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Rove Beetles of the World, Staphylinidae (Insecta: Coleoptera: Staphylinidae)[1]

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Introduction

The family Staphylinidae belongs to the suborder Polyphaga of the order Coleoptera (beetles). The superfamily Staphylinoidea includes the small families Hydraenidae, Ptiliidae, Agyrtidae, Leiodidae, Scydmaenidae, and Silphidae, and the huge family Staphylinidae.

SUBORDER Polyphaga -

SUPERFAMILY Staphylinoidea -

FAMILY Staphylinidae

At present, more species of beetles are known than of any other insect order. As now constituted, Staphylinidae are one of the largest families of beetles, with over 45,000 species known worldwide and probably over 75% of tropical species still undescribed. It is the largest family in the British Isles and in America north of Mexico, and it may prove to be so in other regions when huge numbers of now-unknown species are described (if they are described before they become extinct by habitat destruction). In the future, systematists may, however, choose to split the family into four phyletic lines to form four families. This document takes a worldwide perspective, emphasizing the role of the extremely few species that have been studied; identification is far beyond the scope of this document because of the size of the family.

Classification

Phylogeny

Four phyletic lines are now (Lawrence and Newton 1995) included in Staphylinidae:

- subfamilies Glypholomatinae, Microsilphinae, Omaliinae, Empelinae, Proteininae, Micropeplinae, Neophoninae, Dasycerinae, Protopselaphinae, and Pselaphinae;
- subfamilies Phloeocharinae, Olisthaerinae, Tachyporinae, Trichophyinae, Habrocerinae, and Aleocharinae;
- subfamilies Trigonurinae, Apateticinae, Scaphidiinae, Piestinae, Osoriinae, and Oxytelinae;

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- subfamilies Oxyporinae, Megalopsidiinae, Steninae, Euaesthetinae, Solieriinae, Leptotyphlinae, Pseudopsinae, Paederinae, and Staphylininae.

The former taxa Brathinidae (now just part of subfamily Omaliinae), Dasyceridae (now subfamily Dasycerinae), Empelidae (now subfamily Empelinae), Glypholomatini (formerly a tribe of Silphidae), Microsilphinae (formerly a subfamily of Silphidae), Pselaphidae (now subfamily Pselaphinae), and Scaphidiidae (now subfamily Scaphidiinae) of earlier authors are here in Staphylinidae.

Fossils

Pleistocene fossil Staphylinidae have been reported from peat bogs in northeastern North America and from Europe. They seem to be of extant species and help to show former distribution of some of these species. Oligocene fossils are from amber from the Baltic, the Dominican Republic, and elsewhere, and from shales in the USA (Colorado), France, Germany, and elsewhere. Most of these are recognizably members of modern genera. Deposits from the mid-Cretaceous to lower Jurassic in Eurasia have also yielded fossils. Most of these resemble members of modern subfamilies. The oldest recorded staphylinid, more than 200 million years old, is from the upper Triassic of the USA (Virginia). Species-level identification of present-day staphylinids normally requires dissection, at least of the genitalia - when this cannot be done with fossil specimens they have limited value.

Appearance

Adults

The length of adult Staphylinidae ranges from less than 1 mm to 40 mm. Most are under 7 mm long. Most have short elytra, exposing several abdominal segments, but it would be an error to imagine that all have short elytra, or that all beetles with short elytra are Staphylinidae. Typically, they are slender with short elytra and powerful abdominal musculature that renders them very flexible, thus able to enter narrow crevices. Those that have short elytra trade flexibility for exposure, rendering them subject to desiccation and dependent upon humid habitats. Abdominal segments are surrounded by sclerotized plates (a large dorsal plate called a tergite, a large ventral plate called a sternite, and up to two pairs of dorso-lateral plates called paratergites) with membranous connections. In some genera (e.g., of Paederinae, Euaesthetinae, and Osoriinae, and partially so in Steninae) the tergites-paratergites-sternites are fused into rings around each segment, probably limiting water loss. The length of adults, which is nevertheless normally used to express size, is an inaccurate determinant of size because abdominal segments typically can be telescoped, making the body appear longer when under moist conditions and alive, but shorter when dried and dead. Eyelessness has evolved in some soil-inhabiting (Leptotyphlinae) and cave-inhabiting species, and winglessness in species occupying environments including mountains, the soil, caves, and seashores.

Non-entomologists sometimes confuse Staphylinidae with Dermaptera. However, the non-opposable valvulae (appendages of the 9th abdominal segment) are not the opposable forcipes of Dermaptera, and the radial wing-folding pattern of Dermaptera is unlike that of Staphylinidae.

Immature Stages

Staphylinid eggs typically are white, spherical, spheroidal, or pyriform (pear-shaped). Eggs of some genera in the Staphylininae (e.g., *Philonthus*) have pronounced surface sculpture, allowing identification at least to the species-group level. Larvae are campodeiform (sometimes called staphyliniform). In some subfamilies (Paederinae, Staphylininae, and to a lesser extent in their immediate relatives) the head is relatively more heavily sclerotized and there is a distinct "neck" (nuchal constriction of the head). Prepupae of Steninae, at least most Aleocharinae, and *Astenus* (Paederinae) spin a silken cocoon in which they pupate. Pupae are obtect, pigmented, and sclerotized in the subfamily Staphylininae, but exarate, white, and unsclerotized in all the other subfamilies. In general, the immature stages develop rapidly, in a few days to a few weeks, and the adults are long-lived.

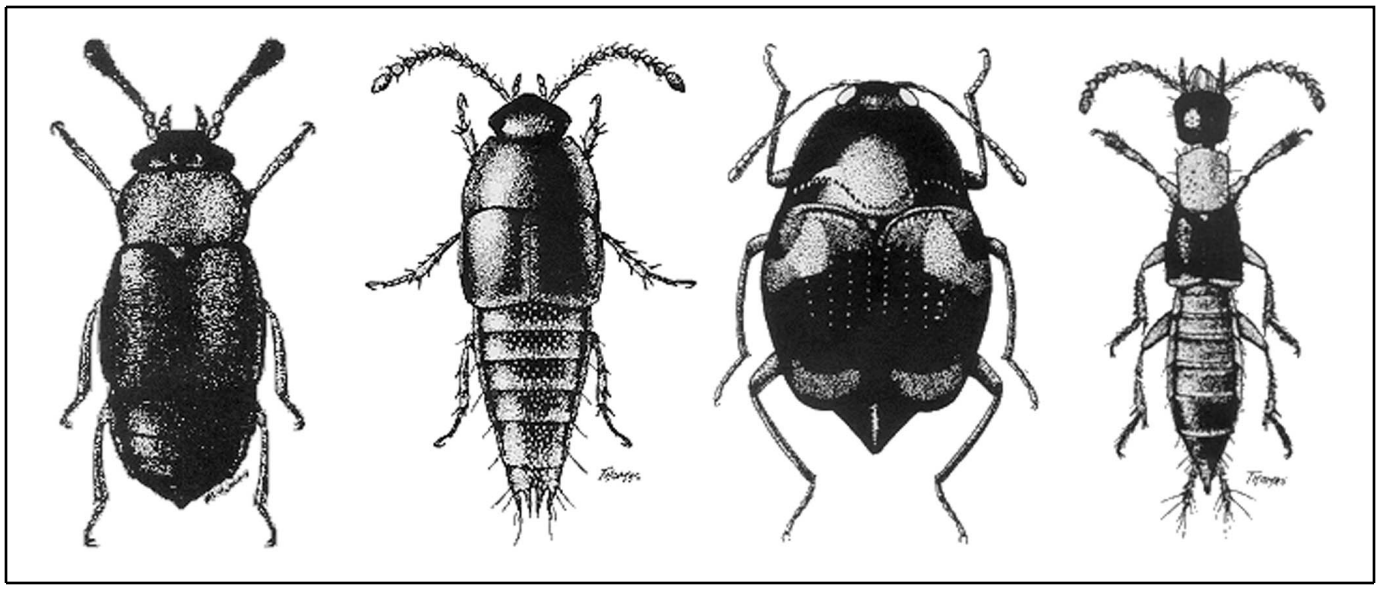

Figure 1. Representative adults of four subfamilies (left to right): *Proteinus thomasi* Frank (Proteininae) 1.5 mm; *Coproporus rutilus* (Erichson) (Tachyporinae) 3.8 mm; *Scaphidium quadriguttatum* (Say) (Scaphidiinae) 4.3 mm; *Neobisnius ludicrus* (Erichson) (Staphylininae) 4.1 mm. Credits: M. C. Thomas, Division of Plant Industry

Habitat and Food

Habitat

Staphylinidae occupy almost all moist environments throughout the world. Because none of them is truly aquatic, they do not live in open waters; although winged adults may be skimmed from the sea surface far from land, their presence is due to misadventure but attests to their dispersive ability. They live in leaf litter of woodland and forest floors and grasslands. They concentrate in fallen decomposing fruits, the space under loose bark of fallen, decaying trees, drifted plant materials on banks of rivers and lakes, and dung, carrion, and nests of vertebrate animals. Several hundred species live only on seashores. Many are specialized to existence in nests of social insects. Many inhabit caves, underground burrows of vertebrate animals, and smaller soil cavities, even of burrows that they (a few of them) excavate. Many live in mushrooms. Adults and even larvae of a few are associated with living flowers. Others climb on plants, especially at night, and hunt for prey. A few seem to live with terrestrial snails. Their distribution in arid environments is restricted to moist microhabitats.

Food

A little about the feeding habits of Staphylinidae has been deduced from casual observations by many observers, and from dissections of alimentary canals and from feeding trials and examination of mouthparts by a few. Archetypal staphylinids probably were saprophagous (scavengers). Saprophagy is still a major feeding mode in Piestinae, Osoriinae, and Proteininae, perhaps with some adaptation to mycophagy. Mycophagy has evolved in Oxyporinae, Scaphidiinae, some Tachyporinae, and a few Aleocharinae. Phytophagy has evolved in some Oxytelinae - to the point where the diet of adults and larvae of *Bledius* consists of diatoms, and at least one species of *Apocellus* has been accused of damaging flowers, one species of *Carpelimus* has (probably wrongly) been accused of damaging cucumbers, and one species of *Osorius* (Osoriinae) has been accused of damaging turf grass. Further, one species of *Bledius* has been blamed for its tunnelling, by which it damaged earthen banks around irrigated crops. Some Omaliinae have evolved toward eating floral parts of plants, and others toward carnivory. Saprophagy has evolved toward carnivory in other subfamilies (many Tachyporinae, most Aleocharinae, Pselaphinae, Euaesthetinae, Steninae, Paederinae, and Staphylininae), representing the bulk of species in the family, so that it may be said that most Staphylinidae

-- tens of thousands of species -- are facultative predators. Some have specialized, for example *Oligota* (Aleocharinae) as predators of mites, *Erichsonius* (Staphylininae) as predators of soil-inhabiting nematodes, *Odontolinus* (Staphylininae) on mosquito larvae in water-filled flower bracts of *Heliconia* (Heliconiaceae), and *Eulissus* (Staphylininae) on adult dung-inhabiting scarab beetles. *Aleochara* (Aleocharinae) has evolved to become parasitoidal in fly puparia.

Behavior

Presocial or Subsocial Behavior

Such behavior is known in *Bledius* and *Platystethus* (Oxytelinae) and *Eumicrota* (Aleocharinae). Adults construct chambers in which they deposit and guard their eggs and young, *Bledius* in sandy or muddy shores, *Platystethus* in the dung of ungulates, and *Eumicrota* in mushrooms.

Relationships with Social and Communal Insects

Another dimension of social behavior has arisen in interactions with termites and ants -- thousands of species of Aleocharinae, and many species of several other subfamilies, are inquilines in the nests of these social insects, some with bizarre structural and behavioral adaptation. *Emus* (Staphylininae) invades bee nests in Europe, and a species of *Euvira* (Aleocharinae) develops in communal nests of a butterfly in Central America.

Relationships with Higher Plants

Adults of some Omaliinae are attracted to flowers, and some of these have been demonstrated to pollinate the flowers. An example is *Pelecomalium testaceum* (Mannerheim) (Omaliinae), which pollinates *Lysichiton americanum* Hultén & St. John (Araceae) in the mountains of the Pacific coast of the USA and Canada. It is conceivable that *Polyobus* spp. (Aleocharinae) do the same for *Espeletia* spp. (Asteraceae) in the northern Andes of South America. *Charoxus* spp. (Aleocharinae) have a different, but yet highly specialized obligate relationship with plants -- the adults are attracted in the Neotropical region to the syconia of *Ficus* spp. (Moraceae) within which they oviposit, but the adults and larvae feed on pollinating wasps (Agaonidae) of those fig flowers.

Relationship with Fungi

There are three forms of relationships with fungi. Adults and larvae of many species eat fungi. Others find prey items (fly larvae and other organisms) in fungi. A major association with fungi is that adults of many species are infected by Laboulbeniales (Ascomycetes) and some other fungi, many of which specialize at the level of host genus, tribe, or subfamily.

Relationships with Decomposing Plants, Dung, and Carrion

The frequent presence of staphylinids at decaying plant materials raises the question of whether they arrived there by random movement, and then remained there, or whether they are attracted in much the same way that adults of their prey (fly larvae, etc.) arrived there. Thus, adults and larvae of *Cafius* (Staphylininae) inhabit decaying brown algae (Fucales [kelp or wrack]) on sea beaches and eat fly larvae; adults and larvae of some *Philonthus* (Staphylininae) occur in dung of ungulates and eat fly eggs and larvae; adults of some *Eulissus* (Staphylininae) occur in dung of ungulates and there maim, then eat, adult scarab beetles; adults and larvae of some *Belonuchus* and *Philothalpus* (Staphylininae) occur in decaying fruits, and eat fly larvae; adults of some *Platydracus* (Staphylininae) occur in carrion and eat fly larvae and adults.

Relationships with Terrestrial Molluscs

Some staphylinids have been shown to feed occasionally on slugs and snails, although apparently they are not specialized to do so as are Cychrini (Coleoptera: Carabidae), nor have slugs and snails been shown to be an important part of the diet as in some Silphinae (Coleoptera: Silphidae). However, a strange, almost commensal relationship with snails has evolved in some Asian Aleocharinae such as *Zyras sagax* Cameron, in which the adult beetles enter the mantle cavity of *Ryssota* (Pulmonata: Helicarionidae) and perhaps feed on mucus or feces of the snail.

Nests of Vertebrates

Some staphylinid species have specialized to live in the nests of vertebrates, especially tortoises, birds, and rodents. Their prey seems to be mainly the larvae of fleas and flies. In Florida (USA) where populations of the tortoise *Gopherus polyphemus* (Daudin) (Testudines: Testudinidae) are declining through habitat loss and disease, populations of the staphylinid inhabitants of its nests also must be declining. Names of species of Staphylinidae found in birds' nests were compiled almost 30 years ago, but there is little information on their behavior. In central Asia, where sylvatic plague is endemic, some staphylinids are credited with suppressing flea populations, and thus help to suppress transmission of plague. Adults of *Amblyopinus* and close relatives (subtribe Amblyopinina of subfamily Staphylininae) occur in the fur of some rodents in Central and South America. For years they were suspected of being parasites of these rodents, and taking blood from them. Now, however, they are believed to be phoretic on the rodents, thus being transported from nest to nest. They oviposit in the nests, and larvae feed as predators there of other arthropods.

Structure and Function

Secretions and Glands

Glandular systems of Staphylinidae are mainly implicated in the production of defensive secretions, of which there is a remarkable array. However, glands of some species that are inquilines in nests of social insects produce substances that appease rather than repel the nest-builders. Further, glands of adult *Stenus* (Steninae) produce a surfactant, stenusin, that enables these beetles to skim over the surface of fresh water into which they have fallen, to regain dry land.

Pederin is a powerful toxin and DNA inhibitor circulating in the hemolymph of all developmental stages of some species of *Paederus* (Paederinae) and close allies in the subtribe Paederina. It is produced by endosymbionts in some, but not all, adult females, is transferred to eggs at oviposition, and thus to larvae and pupae. Males may obtain it by eating eggs. It is a defensive secretion active against spiders, but seems to have no insecticidal effect. It is a contender for the title of most powerful animal toxin. It produces dermatitis on human skin and severe damage to human eyes, but its therapeutic effects can be harnessed to heal chronic lesions in humans and cure cancerous growths.

Pheromones

A female sex pheromone has been identified in *Aleochara curtula*, but pheromones in 45,000 other species remain unidentified.

Prey Capture and Pre-oral Digestion

The mandibles are the mouthparts typically associated with prey capture by predatory adults and larvae. However, adult *Stenus* (Steninae) use a prey-catching apparatus in which the labium (with its palpi) can be protruded by hemolymph pressure to grip small prey such as Collembola. Oxyporinae, Steninae, Euaesthetinae, Paederinae and Staphylininae have pre-oral digestion. They use mandibles to hold their food, secrete digestive fluids, and imbibe partially-digested food. A consequence is that their digestive systems contain much liquid and few solids, so visual identification of food is difficult. Drops of anal secretions of Neotropical *Leistotrophus* (Staphylininae) adults placed on leaves attract their prey.

Causes of Mortality

Natural Enemies

Scattered evidence needing review suggests that spiders, various insects (including Reduviidae, Carabidae, Asilidae, Formicidae, etc.) amphibia, reptiles, birds, and bats, include Staphylinidae among their diets. Among the parasites, fungi play a major role, and hymenopterous parasitoids, nematodes, and Nemata, a relatively minor role. In temperate regions of the world as contrasted with tropical regions, staphylinids may achieve very high population levels at the soil surface; in tropical regions, at least at lower altitudes, ants are ubiquitous and staphylinids less numerous in numbers of individuals; this suggests that ants may limit population levels of staphylinids in tropical regions.

Effects of Pesticides, and Habitat Destruction

There is a growing literature about non-target effects of chemical pesticides on Staphylinidae in agricultural crops and turf grass, to the point where *Aleochara bilineata* (Gyllenhal) (a demonstrably beneficial species) has become a favored test animal for the effects of insecticides, herbicides, and plant-growth regulators. Destruction of natural habitat by humans, especially in the tropics, undoubtedly contributes to the rarity of many poorly-known staphylinid species.

Importance to Humans

Use in Biological Control

Biological control practitioners have observed predation by various non-specialist Staphylinidae on fly larvae and other invertebrates and have imported various Staphylinidae into Italy, Hawaii, mainland USA, and Easter Island, to capitalize on the perceived benefits -- without evident success. Species of *Belonuchus*, *Creophilus*, *Ocypus*, *Philonthus*, *Philothalpus*, and *Thyreocephalus* (Staphylininae) and *Paederus* (Paederinae) have been moved. Other attempts have involved more specialist *Oligota* (Aleocharinae) against tetranychid mites in East Africa, and *Aleochara* against horn fly in mainland USA, but again with little success. Current attempts in Europe involve conservation of native staphylinids, including *Tachyporus* (Tachyporinae) as predators of cereal aphids, and *Aleochara* as predators of root maggots (including augmentative use).

Other

The importance of staphylinid predation on pests has been demonstrated repeatedly in the literature. They suppress populations of pest insects and mites in numerous crops (agricultural, horticultural and forest entomology), and of biting flies (including mosquitoes) and fleas (medical and veterinary entomology). Their presence in carrion gives them a role in forensic entomology. With one exception (*Paederus* and its close allies) they have trivial importance as pests; but although contact of humans with *Paederus* may cause dermatitis on human skin,

Figure 2. Rove beetles attacking a house fly maggot. Credits: Jim Kalisch and Barry Pawson, University of Nebraska-Lincoln (http://entomology.unl.edu/)

the toxin pederin may be harnessed for its therapeutic effects, and some *Paederus* species are valuable predators of crop pests. Finally, Staphylinidae form a substantial part of the world's biodiversity.

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