one occurred near the kitchen when a herpetologist flung the tommygoff in my direction towards the cage. One time an animal stalked alongside me as I walked back from collecting at dusk. I was alone, and I could hear its footsteps near me the whole way back, but it remained invisible in the vegetation, giving me a bit of a scare.

There are also numerous fungal and bacterial rashes and random infections rampant in the rain forest. Having brought only two long sleeved shirts, my wardrobe quickly became dirty and crusted with sweat, although the humidity kept the shirts from ever drying. Not wanting to scrub the shirts in the river, I wore them each day, unaware of what was happening to my body. All of a sudden, my entire upper body was attacked with acute pins and needles pains all over. These would come in relentless waves and sometimes stagger me to my knees. Needless to say, I quickly washed
my shirts and bathed incessantly, and the pain subsided in a few days.

Beefworms are another discomfort of the jungle. Although they didn't bother me while I was living at BFREE, it is not rare for people studying there to have ten or more of these creatures gnawing into their flesh. Although these didn't bother me then, the pain now is excruciating. Right now I can feel the worm in my arm chewing, and it feels like a lit cigarette is being pushed into my skin for about three minutes. I can see him pumping pus and blood out of his breathing hole and occasionally catch a glimpse of the white tip of his tail. Since there are two small bumps surrounding the larger one, I suspect there are two or three beefworms sharing the same breathing hole (this can often happen).

Ironically, the bugs were the most annoying part of my insect collecting experiences. I was constantly followed by a swarm of hungry mosquitos, not to mention other biting flies. Pausing to examine leaves or to capture an insect resulted in multiple bites every time. Sometimes I would be delicately trying to coax an insect into a container, and no hands would be free, so I had to let the mosquitos happily gorge themselves as I focused on not losing the insect. Since I wore long clothes, my hands and face were covered with itchy red welts. My eyelids and lips were the worst places to get bitten.

Overall, hiking in the bush is a blast, and if you don't mind tramping through puddles and rivers and beautiful rain forest, I would strongly recommend it.
Making a Collection

An insect collection is a useful scientific and educational display. It is also a huge undertaking, especially for one person in three and a half weeks. Anyone interested in doing this should be prepared for intense collecting experiences as well as time consuming delicate pinning work and possible ethical problems.

The pinning of the insects took much more time than I expected. It is painstaking, but rewarding to pin out each leg and each antenna. Sometimes insects break, and I was angry with myself and disappointed. The butterflies are especially hard to pin, and I didn't have the right equipment. The cerrated forceps and flat styrofoam and paper strips were poor, and often I damaged the wings and became very frustrated.

Another recommendation I would make is to pin the insects as they are collected and bring plenty of tupperware and styrofoam as storage and pinning space. I stored most insects in tupperware and let them dry until near the end of my study when I suddenly realized how much work I had to do just pimming, and it cut into my collecting time. It is also easier to pin the insects before they have become dry and brittle (although the relaxing chamber works pretty well).

The most annoying part of pinning the insects is one that can easily be avoided if someone has a place to work indoors. I often sat for hours at a time, and sometimes all day pinning under my thatch. Both hands were delicately holding pins and concentrating intensely on the insect until my eyes became blurry and painful. Meanwhile the mosquitos and botlass make the best of my handicap. It is extremely hard to hold a fragile leg out with the forceps while pinning it with two pins in an x shape while twenty mosquitos are biting you on your eyes and all over your face, neck, hands, and even your testicles through your pants. I often found myself swearing outloud, even
though no one was around.

The transport of the insects was a tricky and scary operation. I pinned them carefully in tight groups in styrofoam plates in tupperware containers. I tied all the containers in two piles and carried them by the top of the string [see photograph]. There was no other way to hike the six miles out to the road without breaking them. The walk was slow, and as I slowly inched along the slippery narrow underwater muddy ruts that separated two deep puddles, my mind raced with fear and memories of the long hours spent on these bugs that could all be destroyed in a second. Occasionally the tupperware caught on a branch and swung backward, and a couple times I lost my balance and barely caught myself, holding the insects in front of me like gold. After making it to the road, my arms were tired from the hike and my shoulders were sore from my heavy pack. The long drive back up north with the insects was as punishing as the hike. The containers jiggled and shook at every bump and pothole, and if you've seen the roads in Belize, you know what I mean. I clutched them tightly in my lap, trying to absorb the shock from the road with my body. They were my babies. Luckily, the insects did make it back without too many casualties.

I was also frustrated when I missed catching certain spectacular insects and also never found many of the insects I was searching for. This is something to be prepared for, and I finally just accepted it.

I reached a point early in my project when I lost all enthusiasm to continue collecting and killing the insects. I was questioning how useful the collection could actually be. I was an amateur entomologist, having never made a collection before. I was a college student without a solid research background. My project was Sh011, and what possible value could the end result really have? I didn't feel as though it could actually be useful as scientific information because of my
credentials, and my only hope was that it could encourage interests in young people. But then I questioned how many people would actually come to BFREE and see the collection.

I have no problem with the death of animals, such as for hunting or scientific purposes. Senseless killing disgusts me, and that's what I was felt I was doing. I had a long talk with my advisor about this, and felt much better. He reassured me that the collection really would be useful for baseline data of the BFREE area in November of 1996. There also will be more and more groups coming to visit and learn at BFREE, and this collection will be interesting for them also.

As it turned out, I am very pleased with my collection and proud of its scientific and educational value. I would recommend to any amateur that is interested in making a collection that they think about the ethics of it beforehand.

**Seasonality**

Seasonality of insects in the rain forest is a huge issue, and one that I will not be able to address completely in this paper. My project was not nearly long enough to obtain good assessments of seasonality, but I definitely observed trends and also gleaned information from the director of BFREE.

Assuming that seasonality is probably affected by rainfall and temperature as well as other general weather conditions, I decided at the beginning of my study to record this information. I intended to use this as a backdrop to compare with my observations of seasonality in the field and draw conclusions from this. I soon learned that it's not nearly so easy.

The most obvious examples of seasonality I observed was the absence of certain insects. I
knew from talking to the director of BFREE that certain insects could be common in the area. Insects that have been commonly found at BFREE in the past but that I either observed occasionally or not at all, included cicadas, rhinoceros beetles, peanut head bugs, blue morphos, white wasps and horseflies. There are also times that entire orders of insects are much more abundant, such as beetles or butterflies. From the abundance of caterpillars at the end of my study, it seems butterflies will dominate in a few months.

My time at BFREE was spent during the worst mosquito months of the year. By keeping a record of mosquitos and also temperature and rainfall, I noticed slight trends in abundance [see appendix 1]. Although this was hard to predict, periods of increased rain seemed to bring mosquitos out in greater force (which makes sense since the larvae live in water). But since the life cycle of mosquito larva is not instantaneous, I could not accurately predict exactly how long after heavy rain it would take for the mosquitos to emerge. It would seem that the advent of water with heavy rain would increase the feeding of the female mosquitos so that they call use the protein to make more eggs and take proper advantage of the new breeding grounds. This was supported by my data and is demonstrated in appendix 1. A more immediate change seemed to be effected by cold weather. A couple particularly cold nights were a blessing, as they seriously reduced the mosquito abundance the next day (but it didn't take long for them to bounce back!).

I also observed that specific insects, and sometimes specific families of insects seemed to be more prevalent on specific nights. For two or three nights in a row, I would observe either a steady abundance of grasshoppers, or beetles, or stick insects. There were also specific species that I had never observed that would suddenly appear for a few nights in abundance and then disappear again. The green stink bugs did this, as well as a few species of beetle and true bugs.
There are so many factors affecting seasonality that this would have been an entire project in itself. These include topics associated with rainy and dry season such as changes in soil moisture, flooding, windiness, wind direction, rain duration and intensity, cloudiness, fluctuation in temperature, average temperature, abundance and quality of carnivore prey and plant parts and species, vegetation shadiness, humidity, and other environmental traits (Janzen, 1983: p.623). These factors affect insect dormancy, breeding, migration, local movements and other things, all of which affect insect populations. The combination and intertwining of all these factors make seasonality a very difficult subject to decipher.

Seasonality is definitely an important subject to study at BFREE. It should be given long term attention. Since it is so affected by environmental changes and many other external conditions, it is very useful to study, especially in light of the disturbance caused by the development of BFREE as well as the pollution and other environmental changes that are taking place on our planet.
Conclusion & Recommendations

My entomological project at BFREE was a great success. Not only did I achieve what I had set out to do, but I gained incredible experience in the field. This is the kind of work I would like to do for the rest of my life. I would like to work as a tropical research field biologist, and this experience taught me a lot about the jungle and about collecting.

The behaviors and observations I made of insects were numerous and fascinating. It was fun to form my own hypotheses about what I was observing and a valuable lesson in my thinking and approach to animal behavior, a subject I am deeply interested in. I have immense respect for insects, as well as all other animals. Their social behavior and complex symbiotic relationships are admirable. I know many people that would do well to treat ants as their role model. They have a strong work ethic and remarkable communication and cooperation.

The need for field biologists is strong. Baseline data is especially important as we face so many environmental problems, such as pollution and deforestation. This data is necessary to provide hard backup evidence to support demands for political conservational action.

I compiled a large collection of insects from the BFREE area. I spent a lot of time preparing these insects and making them look nice. I am very pleased that this information will be useful scientifically. The baseline data is good for BFREE to have. It is something that can be referred to at any time in the future as development at BFREE continues and possible ethical questions or questions of the surrounding environmental impact of BFREE arise.

I admire the efforts and goals of BFREE very much. There is a fine line to draw between protecting natural rain forest and allowing people to live and learn in it at the same time. The protection of the forest is necessitated by teaching people more about it and making people aware.
This is impossible to do without causing some disturbance.

The development at BFREE has cleared a lot of forest and will clear more as plans continue. This clearing has pushed certain species of insects out of their habitats. However this change also allows different species to move in, species that can inhabit disturbed areas. I do not think this is bad, especially since the forest is constantly changing. The results of my study showed that the insects of BFREE are diverse and plentiful. They inhabit all areas of the camps as well as the surrounding forest, showing a tremendous number of species in both disturbed and undisturbed areas.

The key is to minimize the impact and live as self sufficiently as possible. BFREE is very aware of this and of the impact it has had and will continue to have as development continues. Because of their efforts, the rain forest in the surrounding area will remain pristine. People will learn more about the forest and conservation, starting on a small scale, will be reinforced. Hopefully for hundreds of years, this forest will continue to sustain the beautiful and natural life that attracted me to BFREE in the first place.

I strongly recommend that a longer and more thorough entomological study be conducted at BFREE. The area is diverse with insects, and although I worked hard, my project did not do it justice. Without the right equipment, I missed large chunks of the insect populations. A blacklight is essential for collecting. I also would recommend equipment for collecting insects in the canopy. This contains another world of insects that I couldn't even see. I also didn't include underground and aquatic insects in my study.

A longer study could also determine a much better assessment of seasonality in the area. It would be very useful to keep an ongoing record of general seasonal insect observations at BFREE
by whoever is living there. This is an important topic in the long run as it relates to environmental changes and the impacts of people on the rain forest.

If my study had been longer, my collection could have been much broader, and the baseline data would have been much more helpful. As well as serving as this baseline data for BFREE, I hope the collection will be housed at BFREE in a place where every visitor can look at them with fascination. I am excited for young people to share the interest I have in the diversity and uniqueness of insects, and more generally, in nature. I encourage any naturalist (young or old) to draw what they see in nature. It is a rewarding and relaxing experience that I enjoyed thoroughly. I hope that in some small way, perhaps even unconsciously, I can affect some people and be a tiny part of their influence that leads to a sincere love of the natural environment. The natural world is a beautiful thing that deserves and needs conservation. I am excited to see organizations such as BFREE all over the world and optimistic for the future.
Works Consulted

Arrigoni, James E. *Rapid Zoological Assessment, Forest Hill Area, Bladen Branch.* Belize: 1995


## Appendix 1

<table>
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<tr>
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Nov. 9th - burning cardboard - found:
2 whip-tails
2 scorpions - one tiny w/ orange pieces - other large w/ no stingers - roads
2 big spiders (horse spider or wolf?) w/ egg sacs
dragged huge bluish egg sac on abdomen everywhere

Nov. 10th - bright, clear, sunny

It was a butterfly day. In the morning I drew. After the very cold night, the sun came out today and warmed everything up. The wind was one and there were many butterflies. I caught some around camp and then hiked down the river and got some more, including a gorgeous bright blue one with small tails on the ends of its wings. It would sit upside down on a leaf with these thin extensions exposed and rub them together. It looked very much like the head of an insect such as a butterfly or fly. Perhaps if a bird attacks this end of it, the butterfly will have the chance to fly away. This it was very fast.

I also caught an amazing fly on the beach. I think it has to be a botfly. It is so fast and very noisy. Very large and covered with long hair. The body is black and a long thin yellowish-orange hairy abdomen comes out. Very scary looking. It has a long sharp protruding thing out of its mouth and a thin bendable black stinger thing coming out of the end of its abdomen. It also had an egg like thing on the end of the abdomen. I also caught a blue winged grasshopper and a red winged grasshopper on the beach.

Next I headed to a spot at the base of colchic ridge. It was cool and well shaded with sparse understory. I was hoping to find owl butterflies.
I searched in vain until on the way back, a pair of them danced in front of me, perhaps in some sort of mating ritual or territorial squabble. They were the rarer species with purple on the upper wing that I had been looking for.

I lunged forward with my net and they split up. I followed one back along the trail I had come from. As it slotted back and forth, I sprinted in pursuit and tripped over a giant weee-nee nest.

I swung for it a few more times as I ran blindly through vines and prickly trees way off the trail.

Just as it seemed to disappear, I would see a dark shape out of the corner of my eye. Eventually I couldn't find it again. I returned the other way to look for the other. I was still in the area and led me on a similar chase. It disappeared sooner than the others, leaving me panting for breath and needing a rest. I walked back and forth for a few more times but saw nothing except tape and previous footprints. Maybe tomorrow.

I left my tent open and it is filled with insects. Unfortunately most of them are biting flies.

The anopheles mosquitoes that transmit malaria were out in force last night. They have a more painful bite and stick their abdomen straight up in the air as they plunge into their victim, not characteristic of other mosquitos.

The weewee mound today was huge. 10-15 ft across and very high. The cleared trails through the floor of the cave led into holes in the dirt mound from all directions.
Last night on my night search, I observed many things. It seems that many insects are nocturnal and a lot of feeding occurs at night.

Large leaf-shaped katydid eating the bud of a plant.
WOLF SPIDER or large brown grasshopper of equal size.
Many leaf-shaped katydid in the leaves at night. Feeding, while in the day they hide in the grass."

We've found young ups tree trunk carrying many leaf pieces down. I have seen abandoned piles of cut leaves, presumably because rain has started and the ants would be washed away like a sailboat unless they ditched their load.

Large weed with clusters of orange eggs on either side of its head. I have never seen eggs like this on the undersides of beetles too, but never in such masses.
A small spotted mantid. These appear fairly common day and night. About an inch to an inch and a half long, they are incredibly quick at starting in my direction and are well camouflaged on trees and on the cement of the house.

I also ran into an owl butterfly perched upside down on the bottom of a leaf right over the path. I grabbed it with my fingers on the thorax and examined its colors and condition. I wasn't sure if they were diagonal or nocturnal, but now I think they're diurnal. They definitely like shaded areas and are out in the day, but not in the hot sun. They have also often glamour around my headlamp at night. But I think they have to be woken up at night, and then they are attracted to the light. This one didn't move until I grabbed it and usually in the day they stay well ahead of me.
I saw some more mating flies. Again, one was 
1/2 of the size of the other and this time was 
a different color. It looked like a different 
species altogether. Their abdomens were linked with 
their heads facing away from each other and the 
small one was dragged around. 
My pitfall with the fishhead was successful. 
Although the head was taken, I guess by a 
mammal, there were two plump round black beetles 
in the tin. It smelled like dung for some reason. 
Maybe they are dung beetles.

11th bright, clear, sunny, calm 
agreed it was cold, but it warmed up. I hiked 
down the blader for butterflies and dragonflies 
and caught a few of each. They 
know I'm there and they try with me, just above the 
rat so they can watch me jump and fall on the rocks. 
On this occasion I also saw an old man wizard - very 
neverly seen - with a large glittered crest on the 
back of its head. It was in some vines above the river. 
I also saw some hawks as they soared, and I dropped 
my gear and plunged through reeds and vines and thorns 
up above my head until I got under the tree. I 
had a clear view of them hunting as they made their nest 
into a big circle. I got cut all over and didn't have a 
machine. I got lost and couldn't get back through to 
the river. I found what seemed to be a tapir bedding near 
a huge glittered area in the vegetation near the river. 
My netting grid box caught a large weevil today. I was 
exited because it usually only has drunken paymen. 
I saw a large heron that looked like a type of
and night. They seemed a bit more sluggish at night, and I tried to catch one, but they got angry and I got scared.

I saw a Mexican tree frog in a bush—first one here. Also a coffee snake by a log—pretty red, with small black spots and a black head with a cream band.

I saw a salamander on a leaf. These I know are fairly rare here and there are few species. I considered catching it to show Jake later, but I didn’t want it to die, and I didn’t think he’d probably seen many. So I took a good long look and moved on.

It was mostly red/orange on its back with parallel rows of black splotches. Near the underside the color abruptly changed to tan/cream. The body was unusually long with stubby legs and a stubby tail.

I asked Jake today and looked in the book. It doesn’t fit any of the species! It is quite possible it could be a new species—very little is known about salamanders here. My camera was waterlogged, so I couldn’t take a picture. Jake is mad and so am I that I didn’t catch it. The closest thing is Mexicanus, but the cream underside is different and different body proportions. I’m going to scour the area tonight.

This morning I parked until my neck was too sore. I searched for the blue & yellow and butterfly along the ridge and found just one of the common yellow species. A blue morpho barely got away near the kitchen. It was the first time I’ve seen one with my net, and my heart was pounding. I ran after it into the bush, tangling in vines and thorns and falling over as it flew magnificently away.