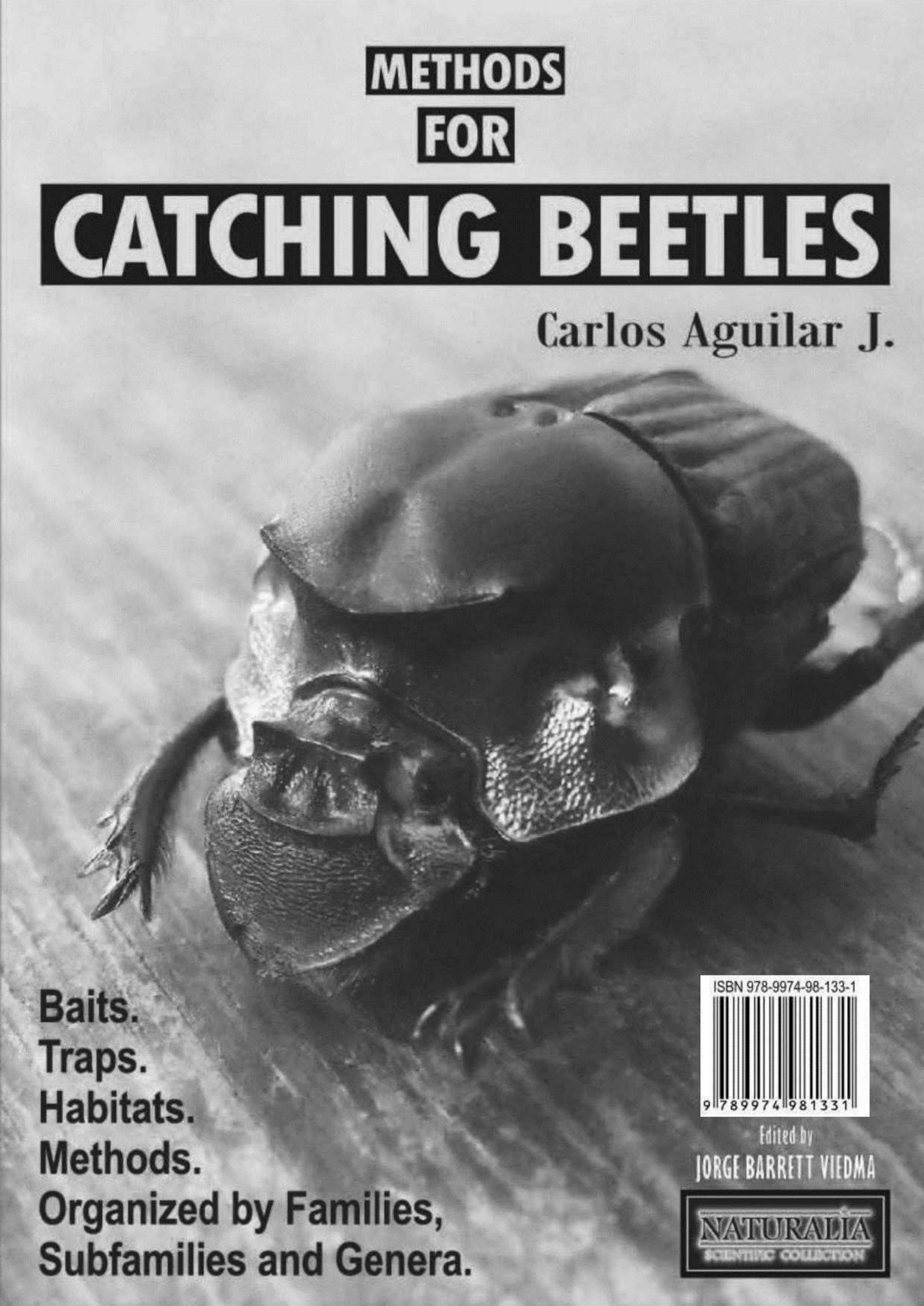
METHODS FOR CATCHING BEETLES

Carlos Aguilar J.



Baits.
Traps.
Habitats.
Methods.
Organized by Families,
Subfamilies and Genera.

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SCIENTIFIC COLLECTION

Additionally, the signal lights of adults and larvae of these beetles can be impressively abundant on mats of floating vegetation of still bodies of water in interior South America (Peck Stewart, pers comm., 2010).

Warning!!

In the mangroves, mosquitoes often are incredibly numerous and their degree of abundance is exceptional (Mavnea, 1968). The populations are often dense. Thangam and Kathiersean (1993) reported that the Pichavaram(1) mangrove are 18 species of mosquitoes, these authors also reported the presence of filariasis, malaria and encephalitis. The high incidence of filariasis is because of the high population of the filaria vector (*Culex quinqufasciatus*). In the Solomon Islands, the mosquito (*Aedes pangiforceps*) was captured while biting a species of Periophthalmus(3) (Sloof and Marbs, 1965). Also, biting flies of the family Tabanidae(2), are abundant in the Mangroves.

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1. **Pichavaram mangrove:** is the second largest mangrove forest in the world, located near Chidambaram in the Southern India.
2. **Tabanidae:** family of biting flies, commonly known as horse flies or deer flies. (Tábanos in Spanish). The name sand flies usually refer to bitting flies in the family Ceratopogonidae.
3. **Periophthalmus:** mudskippers are members of the subfamily Oxudercinae (tribe Periophthalmin), within the family Gobiidae (Gobies). They are completely amphibious fish; they can use their pectoral fins to walk on land.

FOREST AND WET FORESTS

By Carlos Aguilar J. and Sergio D. Ríos D.

There are many different types of tropical forests (Fig. 39). Among the most famous are the equatorial rainforests, found in a belt around the Equator line, into three main regions of the world: South America, Africa and Southeast Asia. These forests contain the greatest diversity of plants and animals, the largest biomass of living material per unit area and maintain a pattern of growth uninterrupted throughout the year (Moore, 2008).

Fig. 39 - Mbaracayú forest (Dpto Canindeyú, Paraguay). *(Photo: Carlos Aguilar).*

The tops of forest trees are evergreen, have a great variety of flowers, fruits and billions of leaves and branches which help to cover the needs of myriad of vertebrates, insects and microbes living there. This is the forest known as "the jungle". "Jungle" is a word that derives from the ancient Sanskrit language of India, and means "a desert". This word was adopted by the English language and distorted in their pronunciation and meaning, and came to be applied specifically to tropical forests. Particularly to the impenetrable growth of vegetation associated with forest edges (Moore, 2008).

The richest forests in species are the Primary forests, which are virgin forests with a underbrush free of weeds, litter on the floor, stratificated tall trees, broad leaf, with a much larger number of species than individuals per species. They have no human interference, there are a full coverage of foliage and are equivalent to mature forests (Sarmiento, 2001).

To give an arbitrary distinction between forests and the more open conditions of woodlands, ecologists have given the value of 40% canopy cover as the maximum for the woods. If the canopy covers more than 40% of the ground, then the vegetation can be defined as forest rather than woodland (Moore, 2008). The woodland is an oligo-specific tree planting made for the purpose of commercial exploitation or decorative (Sarmiento, 2001).

The forest structure

According to Brokaw and Lent (1999); Newton (2007) and Steeter et al., (no date) cited in: Sarmiento (2001), the structure of forest habitat is divided into several layers and is classified as:

Vertical stratification:

Belowground

Aboveground which includes: the Creeping, the Herbaceous and the Understory
The logs (Overstory)

The treetops (Canopy).
Emergent layer, which includes trees that stand out above the general canopy.
Forb layer, of epiphytes and/or aroids.

Horizontal stratification

Refers to the existence of different vegetation types from the center to the boundaries of the ecosystem. These variations are due to climate and local factors of the substrate.

However, until now, the layers of primary forests have not been clearly defined (Kricher, 2008 and Richard, 1952).

Departing from the equator to the South or North, the weather gets drier. This means that forests are becoming less dense in structure and evergreen trees are replaced by deciduous.

Finally, forests are replaced by savannas with thorny vegetation and dry seasons are longer, producing longer droughts. In some tropical locations, such as Northern India, heavy rains occur in a single period of the year (Monsoon) and as a result a distinctive monsoon forest appears. In high mountain tropics, forests are subjected to different environmental conditions as they acquire other aspect. The tropical mountain forests are sometimes called "elfin forest" because the small stature of the vegetation and lichen cover gives them a miniature look.

The following are some important places to take into account when collecting beetles in a tropical forest:

Clearings

Occasionally some very strong winds hit the top of the forest and the tallest trees, and the tallest trees pushed by the wind fall slumped to the ground, dragging in its way the smaller trees (Fig. 40). This fall removes several square meters inside the forest, producing what is known as "clearing". Sometimes the man produces these "clearings", cutting down a swath of jungle. Furthermore, it should be noted that the gaps are essential to the existence of the jungle, since the smaller plants and other shrubs, including the lowest level of the forest (underbrush), have the opportunity to grow receiving the sunlight.

On the other hand, the vegetation may change as time passes (Kricher, 2008).

If the clearings did not exist, then the amount of plant species within the forest would be minimal, because only trees that reach great heights, in order to carry out photosynthesis, would be able to prosper. The lower strata simply would perish, either by lack of light or completely devoured by hordes of herbivores and indirect herbivores (ants, for example). When collecting within the forest it is always more productive to look clearings in them and inspect the wood with sunlight; many species of beetles and sometimes in large numbers can be found in these habitats.

Among the leaves and flowers of the shrubs in the underbrush, or in old clearings, especially when they have flowers or fruit, there are many Buprestidae, Cerambycidae, Scarabaeidae, Chrysomelidae, Nitidulidae, Curculionidae, Carabidae, Elateridae, Dascillidae, Cantharidae, Cleridae, Melyridae, some Meloidae, Oedemeridae, etc. An aerial net with a long handle is useful to collect them. The sunlit logs and trunks usually have Buprestidae and Cerambycidae. On the ground, among or under leaf litter, in fungi, roots and fallen

Fig. 40 - A clearing in the jungle, produced after the fall of a great tree, the tree was removed by farmers (Canindeyú, Paraguay). *(Photo: Carlos Aguilar).*

sticks, live many species of Scarabaeidae, Pselaphidae, Staphylinidae, Carabidae, Ptiliidae, Tenebrionidae, Histeridae, Anthicidae and many other families. Inside the rotten trunks there are Passalidae, Scarabaeidae, Elateridae, Bostrichidae, Scolitynae, Platypodinae and larvae of several different families.

In these places ligth traps are very productive and better if the trees collapsed less than a month ago because the smell of dying wood attracts many beetles which lay their eggs in it and the lights will attract these beetles. The lights can also be used in the wide roads recently opened in the forests. Also, in the clearings it is very interesting to use Malaise traps, but it is better to choose places without people or domestic animals, who often destroy or remove the traps. If there are no gaps inside the forest, it is best to collect on the edge because the beetles within the forest are well hidden and those which become visible are generally common species. But if you check the humus and litter fallen in the forest, you will have many different species of Pselaphidae, Anthicidae, Carabidae, Tenebrionidae, Ptiliidae, Staphylinidae and many other families of small size.

The Canopy

Different groups of beetle species live in different levels of the forest habitat, ranging from the forest floor to the highest level of canopy (Fig. 41).

An expert on Carabidae, Terry Erwin (1983), conducted a study in the Peruvian jungle, clearing the base of a tree and setting it free from shrubs and other plants. Then he spread some clothes beneath and proceeded to fumigate. He caught all invertebrates that fell into the sheet (most from the canopy) capturing more than 300 species of beetles on a single tree.

Fig. 41 - Canopy in the forest of Misiones, Argentina *(Photo: Jorge Barrett).*

Erwin repeated the same study in another tree, where a similar number of insects were caught. By doing some calculations comparing the amount of Coleoptera found in each tree, with the number of species of known trees across America, he found that probably the number of Coleoptera still waiting to be discovered can be about several million species.

At present about 400,000 species are known worldwide. Erwin's calculations may seem exaggerated, but you must bear in mind that only now the Canopy is beginning to be studied. Moreover, this is a very incipient study which has been done only in some tropical countries. It is necessary to do these studies in the rest of the planet. The Canopy is one of the last biological frontiers (along with the deep sea) which still remain largely unknown.

In addition, there are many regions in many countries, still unexplored. . It is important to collect in the litter and many other micro-habitats scattered throughout the world which remains very poorly known. Considering these facts, the number of Coleoptera that Terry Erwin believes are still to be discovered does not seem so absurd.

In recent decades there have been several studies to examine the stratification of insects in a forest (Sutton & Hudson, 1980; Sutton, 1983; Davis et al., 1997; Bruhl et al., 1998), and for this purpose different sampling techniques have been used. The methods to access the canopy were discussed by Lowman et al., (1993) (interesting work available online, see bibliography) and Moffett (1993), while sampling in the canopy was deeply discussed by Basset et al., (1997) and Leather et al., (2005). The means to access the treetops have been an obstacle for those who are studying the canopy, and the access to it has developed in the tropics. One of the first attempts to climb the canopy was performed by means of ladders and pulley systems used by scientists in an expedition to Guyana in 1929 by the University of Oxford. The few studies conducted before 1970 used fixed systems such as multiple towers, platforms, walkways and stairs. In 1978, Donald Perry used a single cable where he tied a box, using it to climb the trees in mountain forests. It was the same technique used by speleologists to climb the vertical walls of the caves. In the next decade, new methods were tested which allowed access to the canopy, including the canopy raft and accompanying sledge. The canopy is also studied with satellites. In December 1999 four missions with canopy raft were completed and four canopy cranes were used regularly in the tropics. In an interesting

article available on the Internet, Basset, Yves et al., (no date, see references) described the key scientific findings contributed by the International Canopy Crane Network (ICCN) since 1990.

Coleoptera are collected by taking samples of the habitat (soil, leaf litter, or moss) in the canopy and then removing the animals in the laboratory either by active extraction (e.g. Wrinkler extraction, Berlese funnel) or by washing (Behan-Pelletier et al., 1996; Leather et al., 2005).

In any case, to collect in the canopy it is advisable to fogging the foliage (discussed in Chapter III of this book) and the use of different aerial pitfall traps, bottles with bait, malaise traps, others intercept traps and also if possible, must be climb trees and beating the foliage. The epiphytes bromeliads must also be checked. Light traps can also be used very effectively in the tree tops to collect actively flying insects (Ozanne 2005).

Lowman and Moffett (1993) in their work (available online, see bibliography) discusses the ecology of the canopy.

The Ecotone

The ecotone is the transition zone between two ecological systems and has a unique set of characteristics, defined by time, space and the strength of interaction.

The ecotone generally has more species than nearby ecosystems, because apart from the species present on both sides, the typical species are generally restricted to the ecotone. This trend toward diversity and intensity increased at the juncture of communities is known as “edge effect” and is explained by adjacent hybridization of the genomes involved (Sarmiento, 2001).

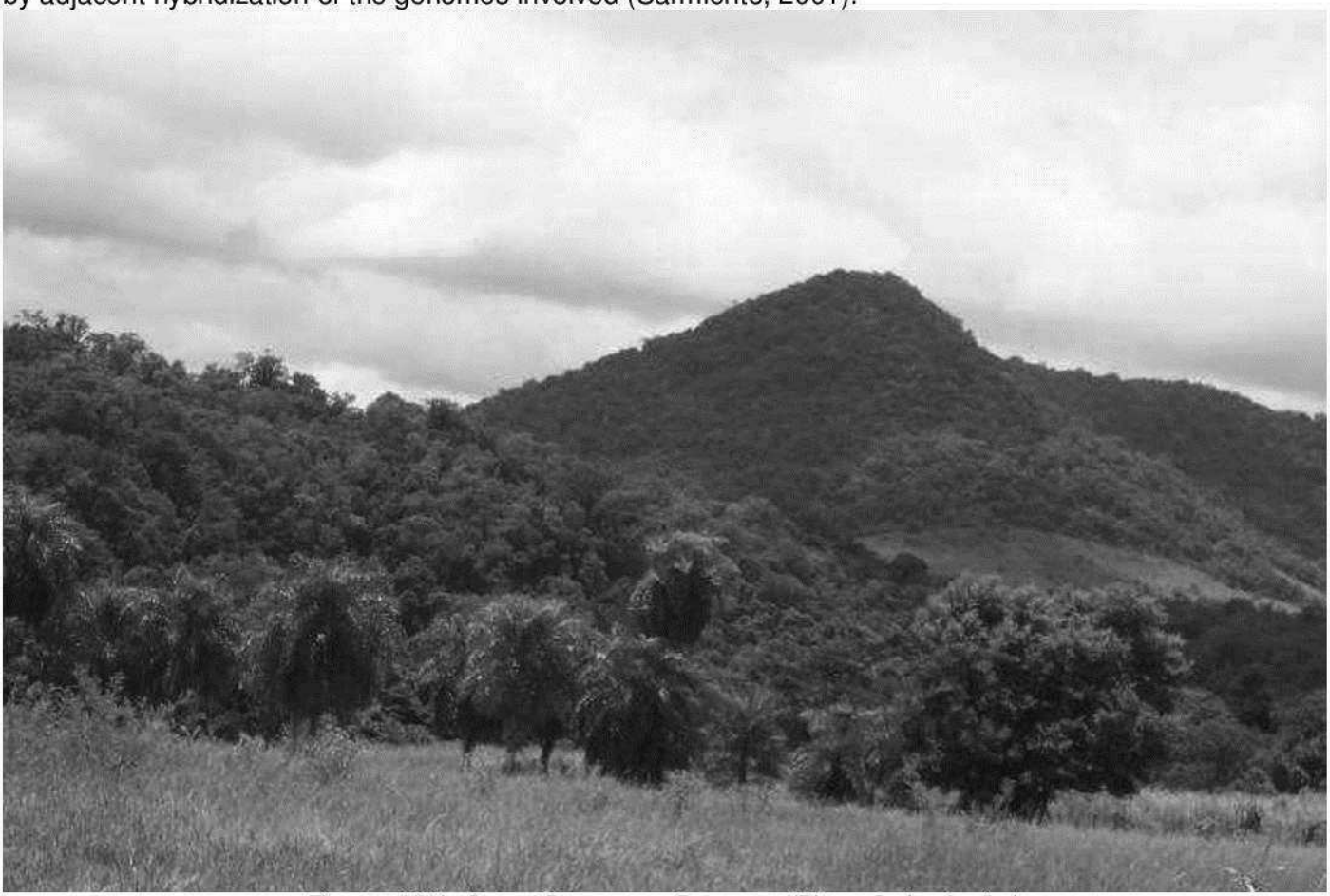


Fig. 42 – Hill in Central Department, Paraguay. *(Photo: Carlos Aguilar).*

That is a reason to practice beating and sweeping in vegetation on the edge of the forest (ecotone) you can practice beating and sweeping; there are many species of Elateridae, Carabidae, Cantharidae, Coccinellidae, Meloidae, Nitidulidae, Mordellidae, Chrysomelidae, Curculionidae, Bruchidae, and other families of beetles. At the edge of a forest a ligth trap is very helpful, this must be located a few meters outside the forest. Also in these, the traps on the trees baited with fruit are successful, attracting a wide

variety of Cerambycidae, Elateridae, Cetoniinae and other Scarabaeidae. These traps should be hung in trees at different heights, to have a representation of all the different stratifications.

Forest Fragments (Forest Patches)

It is hard to decide where to collect when you have to choose between multiple pieces of wood. With respect to these fragmented forests, Brazil is conducting a study to decide what happens to the wildlife that lives there. Kricher (2008) gives a good overview of the project, which is known as "Biological Dynamics Project in Forest Fragments" (BDFFP).

The intent of this project is to evaluate the ecological effects generated by changes in the size and degree of isolation in forest frag-ments. The project is designed to serve as a model for the theory of island biogeography (MacArthur and Wilson, 1963 and 1967).

This theory describes a hypothetical mathematical relationship between the biodiversity of the island, its size (total area) and its distance to the source of colonization (land).

Fig. 43 - Aerial view of fragmented forests, Southern Brazil.

With this model it follows that at some point all the islands reach a balance with regard to the richness of species, here species immigration rate equals the rate of extinctions.

In balance, the large islands near the mainland will have a larger richness of species than small islands and more distant from the mainland. The important thing is that this model predicts the difference in richness of species between different islands with different conditions.

The model is quantitative and can be tested. As fragmented forests are like islands, it was recognized that the model had implications for the structuring conservation of parks and reserves (Diamond, 1976).

The project researchers worked together with owners of cattle, to whom the Brazilian government required to protect 50% of the forests on their land. They were asked to cut down their forests leaving some fragments of different sizes and different distances from a protected area of 1,000 hectares (source of colonization). The area of each fragment was thus: 5 fragments (1 ha. each); 2 fragments (10 ha. each); 2 fragments (100 ha. each) and 1 fragment (200 ha).

Studies of BDFFP are still being pursued, but some interesting results were already obtained. It has been shown that all species studied have varying degrees of sensitivity to the effects of area and distance. For example, underbrush birds decreased dramatically after 7 months compared to the number of species that existed before fragmentation, thus part of the biodiversity plummeted, an effect known as "Collapse of fauna" (Kricher, 2008). Moreover, Euglossinae bees were reluctant to fly to fragments that were more than 80 meters from other forests.

The decline of wildlife did not occur in all cases, for example, populations of small mammals in fragments of 1 hectare increased, compared to 10 ha fragments and continuous forest. Some Scarabaeidae and other scavengers decreased in small fragments, but that was probably due to lack of dung and carrion which disappeared when larger animals migrate.

According to the author's experience collecting in fragmented forests of varying sizes, the species of Scarabaeidae collected in small islands, scavengers and coprophagous, are linked to bovine cattle living in nearby areas.

When a large forest is cut, the beetles are very abundant during the first two years. Thereafter, their populations drastically reduce, and some species disappear. Probably a 10 hectares forest may consistently contain several species of interesting beetles. As an example, in central Paraguay (Department Paraguarí) the author and others have collected many rare species of Coleoptera families, including the Subfamily Cicindelinae *(Oxycheila pochoni* Mandl*, Brasiella minarum* (Putzeys), etc), Cerambycidae *(Navosoma luctuosa* (Schoenherr), several *Callipogon,* and many rare Lamiinae), Scarabaeidae *(Strigidia, Pelidnota, Dichotomius, Dendropaemon, Eurysternus* and Canthonina, *Coprophanaeus, Megasoma,* Phileurini, etc.) and many other families. These forests today are highly fragmented; some of them have only a few hectares and are very disturbed. However, according to Laurance and Lovejoy (2002), in the course of time, opportunistic and generalist species are those that dominate the fragmented forests.

A study conducted in Europe on fragmented forests suggests that reducing the fragment size, adversely affects the capture of Carabidae and its richness in species.

Besides, urbanization affects also the populations of Carabidae. For example, when two forest fragments are separated by a road (common in South America), these beetles rarely move from one fragment to another. Therefore, the roads are dispersive barriers for forest Carabidae (Matti and Hendrik, 2005).

When choosing a small forest fragment, it is important to have a great variety of trees, much undergrowth, and trees of considerable size (pers. obs.).

Kotze and Samways (1999) conducted a comparative study of Staphylinidae in several forest fragments in Colombia. They concluded that small forest fragments (3 hectares to 6 hectares), have few species of Staphylinidae, and medium-sized fragments (more than 6 hectares) have more species. To get that forest fragments have variety of species, it is important that they are not too far from each other. Still better if they are connected to each other, or connected somehow between themselves or to a larger one, even with some planting of introduced trees containing underbrush.

Apparently, the presence or absence of some beetles is determined by the intensity of light entering into the forest and also by humidity and other environmental factors (presence of humus, canopy, etc.), which change dramatically when clearing a forest or the larger trees are removed.

In some savannas and natural grasslands there is a kind of small forest called "island of forest", with a few hectares in size which have not nearly been modified or at least have not been logged. In fact its main degradation has been the effect of grazing by the cattle.

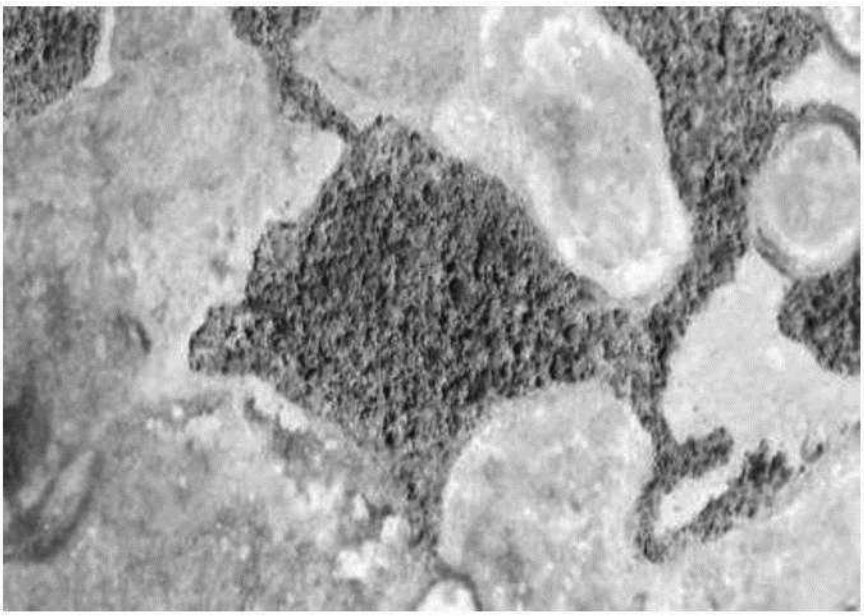
Many of these forests are flooded the majority of the year; however there may be found some interesting beetles.

It is interesting to note that forest fragments are close to each other, since those which are closer to large forests have more species, while those most distant and separated from each other include smaller amounts. As insects and other animals use these fragments to move from one forest to another, as in the gallery forests, which follow along water courses such as the Scarabaeinae *Sulcophanaeus faunus* Fabricius (Edmonds 2000). Still better if they are connected to each other, or connected or to a much larger one, even if part of the vegetation is introduced (Fig. 43).

With regard to the collection, at the edges of these forest fragments it is advisable to use beating-sheet, pitfall traps and ligth traps. Bottle traps in trees are not very productive except in certain fragments connected to larger ones.

Forest Islands

The forest islands (Fig. 44), which are in the midst of some natural savannas or within a pasture or natural grassland, often have been formed from the remains of a forest that was cleared, or it is what remained of a great forest that led to a natural savanna. This is a process of advance and retreat of the savannas, which sometimes takes thousands of years. Many of these forest islands have soils that used to be flooded, sometimes with the accumulated water of the rains, others by a stream or creek flowing through that produces seasonal flooding. Some of these small forests are composed of a ground devoid of grass, but with many terrestrial bromeliads and epiphytes in trees. There are also trees with half-naked trunks and with many lianas.



In this type of small size forest there are not many species of beetles, except for some Scarabaeidae, Cerambycidae, Bruchidae, Tenebrionidae, Carabidae, etc. which may be in dry soil, or partly humid. To collect many species of beetles examine the branches and trunks and even the tops of the trees, especially when they have mature fruits or flowers.

It is important to note that, in the open areas surrounding the forest islands, in floodplains, there are several species of Scarabaeinae. But the traps must be buried when these places are not flooded.

Fig. 44 - Forest island surrounded by floodplain

Forests of introduced trees

In South America there are many pine and eucalyptus (not native, originally from Australia, see fig. 45) forests. In general, these are not good places to collect beetles. However, if they have plenty of native underbrush they may contain interesting species of beetles.

Fig. 45 - Eucalyptus forest in Pando stream, Uruguay *(Photo: Jorge Barrett)* .

For example, in Chile was made a comparative study of the epigeal Coleoptera in a reserve, including the surrounding native forest fragments and surrounding pine plantations. The averages of beetles collected were slightly lower in pine plantations than in the native forest, but these differences were not significant (Grez et al., 2003). The study concluded that if the pine forest has rich native underbrush, then it might still harbor an interesting fauna of beetles.

Most beetle species such as Cerambycidae and Scarabaeidae (Rutelinae, Cetoniinae and Dynastinae) and other families live almost exclusively in native trees that are not present in introduced forests (though these have native underbrush).

In any case, when collecting in these environments, light traps, sweep net, beating-sheet, pitfall traps, malaise traps, etc. can be used. Bottle traps in trees are not very productive for collecting Cetonidae, Scarabaeidae and Cerambycidae since introduced trees do not have many interesting species of beetles. However, traps can be used for other xylophagous beetles such as Scolytinae, Platypodinae, Bostrichidae or Anobiinae since many of its species attack the plantations.

Forests in gallery

The "forests in gallery" are a type of riparian forest, the term Riparian comes from the Latin word "Riparius", meaning "of or pertaining to the bank of a river" (Webster's Revised Unabridged Dictionary in 2010). According to Peck (2007) the riparian, refers to biotic communities that occupy the banks of rivers and streams. Riparian areas are the transition zone between the terrestrial environment and rivers.

Fig. 46 - Margins of a stream into a forest (Naranjo, Department Cordillera, Paraguay. *(Photo: Carlos Aguilar).*

The "forests in gallery" are common in Uruguay, Paraguay and many other countries worldwide.

Its structure is somewhat different from the "jungle" and includes forests that follow the banks of streams, where vegetation is set on a very wet soil and occasionaly flooded in certain months of the year, and sometimes permanently.

They are characterized by deciduous tree species in climates with summer drought. In these environments branches near the ground are somewhat bare of leaves and often prickly. The riparian vegetation of rivers is relatively independent of the territory general climate. In areas of high rainfall, differences with the dominant vegetation in the vicinity may not be very pronounced. In contrast, in areas of dry climates, or even semi-arid Mediterranean, "riparian" vegetation appears as a tree or shrub leafy system, in linear distribution, or along the paths of water showing enough contrast to the surrounding landscape; for this reason this type of forest has been called "riparian forest" (Aguilella and Russell, 2004).

In the fallen trunks in gallery forests, the beetles are not frequent, although sometimes, inside rotting logs, Passalidae, Lucanidae and other families can be found. In these habitats, it is better to use bottles of intercept traps in trees and logs. Although gallery forests do not have such a variety of beetle species as the most extensive jungles, these forests are an important biological corridor because they connect two or more forests, where the rivers with "riparian forests" pass through. This allows finding many rare and interesting species of beetles. For example, in the Amazon basin is widely distributed a set of coprophagous Scarabaeinae (*Sulcophanaeus* spp.) and among them, the nocturnal species *Sulcophanaeus faunus* (Fabricius). This species was known only in the Amazon basin. The author of this book found it in a much more Southern forest (with pitfall traps baited with human feces) in the biological reserve of Mbaracayú (in Northern Paraguay). Probably, this beetle arrived in Paraguay from the ancient gallery forests that connected the Paraguay River with a large area of Mato Grosso, and consequently, to the Amazon basin (Edmonds, 2000).

In the gallery forests, after flooding, the soil should be examined both day and night, since there can be found walking Cicindelinae, others Carabidae, Tenebrionidae, Anthicidae, etc.

In the meanders, or small pools of muddy water formed by the flooding of rivers, Hydrophilidae and other aquatic beetles can be found. Also at the edges of these habitats there are many Carabidae, Anthicidae, etc. Places with land snails (which are common in these habitats) must be found because there can locate some interesting Carabidae (*Brachygnathus* spp., Carabus spp.) that feed on these snails. On the tree branches Buprestidae are common (especially in sunnier sites). On the trunks and between them (and branches) Anthribidae, Cerambycidae, Tenebrionidae can be collected (including Alleculinae, Lagriinae, etc.). Under the bark there are Scolytinae, Bostrichidae, Anobiinae, Platypodinae and other xylophagous beetles. Nitidulidae abound in fruit fallen on the ground.

In this type of forest (as in the patches), only the pitfall traps should be used during the period in which there is no flooding. The use of malaise traps and intercept traps gives good results, like the light traps. In any case, if you intend to use pitfall traps, it is convenient baited them with fish or shrimp and/or feces, but they should be placed preferably on the higher mounds, avoiding the traps to be filled with water when it rains.

Occasionally "Gallery forests" are not very wide, either by deforestation or because these forests are located in rivers running through a savanna or natural prairie.

THE SAMPLING METHODS IN THE FOREST

In the big forests, most of the beetles live near the tops of trees, in flowers, fruits, leaves and branches. The main families living among the foliage, in both the canopy and the underbrush are: Scarabaeidae (Cetoniinae, Rutelinae, Trichiinae, Dynastinae, Melolonthinae, etc), Lucanidae (some small species have been found on the flowers) Glaphyridae, Cerambycidae, Buprestidae, Throscidae, Lampyridae, Lycidae, Coccinellidae, Chrysomelidae, Curculionidae, Carabidae, etc. So, to collect the widest possible range of beetles within the forest it is appropriate to review:

Collecting at night

Walk into the jungle to find the beetles during the day is not a very good system, however it is convenient to do it at night with a flashlight or lantern.

In this time of the day, it can be found on the branches or trunks specially some Tenebrionidae, Anthribidae, Brentidae, Cerambycidae, Lucanidae, Erotylidae, etc., and between beetles walking in the soil can be found Carabidae, especially Calosoma spp, Galerita spp, Brachynus spp, Ceroglossus spp, and some Cicindelinae Subfamily species.. Many species hide during the day and just take a walk at night, so their collection is difficult.

To catch them, different methods can be used: beating the foliage, strain the leaves and humus and even the earth below the humus, check the fungi. To do so, must be used Berlese funnels or "Wrinkler/Moczarski" eclectors, and different types of traps, like pitfall traps or bottles in the trunks and other baited traps. Intercept traps and light traps are also very productive.

Collecting in flowers and fruits:

Flowers are very attractive to many beetles, so, it is important review them constantly. Fruits, especially those which are rotting and/or those that are fermenting are an excellent food source for beetles. The fruits attract various species of beetles, such as Elateridae, Nitidulidae, Helotidae, Silvanidae, Cerambycidae, some Scarabaeidae and other families. The fruits in a very advanced stage of putrefaction attract only Nitidulidae, Silvanidae, some Histeridae and Staphylinidae. Fruits also can be used as bait in the traps. The accumulations of petals fallen on the floor may have varied species of Carabidae and other families.

Collecting in decomposed organic material

Odoriferous particles of dead bodies, feces and other decaying substances are more easily detected by the beetles which live at a certain height, than those sitting on the floor. Some Scarabaeidae perch on shrub leaves, either a few centimeters above the soil or even some meters height. The olfactory helps to detect feces and/or decomposed bodies and also to keep track of certain mammals (monkeys, koatis, tapirs, etc.). This is an energy saving method because they do not have to fly constantly in search of food. This behavior has been recorded in almost all the world's forests. *Onthophagus semiaureus, Onthophagus semicupreus, Sisyphus thoracicus* (Hanski, 1989), to name a few, have been found in Malaysia, perched on the leaves. Although these species live primarily in the soil, Davis et al., (1997) revealed that some species of *Onthophagus* are arboreal. They have been found a few meters above the forest floor, even in the upper canopy.

These beetles feed on primate dung living in the Canopy (Hanski, 1989). In Paraguay, the author has collected many times *Canthon virens* Mannerheim, some C*anthidium* spp. and *Chalcocopris hesperus* Olivier, perched on leaves in the forest at low altitude.

According to Howden and Young (1981): "*Canthon angustatus* Harold *and another congeneric species (Canthon subhyalinus* Harold*), have evolved the ultimate behavior pattern for locating food in the threedimensional space of a tropical rain forest. Howler monkey faeces, placed at the top of a 23 m tower was approached first at a height of only 15 to 60 cm above the ground, and then, from the base of the tower, by vertical flight up to the top of the tower. These two species are able to form and roll primate faeces adhering to leaf surfaces. The beetle remains attached to the ball as it falls to the forest floor, managing to land on top of it."* So when pitfall traps are used, it is convenient to review the underbrush foliage in the vicinity of these traps.

Collecting in plants or shrubs that have leaves chewed

In these cases the culprits must be sought, which usually are Chrysomelidae and other beetle's larvae. Furthermore, some species of Salpingidae (Othninae) can be found running on the foliage present in the wettest parts of the forest.

Beetles walking on the trunks

The following families are usually found walking on dead or alive trunks: Tenebrionidae, Alleculidae, Brentidae, Anthribidae, Curculionidae, Cerambycidae, etc. and under the bark can be found: Cucujidae, Lucanidae, Buprestidae, Chelonariidae, etc.

Collecting in stumps, logs and dead branches:

Examining the dead wood is one of the most productive methods for obtaining a wide diversity of beetles. This is because many beetles and their larvae use wood as a source of food and feed on other insects living there, algae, mosses, vascular plants, fungi, slime molds and even colonies of bacteria.

Should look bellow the trunk and/or on the bark and break it to be able to find: Carabidae, Lucanidae, Histeridae, Elateridae, Bostrichidae, Anobiinae, Cleridae, Sphindidae, Cucujidae, Colydiinae, Tenebrionidae, Cerambycidae, Anthribidae, Curculionidae and many others beetles.

Also must be hit the bark with a stick to make the smaller specimens fall on a white cloth. Different species of beetles can be found in different ages of the wood. The freshly cut wood will attract different species than those which are attracted when it starts to rot.

Other species are attracted to even older wood. Must be carefully examined each part of a trunk. After reviewing over the bark it should be removed carefully so that beetles fall to the ground. It is better to lift the bark sections, helped with a small knife or machete and place a white cloth or beating-sheet under the trunk, so it will be easier to locate some beetles when they fall. It is also useful to examine the holes and galleries made by other insects inside the trunks and branches; if there are small brown elliptic pellets, usually they are Cetoniidae droppings (or other Scarabaeoidea), so these must be carefully reviewed. To find the species hidden among the dead roots and trunks, a small hatchet or knife can be used. In very old and rotten wood you can find many Tenebrionidae and Carabidae, and also some Cerambycidae, Lucanidae, Passalidae, etc. There are larvae or pupae of many rare species protected by a brown shell, like a small bird's egg, covered in their droppings.

Collecting in natural tree holes:

Many trees have natural cavities and these are filled with rainwater, sometimes these are very large. Many beetles (and other animals) used these cavities as habitat. In the article "Collecting in aquatic and semiaquatic environments" (Chapter II), is explained in more detail the ecology and methods to collect the beetles that live within these cavities.

Beetles in fungi:

(See "Beetles in fungi", Chapter III). In fungi can be found Myxophaga, Endomichidae, Mycetophagidae, some Geotrupidae, Staphylinidae, Tenebrionidae, and many other small beetles.

Collecting in dung(1):

Search for Scarabaeidae (Scarabaeinae: Phanaeina, Canthonina, Dichotomina, also Onthopagini, Aphodiinae, etc.), Geotrupidae, Trogidae, Hybosoridae, Histeridae, Staphylinidae, some Hydrophilidae, etc.

Collecting in carrion:

Here there are Silphidae and Scarabaeidae (Scarabaeinae: Phanaeina, Canthonina, Dichotomina, also Onthopagini etc. and Aphodiinae), Hybosoridae, Trogidae, Geotrupidae and some Hydrophilidae, Histeridae, Staphylinidae, Dermestidae, Cleridae, etc.

Beetles living in association with other animals:

Some beetles are associated with the nests of ants, termites, birds, mammals and reptiles which use the dead logs (see: beetles associated with others animals, chapter III).

Using the pitfall traps:

To collect Ground beetles pitfall traps must be used with which you can catch mainly Carabidae, Tenebrionidae, Staphylinidae, Histeridae and Scarabaeidae. Locate these traps on the floor, even better if it is near a tree, a fallen tree or other natural barrier.

Using traps in the trees:

The traps in the trees are very good to collect Cetoniinae, Scarabaeidae, Cerambycidae, Lucanidae, etc. The bottles with holes and stuffed with sawdust, can be hung on trees to attract some Cerambycidae, Scolytinae, Platipodinae, Anthribidae, Brentidae, etc. (See chapter III).

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1. In mountainous forests, humidity is permanent throughout the year and necrophagous and coprophagous beetles appear in the warmer months of spring and summer. In humid forests just as in some tropical savannas beetles are abundant all year. When there is a light wind, necrophagous and coprophagous beetles are more active than in heavy wind or rain.

During prolonged droughts the beetles are hardly found, except in dry regions. In these regions, beetles are much more abundant after a rainfall.

Using sticky traps

With sticky traps on logs, stumps, branches, soil, etc. many species of beetles that use to walk on them can be caught.

Using traps for underground beetles

The underground traps like tubes with holes, filled with sawdust, are useful to collectmany small subterranean species (Staphylinidae, Pselaphidae, Carabidae, various larvae, etc.). Another method consists of using a wire grid (5 mm mesh), for draining the rotted leaves and leaf litter on a white cloth. You collect the beetles walking on the cloth. The leaves and twigs lying on the grid are discarded, but the remains of humus, which are smaller and lying on the white cloth, will be stored in cloth bags (with all data collection) and later will be separated with a Berlese funnel or with a Wrinkler/Morczarski eclector.

Beating method

A very effective method to collect many species is the use of an beating sheet. The roads within the forests are advisable to collect, especially where they have been recently opened. Bottle traps in trees, light traps, intercept traps, pitfall traps, etc. are also useful.

Fogging

Find a tree (or fallen log) that is off the ground by one end, or leaning against another tree (see “Fogging trees”, Chapter III).

Below ...

Must lift up anything that is on the ground: stems, bark, stones, piles of branches or fallen leaves, etc. Many species are hidden there, especially under or near logs where the highest soil moisture is concentrated, such as: Carabidae, Erotylidae, Endomichidae, Tenebrionidae, Staphylinidae, Corylophidae and many other families.

Rearing larvae to get adults

In the rainforest some pieces of wood (not too old) can be picked up, to be able to raise the larvae of many borer species (Cerambycidae, Tenebrionidae, Buprestidae, Bostrichidae, Mordellidae, etc.) and their predators (Cleridae, Elateridae, etc.).

Warning

In the “Riparian forests” and “patches” in general, mosquitoes and other biting insects abound, and almost all of them have a strong bite, so you should enter into these forests with a good dose of repellent. When visiting a forest where it is suspected that many mosquitoes are present (which are almost always there haunting their victims) it is best to dress in light clothing covering most of the body; shirts and pants in “jean” are fresh and useful for this purpose. It is not advisable at all going into those habitats in short pants or short sleeve shirts.