CHAPTER 1: INTRODUCTION/ LITERATURE REVIEW

OBJECTIVES

1. Compare spider diversity in mature and second growth mixed mesophytic hardwood forests.
2. Provide a checklist to litter and ground surface dwelling spiders of mixed mesophytic hardwood forests.
3. Identify disjunct, endemic, and new or unrecorded species of spiders and discuss them in a regional biogeographic context.

HABITAT

During Pleistocene glaciation much of the southeastern United States was covered with a forest type called mixed mesophytic hardwood (Martin et al., 1993). As the glaciers receded, the forest type migrated gradually northward. Cool moist air was trapped in river ravines, especially those along the Mississippi River, creating refuges for the forest (Delcourt and Delcourt, 1984). They exist on deep, well drained, nutrient rich soils (Landenberger, 1998).

These forests are composed predominantly of magnolia (*Magnolia grandifolia*), holly (*Ilex opaca*), and beech (*Fagus grandifolia*) with a distinctive understory. The understory's distinctive nature derives from the presence of plants with more northern affinities such as maidenhair fern (*Adiantum pedatum*), ginseng (*Panax quinquefolius*), virgin's bower (*Clematis virginiana*), and wild hydrangea (*Hydrangea arborescens*). Their main ranges occur in the north central United States and along the Appalachian Mountains (Delcourt and Delcourt, 1975). They are found along the Gulf Coast only in these cool, moist habitats. During glaciation, southern

pines were lacking in the area occupied by mixed mesophytic forests; however, southern pines presently cover much of the Gulf Coast. Southern pine is still not a major component of undisturbed mixed mesophytic forest (Delcourt and Delcourt, 1974) but encroaches on the habitat following disturbance.

Remnants of mixed mesophytic hardwood forests can still be found in the southern United States. Extensive tracts are located along the Blue Ridge Mountains, the Great Smoky Mountains, and the Cumberland Plateau in the southern Appalachians where they are referred to as cove hardwood or Appalachian cove forests. Mixed mesophytic hardwood stands occur along river bluffs, limestone cliffs and sinks, and hilly areas on the Gulf Coastal Plain (Delcourt and Delcourt, 1975). Scattered mixed mesophytic remnants are found as far west as Texas.

In Louisiana, mixed mesophytic hardwoods are found mostly in West Feliciana Parish (Delcourt and Delcourt, 1975), particularly in the St. Francisville area. This area is known to harbor a number of disjunct species of plants and animals with northern affinities. The hills are considered to represent a refuge for those species present during the last glaciation. By analyzing patterns of relationship among endemic and disjunct species in areas such as the Tunica Hills, discoveries can be made about the historical patterns of distributions of these organisms in Louisiana and the southeastern United States (Delcourt and Delcourt, 1975).

SPIDERS

GENERAL INFORMATION

The order Araneae is one of the most diverse groups of organisms on Earth with over 30,000 described spider species worldwide (Coddington and Levi, 1991).

They have, however, largely been ignored because of the human tendency to favor some organisms over others of equal importance because they lack a universal appeal (Humphries et al., 1995). Spiders generally have humidity and temperature preferences that limit them to areas within the range of their "physiological tolerances" which make them ideal candidates for land conservation studies (Reichert, 1974). Therefore, documenting spider diversity patterns in mixed mesophytic hardwood ecosystems can provide important information to justify conservation of relict stands of this ecosystem.

Comparing spider species found in a mature ecosystem to those in more recent growth is necessary because both the population density and species diversity are affected by human actions and habitat stability. Culin and Yeargan (1983) noted that the abundance and species richness of spiders is significantly higher in systems that have not been heavily manipulated. Species richness is only one way of assessing habitat quality. The uniqueness of species compositions, as indicated by levels of endemism and habitat specialization, is more important in establishing regional conservation priorities.

Despite their size, the ecological importance of spiders is undeniable as they are abundant predators of other forest litter arthropods (Platnick, 1995). Forest litter provides a wide range of microhabitats for spiders through variations in moisture, cover material, and litter depth and structure. A strong correlation between species diversity of ground surface spiders and their litter habitat is thought to exist because habitat affects spiders through prey availability, temperature fluctuations, moisture content, and harborage (Uetz, 1975).

Most studies of spiders in Louisiana have been done on agricultural systems rather than natural ones (Negm et al., 1969; Mysore and Prichett, 1986; Ali and Regan, 1985). These studies indicated the presence of approximately 247 spider species in 25 families in Louisiana. No studies of forest litter spiders had been conducted previously in Louisiana. Among surrounding states only forests in Arkansas have been studied. Peggy R. Dorris conducted multiple surveys of the spiders of Arkansas (Dorris and Burnside, 1977; Dorris, 1985; and Dorris, 1989). Dorris et al. (1995) conducted a study of forest litter spiders in a mixed mesophytic forest in western Arkansas between 1991 and 1992.

My study is the first comprehensive survey of forest litter spiders in mixed mesophytic habitats of Louisiana. It focuses on a little-studied forest type and provides data about species that were present during and after the last glaciation. It also emphasizes the need for conservation of forest remnants by characterizing species diversity and highlighting rare and endemic species in the Tunica Hills.

IDENTIFICATION

MORPHOLOGY

The process of identifying spiders involves two main aspects. The first of these is learning spider morphology, which involves becoming acquainted with the physical characteristics of spiders. The second aspect is learning spider taxonomy, which involves learning the morphological characters that characterize spider taxa and being able to use a taxonomic key to identify organisms. Most of the information presented here is based on Foelix (1996), Kaston (1978), and my own

studies of *Nephila clavipes* (L.). I used *Nephila clavipes* for morphological study due to its large size and common presence at the sites studied.

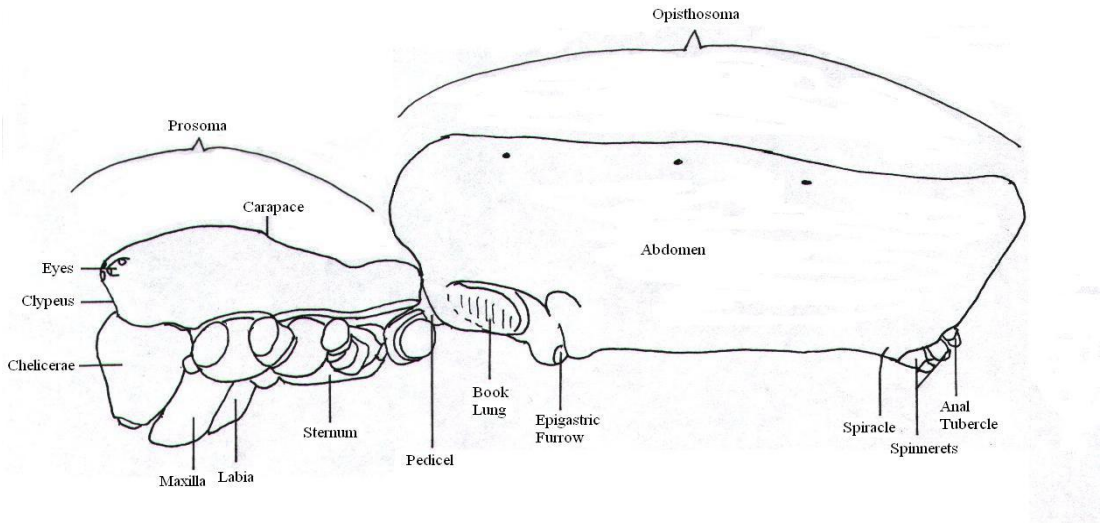

Figure 1: *Nephila clavipes* External Lateral View.

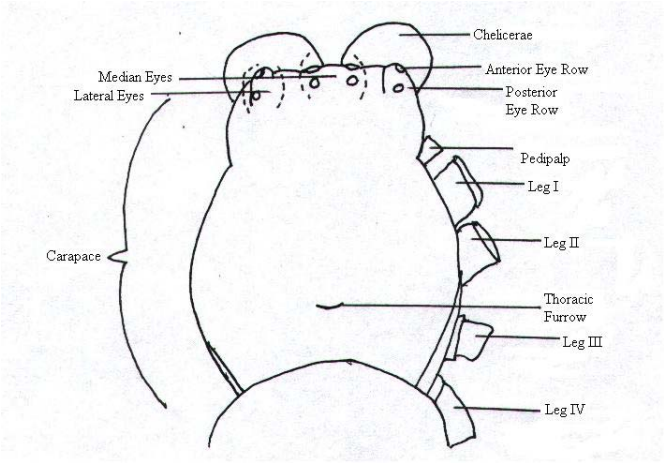

Figure 2: *Nephila clavipes* Carapace.

The spider has two body sections, the prosoma and opisthosoma (Figure 1). The prosoma consists of seven fused segments and supports the eight eyes and legs of the spider. A thoracic furrow at the center of the carapace (tergal plate) is an external indication of an internal apodeme that serves an attachment site for the stomach muscles. (Figure 2) The sternal plate consists of four fused sternites (Figure 3).

Located in the head region of the prosoma are the eyes. (Figure 2) Spiders usually have eight eyes but lack ommatidia. They are occasionally located on a hump or tubercule. Eyes are grouped into anterior and posterior ocular areas. They are further separated into median and lateral ocular areas. AME (anterior median eyes), ALE (anterior lateral eyes), PME (posterior median eyes), and PLE (posterior lateral eyes) are acronyms used to indicate the section of eyes that is being emphasized. The color, number, and placement of a spider's eyes also help identify spider families.

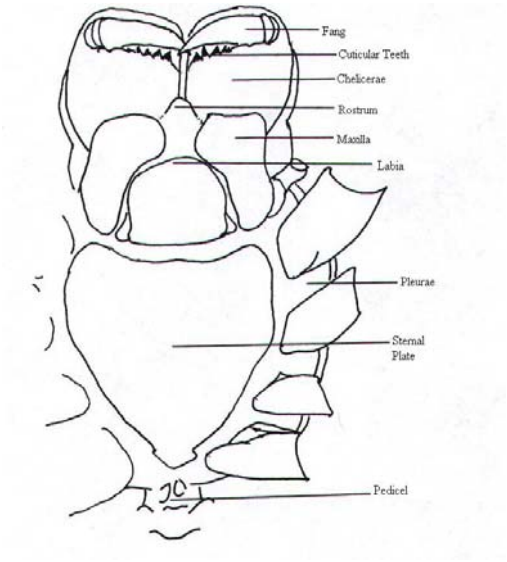

Figure 3: *Nephila clavipes* Sternum.

The prosoma has six sets of appendages. The first set is the chelicerae, which consist of a basal region and a fang (Figure 3). Internally, the chelicerae have poison glands surrounded by muscle that empty venom into the prey (Figure 4). Cuticular teeth, stridulatory organs, or even tubercles may adorn chelicerae. The teeth are located on the distal end of the base on either side of the fangs (Figure 3). The ventral side is called the promargin, and the dorsal side, the retromargin. The

presence or absence of teeth, the number of teeth, and the direction the fangs open are important in spider identification.

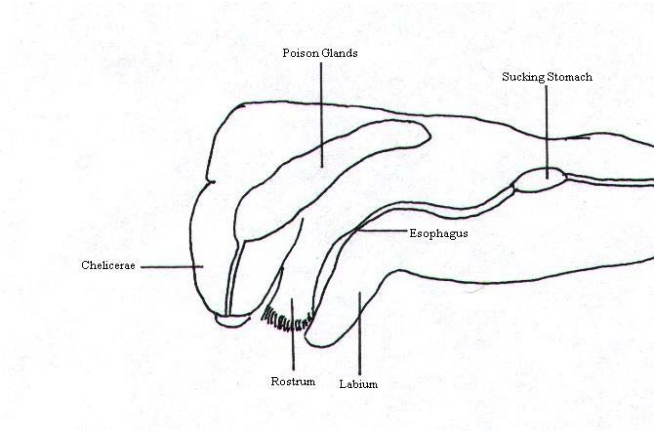

Figure 4: *Nephila clavipes* Lateral Internal View of Prosoma.

The second prosomal appendages are the pedipalpi, which are located anterior to the legs and just after the chelicerae. The pedipalp has only six segments, as the metatarsus is absent (Figure 5). They are not used for locomotion, but rather to manipulate prey and for mating purposes. The maxillae are formed from coxal endites of the pedipalpi.

A significant modification of the pedipalpi can be found on male spiders (Figure 6). Their pedipalpi have been modified into secondary sex organs used for sperm transfer. Sperm is manufactured in testes leading to the epigastric furrow, which is located on the ventral surface of the opisthosoma. It is transferred to the palpal structure via a small silk pouch. The male spider then uses the copulatory structures on the pedipalp to mate with the female. The tarsus of the male pedipalp ranges from a simple bulb-like to a highly convoluted structure.

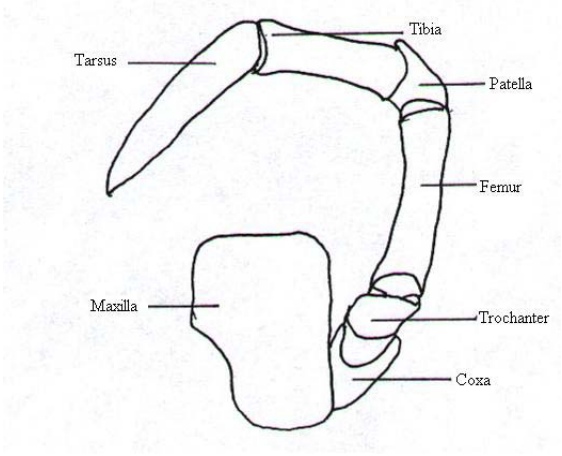

Figure 5: *Nephila clavipes* Female Pedipalp.

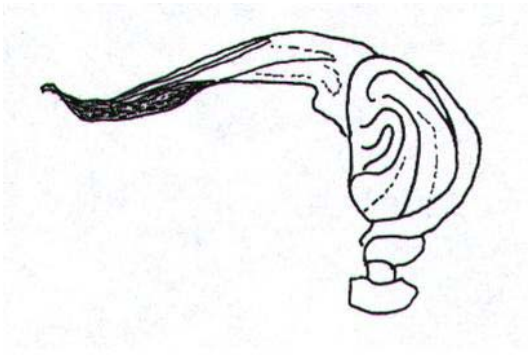

Figure 6: *Nephila clavipes* Tarsus of Male Pedipalp (Modified from Roth, 1993).

In addition to chelicerae and maxillae, spider mouthparts also include the rostrum and the labium (Figure 3). Both are used in the manipulation and ingestion of prey. In addition, the rostrum is covered by hairs, which serve to filter food as the spider feeds.

The other four sets of appendages are the legs. They are seven segmented: coxae, trochanter, femur, patella, tibia, metatarsus, and tarsus (Figure 7). Unlike insects, which often have multiple tarsi, spiders only have one. More significant to the identification of a spider is the number of tarsal claws. Tarsal claws are located at the distal end of the tarsus (Figure 8). Some spiders only have two claws. These

claws are equal size and are sometimes accompanied by a thick pad of scopulae hair. Other spiders have three tarsal claws: two of equal size, and a smaller median claw. One example of three tarsal claws can be found in *Nephila clavipes* (L.) of the Tetragnathidae. In addition to tarsal claws this species has serrated bristles located adjacent to the median claw (Figure 8).

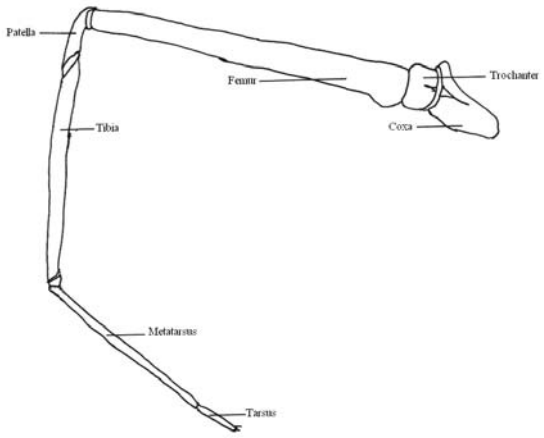

Figure 7: *Nephila clavipes* Anterior Lateral View Leg I.

The hairs on the leg also play a large role in the identification of spiders. Trichobothria are fine hairs that extend at right angles from the surface of the leg. They can be found on all leg segments. The presence and arrangement of trichobothria separate spiders into families. A feature found on the metatarsus of cribellate spider families is the calamistrum, which consists of a series of curved bristles on the dorsal surface of metatarsus IV. In spiders, the abdominal segments are fused and not easily discernible. They are known to have nine abdominal segments, the pedicle being the first and the anal tubercle the last. The exoskeleton of the opisthosoma is very thin and usually not heavily sclerotized. The opisthosoma houses the spider's breathing apparatuses, as well as its reproductive organs and silk producing organs.

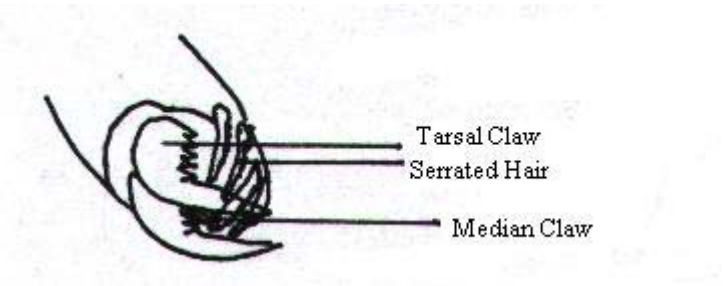

Figure 8: *Nephila clavipes* Tarsal Claws.

Spiders have two types of respiratory organs (Figure 1), which are located on the dorsum of the opisthosoma. The first, and most unique, is a pair of book lungs. Spiders also have a spiracle located toward the posterior of the abdomen. The presence of book lungs and the placement of the spiracle on the opisthosoma are used in the classification of spiders.

The reproductive system of the female can be reached through the epigastric furrow. The female external reproductive features are called the epigynum. The epigynum is made up of a genital opening, two copulatory ducts, and paired seminal receptacles (spermathecae). These are cuticular in nature and shed with each molt. They range in appearance from small slits to highly sclerotized structures with elaborate scapes.

Six spinnerets are located on the posterior section of the opisthosoma. These correspond to six types of silk glands, each performing a different function. Each spinneret is supplied by a minimum of two silk glands. Spinnerets are usually arranged in a circular pattern and grouped into anterior, median, and posterior (Figure 9). Spinnerets vary in length, shape, and arrangement. Three other structures of note are found near the spinnerets. The colulus is a small fleshy structure found between and in front of the anterior spinnerets in some spiders.

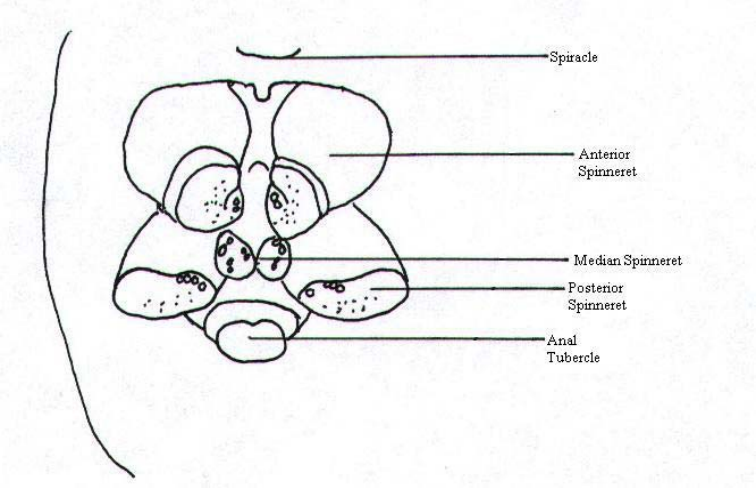

Figure 9: *Nephila clavipes* Spinnerets.

The cribellum is a transverse plate also located in front of the anterior spinnerets in cribellate spiders. The cribellum is coupled with the metatarsal calamistrum in the families where it occurs. Lastly, the anal tubercle, which is found just above the posterior spinnerets, is important because it can sometimes be mistaken for a seventh spinneret (Figure 9).

An example of some morphological characteristics that are used in identification can be illustrated using Salticidae, or jumping spiders. Diagnostic features include placement of the eyes in three rows with the last two rows forming a square, enlarged AME that give salticids the best visual acuity of any spider family, and enlarged forelegs, accounting for the distinctive way jumping spiders move.

TAXONOMY

The order Araneae is divided into two suborders. The Mesothelae includes only the Liphistiidae which can be distinguished from more evolved spiders by the presence of an abdominal plate. Members of Liphistiidae are found only in China, Japan, and Southeast Asia (Platnick, 1995).

The Opisthothelae is divided into two infraorders, the Mygalomorphae and the Araneomorphae (Platnick, 1995). In older literature, mygalomorphs are referred to as orthognatha, and araneomorphs are known as labidognatha. They are separated by the direction their fangs open. Mygalomorph fangs open forward, whereas araneomorph fangs open to the side. Members of the Mygalomorphae also have two pairs of book lungs. Most are hairy with heavy bodies, and stout legs. Included in this infraorder are larger spiders such as tarantulas and trap door spiders. (Kaston, 1978)

The vast majority of spiders are included in the Araneomorphae. They are much smaller than members of the Mygalomorphae, some even quite minute (i.e. less than 2 mm in body length). The more derived families have lost book lungs (Kaston, 1978).

Although accurate identification of the organisms collected is fundamental (Humphries et al., 1995), identifying immature spiders to species is considered impractical because sexual characteristic are needed for species level identification (Edwards, 1993).