of any race of *A. mellifera*. Migratory beekeepers managing *scutellata* in the northern part of South Africa have moved bees into the fynbos region of South Africa where the Cape bee is present (the reciprocal also happens). This has allowed Cape workers to drift into and parasitize *Apis mellifera scutellata* colonies. This action has been a significant problem for beekeepers because Cape-parasitized colonies often dwindle and die. Furthermore, Cape bees are specialist foragers in the fynbos region and they often perform poorly when taken outside of this region. So *Apis mellifera scutellata* colonies parasitized by Cape bees in the northern part of South Africa can become useless to beekeepers.

Beekeepers in South Africa often consider Cape bees more of a serious threat to their colonies than varroa mites (*Varroa destructor*, the most prolific pest of honey bees). Because of this, researchers globally have taken notice of Cape bees. Many fear that if Cape bees ever spread outside of South Africa, they may be a significant problem for beekeepers worldwide.

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Capitate

Having an expanded tip or club-shaped, and usually used in reference to antennae.

► Antennae of Hexapods

Capniidae

A family of stoneflies (order Plecoptera). They sometimes are called small winter stoneflies.

► Stoneflies

Capsid

The protein coat or shell of a virus particle; the capsid is a surface crystal, built of structure units.

Capsids

Some members of the family Miridae (order Hemiptera).

► Plant Bugs

► Bugs

Capsomere

A cluster of structure units arranged on the surface of the nucleocapsid, in viruses possessing cubic symmetry.

Carabidae

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Carabid Beetles (Coleoptera: Carabidae) as Parasitoids

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Several genera of carabid beetles are ectoparasitoids as larvae. The parasitoid habit is uncommon in beetles; only eleven beetle families include parasitoid species, compared to a much wider diversity of parasitoids in the Diptera and Hymenoptera. The evolution and ecology of these parasitoid beetles is fascinating, but their host associations are poorly known.

Carabid beetles have been stereotyped as ground-dwelling generalist predators, yet in recent

years many counter-examples have shown the Carabidae to be more diverse in form, habit, and trophic association. Many carabids, especially tropical species, are arboreal. Granivory, herbivory, and specialized predatory habits are widespread. Three of the 76 recognized tribes are known to have parasitoid species: Brachinini, Peleciini, and Lebiini. All of these are ectoparasitoids on pupae of other beetles or, in one Peleciine genus, on immature millipedes.

In all known parasitoid carabids, the larva passes through three distinct development phases. First, the free-living first larval instar emerges from an egg laid in the host's habitat, and locates a host. Then, the larva feeds on a single pupal or pre-pupal host, while it molts zero to four times. Third, after the host is consumed, the larva undergoes a non-feeding larval stage ("pre-pupa") with zero to two molts; it then pupates next to the remains of the host. The total number of larval instars often deviates from the three molts typical for Carabidae, ranging from one (*Pelecium*) to five instars (some *Brachinus*). The adults live in the host habitat and may have a narrow or broad range of prey, including the immature stages of the host.

The best-known genera of parasitoid carabids are *Brachinus*, *Lebia*, and *Lebistina*. *Brachinus*, the celebrated bombardier beetle, emits a directed, explosive spray of boiling-hot quinone solution, which is considered the most highly evolved defensive secretion of the many types documented in the Carabidae. Studies by Eisner and colleagues have shown the elaborate mechanisms which allow the orchestration of this exothermic reaction while protecting the emitter and instantly repelling potential predators. They have also shown the chain of evolutionary developments leading to this impressive set of defensive organs. North American *Brachinus* are found in littoral habitats near fresh water, where the known beetle hosts in families Hydrophilidae, Dytiscidae, and Gyrinidae emerge to pupate from their larval aquatic habitats. Recently, dryland European *Brachinus* have been associated with carabid hosts of the genus *Amara*, broadening the known hosts to 11 species, for only nine of the approximately 300 *Brachinus* species described.

On the basis of fragmentary observation, it appears that *Pelecium sulcatum* (Pelecinii) develop as parasitoids on chrysomelid pupae and immature millipedes, and have only one larval instar.

Lebia species number over 450 and the genus is cosmopolitan, with 47 in North America. Adults typically seek prey in plant canopies, and all known larvae are ectoparasitoids of chrysomelid beetle pupae, yet only four species' hosts have been documented. Many additional *Lebia* species are reported to be associated (often with adult mimicry) with specific chrysomelids, particularly flea beetles (Alticinae) and casebearers (Cryptocephalinae), implying a host-parasitoid relationship. Two species parasitize economically important hosts: *L. scapularis* on elm leaf beetle, *Xanthogaleruca luteola* in Europe, and *L. grandis* on (Fig. 14) Colorado potato beetle, *Leptinotarsa decemlineata* in North America. Although elm leaf beetle is a significant invasive pest of ornamental elms in North America and elsewhere, *L. scapularis* apparently has not been considered for classical biological control. In contrast, *L. grandis* was introduced to France in the 1930s, and its parasitoid life history discovered, as part of a USA-France

Carabid Beetles (Coleoptera: Carabidae) as Parasitoids, Figure 14 ***Lebia grandis*** **fed first instar larva (top) with its prepupal host, Colorado potato beetle,** ***Leptinotarsa decemlineata*** **(photo by Caroline Chaboo).**

classical biocontrol program. Since the carabid was originally described from North Carolina in 1830, over 60 years before Colorado beetle arrived there, its putative original host was the false potato beetle, *L. juncta*, the only *Leptinotarsa* present. Although the introduction to Europe failed, there is interest in future classical biocontrol because of the apparent host specificity and the fact that the adults are the most voracious predators known on eggs and larvae of Colorado potato beetle. *Lebia* adults are typically found in close association with their host species, and females oviposit in close proximity to the host pupal habitat; in the case of *L. grandis*, this takes place in the soil below infested host plants.

Lebistina, an African genus closely related to *Lebia*, shows adult mimicry of its chrysomelid hosts, a pattern shared with some *Lebia* species. *Lebistina* is one part of a complex anthro-ecological story involving the San indigenous tribe of Southern Africa. San tribe members dig underground for the pupae of chrysomelids and their carabid parasitoids, both associated with the aromatic shrub *Commiphora* in the incense tree family, Burseraceae. Pupae of both the chrysomelid *Diamphidia*, and especially its parasitoid *Lebistina*, are collected for their potent neurotoxic arrow-poisons, which allow San hunters to fell large prey such as giraffes with small bows and arrows, but usually only after several days of tracking the injured animal.

Parasitoid carabids present some fascinating evolutionary questions, not the least of which is why both the impressive arrow-poisons and the explosive exocrine toxins are associated with these genera. Yet, at most, 1% of their hosts are known. In addition, the possible management of predator/parasitoid beetles may offer an interesting opportunity for "double control" of chrysomelid pest species.

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Carabiform Larva

This is another term for campodeiform larva.

► Campodeiform Larva

Caraboid Larva

A larval form that is similar to campodeiform, but usually more chitinized and with stronger mandibles and short antennae. It is found in the families Staphylinidae, Carabidae, Dytisidae, and Hydophylidae (all in the order Coleoptera).

► Campodeiform Larva

Carapace

This is not a term used with insects (hexapods). It is used to describe the fused dorsal covering of crustaceans.

Carayonemidae

A family of insects in the superfamily Coccoidae (order Hemiptera).

► Bugs