The Wild Wonderful World of Fulgoromorpha

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Abstract

This paper introduces and gives references to some of the behavior of Fulgoromorpha that is demonstrated by them as a whole or by some families or genera. Mentioned are the damaged reputation of the lantern fly, protective coloration, bird predation, long range dispersal to islands, wax production and the pretty glands that produce it, cave adapted species, mating calls, oviposition, Dominican amber, and ant mutualism, among others.

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zugleich Kataloge des OÖ. Landesmuseums,
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Introduction

The relationship of Fulgoromorpha to the rest of the Hemiptera-Homoptera is still being worked out, but the most recent studies place Sternorrhyncha (scales, aphids, whiteflies and psyllids) as the sister group of the rest of Euhemiptera (BOURGOIN, pers. comm.). Within this group, Fulgoromorpha are opposed to (Cicadomorpha + Heteroptera + Coleorhyncha), which 3 together are more closely related than Fulgoromorpha. Fulgoromorpha are characterized by morphological characters such as Y-shaped claval veins, placement of antennae and eyes, the shape of spines on their feet, and behavioral characters like feeding on phloem, and jumping.

Depending upon the author, one learns there are 17 to 20 families of Fulgoromorpha. I shall treat them as 18, with two African families, Hypochthonellidae and Gengidae, known from fewer than 3 species each, not being discussed as it has been suggested they be assimilated into the Flatidae and Eurybrachidae.

This article deals mostly with biology and behavior. For more information on morphology and identification, see O'BRIEN & WILSON (1985).

Fulgoridae

Let us start with the mostly tropical Fulgoridae, and the genus *Fulgora* (fig. 1, fig. 2), for which the group is named. The Fulgoridae range in size from a small 4 mm to a large 10 cm and can be identified by having cross veins on the hind wings. *Fulgora*, the lantern fly or peanut bug, has a head that looks like a peanut from above. But from the side, the head looks like an alligator head, complete with false eyes and false nostrils raised above the rest of the head, and a big mouth full of false teeth (fig. 3) that does not open. Specimens of *Fulgora* are up to 10 cm long with a wing span of 14.5 cm, and they sit on tree trunks, high or low, in the jungles from Mexico to Argentina.

Man obviously has wondered about their appearance. The name means brightness, perhaps because the shape of the head resembles a lantern, and biology was going through a phase of naming things after supposed function when the genus was named. (ROSS 1994) In the 1830's an artist, Maria Sybilla Merian, working in Surinam, said that the head lit up at night when there were males and females present, and it was light enough to read by (we think now she saw the light from the eyed elator) No one has reported this since 1952, and RIDOUT (1983) in his thesis at the University of London tested all of the bioluminescent processes known, without getting a response to any of them, so she may have confused it with another insect. BATES (1864) was told "one of these insects emerged from the forest and attacked a boat's crew of nine persons, eight of whom were killed by the poisonous creature, and the pilot only escaped by jumping in the river." BRANNER (1885) was told that "if, in its wild career, it strikes any living object- if an animal, no matter how large or powerful - it falls dead upon the spot; if a tree it soon wilts and dies". I have been asked by college students (males) from Mexico to Argentina whether the current legend is true, that if one is bitten by a peanut bug, one will die in 24 hours unless one is saved by having sex. I, of course, replied that if they could get me nine volunteers, 3 to rescue the others, and 6 to be bitten (but of course those to be saved had to be chosen randomly to make the experiment valid), then we would have a scientific experiment and know. They did not bother me with the question again. There is also a song about *Fulgora*, La Machaca, in the Andes, but I cannot find anyone who knows the words.

I would like to offer a *Fulgora* to a bird, to see if it would eat it. HINTON (1973) is convinced that the peanut bug resembles an alligator to a bird, which hunts by "rapid peering" from several angles, and perception of solidarity and distance is gained by evoking parallax. And they say birds cannot judge size (remember they sit on any size egg put in their nest), but could they confuse a 10 cm insect on a tree with an alligator in the water or on the bank? So who does the mimicry protect *Fulgora* from? Next choices are monkeys and man. I'd love to test a monkey. Or talk to a native of an undiscovered tribe in the jungle.


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Fig. 1:
Fulgora, dorsal view, wings spread, Ecuador.
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Fig. 2:
Fulgora, lateral view.
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Fig. 3:
Fulgora, head, lateral view.
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Fig. 4:
Odontoptera carrenoi SIGNORET, Costa Rica.
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Fig. 5: *Pyrops candelaria*, Asia.
© Photo: M. Boulard


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Scientists collect *Fulgora*, and the beak is underneath and reaches the base of the hind legs, better to feed through bark, but we always pick them up by the sides. Old stories say only shamans could touch them, and they collected them and put them in their amulet bag. Forest dwellers are being interviewed about *Fulgora* again in Brazil (Costa Neto, pers. comm.) I'm anxious to hear what he is being told now.

In the New World, the Fulgoridae have a number of strange head projections (fig. 4). In the Old World, the greatest variation is in color, so that Norman Penny, looking at them, said "butterfly bugs!" (Fig. 5). I suggest this is a good name for them and should replace the common name lantern-fly for the family (see NAGAI & PORION, Fulgoridae 2, Illustrated catalogue of the Asiatic and Australian Fauna).

One of the strange headed American genera is *Phrictus*, (frightening), with this lovely prickly head (fig. 6). The first specimen I was given had flown into a screen with large openings and gotten stuck there by its snout. Its legs wouldn't reach far enough forward to push it off the screen. The specimen shown here is parasitized by 3 large Epipyropidae, a strange parasitic moth which inserts its mandibles through the membrane between segments and feeds on the haemolymph (blood) (MARSHALL 1970). It is found in at least North America and Asia on at least fulgorids, issids, and flatids.

Many species of Fulgoromorpha produce "wax" (fig. 7) which is really an ester of 30-40 carbon atom acids and alcohols, with some of the compounds that are found in the wax of insect cuticle (MASON et al. 1989) that makes them water proof. My theory is that it is a way for the Fulgoromorpha, perhaps the first insects to feed on phloem, to get rid of the excess sugars that otherwise might have affected their osmotic pressure as they ingest enough phloem to get the nitrogen for the amino acids the insect needs to grow. This was suggested because most nymphs have a tuft of wax filaments at their tail, as do many females, who need food to produce many eggs, but few males do. Other superfamilies have developed filter chambers to shunt excess sugars, or excess water in the case of xylem feeders, from the system. In the case of this species, *Cerogenes auricoma*, (it's scientific name translates as wax bearer with golden hair), the Indians make a dye from the yellow wax near the head and Taylor reported that the insects catch the thermal currents late in the day and soar hundreds of feet above the oak forest, being very visible from the ground because of the waxy tail reflecting sunlight, so that they look like large floating snowflakes (HOGUE et al 1989).

HOGUE (1984) suggested that *Fulgora* resembles a lizard and may escape predation by lizards by looking like them, and ZOLNEROWICH (1992) suggested that a nymphal fulgorid looked like a jumping spider when viewed from behind (bumps on tops of its abdomen look like eyes), which might protect it from predation by spiders.

Wechsler photographed this *Pterodictya reticulata* OLIVIER (fig. 8) after being caught by a black chinned *Jacamar* (fig. 9). SHERRY (1983) reported that the ruddy-tailed flycatcher in Costa Rica feeds on jumping Hemiptera, 71% Fulgoroidea and 23 % Cercopoidea, and the Cocos Island flycatcher eats 42-60% fulgoroids (nogodinids, cixiids, flatids, tropiduchids). The Painted Redstart in Arizona collects fulgorids, issids, and flatids in the bolus they carry back to the nest to feed chicks (Hespenheide, pers. comm.). Interestingly, the insects are whole in the bolus, and in excellent condition except for the color being faded.

I've been told that *Fulgora* lay eggs on the same tree year after year, and can almost always be seen on that tree in season (a boon for ecotourism if the guides need to find them only once!) In Belize an anthropologist said many specimens had been on the tree behind his tent for three weeks. And in La Selva, Costa Rica, students made maps of where I could find trees with fulgorids on them, and said they had been there for days, and the previous year, too. And egg types in fulgorids vary, from a flat patch covered with wax against a tree trunk to a case that looks like a mantid egg case (preserved with nymphs at the British Museum), to a mound that looks like each egg on the outside has its own cocoon of wax (HOGUE et al. 1989).

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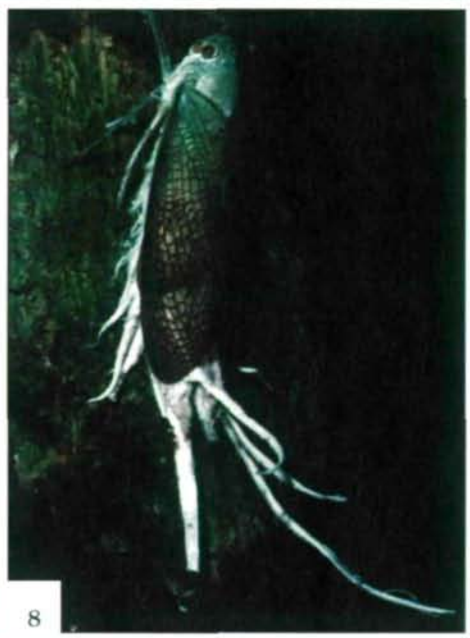

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Fig. 6:
Phrictus tripartitus METCALF with parasitic Epipyropidae, Panama.
© Photo: W. Foster

Fig. 7:
Cerogenes auricoma BURMEISTER, Mexico.
© Photo: E.L. Mockford

Fig. 8:
Pterodictya reticularis OLIVIER, Ecuador.
© Photo: D. Wechsler

Fig. 9:
Black-chinned Jacamar with *Pterodictya reticularis*, Costa Rica.
© Photo: D. Wechsler

Fig. 10:
Hypaepa illuminata, Honduras.
© Photo: H. Howell

Most new world species depend upon cryptic coloration of the body and front wings against a tree trunk (fig. 10). A number of species resemble lichens (fig. 11).

I have observed several species ejecting a long straight horizontal stream of honeydew about a meter long that looks like a spider web thread in the sunlight. In these cases, wasps and ants have come to the honeydew where it landed on plants below. Yet here is a picture of an ant near a fulgorid (fig. 12). Will further observation reveal some sort of interaction?

I've tried sweeping up, down, sideways and to the tree, without catching many fulgorids. The best way to catch them on a tree is to hold one's fingers on each side of a clear glass vial and move slowly, slowly, slowly toward their head. At the last second they jump toward the end of the vial which seems clear. At night at light they are less wary and can easily be caught with either fingers or the vial.

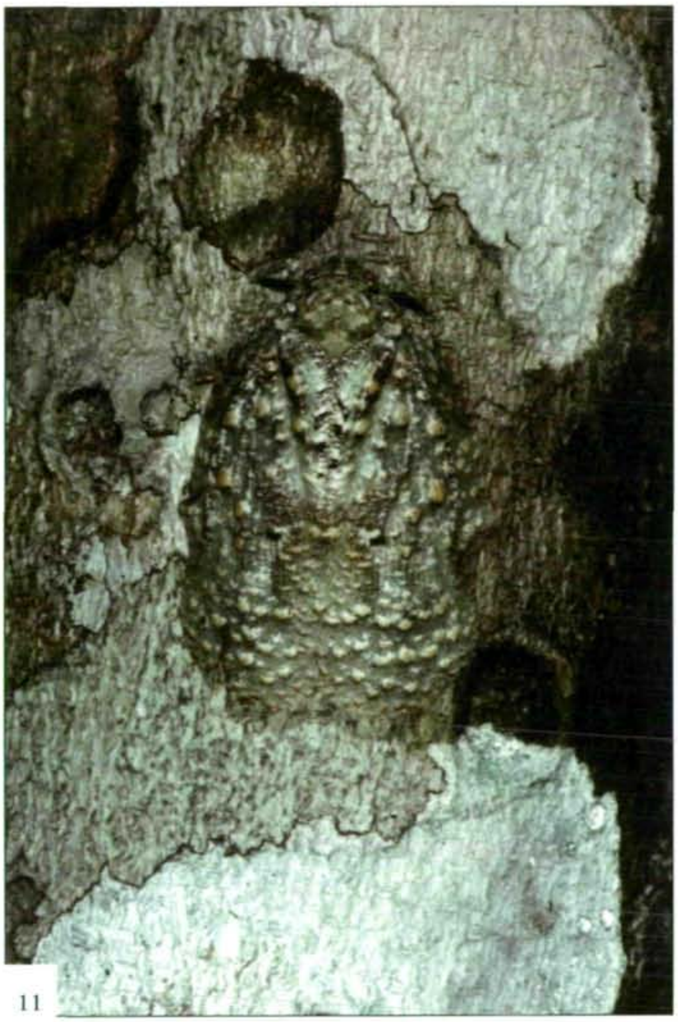
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Fig. 11:
Flatolystra sp., Ecuador.
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Fig. 12:
Enhydria sp. with ant, Ecuador.
© Photo: D. Wechsler

Delphacidae

Delphacidae can be easily identified to family by the moveable spur on the hind tibia. When sorting delphacids from cicadellids in a collection, one may often use the short antennae of most delphacids to separate them from the long, very thin, antennaed cicadellids. They are usually small sized, 2-6 mm in length, and along with cixiids have the broadest distribution in cold climates and on islands (fig. 13, with a cixiid, and fig. 14).

This is the most economically important family in Fulgoromorpha, because it feeds on monocots and has pest species on rice, wheat, corn, and sugarcane. Since the early 1970's, the brown planthopper, *Nilaparvata lugens* (STÅL) has been the most serious pest of rice in Asia. Many delphacid pest species cause more damage by vectoring virus diseases than by feeding damage.

"Love songs from Paradise", © M. ASCHE & H. HOCH, Berlin, Germany. Since I, as a female, want the human race to be a tie, I'm happy to work on a group in which the females can sing, too. I've always been annoyed by Aristotle's witticism, "Happy are cicada's lives, for always silent are their wives!" Ugggh. Do you know of any other animal, except people at a sporting event, that can be so loud for so long?

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Fig. 13: ***Tachycixius venustulus*** **(Cixiidae; left) and** ***Asiraca clavicornis*** **(Delphacidae; right) on a green twig, France. © Photo: M. Boulard**

Fig. 14: ***Chloriona smaragdula*** **(STÅL), a brachypterous female, Germany. © Photo: E. Wachmann**

One can hardly say the sugar cane leafhopper, *Perkinsiella saccharicida* KIRKALDY, is beneficial, but its control by the mirid egg predator *Tytthus mundulus* (BREDDIN) in Hawaii in the 1920's saved the sugar industry there (CLAUSEN 1978) and was one of the earlier successes of biological control of insects.

Ossiannilsson studied the morphology of the Auchenorrhyncha, the jumping Homoptera, and found tymbals that are homologous to those of cicadas in all superfamilies, the leafhoppers, froghoppers or spittle bugs, and planthoppers. The sounds are transmitted through the substrate rather than strongly through the air as in cicadas. Studies with an oscillograph have shown that a male delphacid jumps on a plant and calls. If a receptive female is present, she answers, and he moves toward her, with each calling in turn until they find each other and mate. Each sex and different species use a distinctive "song" (for a summary, see CLARIDGE 1985). If you would like to hear them, get a copy of the CD-ROM,

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HOCH & ASCHE have tested the response distances for these vibrations. Extrapolated to our size, they can transmit and respond for the distance of a mile (1.6 km.).

The Bishop Museum studied the aerial flotsam over the Pacific from 1957 to 1970, hanging nets high on ships to see what insects might be collected flying or being blown over the ocean. (HOLZAPFEL et al. 1978). Delphacids were always there, which may explain why they are present on most islands. Apparently they get frequent reinforcements, so they often are not isolated enough to evolve into new species. The rice delphacids are blown from China to Japan every year. Usually it is too cold for them to overwinter in Japan (see also DELLA GIUSTINA, in this volume).

Fig. 15:
SEM Photo of wax pores on a wax plate of a flatid, N.Z.
© Photo: C. Morales.

ASCHE (1985) studied the phylogeny of the tribes of delphacids, and has completed cladograms of UGYOPINI (1987).

Cixiidae

The females of the Cixiidae have a long swordshaped ovipositor like the delphacids, and lay their eggs in plant tissue or the soil, and often cover them with wax. They are from 3 to 13 mm in length, and usually have membranous wings with pustules on the veins (fig. 13). They too can live in harsh climates as well as the tropics and are economically important because they transmit the plant disease vectors mycoplasma-like organisms, such as the lethal yellowing that killed the palms in the West Indies and Florida in the 1990's.

Their nymphs feed on roots underground, and some found themselves in caves and eventually evolved to eyeless, sometimes wingless, almost colorless cave adapted species (troglobites). An attempt to identify the species of *Oliarus* in Hawaii, which have evolved from probably one founder species to over 80 species, incorporated the mating calls because the species are very similar morphologically. It was discovered that the lava tube adapted species on Mauna Loa and Mauna Kea on the island of Hawaii were more closely related to the epigean species above them than to the species found in the lava tubes of the other volcano, despite extensive cracks in the lava beds which could allow them to move great distances underground (HOCH & HOWARTH 1993). Since the dates of lava flows have been recorded for some time and will continue to be recorded, we now have a natural situation in which to measure the rate of evolution.

POPE (1985) studied the external pores of the wax glands of nymphs of a cixiid, *Myndus crudus*.

He found hundreds of low mounds surrounded by 5 or 6 smaller mounds, each of which secreted a tube of wax. These were placed close enough together that the strands touched, making a tube of tubes of wax. The set of 6 plus the mound in the center remind me of some buttons I've seen. Again we are dealing with a subject scarcely studied, but fig. 15 shows some wax pores of a wax plate of a flatid nymph similar to cixiids, while adults of kinnarids and meenoplids (BOURGOIN 1997) have a flat surface with indented circles or squares. Pope asked me to brush the wax off living nymphs and then place them in a freezer after 5, 10, and 15 minutes and then send them to him. That allowed time for a very small amount of wax to grow that could be viewed from the end of the tube, providing essentially a crosssection of it as opposed to a lateral view of the strands, so that one could see the source of the wax.

Most nymphs (fig. 29) have a caudal tuft of wax from the wax glands at the side of the 6th-8th abdominal segments (fig. 15), but some have these grouped into 6 tufts (probably one from each segment on each side) that they can move toward predators or spread or contract. Others have a sunburst that can be closed into one narrow tuft or spread in a perfect circle, and some are just covered with the wax, which can also be extruded through the integument of wing or body without pores visible by SEM (Scanning Electron Microscope). In nymphs of some unidentified species, some tufts seem to be encircled by a spiral of differently textured wax. The wax glands, or multilocular pores as they are called in scale insects, provide one of the best means of separating the species and higher categories in that group. We need to learn more about them in Fulgoromorpha.

Kinnaridae

The mostly tropical Kinnaridae are a small mostly New World family with almost 3 times as many species known from the Caribbean islands as the mainland (47 to 16 species). The mainland species might be mistaken for cixiids; the island species are usually smaller, 2-4 mm. They are not common in the Old World, but have been found in Somalia, Iran, the Canary Islands, India, Vietnam, the East Indies and Russia. We know almost nothing of their biology, but believe nymphs are found underground, and three species (Mexico, Jamaica) are cave adapted.

The females have the 6th-8th abdominal tergites chevron shaped, with large wax secreting plates. These waxes are water repellant, and are often used to cover the egg masses or waterproof chambers in the soil or wood. They also repel predators and parasites, and are said to reflect ultraviolet light, which may contribute to species recognition, since insects see in the ultraviolet.

Meenoplidae

The mostly tropical family Meenoplidae is a small Old World group of Fulgoromorpha with small specimens, 3-7 mm long with pustules along the anterior claval veins and a long apical segment of the labium (derbids may have the secretary pores or pustules but have a short apical segment of the labium). They are the sister group of the Kinnaridae, and both nymphs are supposed to be associated with the soil. Both families reach oceanic islands, but they were not reported in the aerial insects in Bishop Museum studies. Meenoplids have also become cave fauna, especially in the Canary Islands and in the cave area in Queensland. For illustrations of some wax plates see BOURGOIN (1997).

Achilixiidae

This small tropical family with 2 genera and 24 species, with specimens 4-8 mm long, can be recognized by a strange lateral projection of the abdomen. The family has been placed in the achilids, derbids, kinnarids, and cixiids. No one knows what the projection is for, but when I asked if it might be an evaporative surface for pheremones, Aldrich (pers. com.) said he believed Fulgoromorpha did not produce them. Eight species are found in the Neotropics and sixteen in the Philippines and Borneo. We are trying to place each cluster with a larger family, which is also true of the other 2 small families.

Achilidae

The Achilidae may be identified by the tips of their fore wings being overlapped similar to the Heteroptera. Specimens are from 3-13 mm long, usually cryptically colored tan or brown. Their nymphs are found in holes in logs or under loose bark or in litter, and they are thought to feed on fungus, while the adults feed on tree phloem. Studies have been done tracing the salivary tubes which are secreted as the mouthparts penetrate the plants(for this and other feeding behavior, see BACKUS 1985). Most Hemiptera feed only on phloem or xylem tubes with a few simply penetrating one leaf cell and then another, but some have branched tubes that sample one of the three and then another. These feeding tubes have even been found in cross sections of leaves of fossil ferns from the Early Devonian to Late Pennsylvanian (395-290Ma) (LABANDEIRA & PHILLIPS 1996). Still, it has been suggested that the achilids have very long mouthparts in the nymphs, coiled so that they can penetrate fungal hyphae cell by cell. They are found in the tropics, but are also common at higher latitudes and elevations.

A key is provided to the genera of the world by FENNAH (1950).

There are at least three methods of egg deposition in Fulgoromorpha, and sometimes more than one type per family. Delphacids and cixiids have a long sword-shaped ovipositor with which they insert eggs into plants or into the soil. The second type, called "raking-sweeping" rakes the substrate and attaches eggs to particles of bark or soil. This is done in the achilids and probably the families from Kinnaridae to Dictyopharidae in this paper. The third method is gluing eggs to the substrate, used in some fulgorids and eurybrachids. A second type of piercing excavating ovipositor evolved, using only the first and second valvulae, in some of the issids, flatids, tropiduchids and ricaniids. (See FLETCHER 1979, WILSON et al. 1994, EMELJANOV 1984).

Fig. 16: Two Mysidiini. © Photo: D. Wechsler.

Fig. 17: Zoraidini, Borneo, with wings hanging down from leaf. © Photo: D. Wechsler.

Derbidae

Derbids are fragile-winged insects from 4-14 mm long with bright-colored, white, and dark species. They have several methods of holding their wings, perhaps related to their means of protecting themselves from raindrops in their tropical habitats. Moth derbids (Mysidiini) (fig. 16) sit underneath broad-leaved plants in the new world tropics with their broad wings flat against the underside of the leaf. Cenchreini sit like delphacids, on top and parallel to the leaf, with heads up and roof like wings. Dawnaroidini have veins meeting at other than right angles, so they may be curled into a cylinder along the length of the wing, and this is held at a 45 degree angle away from the body, like rabbit-eared antennae. When the insect dies, the wings relax and flatten. An old world long-winged tribe Zoraidini hangs under leaves, often of palms, with its wings hanging down, folded together perpendicular to the body (fig. 17).

The moth derbids aggregate under the broad leaved plants (but how do they find each other-accoustically, plant type, plant hormones, what?) and I walk back from each collecting trip tapping such plants to see if any insects fly out. I also use a light blue bathtub-shaped beating sheet. In this sheet, the insects jump from side to side, giving me two or three chances to catch them before they escape.

Recent papers on the Mysidiini (BROOMFIELD 1985) and the genus *Cedusa* (FLYNN & KRAMER 1983, KRAMER 1986) suggest that we have only begun to name all of the species of derbids. BROOMFIELD had 4 genera and 46 described species when he started and added 6 genera and 134 species. KRAMER and FLYNN started with 53 species and added 94, and I have seen at least 100 new species of *Cedusa* since then, and also many Mysidiini. Such numbers are common in all of the families with small sized species.

There is an old mostly discarded theory about mating in insects called the lock and key theory. The male genitalia, with its spines, bumps, and inflatable tubes (and the claspers and the anal flap, which protect it) are supposed to fit only the female genitalia of the same species. Actually, other types of sexual selection that work at a longer distance (such as accoustic communication or pheromones) usually keep different species from approaching one another. Dozens of species may have the same external appearance as in the black *Cedusa* species, but differ incredibly in the male genitalia (fig. 18). Sometimes the specimens mate for hours, many approaching from behind and in a parallel position, but rotating so that the heads are at opposite ends of the pair after a time. Many of these structures area flexed outward or expanded to help hold them together.

Dictyopharidae

The Dictyopharidae (fig. 19), the sister group of the Fulgoridae, vary in size from 3 to 33 mm, have membranous wings tinted green or brown, and often have a long snout. Both families have expandable male genitalia, and it is difficult to get them to expand. Clearing them with a potassium hydroxide solution works, as in the other families, but instead of 12-24 hours, it may take a week of lowering and raising the concentration of the KOH-a process once named "controlled rotting". And then if one transfers the abdomen to glycerin to draw it, one can see it deflate as one tries to draw. Very frustrating. We are hoping that one of the chemicals used in histology to fix tissue will fix it in the expanded position.

One subfamily, Orgerini (fig. 20), is mostly desert dwelling in the Southwestern U. S., but is also found in S. Europe, Russia, Africa, and Asia. It is usually brachypterous with opaque wings and no tegulae, small sclerites that cover the base of the wings.

Many people think of a snout (head projection) as characteristic of the fulgorids and dictyopharids. Actually, of the 18 families discussed here, I know of at least one genus with an elongate head in every family but the meenoplids, achilids, nogodinids, issids, ricaniids,

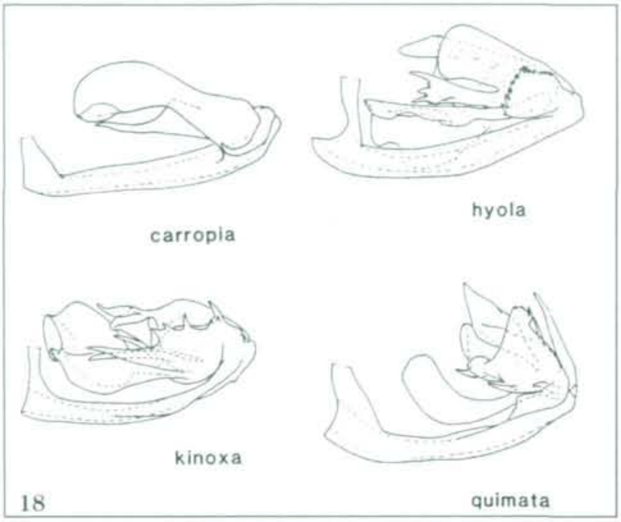

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Fig. 18:
Male genitalia of four species of *Cedusa*, from KRAMER 1986.


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Fig. 19:
***Hyalodictyon* sp.**
© Photo: D. Wechsler


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Fig. 20:
***Bursinia hemiptera*, frontal view , France.**
© Photo: M. Boulard

eurybrachids, and perhaps flatids (some heads are conical but not really elongate), and I doubt if 40% of the species of Fulgoromorpha are described yet. In *Fulgora*, the snout is empty except for a pouch that connects to the digestive system. It has been suggested that this stores extra sap, or alternately that it fills with liquid when the insect flies to help balance it, or that it somehow serves the function of the

Fig. 21: *Thionia simplex* **with nematode, issid 6.5 mm; nematode 69mm. © Photo: C. Sperka**

filter chamber in other Auchenorrhyncha. We don't know.

At least one genus, *Taosa*, feeds on emergent aquatic plants. If the nymph falls into the water, its very broad spiny hind tarsi allow it to reach the plants somehow again.

This is the last of the 9 basal families, identified by having the third metatarsal segment with a row of spines. There are two other groups, one with a pair of spines, (issids, caliscelids, tropiduchids, tettigometrids, and flatids) and one with none (ricaniids, lophopids, eurybrachids). The cixiids, derbids, achilixiids, achilids, kinnarids and meenoplids are thought to have their nymphal stages cryptic or associated with the ground or spaces under bark or in logs rather than being in the open on the plants as the adults are. The delphacids, dictyopharids and fulgorids and the rest to be discussed have nymphs feeding on plants above ground as their parents feed.

Issidae (including Acanaloniidae)

Issids are opaque winged usually small Fulgoromorpha, 2-8 mm long, found in temperate regions and the tropics. While most issids are thought to glue their eggs singly or in groups to plant parts, two genera of Hysteropterini, the holarctic genus *Hysteropterum* (s.l.) and palearctic genus *Agalmatium* make mud nests. The female scrapes dry soil with the third valvulae of the ovipositor (which is sclerotised and toothed) into the geotheca and styloidal antechamber and carries this without jumping, because it is estimated to be up to 5 times the weight of the female in *Agalmatium*, to the oviposition site. She mixes the soil with liquid from an accessory gland of the oviduct and lays up to 16 eggs, each being covered as it is laid (BOULARD 1987; SACCHI 1930). In vineyards in California in 1958, one grapevine stake (1.2 m x 4.4 cm x 8.6 cm) had 5,680 egg cases (SCHLINGER 1958)!

Fulgoromorpha can be parasitized in all stages by other insects. In the case of this issid, a nematode was the parasite. This host (fig. 21) was 6.5 mm long, the nematode 69 mm long!

Caliscelidae

This worldwide group has recently been raised again to family status. They are sometimes found in museum collections among the weevils, because they have a snout often aimed downward, and they are mostly brachypterous and small, 1-5 mm, so they look like nymphs, and often are not collected. In South America, many feed on bunch grass; in the U. S. the records are on grasses, sedges, and an introduced species on palm. One European species, *Caliscelis bonelli* LATREILLE, was found in California, perhaps introduced north of San Francisco by ballast from European boats long ago. The species is dimorphic, with the male a prettily marked yellow and black strutter (Fig. 22), who lifts one broad front leg and waves it in the air once or twice before moving forward, and then does the same with the other, perhaps mimicking jumping spiders. The female is an inconspicuous brown (fig. 23).

the Issidae to the Nogodinidae, changing the characterization so that it is easier to identify a specimen to tribe and then see which family the tribe is in than to identify a specimen to family and then tribe, because each family has very distinctive groups that do not resemble each other. A key for the identification of Nogodinids, Issids and related families is provided by EMELJANOV (1999).

Fig. 22:
Caliscelis bonellii **LATREILLE, male, France.**
© Photo: E. Wachmann

Fig. 23:
Caliscelis bonellii **LATREILLE, female, France.**
© Photo: M. Boulard

Nogodinidae

This mostly tropical family usually has membranous wings (or membranous cells in them), with specimens 4-16 cm long. In 1984 FENNAH moved some California genera from

Tropiduchidae

The Tropiduchids are a small family of mostly green or brown translucent winged medium sized (5-13 mm) insects with the mesonotum with its apical angle separated by a transverse groove. Their idiosyncrasies are oddly shaped heads, variable wing patterns, and red carinae or color patterns thrown in every now and then. They are found on ferns, palms, grasses and dicots. The Dubas bug (Dubas means honeydew in Arabic), *Ommatissus lybicus*, is the greatest pest of date palms in the middle east and can cause the death of trees (ASCHE & WILSON 1989).

Fig. 24:
***Tettigometra sulphurea*, imago and nymph.**
© Photo: M. Boulard.

Fig. 25:
***Euphyonarthex phyllostoma* with ants *Camponotus acvapimensis*.**
Photo: A DEJEAN, © Publications Scientifiques du Muséum national d'Histoire naturelle, Paris

Tropiduchids are common in the West Indies, and have been found in the Dominican amber. In the West Indies, the number of Fulgoromopha specimens is a much higher percentage of the insect population than it is on the mainland. This is also reflected in the Dominican amber, although nymphs are even more common than adults in the amber (see SZWEDO, in this volume).

Tettigometridae

The members of this small, opaqued winged, 3-11mm sized, Old World family (fig. 24) of Fulgoromorpha display "ant-mutualism". Its placement among the families has been in doubt, but recent studies show it lacks several fulgoromorph larval characters (secondarily lost) such as no jumping apparatus, no wax plates, no sensory pits, and other adult characters, including molecular, that place it among more "advanced" families, in a group with Tropiduchidae and Flatidae.

Ants collect honeydew from the anal opening and regularly antennate the planthoppers (BOURGOIN 1997) (fig. 25). The tettigometrids are sessile and the nymphs remain in groups, two characters often associated with ant trophobiosis. Indeed, the presence of *Hilda undata* WALKER on fig trees, which provides honeydew to the ant *Camponotus brutus* FABRICIUS, can change the behavior of the part of the colony foraging on that tree. With the tettigometrid to provide food, the ants are active on the tree day and night rather than just at night, and they are more aggressive toward other ants (they became sub-dominant rather than non-dominant). This combination also may affect the seed production of the fig, since some of the other ants tending scales on the trees or feeding on extrafloral nectaries tend to eat the unripe figs, destroying the seeds and also the immature pollinators (DEJEAN et al. 2000).

Flatidae (including Hypochthonellidae)

These are probably the next most spectacular family after Fulgoridae because of their size and color (fig. 26). They may be pink, red, yellowish, green, white, brown, or black; striped, spotted, or plain; small or large (4.5-32 mm); flattened laterally or dorsoventrally; are common; and are found on all continents. The best story about them is about an African species that has both pink and green specimens (morphs) in the same species. The story is that they sit at the top of the plant in clusters-mimicking the flowers and buds. Only the flowers bloom from the top down rather than bottom up, so the pink ones are on top and the green buds are below. If the insects are disturbed, one observer says they resettle in the same pattern (another found they settled irregularly).

The genus *Poekilloptera* (fig. 26), found from Brazil north and west to Costa Rica, (and Honduras and Guatemala) has black spots on white to gold wings. There are a number of patterns that look distinct, but when enough specimens are gathered one finds continua in the patterns, not distinct breaks between species. The genitalia are all similar, so the 5 New World species described are now considered one. Are they? They have not been studied by someone living in the area to determine the size and variability of a population or the hosts or acoustic signals used. Perhaps audio or molecular studies will help determine what a species is. Scientists still use the definition that a species is an interbreeding population which produces fertile offspring, and is reproductively isolated from other species, but this is difficult to test.

The contrast between the lateral and dorsoventrally flattened species (fig. 27) is perhaps most obvious in this family, but it occurs also in the fulgorids, cixiids, achilids, derbids, dictyopharids, issids, nogodinids - all of the larger families except delphacids. Some of the dorsoventrally flattened species sit on trunks as the fulgorids do, but I have also seen them curved around stems, surrounding about 2/3 of the circumference of the stem. Fig. 28 shows a species that mimics thorns.

One U. S. flatid, *Metcalfa pruinosa* (SAY) has somehow been introduced into Italy from which it is spreading to the rest of southern Europe. It is not a severe pest in the U. S., although it feeds on at least 100 species of plants here. But it has had a population explosion in Europe without the predators and parasites found in the U. S. (see ALMA, in this volume). The wax it produces covers the produce, most-

Fig. 26:
***Poekilloptera phalaenoides*.**
© Photo: M. Boulard

Fig. 27:
Flatoidini flat against tree trunk.
© Photo: D. Wechsler

ly grapes, or the honeydew serves as a substrate for mildew, both reducing the value of the grapes. It is thought that the feeding, despite the large numbers of insects, does not seriously injure the plants, but it does damage the appearance of the fruit. The honeydew does provide food for honeybees in August, when flowers are scarce. A dryinid wasp has been introduced to try to control it (LUCCHI 2000).

Fig. 28: Thorn mimic, *Cyarda* sp. © Photo: D.J. Shetlar

Fig. 29: Flatid nymphs with waxy tails. © Photo: D. Wechsler

Ricaniidae

The next three tropical families have no spines on the third metatarsomere. They are mostly Old World, with one genus of lophopid and 4 genera of rare ricaniids in the new world. The ricaniids usually have triangularly shaped membranous black, brown, or membranous forewings or a combination. They are 4-12 mm long, but the wings may be up to 30 mm wide when spread.

One ricaniid in Australia, *Scolypopa australis* WALKER, sometimes feeds on a poisonous plant tutu, (*Coriaria arborea* LINDSAY), and secretes a honeydew. In times of poor nectar supply, bees collect this honeydew and incorporate it into their honey. This honey is poisonous to man (PALMER-JONES 1947). This ricaniid has been introduced into New Zealand.

Lophopidae

The lophopid and eurybrachid wings are subquadrate, and usually the colors, mostly tans and browns, are opaque. The lophopids have a narrow head, the eurybrachids have the vertex 3 x as broad as long.

This tropical Old World family of 41 genera and 140 species is the first to have a modern generic level phylogenetic treatment and analysis of biogeography (SOULIER-PERKINS 2000). Specimens are 5-15 mm long. Only one genus is found in the New World, but there is a fossil recorded from Colorado. *Pyrilla* is a serious sugarcane pest in India, and also feeds on other monocots such as corn and rice. *Zophiuma* and *Painella* in the Solomon Islands seem to be linked to coconut diseases.

SOULIER-PERKINS & BOURGOIN (1998) have also studied the copulatory mechanisms in lophopids, and hypothesized which factors affect mating and sperm selection, including mating times from 1 second to 2 hours in different species of Fulgoromorpha.

Eurybrachidae (including Gengidae)

This Old World tropical family has specimens from 7-29 mm long. They are usually broadly rectangular and opaque and have a vertex 3 times as broad as long (fig. 30). Some species have a protective coloration pattern that makes both ends look like heads. In the Asian genus *Ancyra* (meaning without a tail), they very closely resemble some ginger weevils (Rhynchophorinae) that also appear to be two headed. There are a black eye bump and an antenna formed at the end of each forewing,

Fig. 30:
Mesonitys taeniata **SCHMIDT.**
© Photo: M. Boulard

Fig. 31:
Harmosa bivulneratum**.**
© Photo: M. Boulard.

and the hind wings have an elongation that looks like a beak. Five species can be arranged in a heuristic sequence that more and more closely resembles the weevils in color, shape of thorax, angle of sitting on the plant. A second genus from Africa, *Harmosa*, (fig. 31) has the "antennae" extended from the forewing (but no clear eye spot), and the hind wing extended to appear to be a head below the antennae.

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Outlook

To complete this discussion, where do we stand now? The METCALF catalogue, a catalogue of the Auchenorrhyncha of the world, while superb, is 50-70 years old. The bibliography is thru June 1, 1942. Probably all the species of only few countries, Great Britain and Scandinavia, have been described. Next would be Central Europe or the U. S. and/or Canada, or surprisingly, the biologically diverse Taiwan, where Professor C.T. Yang and his students have monographed the fulgoromorphs except the rare dictyopharids and fulgorids. In the rest of the world, estimates of the percent of undescribed, unknown species range from 80% downwards.

Very few nymphs have been associated with adults, and our host plant records are shaky, often recording a plant on which a single specimen was collected. For the most part, we know the life history of only economic species. We know little of the habits, habitats, predators, parasites, anything.

Once we compared the number of people at the field museum studying insects and mammals. If we had had the same number of entomologists per species of insects as mammologists per species of mammals, we would have had 278 entomologists. There were three. And the ratio hasn't changed.

Since 1983, Auchenorrhynchists in Europe have had meetings every three years, and two of these meetings have been in the U. S. and one in Australia. There is a newsletter, Tymbal, on the web in Australia produced by Murray Fletcher at http://www.agric.nsw. gov. au/Hort/ascu/tymbal/tymbal, and he is producing a checklist and key and illustrations of the Australian fauna for the web at http://www.agric.nsw.gov.au/Hort/ascu/fulgor/species.htm. A European checklist is being prepared by ASCHE, and checklists are being updated with the hope of putting them on line at http://flow.snv.jussieu.fr, and the "biodiversity and evolution of Fulgoromorpha research initiative" (BEFRI) project is being initiated at http://bach.snv.jussieu.fr/befri.

Since 1965, many of the insect systematist positions at Universities in the U. S. and Europe have been replaced by molecular biologists. With estimates of from 10 to 30 million insects in the world, mostly undescribed, and many not even collected, and the rapid destruction of habitats everywhere, there have been questions whether all of the animals (read insects especially) will ever be named. Remember that in the Bible, God told Adam to name the plants and animals, before Eve was created. Taxonomy is the oldest profession! Actually, it may be. Surely primitive *Homo sapiens* had to recognize the plants that were safe to eat, which is simply applied taxonomy.

If that was man's first profession, why aren't all the species described by now? Will thousands of species become extinct before we even collect them? There is work for many more people, both amateurs and professionals. Join us!

Zusammenfassung

In dieser Arbeit werden die Fulgoromorpha (Spitzkopfzikaden) auf breiter Basis vorgestellt. Familien und ausgewählte Gattungen werden charakterisiert und interessante Daten zu Verhalten, Färbung, Verbreitungsmuster, Feinde und Feinabwehr, Mutualismus, Höhlenbesiedelung, Gesänge, Eiablage usw. werden präsentiert.

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