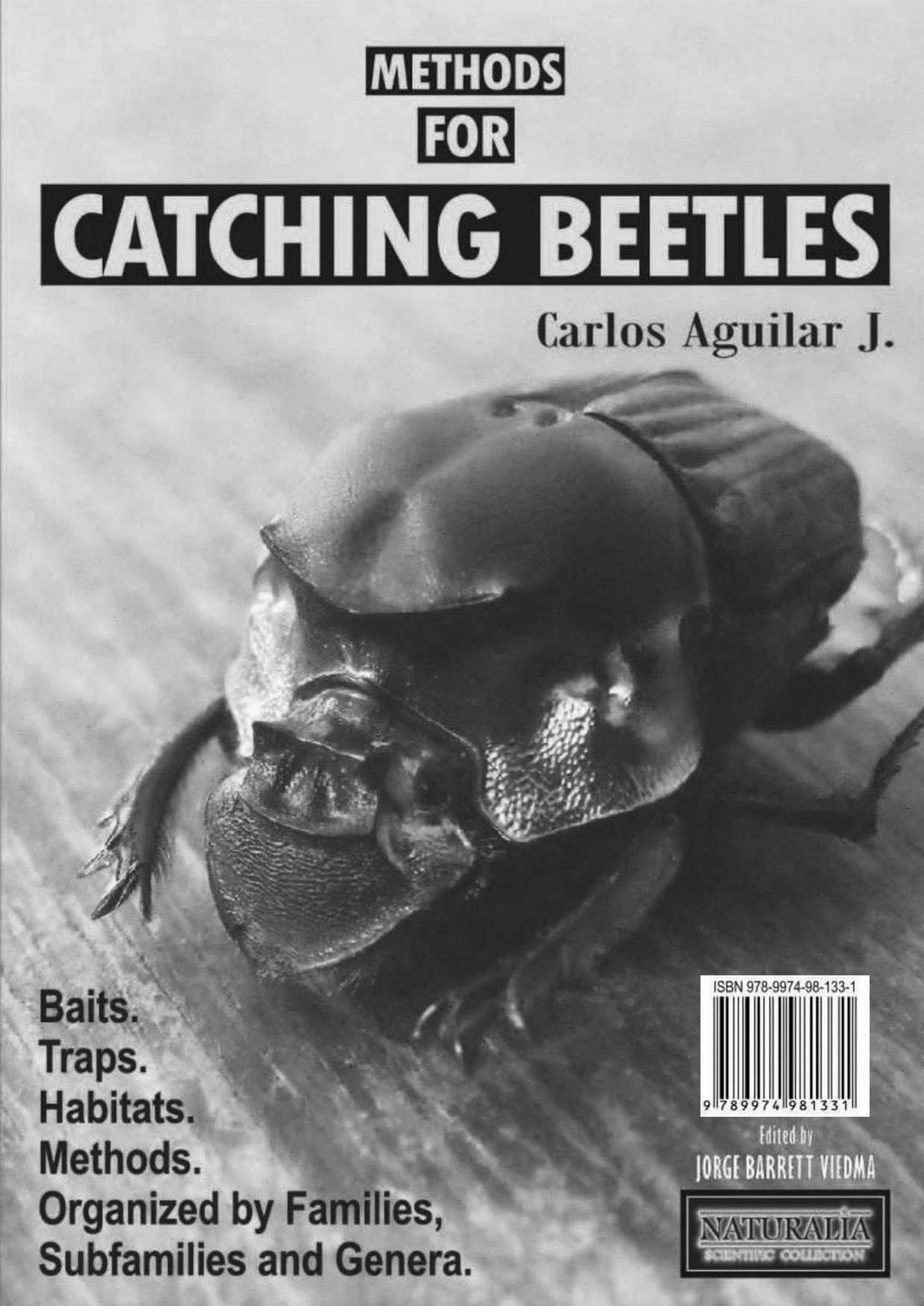

METHODS FOR CATCHING BEETLES

Carlos Aguilar J.

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

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JORGE BARRETT VIEDMA

NATURALIA
SCIENTIFIC COLLECTION

COLLECTING IN AQUATIC AND SEMIAQUATIC ENVIRONMENTS

By Carlos Aguilar J., Eric Chapman(1), Sergio Ríos(2)

Aquatic beetles include many different families of Coleoptera: crawling water beetles (Haliplidae), water scavenger beetles (Hydrophilidae), predaceous diving beetles (Dytiscidae), water penny beetles (Psephenidae), riffle beetles (Elmidae), whirligig beetles (Gyrinidae), minute moss beetles (Hydraenidae), etc. Some aquatic beetles are substrate dwellers (e.g., Elmidae, Psephenidae), while others are free swimming (e.g., Dytiscidae, Gyrinidae, Haliplidae, Hydrophilidae).

Aquatic beetles are present in all available habitats: ponds, lakes, marshes, swamps, streams, rivers, seepages (i.e., spring heads), holes in trees, cavities or cracks that can hold water, etc. Thanks to their small size and high capacity of adaptation, beetles can live in almost any aquatic habitat available, and are only absent in the middle of the oceans (although a few species live in the intertidal zone).

Beetles occupy most non-marine aquatic habitats. Over 80% of aquatic species live in freshwater lentic systems (Pond Action, 1994). These systems include temporary pools and streams, which are an important habitat for Coleoptera. Beetles are present throughout the water phase and many species have specific ecological requirements, which help biologists to detect and prevent alterations in ecosystem quality and/or simply help them to characterize habitats. Also, the general characteristics of the water cycle and the extension of the drought period in some cases can be detected with great accuracy using aquatic beetles as indicators, as demonstrated by Wiggins and his colleagues in 1980 (quoted in Correia, 1999), therefore the characteristics of the immediate history of the habitat can be determined.

As for environmental assessments, information obtained from aquatic beetles provides a better method of evaluation of different river environments than the one of other groups traditionally used (Bournaud et al., 1980; Kaesler et al., 1978). Among them are included species of superfamily Bhyrroidea (Shepard & Aguilar, 2010). Aquatic beetles are good water quality indicators, reflecting environmental conditions. The presence of indicator taxa can help regulators make priority decisions on areas to be preserved. However, aquatic beetles are generally poorly represented in most samples of statistical studies of the water fauna. The reasons vary:

- Many species have low population densities
- Most aquatic beetles and their larvae are often found in places of difficult access, such as:
  * Dense vegetation
  * Debris in or on the water surface
  * Holes in trees
  * Cracks in rocks, etc.

To obtain increased representation of aquatic or semi-aquatic Coleoptera it is best to visit and examine as many habitats as possible. This article will serve as the basis for determining where to sample in different environments.

To learn where to find specific groups of beetles the reader can see the article "Where do they live...?", Chapter IV.

It is not a fundamental requirement to review and collect a large area, which eventually becomes exhausting. However, studying a large area means: sampling of a relatively large area and employment of techniques useful to separate the beetles from the different substrates. On the other hand, Eyre et al., (1986) and Eyre & Foster (1989) indicate that most species of aquatic Coleoptera can be collected in any season and any time of day.

Nevertheless, when the courses or bodies of water are scarce or become smaller, there is greater concentration of aquatic species than in the wettest period in which water is abundant (William Shepard, pers. comm., 2010).

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Before going out to collect aquatic or semi-aquatic beetles, it is good to have some idea about the microhabitats in which they live. This helps the researcher decide which habitat(s) is/are more appropriate to conduct the study. Moreover, this information should be recorded on the labels that accompany each sample of specimens. For that reason, a brief overview of aquatic and semi-aquatic environments where these beetles are abundant, and methods and tools that can be used to catch them is presented.

Coleoptera are present in different terrestrial, aquatic and semi-aquatic habitats and each species occupy specific niches within each ecosystem**(3)**. Therefore, for a better understanding of aquatic and semi-aquatic ecosystems and to know where to find the different families in these habitats, the following classification is presented (based on Rosenbauer, 1999):

Lotic habitats

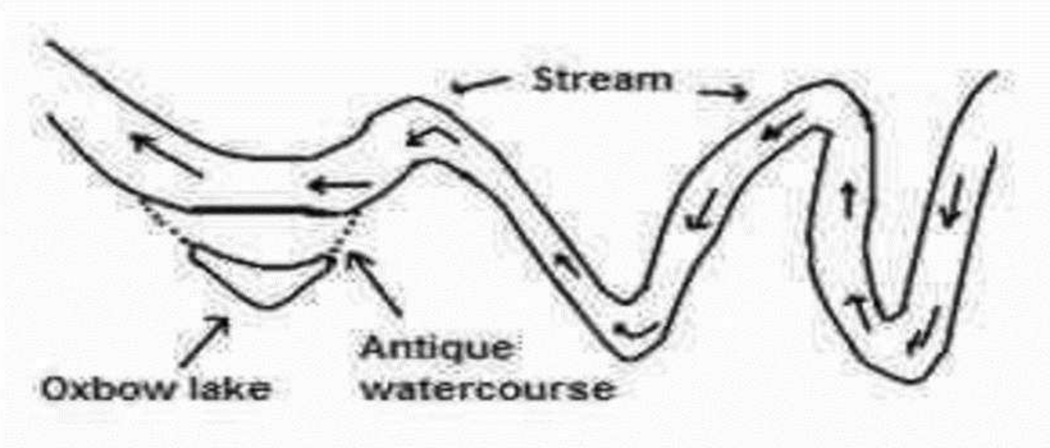

Fig. 10 - Oxbow (or small lagoon), it is formed when the watercourse has cut a curve of a stream or river.

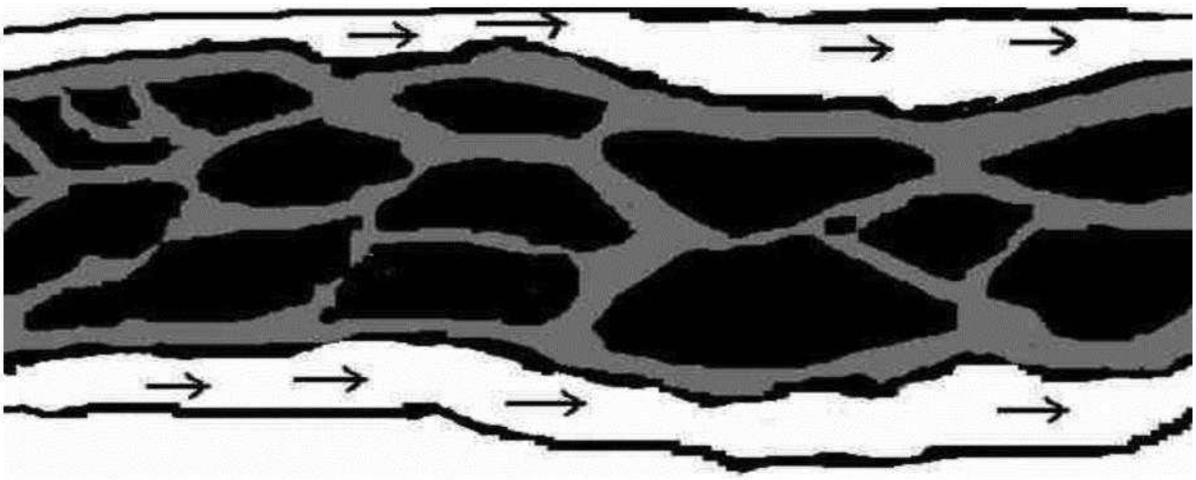

Fig. 11 - Braided stream. *(Drawing of Carlos Aguilar)*.

3. However, some competing terrestrial species can coexist on the same resource with no observable evidence of niche differentiation. For example, some Chrysomelidae of the subfamily Hispinae, which eat the same food and occupy the same habitat, can coexist without any evidence of segregation or exclusion (Strong 1982).

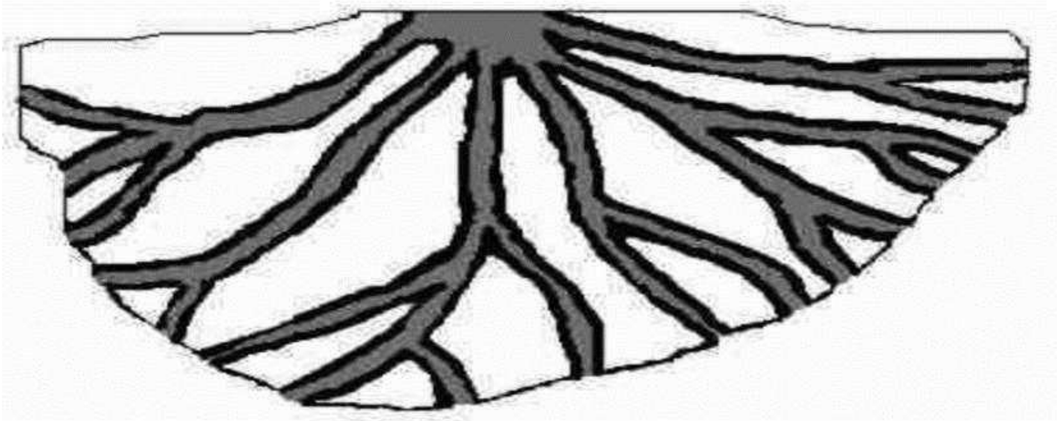

Fig. 12 – Fan shaped streams. (Drawing of Carlos Aguilar)

Composed of rivers streams and springs, these habitats are characterized by the constant flow of their waters, even though some are temporarily dry.

Rivers and streams have two types of conformation of their beds that are important for Coleoptera collection: pools and riffles. Also important are stream margins, especially where the root masses of terrestrial plants hang into the water and undercut banks where you can get large numbers of dytiscids and gyrinids, especially as winter approaches, because many species overwinter in undercut banks.

Different stream habitat types:

A stream is a body of water with a current, confined within a bed and stream banks. In some countries or communities a stream may be defined by its size. The biological habitat in the immediate vicinity of a stream is called a riparian zone.
There are five types of Streams:

a) Meandering Streams:

An unmodified or natural stream usually consists of successive meanders (curves). Meandering streams develop in relatively flat areas, such as a floodplain, and where sediment consists primarily of fine sands, silts, and mud. They form in lowland areas with low overall gradients, either where sediment is not very available or where the stream has lost so much of its sediment behind as its gradient has declined that it no longer has enough to carry to accomplish its work. Over time the stream is cut into bends, forming small lagoon-shaped gaps. In these meanders there are usually copious amounts of aquatic vegetation which serve as habitat for many species of beetles, especially Hydrophiloidea.

b) Braided Streams:

These streams sometimes carry loads water that exceed their normal capacity (Fig. 11). During such spate events, sediments are rapidly added to the channel by external erosion processes or where discharge (capacity) fluctuates drastically. Many aquatic plants grow in these sediment deposition areas which create a variety of aquatic beetle habitats.

c) Fan-Shaped Streams:

Where canyons open out onto flatter and more open land, large amounts of sediment is carried by the stream and deposited in the lower basin stream in a fan-shape. Much of the sediment, particularly the coarser parts, may be lost to produce an alluvial fan (Fig.12). Here you can find beetles; however, it can be difficult to collect in these places because the heavy clay can make footing difficult and clog collecting devices.

d) Riffles:

Riffles occur in areas of streams where larger rocks and stones have been deposited where the bed is elevated in relation to areas immediately up and downstream.

Such areas have much faster flow than deeper adjacent areas and can be very violent and impetuous. When the bed has gravel, stones or very small waterfalls, and the water drains rapidly between the stones, beetles of the families Elmidae, Dryopidae and Lutrochidae can be found in the interstices.

e) Stream Online:

The erosion that brings the upstream part of the river down to its equilibrium level will be down cutting erosion creating a deep canyon and a straight channel (Fig. 13).

The pools which are formed in these streams, discussed above, are habitats for many beetles.

It is formed by an input, where the stream enters, and also has a tongue, which is the place where the stream begins to narrow.

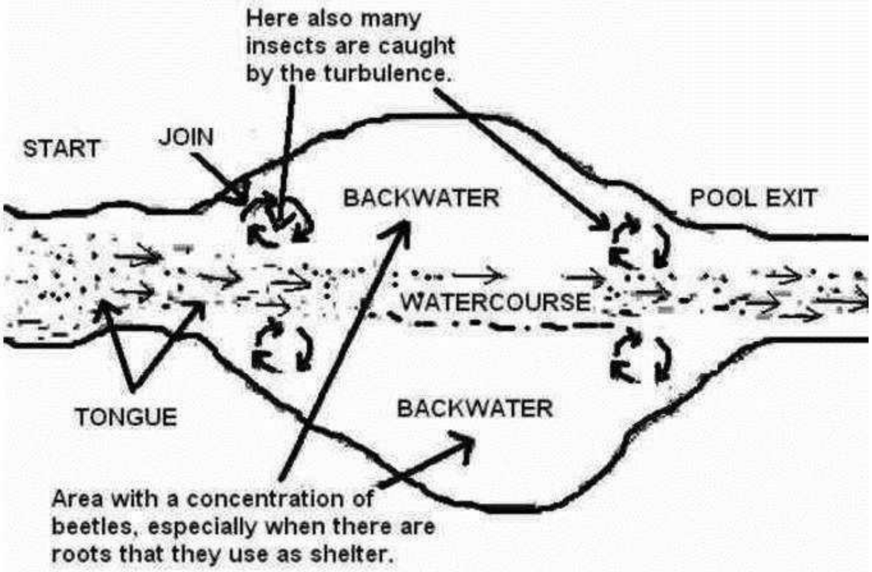

Fig. 13 – Stream online *(drawing based and modified from Wladimir, 2010).*

On each side of the tongue, at the end of the input, there is a turbulence zone. There, the current weakens forming the backwaters along the sides, where the water has very little flow. Along the banks, the pools often have aquatic and/or semiaquatic vegetation. According to Wladimir (2010), an expert on trout fishing, in the junction there is a centrifugal force in which insects are trapped. For this reason, large trout congregate here to feed on insects trapped in the swirling current.

However, Eric Bachman (pers. comm., 2010) stated that most of beetles hide among root mass to avoid predation by fish. In the area of the stream pool, sheltered under stones, are found mainly Elmidae and Dryopidae. Finally, there is the pool exit, where the stream enters the next part of the river. There, under rocks and emerging bran-ches, or hanging over the water surface, water beetles can also be found (Elmidae, Dryopidae, Psephe-nidae larvae, Lutrochi-dae).

f) Stream curve (Fig. 14):
These are shaped like an "L", but there are pools where the curve is more gradual. In the elbow, the current flows against one of the river banks, causing erosion.

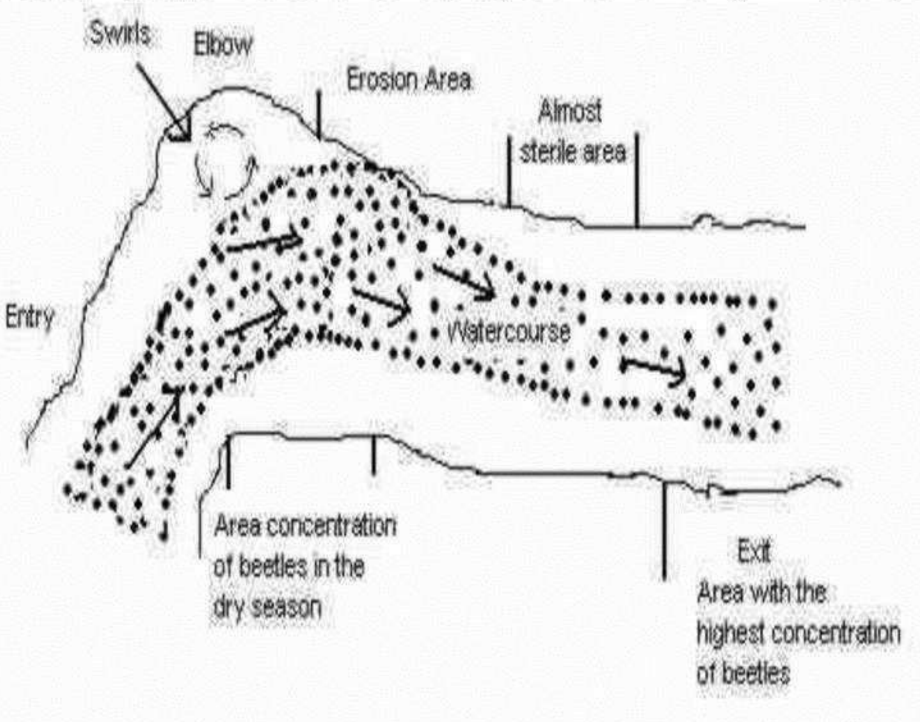

Fig. 14 – physical characteristics of a curve pool (*drawing based and modified from Wladimir 2010).*

Waste produced by erosion is dragged to the back of the elbow, producing an area full of mud and almost barren, in which some beetles living in the mud can be collected (e.g., Heteroceridae).

In the angle of the elbow the water is slow and turns, producing a whirlpool. The speed of rotation will be higher or lower, depending on the river characteristics. At the exit of the pool, where water depth is low, there is lighter and greater oxygenation, the greatest diversity of beetles is found. However, in the dry season, when the rivers have little water, the beetles are concentrated in the inner curve.

g) Springs:

These are areas where groundwater flows upward to the surface. The range in size is variable, from tiny seep holes with only enough water to form a small puddle to large spring streams flowing at a rate of 1,000 gallons per minute (Helfrich and Parkhurst, 2009).

Lentic habitats(4)

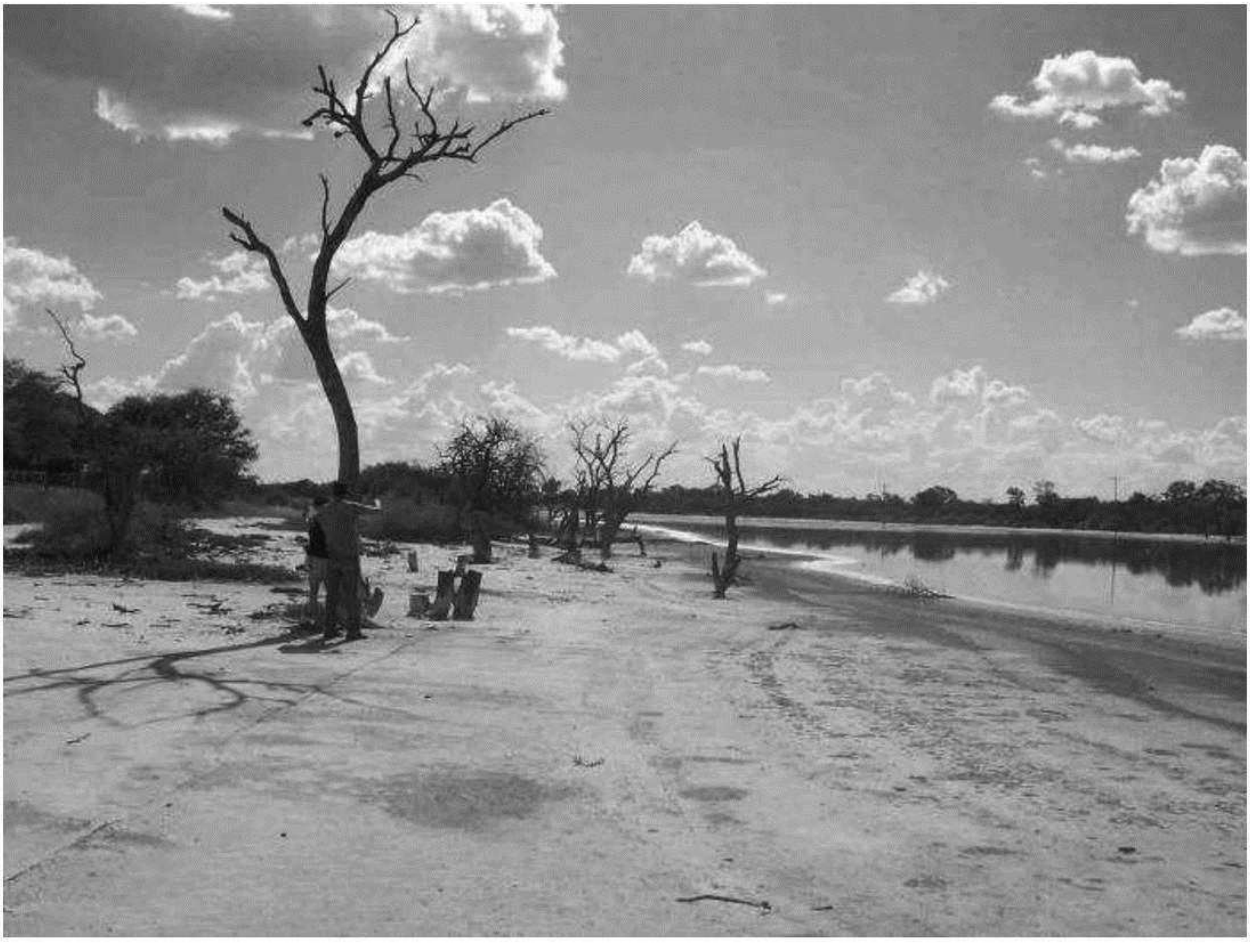

Fig. 15 – "Laguna Capitán." It is a salt lake in the Paraguayan Chaco. *(Photo of Jorge Barrett).*

These are environments where there is no evidence of water flow in the past or present. These are classified according to the water permanence time:

4. Beetles may be collected in these aquatic habitats using just a very fine mesh strainer. With this method of manual collection, one can learn a lot about their habitats, but many specimens are not obtained using only a hand strainer. In addition, many beetles live in inaccessible places (cracks or crevices, or very deep water current, etc.). Therefore, the sampling methods explained in these pages should also be used.

I) Permanent Lentic Environments have presence of water throughout the year. They include lakes, ponds, marshes, and swamps, etc.:

a) A **marsh** is a standing water habitat dominated by herbaceous vegetation. Salt marshes occur along of many coastal areas. They are dominated by salt-tolerant plants (halophytes) like cord grass and are greatly influenced by tides (Helfrich and Parkhurst 2009).

b) A **swamp** is a standing water habitat dominated by woody vegetation. Swamps are sometimes wet in part of the year and dry the remainder of the year, others are permanently wet. Many families of Coleoptera occur in these environments such as Hydrophilidae, Dytiscidae, Dryopidae, Noteridae, Haliplidae, Gyrinidae, Hydraenidae, Carabidae, Chrysomelidae, Curculionidae, and Cerambycideae**.**

c) A **lake** is larger and dee-per than a pond. Lakes can range in size from small (10 acres) to very large (e.g. the Caspian Sea, the Great Lakes, Lake Tanganyika) (Helfrich and Parkhurst, 2009), and they are present in continental areas of different countries of the world. There are freshwater lakes and saltwater lakes (Fig. 15). The latter are dominated by salt-tolerant plants and are found in deserts and mountainous areas (e.g., the Andes).

There are almost no beetles in the water of saltwater lakes, but their beaches can provide habitat for many species of Tene-brionidae and Carabidae and on the plants Chry-somelidae, Curculionidae, Sca-rabaeidae, Bruchidae, Cantha-ridae, Mordellidae and other families can be found. Some sampling methods to collect beetles in the salt marshes are explained in the article on the Deserts, Chapter II.

Fig. 16 – A small pool of water which has many Hydrophilidae. (Dep. Central, Paraguay) *(Photo of Jorge Barrett)*.

II) Temporary Lentic Environments: These areas contain water only during the rainy season (Fig. 16). They include small ponds or puddles of water, roadside ditches, etc. Temporary ponds are environments with dry periods of varying duration (Williams, 1997). Due to their cyclical nature, these environments impose different stresses on their inhabitants than those with permanent water (Fontanarrosa et al., 2004).

Some species of temporary waters specialize in such habitats and are therefore not likely to be found in other habitats, whereas other species are facultative and can be found in both temporary and permanent bodies of water. The existence of insects in this type of environment requires that they survive dry periods in situ, or migrate to other types of aquatic environments, and/or to be re-colonized after the restructuring of the place (Wiggins et al., 1980). Wiggins et al., (1980) point out that the fauna of temporary ponds is poor due to their ephemeral nature. However, in the last decade it was shown that temporary environments can have similar species richness, as compared to permanent bodies of water (Boix & Sala, 2002). Beetles are well represented and are the most varied in number of species in almost any temporary aquatic environment. For example, in several temporary ponds in the city of Buenos Aires, Fontanarrosa et al., (2004) found 36 taxa belonging to 26 genera from 7 families (Carabidae, Gyrinidae, Haliplidae, Noteridae, Dytiscidae, Hydrophilidae and Scirtidae). Moreover, these authors suggest that the wealth of insects (with 58 taxa) in temporary ponds was lower than that of the lagoons, where they found 73 species. Other studies in temporary environments showed a similar number of species to that of permanent environments (Williams, 1996). But the diversity of aquatic insects is typically lower in temporary aquatic environments than in permanent ones. Temporary aquatic environments depend on drought periods imposing strict conditions, which restrict the number of species that can survive in them (Wiggins et al., 1980).

The collection of beetles in standing or stagnant water, such as swamps, shallow ditches and edges of small ponds, can be very productive. But the size of beetle populations depends largely on the abundance of vegetation, fish, substrate type and the size and depth of the water body. The presence of small predatory fishes significantly reduce the mean abundance and species richness of beetles via habitat selection behavior alone. Therefore, aquatic beetles have clear habitat preferences for fishless ponds (Binckley & Resetarits, 2005).

Dytiscidae, Gyrinidae, Noteridae, Haliplidae, and Hydrophilidae are the dominant insects in temporary environments (Colinson et al., 1995). Cicindelinae and others Carabidae inhabit their banks.

Lakes and Ponds: A pond is a body of standing water, eith er natural or man-made, that is usually smaller than a lake. The technical distinction between a pond and a lake has not been universally standardized. Biologists have proposed formal definitions for a pond, in part to include 'bodies of water where light penetrates to the bottom of the water body, 'bodies of water shallow enough for rooted water plants to grow throughout,' and 'bodies of water which lack wave action on the shoreline' (Wikipedia, the free encyclopedia). Each of these definitions have met with resistance or disapproval, as the defining characteristics are each difficult to measure or verify. But, accordingly, some organizations and researchers have settled on technical definitions of pond and lake which rely on size alone (Biggset al., 2005). Sarmiento (2001) defines a pond as "small expanse of water, where the coastal zone is very large in percentage and limnetic or deep regions are absent."

There is no universally recognized standard for the maximum size of a pond. The Ramsar Convention of Wetlands International sets the maximum size of a pond at 8 acres.

However, biologists, have not universally adopted any of these conventions. Researchers from the organization "British charity Pond Conservation" defined a pond as a body of water made by man or a natural water body measuring between 2-5 ha, and that holds water for four months of the year or more (Céréghino et al., 2008). Other European biologists have set other sizes. Sarmiento (2001) defines a lake as a continental body of water of large size which is located in depressions in the ground, and will eventually fill with sediment. According to Helfrich and Parkhurst (2009) "A pond is a small (usually less than ten surface acres in size), shallow depression in the earth filled with water from rain or snowmelt runoff, springs, or groundwater. Ponds can lose water through seepage, evaporation, or transpiration (plant respiration)."

EQUIPMENT AND COLLECTION METHODS

Aquatic Net

The most frequently used instrument for collecting aquatic beetles is the aquatic net.

One can learn a lot about the ecology of aquatic beetles, while sitting in front of a pool of water. They can be collected by hand, or using a tea strainer. However, many species of beetles are difficult to catch with this method, such as beetles living in a lagoon, at the bottom of a pond, in a river or stream, or in all water sources where the water is deep and/or flowing very quickly. In such cases, it is better to use an aquatic net.

A good net consists of a strong and tough triangular (or rectangular) frame in a "D" or "V" shape. Each face of the frame will measure approximately 30 cm long. The net must be designed so that the bag hangs on the frame, but it does not bend completely over it. The bag for the net must be made of a thick tulle with many small holes and needs to have, a thick canvas material on the rim for protection of the tulle and a heavy aluminum or wood handle, about 1-1.5 m long (Fig. 17). These features allow the net to be strongly pushed through areas with vegetation or abrasive rocks.

How to use the aquatic net

When collecting with the aquatic net is a good idea to wear long boots (e.g., hip or chest waders). But such boots can be uncomfortable in hot weather.

For species that live at the bottom of rivers or streams, the best technique is to use the aquatic net vertically, but it will work better if the mud or sand of the bottom of the water course is removed with the feet before (in front of the net). In places with vegetation, the aquatic net must be passed several times back and forth in the same place, moving the water (with the net) and trying to get close to the shore as much as possible. Repeated passes through the same area eventually collect beetles that became dislodged but not captured in earlier passes with the net.

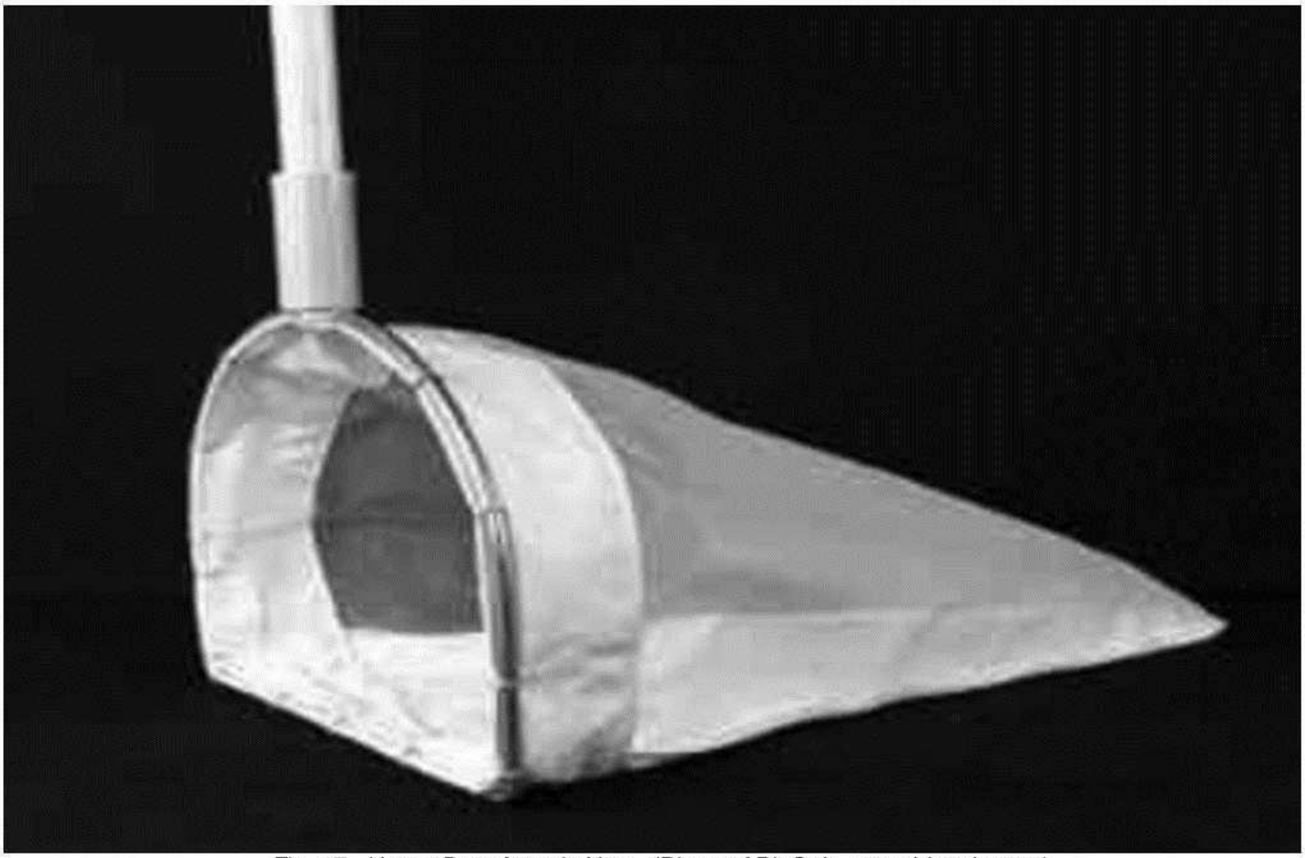

Fig. 17 - Heavy Duty Aquatic Nets. *(Photo of BioQuip, www.bioquip.com)*

Beetles living on habitats inundated with clay, mud or stones, are more difficult to sample with aquatic nets, but the net can be pulled softly on the surface of the water, trying not to take too much mud or sand into the net. To use the quatic net in these places, removing the mud with the hands or feet is very useful. In some places with abundant vegetation, it may be necessary to splash the water by jumping into the water and catching the splash with the net (most easily complished by two people).

Other habitats, such as tiny pools associated with spring seeps, may require passing a very small net (e.g., an aquarium net) through the substrate once it has been stepped on, to create a temporary depression through which to sample.

In streams it is a good idea to sweep the branches hanging above the water surface, and also among those that rise above the water, where you can collect several interesting beetle families, like Dryopidae, Elmidae and Lutrochidae.

In small waterfalls, other families can be captured (e.g. Amphizoidae, Gyrinidae, Pelobiidae, Dytiscidae and Hydrophilidae subfamilies: Hydrochinae and Spercheinae), in these places the aquatic net should be used with energy (moving it vigorously from the bottom up to the surface) especially in places with dense vegetation.

In many streams there are places where the water flows very quickly (especially in streams that have stones on the bottom; e.g., riffles) These area can be kick-sampled: the mouth of the net is placed facing upstream and the rocks that are just opposite of the aquatic net are disturbed with one's heel. The beetles that are hidden under the rocks (e.g. many Byrrhoidea) will be dislodged and swept into the net by the force of the water.

Sweeping the net through floating vegetation can result in the capture of many species of Chrysomelidae and Curculionidae and even species that feed on the flowers of floating plants which, although they aren´t aquatic beetles, are also interesting (e.g., Cerambycidae).

The beetles that are trapped in the aquatic net can be taken by forceps or with an aspirator; in the latter case you can use the following method: The material collected with the net is emptied on a white tray with a 1 cm wire mesh, placed over the tray. The contents of the net (debris and plant material) are placed on the mesh where the beetles trying to escape will fall through the mesh into the tray where they are more easily collected. This makes sifting through the debris much easier.

Fig. 18 - Shovel to collect aquatic beetles. (Drawing of Carlos Aguilar).

Shovel with grid: In stream beds, there is often debris or very abrasive small stones between which can be inhabited by many species of beetles and their larvae. A shovel with grid can be used to collect them. This consists of a metal frame shovel, fitted with a plastic grid or solid wire with approximately 4 mm mesh. At the back there is a small cap. The handle is solid, 1 m long or a little more (Fig. 18). The shovel is dragged through the stream bed and its contents can be poured over a white tray from which the beetles can be extracted.

Screen barrier net: Many beetles can be found in shallow and fast-flowing streams, under rocks and other debris. When lifting the stones, the beetles can escape very quickly, being carried away by the current. To collect them, a screen barrier approximately 1 m² can be used, which can be manufactured with a flexible wire net or a strong plastic net, with very small mesh size (Fig. 19).

The screen barrier should have two bars (as handles), one on each side. The same technique as with the D-frame net is employed: the screen is placed a meter or so downstream of the stones or sticks to be disturbed, maintaining the grid firmly with both hands, somewhat diagonally with respect to the bed of the stream or river. It should be noted that the smaller elmid species are between 1-2 mm in length (with a cross-section < 1 mm) and can go right through nets if the mesh size is not small enough.

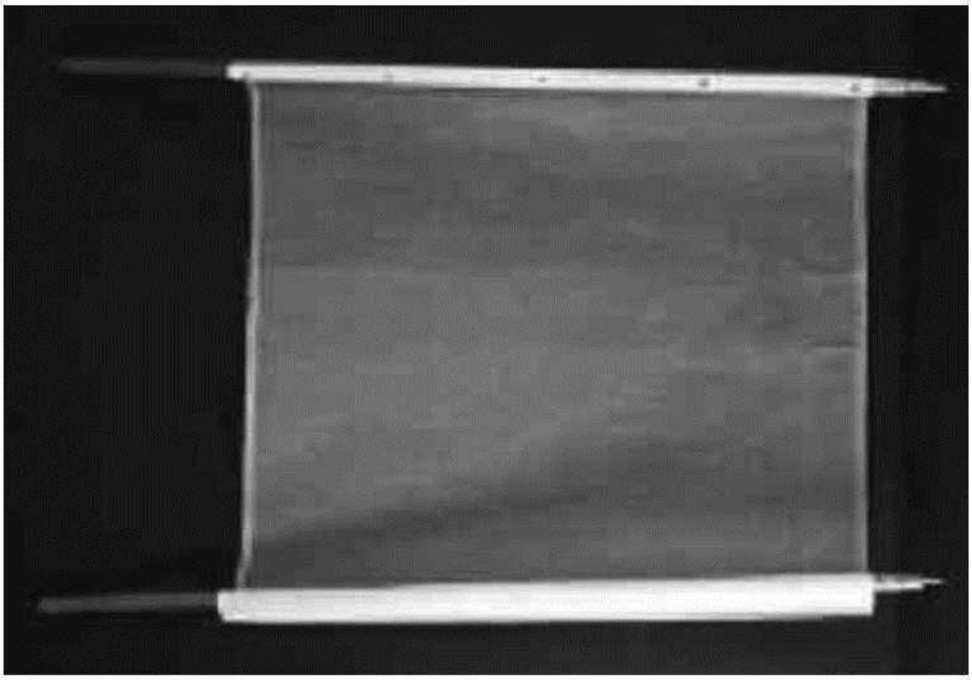

Fig. 19 - Screen barrier (Photo: BioQuip, www.bioquip.com).

The stones and sticks under water are turned over and rubbed together to dislodge the insects by another person situated 1 m upstream (Fig. 20). The insects are washed downstream onto the grid where

Fig. 20 - Collecting aquatic beetles with a grid. *(Photo: Carlos Aguilar)*

they can be captured. The contents are emptied on one of the devices displayed on these pages, or the screen can be laid flat in the sun on the bank where the slower-moving beetles (e.g., Elmidae) will begin to crawl as the screen dries - they can be tough to see when the sitting still on a wet screen, as they can become encrusted with minerals and appear like small stones until they begin to crawl.

Grids for draining: Metal grids with different mesh sizes are useful for collecting larvae and pupae of Donaciinae (Chrysomelidae) and aquatic weevils that occur on the roots or at the juncture of the roots and stems of aquatic plants. An aquatic plant is unearthed with its roots and is placed on the grid to drain the contents onto a tray or a plastic cloth**.** These grids are also useful for sifting moss and plant litter from dry or wet soil.

Strainer with tray and grid: Beetles caught in a net can be collected manually with forceps. However, a separation device can facilitate quicker sorting. A solid grid with mesh size between 5 to 10 mm is placed above a white bucket. Vegetable debris and other wastes obtained with the aquatic net are dumped onto the grid. Water is then poured over the debris constantly for a few minutes washing the beetles into the container (Fig. 21).

Fig. 21 - Washing aquatic vegetation *(Photo: Carlos Aguilar).*

Once the bucket is nearly full of water, the beetles can be collected by pouring the contents of the bucket back through the net and can be removed with forceps or an aspirator.

This method circumvents manually searching through mud and dead leaves for each specimen. Many species of beetles are found in large clumps of algae and other debris deposited on beaches and other shorelines by waves or by flooding of waterways. This separation device can be applied to these samples as well.

It should be noted that that some of the smallest Coleoptera (e.g., some Hydrophilidae), are less active, and will stay among the leaves and algae. To extract them, the debris or algae is placed on the grid and the device placed in the sun. These less active beetles and larvae will eventually migrate to the bottom and fall into the tray or bucket where they can be caught by hand, strainer or aspirator. If water accumulates in the tray, it can be poured over a fine sieve to recover the insects. Aquarium nets are useful for screening small Gyrinidae and other aquatic beetles.

Bucket with water: Adults belonging to some groups of Hydraenidae, small Hydrophilidae, Elmidae, Dryopidae, etc. are not good swimmers; therefore, when these substrates are placed in water and agitated, the beetles come to the surface. To facilitate their collection, the substrates can be shaken in a bucket with water. When floating, the beetles can easily be captured manually or with a suitable strainer.

Aquatic bottle trap and aquatic light trap: Some specialized shops offer aquatic traps as shown in fig.22.

However, similar traps can be made at home from plastic 2 liter bottles. The bottles should have a wide enough mouth to accommodate large dytiscids, and 2 liter bottles have such a mouth. A good design is to remove the top from one bottle and insert it into the bottom of another (Fig. 23).

Fig. 22 - Aquatic Light Trap. *(Photo: BioQuip, www.bioquip.com).*

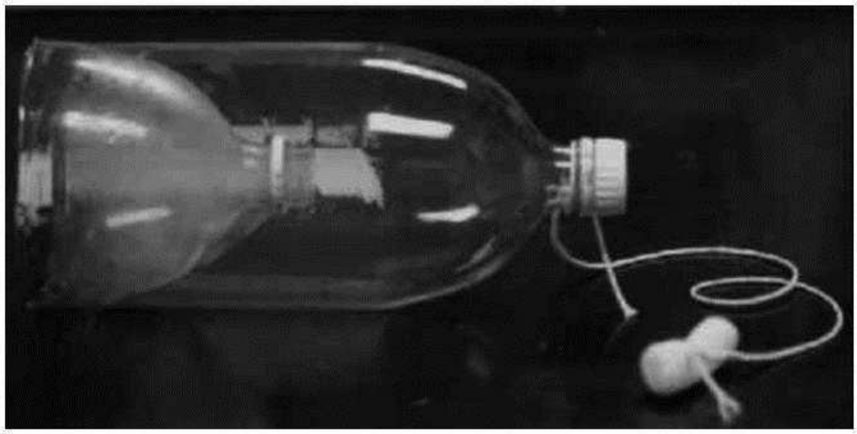

Fig. 23 - Aquatic bottle trap. *(Photo: Eric Chapman)*

The advantage of leaving the top on the bottle is that when the trap is collected, the cap can be removed and the contents poured through an aquarium net or small sieve. A 4" piece of rebar can be put in the trap to act as a weight, which will fall into the net as the contents are poured out (too big of a weight will plug the top). A piece of string tied to the neck with a piece of Styrofoam on the other end lets the user find it quickly, especially when placed in murky habitats where the traps are not so obvious from shore. It is also important to remove all air bubbles when placing the trap, otherwise, the beetles will not drown and may feed on other beetles in the trap, damaging the specimens.

Bottle traps can be very ineffective in streams, as any flow can cause sediments to build up in the trap, plugging the funnel and diminishing the catch. Furthermore, care must be taken not to place traps in pools where amphibians are developing, as the traps can be found completely full of drowned tadpoles. Thus, these traps can be used in swimming pools, artificial ponds, lakes and other lentic environments. They can collect large Dytiscidae (e.g., *Megadytes* spp, *Dytiscus* spp. etc.) as well as many Hydrophilidae (e.g., *Stethoxus* spp. etc.). These traps can be used without baits, or baited with liver or fish. A waterproof flashlight can also be placed within the bottle, functioning as an aquatic light trap.

Floating bottle trap: This is a modification of the trap of Aiken and Roughley (1985), which is similar to the trap described above, but this is placed on the surface of the water in pools, ponds and lakes. This trap can be made with plastic 2 liter bottles.

The posterior side has several small holes and a float with wires attached to the inside of the bottle. One cone with a 2 cm opening at the apex is inserted into the bottle.

The base of the cone is attached over the mouth of the bottle and it is attached at the mouth with wires. The cord is attached at one end to a branch or tree or a brick (or any heavy object) near the water's edge (Fig. 24). A piece of liver inside the trap can be used as bait. This type of trap is extremely successful in trapping large numbers of aquatic beetles.

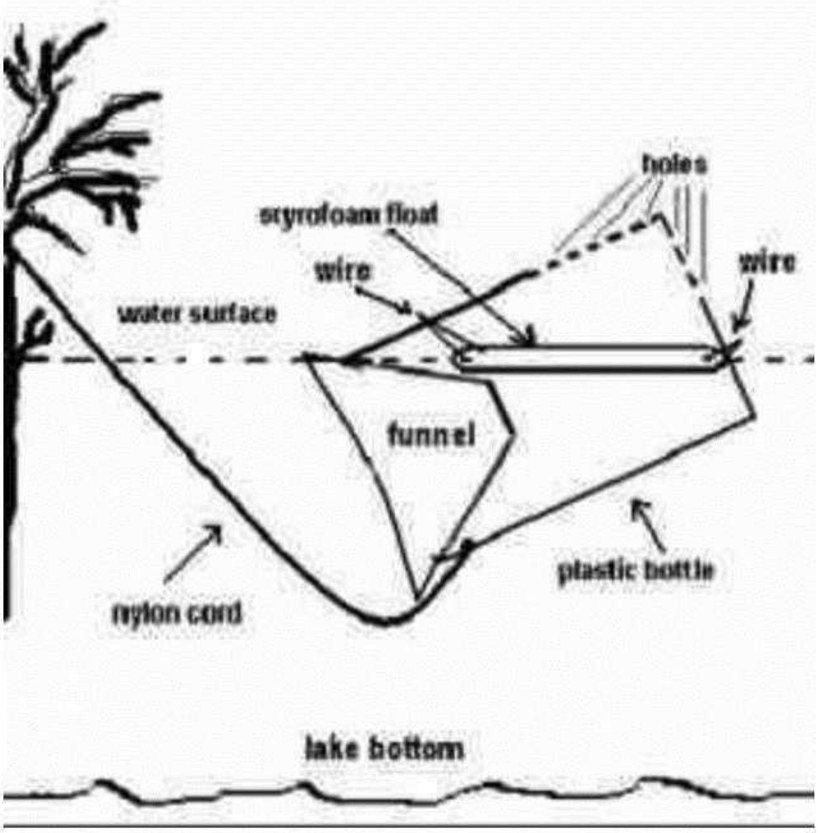

Fig. 24 - Floating bottle trap tied to a tree trunk *(Drawing of Carlos Aguilar)*

Aquatic bucket trap

Andreas Herrmann (pers. comm., 2010) explains a very effective trap for collect aquatic beetles: Figure 25a-b shows a small pond in a swamp with a white 5 or 6 liter plastic container on the bottom of the pond. A piece of pork liver (bait) and a stone is placed in the container, so that it is heavy and can again be plunged into the pond bottom.

A round hole is made in the center of the lid with a knife (3 or 4 cm in diameter) for the beetles to enter the container where the liver can be fed upon. When finished feeding beetles have a hard time finding their way out of the bucket. Alternatively, a plastic pipe or bottle neck can be cut and pasted to the opening of the container, so the beetles will find it even more difficult to escape.

The beetles will eventually drown because of lack of air, therefore it is important to remove all air bubbles when placing the trap.

After the beetles die, their bodies will attract more beetles into the container. When the bin is emptied after a week, it should have many dead beetles. The diagram in figure 26 shows the com-

Fig. 25a - Aquatic beetles bucket trap submerged in a pool of water *(both photos of Andreas Herrmann)*.

Fig. 25 b - Aquatic beetles bucket trap submerged in a pool of water *(both photos of Andreas Herrmann).*

position of this trap. Aquatic traps can be left in the habitat for a number of days. During colder months when the water temperature is near freezing, the traps can be serviced weekly, whereas during warmer weather, the traps should be serviced every 3 days or so to prevent the earliest arriving specimens from rotting inside the trap.

Bright foil traps: Small pools of water often form on surfaces such as paved roads, or on the concrete of ruinous buildings. Such pools often attract many species of aquatic beetles, flying as they move from one temporary aquatic habitat to another.

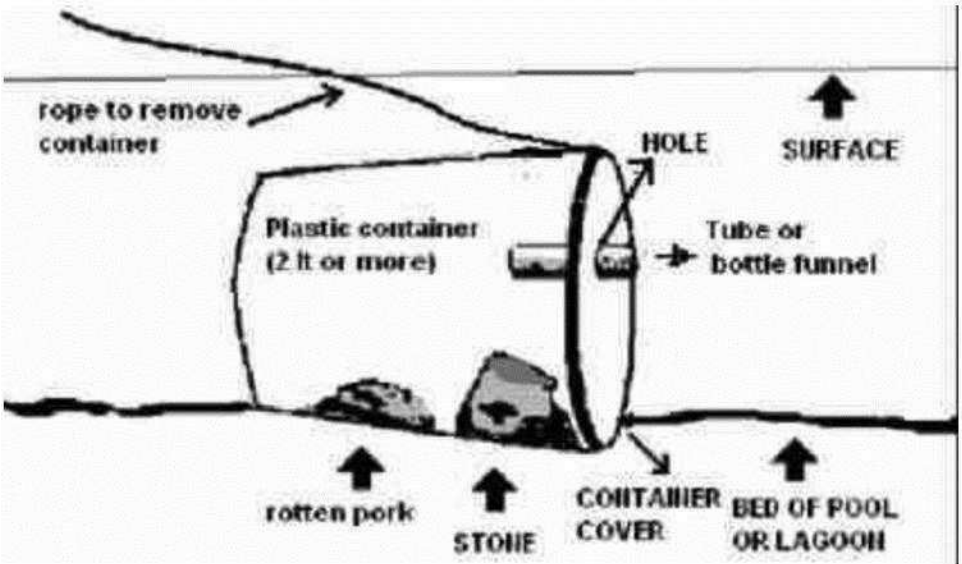

Fig. 26 - Structure and location of an aquatic bucket trap. *(Drawing of Carlos Aguilar).*

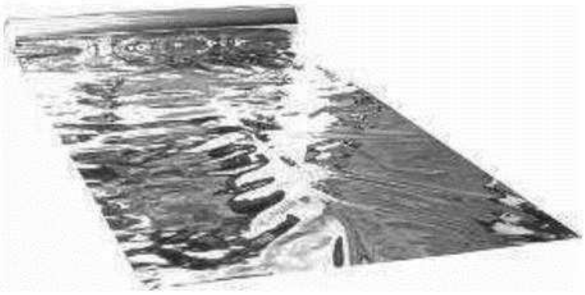

Fig. 27 - This lamina mimics a water source that attracts many aquatic beetles. *(Picture Jack Owen, Canada).*

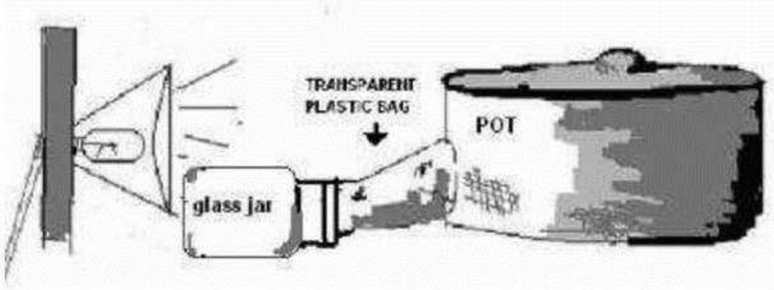

Fig. 28 - Pot trap with light *(Drawing of Carlos Aguilar).*

Certain wavelengths of light are reflected from the surface of water bodies which beetles use to detect the presence of an aquatic habitat.
The reflection of such water accumulations can be imitated with aluminum foil or Mylar sheets (Fig. 27).

This lamina works like fly paper or the "purple trap" (on the top surface transparent non-toxic glue is sprayed), but in this case, the sheet extends on the ground where the beetles will become trapped on the sticky foil. This foil mimics an aquatic environment and is commercially available (Eclipse miler 4 mil: www.mylarstoreonline.com). Ideal glue for such traps is Tangle-Trap Insect Trap Coating Spray (The Tanglefoot Company, Grand Rapids, Michigan, USA). Placing these sheets on the ground in different environments simulates pools of water to the eyes of aquatic beetles, to which they are attracted.

Pot trap with light: This collecting tool is based on the fact that some species of beetles are phototropic (attracted to light). The pot has a lateral hole in which a transparent bag is inserted, which acts as a bridge (in the form of tunnel) between the pot and a transparent outer container (Fig. 28). A light source (60 watt) is located in front of the jar.

Plant material such as humus, algae, mosses, etc., is placed into the pot such that some parts at the bottom of the pot remain free of organic material. This is done so that insects can walk easily and go into the exterior bottle. Larvae and some beetles which are among the plant debris will be attracted to the light and will stay in the bag. Others will walk into the pot.

Collecting in stream ravines and banks:

On the banks and ravines of a stream, river or any watercourse, it is usually possible to find several species of Coleoptera, mainly semi-aquatic.

To collect them, water can be poured on the bank or at its foot. Beetles buried below the surface of the bank will try to escape and can be caught by hand or with a small strainer. Some of the earth can be placed into a bucket of water and the insects will float to the surface.

Fig. 29 - Spraying a bank . *(Photo: Carlos Aguilar).*

These comments also apply to other land ravines, i.e., those dug in the earth by heavy machinery. Some ravines, especially near a stream, quite often have some water seeps, or have small waterfalls produced by the rain.

If the ravines have some vegetation (mold, moss or algae), it can be gathered in bunches and placed into a bucket with water; the beetles will float and can be caught by hand or aquarium net. Ravines can also be sprayed with pyrethroids and the beetles that are hiding in the crevices of the cliff or plants can be evicted with a brush (Fig. 29).

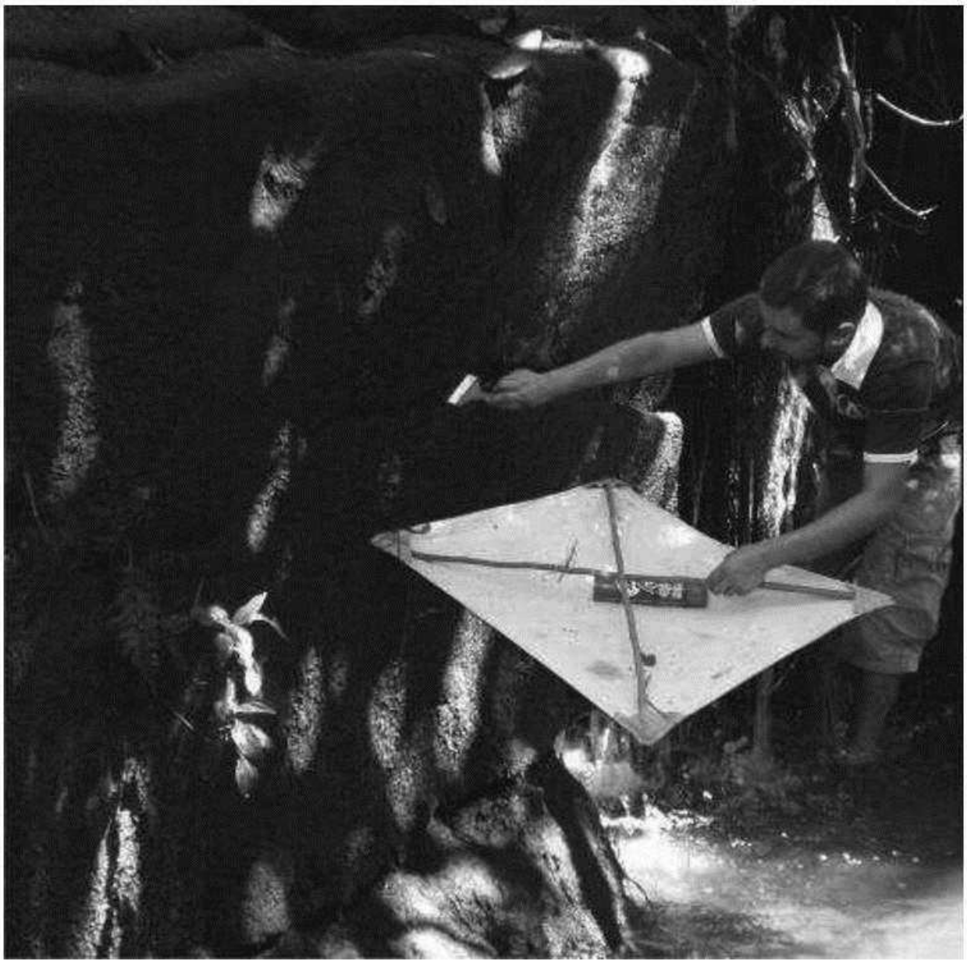

Fig. 30. Brushing a rock wall after spraying. *(Photo: Carlos Aguilar J.*

Fogging: In the crevices of rocks, beetles can be so well hidden that unless they move, they are virtually invisible. A fogging technique can be used to force them out of their hiding places using a pyrethrum insecticide spray. The principle is similar to that used in the fogging of a tropical canopy. A small cloud of poisonous gas is applied to rocks with moss or other vegetation, forcing hidden beetles to come out, facilitating their collection. This technique can also be applied to mosses and other small plants in areas where water splashes or occasionally flows such as the edge of moist gullies, the edges of waterfalls in small streams and over exposed rocks of rivers.

The fogging method does not work very well on smooth, polished surfaces, since very few beetles inhabit such surfaces. Beetles usually inhabit small drops of mud, behind the mosses or liverworts small plants, even in crevices.

When spraying small habitats, an aerial net (with very fine mesh) or a beating sheet can be used. The device is located beneath the site to be fumigated, so insects stunned or killed by the poison will fall onto the net/sheet. Along with the net, a camel's hair or other soft bristled brush can be used to scour the sprayed habitat to remove the beetles between the cracks and crevices (Fig. 30). Larger habitats can also be fumigated, for example, the very slowly flowing and shallow backwater areas of streams. To do so, a net is placed between the rocks, so that it catches the drifting beetles. After spraying moss or other vegetation and waiting 5 to 10 minutes, the area is then sprinkled with water either by splashing with hands or using a spray bottle. Many small aquatic or semi-aquatic beetles and/or their larvae can be collected in this way. To collect beetles floating on the water surface with the fumigation method, it is best to use a natural biodegradable pyrethroid spray. Synthetic pyrethroids such as permethrin can also be used, but with caution, as they can be damaging to the environment.

Collection of beetles among cane or grasses that grow in moist soils: According to Andreas Herrmann (pers. comm., 2010) in Germany: beetles occur in bunches of canes or grass growing on a wet ground, mostly near a pond or a lake. In winter, beetles move to the bottom of such bunches looking for protection against the cold, ice and snow.

This can result in a dense concentration of nearly frozen or very cold (but living) beetles inside the bunch. The bunch can be cut with a knife near the base of the bunch and shaken vigorously over a fabric bag into which the beetles will fall (together with some pieces of earth and small parts of grass). When the bag is emptied in the warmth of a lab, the beetles begin to move; they are not typically killed by the cold.

This method delivers only species which can be caught also in the summer by other methods, but in this way a large number of specimens can be collected and it is an easy method to collect beetles during the winter.

Spilling water:

Fig. 31 - Pouring water on a beach (*Photo: Carlos Aguilar*).

Stewart Peck (2006) who studied beetles of the Galapagos Islands explains the following method of collection: "Netting of aquatic and shore-line species.
Several species of aquatic beetles occur in coastal saline lagoons, and temporary and permanent freshwater pools in the uplands. They are easily caught with a small net. Several beetles live in burrows or litter at the margin of freshwater and saline pools (hydraenids and *Bledius* staphylinids). Splashing water on the shore causes these to come out of hiding to where they can be collected from the shore, or in the water." By pouring water directly onto beaches, on the banks of streams, lakes, lagoons and ponds, often semi-aquatic and ground beetles are collected which emerge rapidly trying to escape of the water. Sphaeriusidae, Carabidae, Staphylinidae, Limnichidae, Heteroceridae, Lepiceridae, etc. can be caught this way (Fig. 31). When water is poured on the gravel that lies on the banks of streams (Fig. 32), small species of Elateridae can sometimes be collected while they try to escape, climbing among the rocks and then flying away.

Fig. 32 - Many species of beetles live on the beaches of streams and they can be collected by pouring water on the dry gravel beaches. *(Photo: Carlos Aguilar).*

Removing and collecting from floating vegetation

Fig. 33 - Removing the floating vegetation on the edge of a river. ***(Photo: Jorge Barrett).***

A good method is to push with both hands and remove vegetation, mud or sand at the bottom, on the edge of a stream, lake or swamp, so that the substrate is altered and beetles are dislodged (Fig. 33). Some beetles which are poor swimmers, become trapped floating on the surface and can be caught with a small mesh tea strainer or aquarium net. Also, Andreas Herrmann (pers. comm., 2010) explained that in Germany:

"In the summer we used to trample with our feet the earth of river - or seaside into the water. We also transported some plants together with their roots to the water and let them dive. After a while the beetles appeared on the surface of the water and could be collected with a sieve. A variation of this method is to carry the water to ruderal places in the surrounding and splash it to the ground, then the beetles came out off the earth."

Water accumulated in plants:

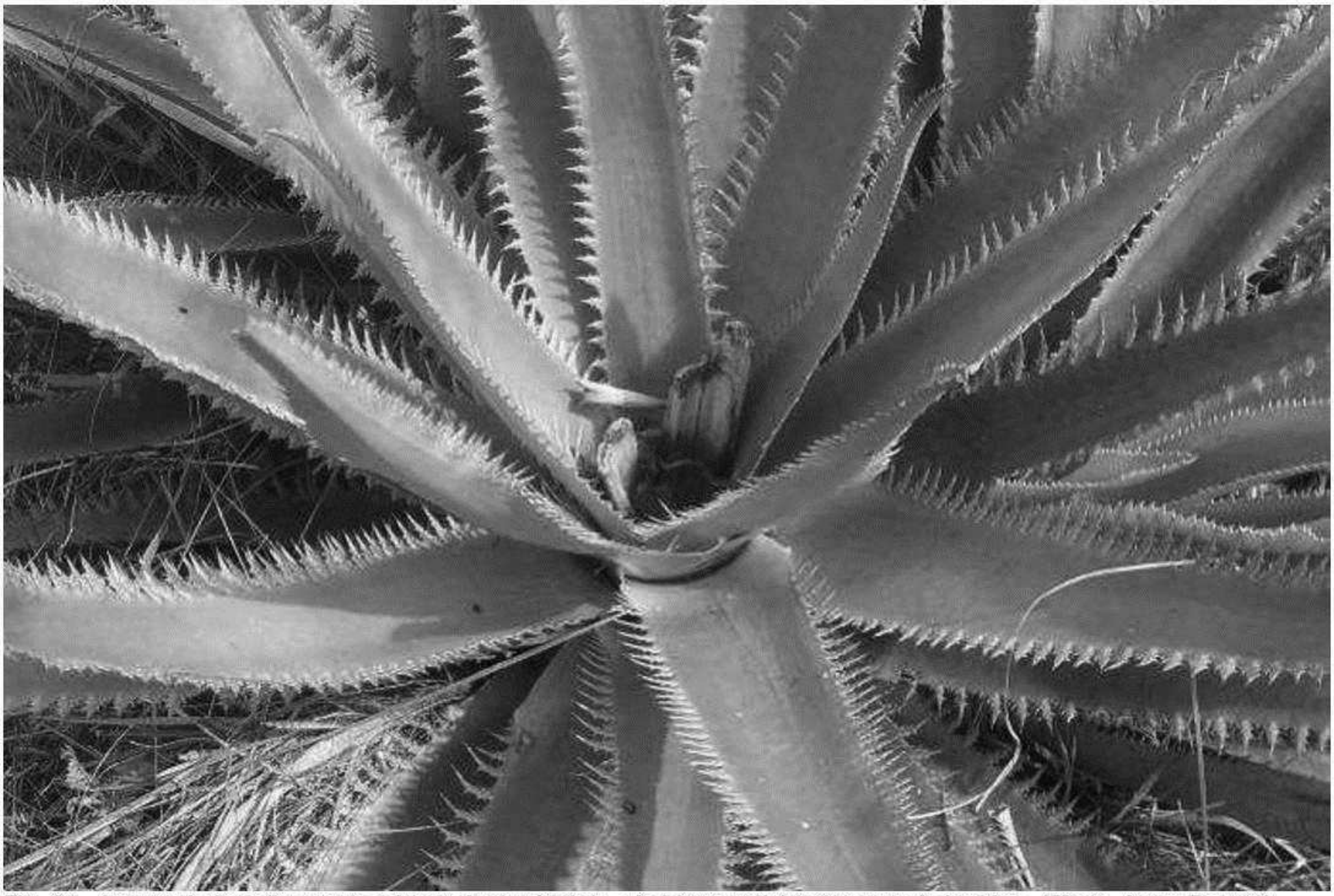

Fig. 34 - Accumulation of water in a bromeliad, which is a habitat available for aquatic beetles. *(Photo Jorge Barrett).*

Some plants form cups that collect water where many species of beetles can be found (Fig. 34). Insects that prefer small aquatic habitats occur in these waters, called phytotelmata "plantheld waters" (Varga, 1928). The best method to remove water that accumulates in plants, together with the insects that live there, is to remove the plant and pour the water that is contained in a bucket. Afterwards, the plant is washed several times with more water until it is clean and free of most insects.

In case that the plant should not be extracted, a noninvasive method is to collect beetles by inserting a small hose into the phytotelmata and extracting the water via suction and pouring it through a sieve or fine-mesh net to remove the beetles. More water can then be added and this procedure repeated to remove any beetles that evaded collection the first time.

Collecting in natural tree holes

Natural cavities in the trunks of trees can collect rainwater (Kitching, 1971a). These water-filled cavities occur in hardwood forests throughout the world (Fish, 1983; Kitching, 2000) and such systems are most abundant in tropical forests. These holes are varied in form and size. They are classified into several types according to the morphology of the opening hole and the ratio of water volume to the surface area (Fincke, 1992a). Some holes occur in the tops of the trees and may contain more than 50 liters of water (Fincke, 1992a; Yanoviak, 1999a and 1999b), while most are much smaller, and many occur below 2 meters, and are more readily accessible. According to Yanoviak (2001) a variety of beetles use tree holes as breeding sites (Dytiscidae: *Copelatus*, *Laccophilus*), Ptilodactylidae larvae, and some Scirtidae (*Prionocyphon* and *Scirtes*), and many species breed exclusively in these habitats. Aquatic insects dominate the macro- fauna in tree hole cavities.

Leather et al., (2005) suggested that sampling at the bottom of a hole can be summarized as a five-step process:

1) First use a flashlight to see that insects are inside the hole and then measure the chemical constituents of water (if this is important to the study).
2) Debris and sediment is then removed (see below);
3) All water is removed from the hole (see below).
4) Clean water is added to the hole, removed and the washing is repeated several times.
5) The inner walls of the empty hole are then inspected with a flashlight.

Researchers have devised a variety of techniques to accomplish this task, but reason ably complete samples are obtained by removing the debris and water and sifting macroorganisms (Jenkins & Carpenter, 1946; Walker & Merritt, 1988; Barrera, 1996).

The most common collection method is the removal of the contents of the hole into a white font, pan or tray. In small holes a simple method is to use a fine tea strainer to remove the debris and insects, placing them in a white tray and removing the beetles with an aspirator.

Larger holes can be emptied by using a flexible garden hose to siphon the water into a pail.

Detritus is then removed by hand (or by using a wooden ruler or trowel to lift small packs of leaves), the tree hole rinsed and the water and set aside. Rather than completely refilling the hole with a large quantity of water, rinsing the walls with a few liters of clean water is an effective way to dislodge remaining insects (Leather et al., 2005).

Pan trap to mimic natural tree holes:

This method utilizes a bucket or pan which is placed between the axils of the trunks of trees (Fig. 35). The inner walls of the bucket are lined with a dark thick cloth bag with some holes. Water is poured into the bucket until almost full. A bit of litter is added to the container along with a small piece of wood, bark or small stone (so that half of this is out of the water). A single fruit fall can result in a pulse of superabundant nutrients (Fincke et al., 1997).

Fig. 35 – Caged bucket trap to mimic natural tree holes. *(Photo: Carlos Aguilar).*

According to Leather et al., (2005) to keep nutrients above some minimum, it may be necessary to add small amounts of litter or a substitute nutrient (e.g. fish food or yeast).

Furthermore, according to Leather et al., (2005) it is best to put this trap inside a wire cage to prevent oviposition by odonates, because they are the most common top predators in these holes (Fincke, 1998) and can severely reduce beetle populations.

The bucket with its contents is removed two to three weeks later. The contents are poured through a net or sieve to remove the beetles, and the contents emptied onto a white pan or tray to facilitate collection. A similar trap is made with a piece of Bamboo that is of 50 cm long and 15-20 cm diameter. The Bamboo is tied to a tree trunk and filled with water and a cage must be put around the top of the trap to prevent odonate oviposition also. The trap is serviced as above once every month.

Collection in Hygropetric habitats: Broadly, these correspond to rocks or wet rock walls which are constantly exposed to water action. It is quite difficult to collect beetles in this type of habitat. For example, looking at two cliffs, one may not have beetles, but the other despite being nearly equal in size, can lodge many species.

Rock walls which are always wet are ideal habitats. A rock face which is only wet when it rains will not lodge water beetles.

Some species of beetles can hide in cracks and moss of water falls whereas they cannot inhabit fast streams where they would be washed away. Therefore, they hang on either side of the waterfall, where water splashes, or in areas where there is a smooth film of water.

Some methods have been devised for collecting in these hygropetric environments, which are detailed below:

Collecting inmature stages

Saturated soils, moss and plant debris found along the margins of water, usually have a mix of terrestrial and aquatic beetles. Most larvae of aquatic beetles pupate in terrestrial sites near the water's edge. To find adults, the stones and logs should be lifted and carefully examined. The leaf litter should also be checked since, both adults and immature stages of these beetles can occur there (immatures can be reared at the laboratory (See below).

For this task a knife (or shovel) can be used which serves to remove the topsoil, which may be loose.

Rearing aquatic larvae: Aquatic Coleoptera larvae are best kept in a split terrarium/aquarium because many aquatic beetles pupate out of water, and offering both habitats gives beetle larvae choices of pupation sites. It is best to put one specimen in each container to prevent the chance of cannibalism or predation. If one knows that the species at hand will pupate in water, a simple rearing chamber is a plastic beverage cup with a loose fitting lid. More elaborate trays with mesh sided cages and aerators to provide oxygen and current to the larvae can increase the success rate.

Each species of aquatic beetles requires different rearing conditions to successfully complete its life cycle and finding these conditions can be tricky, as some species or groups have not been successfully reared (e.g., many Haliplidae). It may be necessary to feed the larvae, and other invertebrates collected in the same habitat make good candidates. With luck the larva will develop to maturity and the adult insect will emerge. For further reading on rearing aquatic beetles, see Brown (1973); White & Jennings (1973); Glaister (1985); Inoda & Kamimura (2004) Fernandez & Campos (2005); Inoda et al., (2009).To preserve the immature stages that are dead: very large larvae should be dipped in hot water for a few moments (this prevents disintegration of the internal tissues thereby maintaining the integrity of their bodies), and then preserved in alcohol; small larvae can be put directly into 75% alcohol; if there are many hundreds, it is preferable to keep them in alcohol at 85% or more, and should be labeled for later identification at the laboratory. A good rule of thumb is to have at least 5-10 times the amount of alcohol as there is total volume of specimen(s). **For rearing terrestrial larvae you can see pages 114-16 and 120.**

FLOOD DEBRIS

Collecting beetles in buildup of organic materials washed away by floods:

Fig. 36 - Collecting beetles in flood debris in Germany *(Photo courtesy of Andreas Herrmann).*

Part of the waste (detritus) carried by stream waters form floating masses of organic detritus which accumulates in the banks, pools and corners of watercourses.

Flood debris (Fig. 36) can trap arthropods that accidentally end up in the water (Irurzun & Moreno, 2003). An example is the delta formed by the mouths of two or more rivers where, after a heavy rain, the rising water carries many cubic meters of floating vegetation and other organic waste from upstream areas. Often there are plants which do not correspond to the local vegetation; and sometimes this vegetation does not even belong to the country where it is deposited.

Reaching the delta, this debris is pushed toward the shore by the currents. The same applies to streams and ditches. Vegetable waste is not only found where two streams converge, it also occurs against fallen trees in creeks, against large emergent rocks, and particularly in backwaters.

During the course of the year, the size and composition of flood debris varies greatly (Irurzun & Moreno, 2003). Sometimes vertebrate carcasses are found, such as lizards, fishes, frogs, birds, rodents and even larger animals. Occasionally, even living animals can be found. This debris sometimes can gather hundreds or even thousands of beetles of all sizes, and from different families (e.g., Dytiscidae, Hydrophilidae, Gyrinidae, Carabidae, Scarabaeidae, Curculionidae, Dryopidae, Chrysomelidae, Buprestidae, Elateridae, Anthicidae, etc.; Schaefer, 1949; Cooter, 1991; Bordy, 2000; Southwood, 1987).

Importance of collection in flood debris: According to Irurzun and Moreno (2003), the number of insects trapped by water in each period is a reflection, although somewhat distorted, of the number of currently active insects. Therefore, continuous collection and data accumulation can provide interesting phenological and faunal information in a particular place, especially in spring and summer, which coincides with maximum vegetative growth and the flowering of most plants.

Also, according to Irurzun and Moreno (2003), insects carried by water are studied both for their large numbers and the large number of species; therefore, it is important to perform quantitative studies during short periods. The combination of short and long term studies show the beetles' rhythms of activity: annual, inter-annual, seasonal and daily. Finally, in reference to these collection methods, Irurzun and Moreno (2003), explain: *"Since walking and jumping species, together with others of widespread appearance and more or less awkward flight, seem more likely to be victims of the currents, and the buoyancy of different species is distinct and makes them more or less likely to be dragged to the bottom, the limitations of this sampling method and study should be taken into account. However, you must properly assess the potential of this type of insect collection since, despite their limitations and drawbacks, properly made they can become an interesting tool for entomological studies."*

How to collect in flood debris: Old debris that is in poor condition is not good for collecting beetles. Furthermore, decomposing vertebrates are often found in these places, so the task may not be so pleasant (Irurzun & Moreno, 2003). Also, it is important to follow the obvious hygiene standards. Improper handling of these materials can be unhealthy; therefore the use of rubber gloves, tweezers or sticks is advisable when attempting to collect beetles from such substrata.

The removal of debris for examination is not always simple and depends on the mass, density and the sizeof its components. Occasionally it may be necessary to use your hands to remove large portions of debris, but this can also be done with a large metal sieve, which is attached with tape or bolted to the end of a stick. This tool can be used on other occasions.

The best time to collect in debris is immediately after heavy rain, when rivers overflow and considerable amounts of debris are deposited on their margins (Cooter, 1991).

In summer, floating debris can be very compact; therefore it must be separated it before removing it from the water. To do so, a gardener's rake can be used. This yields from a few grams to several kilograms of material and its examination requires time and patience.

The remains removed from water can be spread on a beach or on the ground, and the beetles can be collected as they begin to move. To collect them, the debris is placed on a 1 cm wire mesh over a white tray (As mentioned in the **"How to use the aquatic net"** section).

The beetles can be collected once they fall/drop into the tray. Placing the tray in the sun might aid this process as the beetles will try to move away from the sun's heat.

Smaller insects are less visible in the debris, which is usually very dirty due to foam and other items. So these remains should be washed in a bucket with grid, pouring water with a bottle. To remove the insects that have fallen into the bucket the water can be strained with a fine strainer. After the first inspection of debris left on the grid, these wastes are turned back on the same grid and the bonded portions are studied in more detail. Once the debris has been examined, it can be spread it in a thin layer over a clear plastic cloth until nearly dry. Then the debris can be put in a cloth bag and taken to the laboratory and placed in an emergence box (a dark box with a clear bottle attached such that the beetles can crawl into it). The beetles will leave the debris and will be attracted by light to the transparent bottle.

The box should be large enough to allow debris to form a thin layer, making it easier for insects to get out and come to the light.

If the layer is thick, many insects will die and material in poor condition will accumulate at the bottom. This system is ineffective when there is a large amount of debris. It is important to note that it is not possible to collect all the beetles living among the debris.

When sifting through large amounts of debris, it is best to take note of or collect only those of interest.

Variations in the collection process: Andreas Herrmann (pers. comm., 2010) presents a similar method of collection, but with interesting variations in the selection process: *"In spring, when the snow melts in the mountains, rivers increase their flow. A similar situation occurs at harvest time, when the North Sea and its storms push water against the mouths of rivers. Beetles trying to survive climb quickly to the plants and all that is floating around. These floating objects (mainly wood chips, twigs, leaves and trash) loaded with insects, concentrate on the water surface with less flow, and [get] stuck in the banks.*

With a strainer or net, we remove the material from the water allowing it to drip for a few seconds and place it in a pillowcase or a large cloth bag. At home, the pillowcase or cloth bag with the material inside is put in a spin dryer at 3000 rpm. It is surprising that none of the insects die or suffer some damage with this procedure. Then, some of the bag contents is spread out in a thin layer at the bottom of a large plastic container. Of course, this material could also be spread out on a desk or a towel, but most of the beetles are extremely fast and the container's wall will prevent them from escaping.

With this method you can collect some beetles which are difficult to find with conventional methods, for example, those living within the earth".

Killing and conservation Beetles collected in the flood debris are killed in the usual way, with ethyl acetate, which stops the decomposition of insects. At the laboratory, they are carefully washed with water or soapy water, while keeping them in a colander. Once the water is drained, they can be dried with a paper towell or toilet paper and placed in clean jars with ethyl acetate, 70-80% alcohol or some other preservative. It should be noted that to preserve insects for DNA work, >95 % non-denatured alcohol (ethanol or isopropyl) is preferable.

Ethyl acetate destroys the DNA and denatured alcohols can have components that do the same (denaturing agents are variable, depending on the brand). The best preservation method for DNA work involves storing the specimens in >95 % ethanol at -20°C.

MANGROVES

The mangrove association is a type of ecosystem formed by salt-tolerant trees that occupy the intertidal zone near the mouths of freshwater streams, along the coasts of tropical latitudes. Mangrove areas include estuaries and coastal zones. They have an enormous biodiversity with high productivity, containing large amounts of birds, fishes, crustaceans, molluscs, insects, etc (Hogarth, 2007).

Mangroves vegetation is composed of several families and genera of dicotyledonous woody shrubs or trees that are virtually confined to the tropics. They often form dense forests that dominate intertidal muddy shores, frequently consisting of virtually monospecific patches or bands (Hogarth, 2007). The word Mangrove has a Caribbean origin and refers to the features that mangroves have in common, so the word "mangrove" is not taxonomic, but rather refers to physiological attributes (Kricher, 2008).