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BEETLES (COLEOPTERA) OF AUCKLAND

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SUMMARY

Beetles are defined briefly on adult and larval characters. The adaptive importance of elytra is stated.

About 1 500 species of beetles are thought to occur in the Auckland area. The results of intensive surveys on the Noises Islands and the Lynfield district of suburban Auckland are summarised. Most indigenous beetles are confined strictly to native forest.

The biogeography of Auckland beetles is discussed briefly. Geographical variation of coastal species, especially *Mimopeus elongatus*, is discussed in relation to present ecology and past geological events.

The biology of representative beetles in the following ecosystems and habitats is described briefly: sea shore, pastures, crops, gardens, exotic forests, indigenous forests, fresh water, nests and stored products. Suggestions for life history and ecological studies are made.

The paper is illustrated with 36 habitus drawings of representatives of most major and several minor families. All families occurring in Auckland and genera mentioned in the text are listed in Appendix I.

INTRODUCTION

Beetles (including weevils) comprise the insect order Coleoptera. The adults may be recognised by the elytra, hardened forewings which protect the membranous hind-wings, and when closed, cover a cavity over the posterior thorax and abdomen. The spiracles open into this cavity, an adaptation which reduces water loss during respiration, and protects the abdomen from insolation and desiccation. Elytra differ from hardened fore-wings of some other insects (cockroaches, bugs etc.) in being usually convex, embracing the abdomen laterally, and meeting dorsally in a straight longitudinal line (suture) when closed. The striking evolutionary success of beetles is almost certainly related to the effective protection afforded by the elytra in the open and in almost every conceivable terrestrial and freshwater habitat, including living and dead trunks and stems, fruit, seeds, leaves, fungi, soil, sand, leaf litter, nests of birds, ants and termites, vertebrate and invertebrate carcasses, stored products, timber, intertidal rocks, ponds and streams.

Beetle larvae, which inhabit a similarly wide range of situations, but usually occupy different niches from the adults, are more difficult to

recognise. All have a well-developed head with biting mouthparts, and frequently the maxillary galea and lacinia are partly or completely fused. They lack silk glands and crotchet-bearing prolegs characteristic of lepidopterous caterpillars. Most beetle larvae have legs; in the suborder Polyphaga the last two segments are fused as a tarsungulus. Weevil and many longhorn beetle larvae are legless, and some others have reduced legs. The body is usually subcylindrical, but may be flattened (especially in subcortical larvae), or C-shaped at rest (scarabs and weevils).

Beetles are the dominant order of the animal kingdom, at least in terms of species, of which over 300 000 have been described, and perhaps 1 million occur in the world (mostly in the tropics). The New Zealand fauna comprises about 5 000 known species (Watt 1982), at least 1 500 of which probably occur in the Auckland area. As the result of a fairly exhaustive survey, 206 species of beetles have been found on the Noises Islands, which are small (37.3 ha) and modified, and with a very limited diversity of habitats, in the Hauraki Gulf.

On the mainland, Kuschel (1978) found 848 species of beetles (from May 1974 to September 1978) in about 17 ha of second-growth native forest, surrounding gardens and a sheep paddock in the Lynfield - Wattle Bay area of suburban Auckland. Further collecting continues to add to this total.

Before man began destroying the original vegetation, the Auckland area was clothed almost totally in forest. However, it is still surprising that as Dr Kuschel has found in his Lynfield survey, over 94% of the 646 species of native beetles do not occur outside the forest. Apparently they cannot adapt even to gardens in which there are a substantial number of native trees and shrubs growing. The remaining 6% are mostly species such as tiger beetles (*Neocicindela tuberculata*, Fig. 1c) adapted to open country, or the forest canopy. About 50% of introduced foreign beetles are confined to the open, and most of the remainder occur both in the open and in native forest. These figures serve to emphasise the total dependence of most native beetles on forest cover for survival.

Beetles are mostly small: an individual 6 mm in length is larger than average. Auckland's largest beetle is the huhu *Prionoplus reticularis*, large females of which may be 48 x 18 mm. The giraffe weevil *Lasiorhynchus barbicornis* is sometimes much longer (males up to 81 mm), but also much narrower (up to 6 mm). In the following account, dimensions are average lengths of set specimens. Scale lines on the illustrations represent 1 mm. Most adult beetles except wood borers are fairly constant in size. Marked sexual dimorphism is unusual (the giraffe weevil is an extreme example, the two sexes having been described in different genera!). Family names are printed in CAPITALS to facilitate recognition.

IDENTIFICATION

A key to Auckland beetles would exceed the length of this volume, and even an adequately illustrated key to the 80 families occurring here (Appendix 1), out of 91 listed by Watt (1982) for New Zealand, would be impractical. An annotated key to New Zealand families is in preparation. In the meantime, those in Britton (1970), Crowson (1955) or Richards and Davies (1977), will serve to run almost all Auckland beetles to family. The habitus illustrations (Fig. 1-4) include examples of all the larger, and many of the smaller, families. Important characters at the family level and above include the presence (Adephaga) or absence (Polyphaga) of notopleural sutures on the prothorax; the tarsal formula and structure (e.g. pseudotetramerous, i.e. apparently 4-4-4, but actually 5-5-5, with segment 4 very small and largely concealed between the prominent lobes of segment 3: Fig. 4f-i, in Curculionoidea and Chrysomeloidea); antennal structure (lamellate in Scarabaeoidea, Fig. 2a-c); abdominal structure; and form of the hind coxae.

The best book for identifying beetle larvae to the family level is Boving and Craighead (1931). Important larval characters are structure of head, mouthparts, legs, spiracles and terminal abdominal segments.

Below the family level, there is no readily available book which will enable more than a few Auckland beetles to be identified. The best is still Hudson (1934), which is long out of print, and very expensive when occasionally sold second-hand, but it is available in many of the older libraries. Remember, however, that Hudson lived in Wellington, and some species he described and illustrated do not occur in the Auckland area (including some stated to be common and generally distributed). In most such cases, there will be one or more members of the same genus here. Some of the names have changed since 1934. Some other beetles are included in Hudson (1950). Still in print, but including many fewer species of beetles, are Miller (1971) and Manson (1960). Several of the illustrations in the latter booklet are inaccurate.

The Forest Research Institute's leaflets entitled "Forest and Timber Insects in New Zealand" have so far covered about 40 species of beetles. This is an excellent source of simply expressed but accurate information on these species. The same applies to the relatively few leaflets on beetles in the life cycle charts of *DSIR Information Series No. 105.*

BIOGEOGRAPHY

For convenience, "Auckland" is taken to mean the area of that name defined by Crosby, Dugdale and Watt (1976), between Kaweka in the north and Meremere in the south, and including the inner islands of the Hauraki Gulf. Biogeographically, this area includes an important historical barrier, i.e. the Auckland Isthmus, which at various times,

most recently during high interglacial sea levels, has been breached by a strait isolating the North Auckland Peninsula.

Some beetles characteristic of the central and southern North Island reach their northern limit in the Hunua Ranges, e.g. the darkling beetle *Periatrum tumipes* and the large (25 mm) flightless ground beetle *Mecodema crenaticolle*. This species, readily recognised by its cratered elytra, occurs commonly in the western part of the North Island south to Taranaki. The only other Auckland species of this genus, *Mecodema spinifer*, has finely striate elytra. It is common in North Auckland, and extends south into the Waikato.

Few beetles are confined to the Auckland area. Most of these are fairly small and obscure, but there are two large undescribed species, a Carabid in the Dome Valley, and a chafer of the genus *Odontria* in the sand dune country behind Muriwai. This contrasts with Northland (north of Kaweka), which has many endemic beetles.

Curiously, very few northern species reach their southern limit in the Auckland area. Typically, they extend further south and east, into the Coromandel, Bay of Plenty and Waikato areas, frequently coinciding approximately with the distribution of the kauri *Agathis australis* (although very few beetles, e.g. the shortnosed kauri weevil *Xenocnema spinipes*, Fig. 4h, are tied to the kauri as their host plant).

Many native beetles of Auckland are widely distributed in most parts of the North Island, and often at least the northern part (Sounds, Nelson and Buller) of the South Island. "Widely distributed" implies in suitable habitats. Few beetles, even cosmopolitan species, are ubiquitous. Some of the small winged introduced species (e.g. *Cortinicara* spp. and other LATHRIDIIDAE) can be found in most agricultural and other relatively open habitats, but only rarely if at all in forest.

Factors affecting the distribution of beetles vary according to their biology. Obviously, monophagous species are limited by the distribution of their host plant species, but their range is frequently much less than that of the host plant (e.g. the karamu leaf beetle *Pleuraltica cyanea* is confined to the northern half of the North Island, but its host plant, *Coprosma robusta*, extends to Stewart Island). Climate limits the range of all beetles, both directly, and by its influence on vegetation cover. The vast majority of native Auckland beetles are forest species, as noted previously.

Many beetles have reduced or vestigial flying wings, a characteristic of insular faunas which is strongly evident in New Zealand. Such beetles have limited dispersibility, and may be prevented from reaching climatically suitable habitats by minor geographical barriers (including strips of unsuitable vegetation, swamps, large rivers). They tend to form series of semi-isolated populations with limited gene flow between them, and show considerable geographical variation.

Populations of flightless or weakly flying beetles have apparently frequently been completely isolated in the past by geological events such as glaciations, eustatic movements of sea-level, uplift, subsidence and volcanism; and vegetational changes associated with these. When such isolated populations come together again, they may fail to interbreed, having speciated, or they may interbreed to varying extents, producing complex patterns of geographical variation.

A very striking example of complex geographical variation in the Auckland area is shown by the coastal darkling beetle *Mimopeus elongatus* (Fig. 3i), which is found in the craters of Auckland's volcanic cones and also in coastal situations, both on sand dunes and rocky shores, where it lives under such creeping mat plants as pohuehue (*Muehlenbeckia complexa*). Its requirements are apparently free-draining soil or sand, in which the heavily sclerotised, cylindrical false wireworm larvae live; and shelter and a plentiful supply of dead vegetation for the adults. East coast, island and Auckland Isthmus adults have moderate to strong microsculpture, and the margins of the pronotum are only slightly reflexed and scarcely explanate (Fig. 3i). On the west coast beaches, adults have weak microsculpture and the margins of the pronotum are strongly reflexed and distinctly explanate. These and differences in the male genitalia and larvae are striking, and the west coast form was described as a separate species. However, if one lines up specimens from east coast localities from Auckland north to Doubtless Bay, and down the west coast, the extreme forms are joined by a series of intermediates.

It is doubtful whether this is a genuine "ring species", as specimens from Orua Bay near the South Head of the Manukau Harbour appear to be intermediate in some respects, suggesting some exchange of genes between east and west coast forms. Obviously interbreeding experiments are needed. *Mimopeus elongatus* are easy to rear on a diet of "muesli" and brewer's yeast, but their life cycle appears to require two years. Possibly they would rear more quickly on other diets.

No doubt there are a number of factors which have produced distinct east and west coast forms of *Mimopeus elongatus* (and other coastal beetles). It is tempting to speculate that periodic isolation of the North Auckland Peninsula during high interglacial sea levels, divergence in isolation, and partial swamping of differences by southern populations helped up the west coast by longshore drift, produced part of the complex geographical pattern which we now see in *Mimopeus elongatus* in the north. There is even greater complexity in this taxon in the Cook Strait area.

BEETLES OF THE SEA SHORE

There are few intertidal beetles in the Auckland area. *Maoritrechus rangitotoensis* is known from 4 specimens collected under decaying

Zostera well below high water mark at Rangitoto Island, apparently near Islington Bay, in 1920. This intertidal ground beetle has not been found since, despite numerous searches for it.

Three species of *Hyphalus* occur at Goat Island Bay, including *H. wisei* which is not uncommon amongst small barnacles and bryozoans on some intertidal reefs and rock platforms elsewhere. These are quite small (1 mm) blackish beetles. Very little is known of their habits and life history.

At and above the high water mark, beetles are numerous, especially on sandy beaches. Under seaweed on the drift line and above are *Chaerodes trachyscelides* (7 mm) and *C. laetus* (4.5 mm), showing a bewildering array of colour patterns, but tending to be dominated by light individuals on light sand, and dark individuals on dark sand. Also amongst and under seaweed are various large and small rove beetles (STAPHYLINIDAE). These have short elytra, which leave some of the abdominal tergites exposed, and enable the body to be more flexible than that of conventional beetles, facilitating movement through small interstices in substrates such as sand and gravel. *Cafius litoreus* (Fig. 1h) can be common amongst seaweed drift, where it presumably feeds on abundant amphipods, in spring. Most rove beetles are predators, but little has been recorded of the prey of most of the New Zealand species.

Phycosecis limbata (Fig. 3c) is a small (2.7 mm) oval beetle with almost circular elytra; frequently noticed by sunbathers. These beetles and their pale, elongate larvae run rapidly over loose, dry sand, looking for small arthropods on which they prey. The family PHYCOSECIDAE is confined to Australia and New Zealand.

Dead birds and fish on the beach, especially when in or approaching a mummified condition, are often inhabited by various carrion beetles and predators such as rove beetles. Perhaps the most interesting beetle in this habitat is the generically endemic *Reichardtia pedatrix* (Fig. 1f). Like *Chaerodes* and other beach beetles, this species is strongly modified for life in sand, with legs flattened and bearing numerous peg-like setae to facilitate burrowing in sand. Harris (1970) discusses adaptations of New Zealand beach beetles to life in sand. Almost all species he discusses and illustrates occur on Auckland beaches.

On rocky coasts, under mat plants such as *Disphyma australe* and pohuehue, live several characteristic beetles. The coastal darkling beetle *Mimopeus elongatus* already referred to, occurs on rocky coasts as well as dunes. On the Noises, this species is abundant on Maria and the David Rocks, which lack rats, but uncommon on the other islands which had the Norway rat *Rattus norvegicus* until recently. Abundance of *Mimopeus elongatus* on small islands is a sure sign of the absence of rats. Remains of adults have been found commonly in faeces and gut contents of Norway rats.

The coastal ground beetle *Ctenognathus novaezealandiae* (Fig. 1b) is

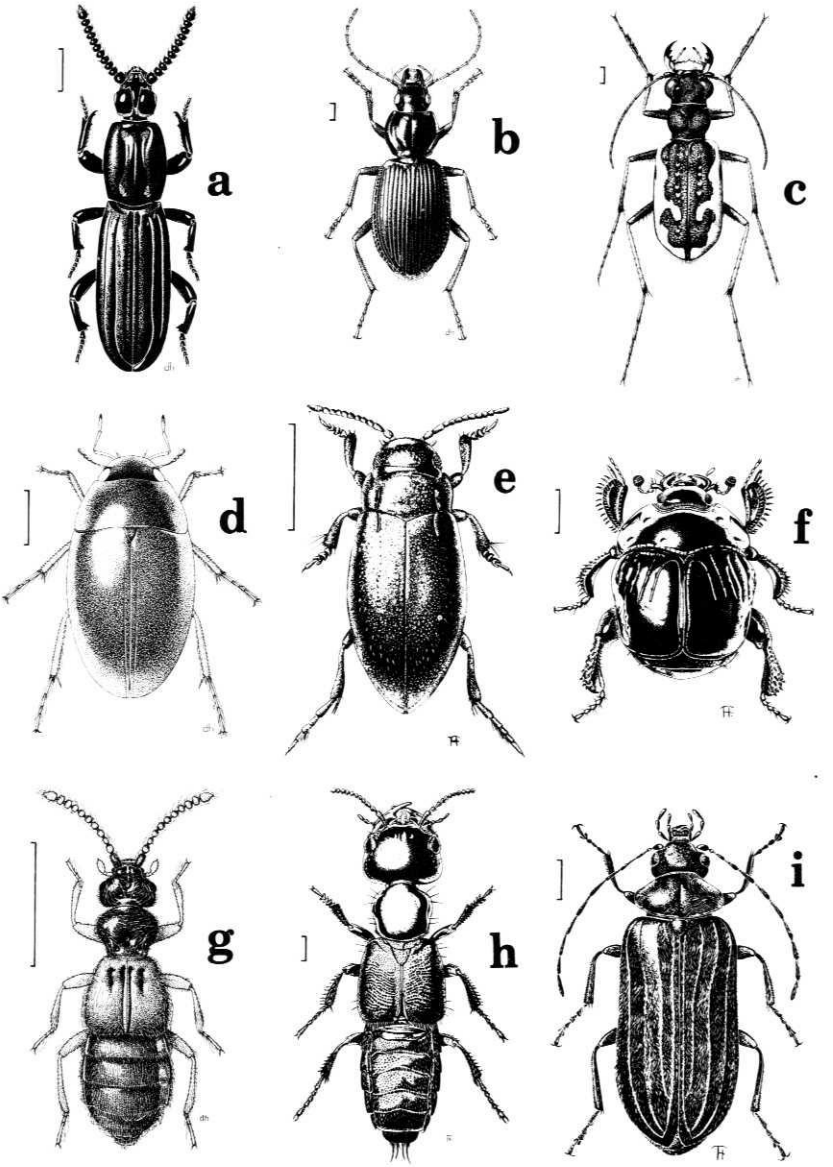

Fig. 1. **(a)** *Rhyzodiastes proprius* **(RHYSODIDAE); (b)** *Ctenognathus novaezealandiae* **(CARABIDAE); (c)** *Neocicindela tuberculata* **(CICINDELIDAE); (d)** *Enochrus tritus* **(HYDROPHILIDAE); (e)** *Liodessus plicatus* **(DYTISCIDAE); (f)** *Reichardtia pedatrix* **(HISTERIDAE); (g)** *Sagola laminata* **(PSELAPHIDAE); (h)** *Cafius litoreus* **(STAPHYLINIDAE); (i)** *Veronatus tricostellus* **(SCIRTIDAE). Bar = 1 mm.**

confined to rocky coasts. Adults are fast-running predators, hunting their prey on tree trunks and on the ground at night, but never very far from the shore. Little is known of the larvae, which have been found rarely in soil. The Noises survey shows that this is another species subject to rat predation, although less so than *Mimopeus elongatus.*

BEETLES OF PASTURES, GARDENS AND CROPS

Very few native beetles will be found in cultivated land, where the vast majority of species are foreigners. A few native beetles have adapted themselves to lawns, shrubberies and hedges.

One of the few endemic beetles to thrive in improved pastures and lawns is the grass grub beetle *Costelytra zealandica* (Fig. 2b). Larvae are white, C-shaped grubs which live in soil and feed on roots, originally of native tussock and intermingled herbs, but now on pasture species. Adults are light yellowish-brown chafers which fly mostly during October to December. Research on this species keeps several entomologists employed, but it is unusual for it to be the cause of economic damage in the Auckland area. Here, the Tasmanian grass grub *Aphodius tasmaniae* in light volcanic soils, and the originally South African black beetle *Heteronychus arator* (Fig. 2c) in somewhat heavier soils, are the most serious scarab pasture pests.

Another common beetle of grasslands is the pasture wireworm beetle *Conoderus exsul.* Although the wireworm larvae of this species are capable of feeding on roots, recent studies suggest that they are predominantly predators. Adults are dull yellowish-brown click beetles, which like grass grub beetles, often fly to artificial lights. The very similar larva of the variable wireworm *Agrypnus variabilis* has occasionally been implicated in damaging root crops such as carrots.

There are several weevils which are pests of pastures, especially the Argentine stem weevil *Listronotus bonariensis,* and the (originally Neotropical) whitefringed weevil *Graphognathus leucoloma* (Fig. 4i). Larvae of the former bore in tillers of ryegrass, sometimes considerably reducing yield. Larvae of the latter feed on roots of a wide range of pasture and crop species, including lucerne, which in recent years has been planted extensively further south because of its resistance to grass grub. Another pest from South America is Fuller's rose weevil *Asynonychus cervinus,* which is common in Auckland gardens and unsprayed crops.

The lemon tree borer *Oemona hirta* (Fig. 4g) is probably the most serious pest of citrus, both in orchards and the home garden. Females oviposit in dying twigs or recent pruning scars. The white, almost legless larvae tunnel through live sap and heart wood, and may eventually kill branches by girdling them, and they otherwise do considerable harm to the tree by destructive tunnelling. Apart from citrus, *O. hirta* has a very wide host range in native and exotic small

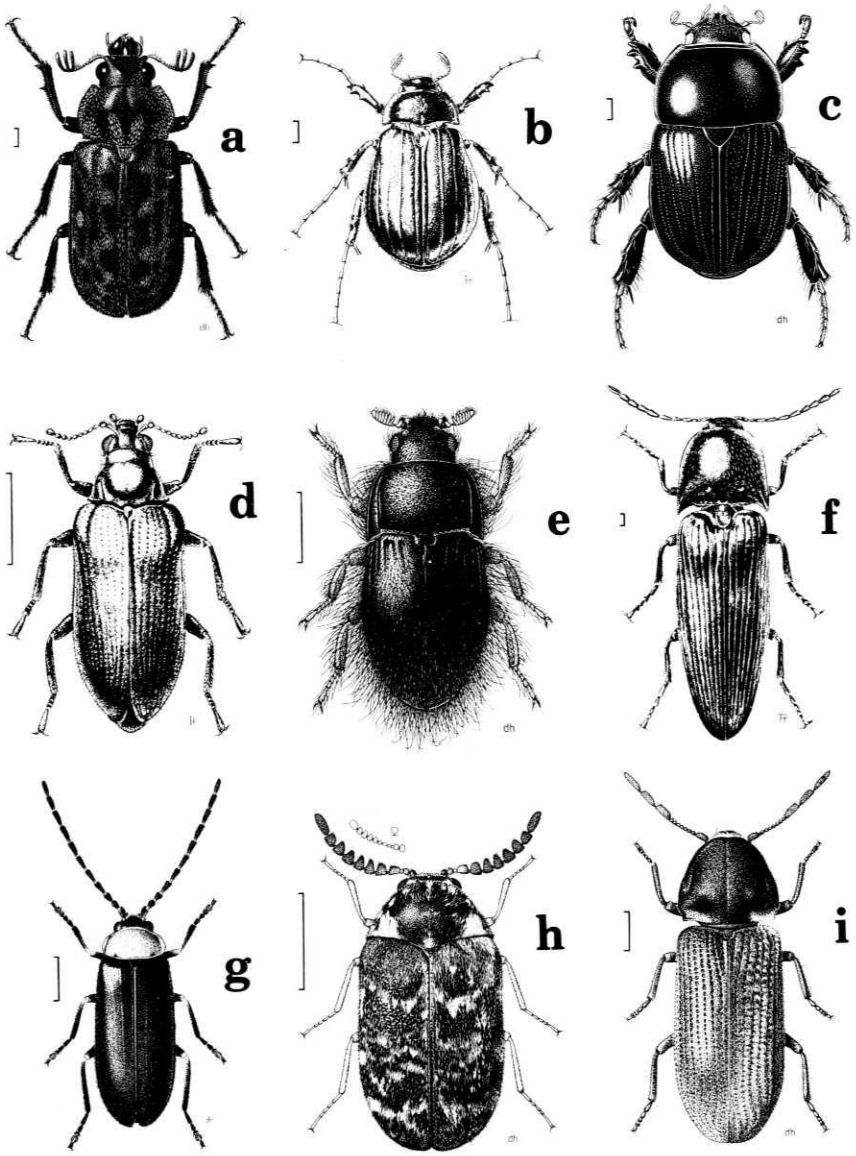

Fig. 2. **(a)** *Ceratognathus parrianus* **(LUCANIDAE); (b)** *Costelytra zealandica* **(SCARABAEIDAE); (c)** *Heteronychus arator* **(SCARABAEIDAE); (d)** *Hydora picea* **(ELMIDAE); (e)** *Parnida agrestis* **(DRYOPIDAE); (f)** *Thoramus wakefieldi* **(ELATERIDAE); (g)** *Asilis fulvithorax* **(CANTHARIDAE); (h)** *Trogoderma maestum* **(DERMESTIDAE); (i)** *Hadrobregmus magnus* **(ANOBIIDAE). Bar = 1 mm.**

trees and shrubs, and can sometimes be somewhat beneficial by damaging gorse.

Bronze beetles (*Eucolaspis* spp., Fig. 4f) are other natives which have adapted to orchards. They have soil-inhabiting larvae which do unassessed damage to roots, but it is the shining brown, convex adults which cause noticable, and often considerable, damage to flowers and fruit of stone and pip fruits. They also attack a range of native trees and shrubs, and can cause severe defoliation of young pine trees.

Most beetles even in agricultural situations are beneficial, or at worst neutral. Beneficial species include a large number of predators of the families CARABIDAE (e.g. *Rhytisternus miser*) and STAPHYLINIDAE (e.g. *Thyreocephalus orthodoxus*) which feed mostly on pests. Many beetles are involved in nutrient recycling by breaking down dead organic matter. Among the more specialised of these are dung beetles, which are not, however, very common or effective in the Auckland area.

Amongst the most conspicuous beetles in gardens are the ladybirds (COCCINELLIDAE). The orange and black elevenspotted ladybird *Coccinella undecimpunctata* is an important aphid predator. The steel blue ladybird *Orcus chalybeus* is common on citrus, where it feeds on scale insects. Unfortunately, ladybirds are often heavily parasitised by Hymenoptera, thus reducing their effectiveness as predators.

BEETLES OF EXOTIC FORESTS

Although native beetles have not been very successful in adapting to urban and agricultural land, a greater number can be found in exotic forests. The huhu beetle *Prionoplus reticularis* is likely to be most noticeable on summer evenings as it bombards lighted windows, or having gained entry, flies noisily around the light. The larva is a large, white, almost legless elongate grub, with two characteristic diagonal whitish pads on the underside of the prothorax. Females oviposit in crevices in the bark of recently dead conifers, and the larvae develop initially in the nutritious subcortical layer, but eventually make their galleries right through the trunk or log, finally reducing it to damp powder.

Rather fat, soft wireworm larvae of *Thoramus wakefieldi* live in galleries of huhus and other woodborers, on which they feed. The dull brown adult click beetles (Fig. 2f) occasionally fly to light in pine forests.

Various other longhorn beetles live in exotic forests. Most of them attack only dead wood or suppressed branches. The larva of the striped longhorn *Navomorpha lineata* is a live wood borer in a wide range of native and exotic trees and shrubs, including Douglas fir. The beetle (20 mm) is boat-shaped, shining reddish-brown, with white longitudinal stripes.

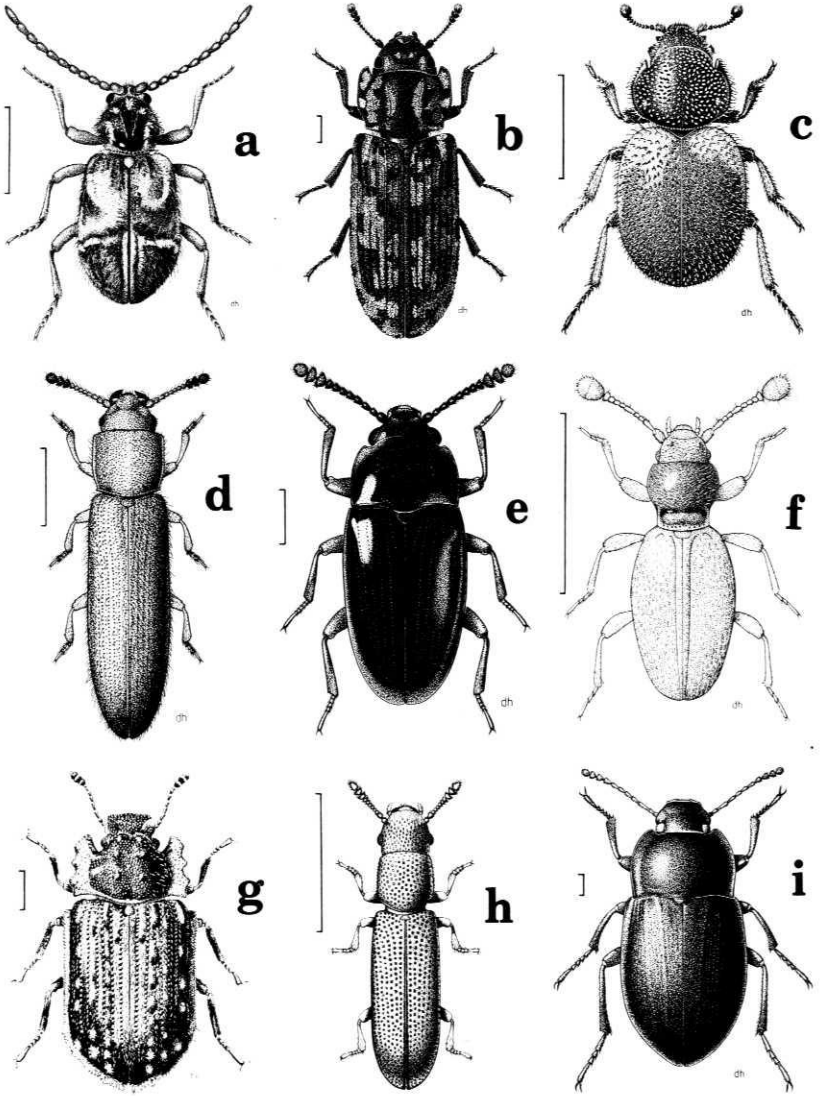

Fig. 3. (a) *Ptinus speciosus* (PTINIDAE); (b) *Leperina nigrosparsa* TROGOSSITIDAE); (c) *Phycosecis limbata* (PHYCOSECIDAE); (d) *Hapalips prolixus* (LANGURIIDAE); (e) *Thallis polita* (EROTYLIDAE); (f) *Holoparamecus tenuis* (MEROPHYSIIDAE); (g) *Pristoderus antarcticus* (COLYDIIDAE); (h) *Rhizonium antiquum* (COLYDIIDAE); (i) *Mimopeus elongatus* (TENEBRIONIDAE). **Bar = 1 mm.**

The beetles most feared by foresters are bark beetles, which are actually specialised weevils (CURCULIONIDAE), although they are usually placed in a separate family (SCOLYTIDAE). They tunnel under the bark of unhealty or recently dead trees. Some species can cause serious degradation of logs and freshly sawn timber, especially when stored in moist conditions. Some specialised bark beetles, the ambrosia beetles (e.g. *Xyleborus* spp.), cultivate fungal gardens in the subcortical galleries, on which the larvae feed. These fungi cause "sap-staining", in addition to the mechanical damage done by the beetles and their larvae.

Native pit or "shotgun" weevils of the genus *Psepholax* have similar habits to bark beetles. *P. sulcatus* attacks live wood of a wide range of native and exotic trees and shrubs. The others are apparently dead wood borers. Each species has a characteristic gallery pattern, formed by larvae boring out from the circular pit or entrance hole cut by the adult female. Infested trunks appear from the outside to have been hit by a shotgun, hence the bushman's name "shotgun weevil". Galleries are often sap-stained, but it has yet to be demonstrated that *Psepholax* deliberately cultivate fungal gardens for their larvae.

Most beetles of exotic forests are beneficial. Even the huhu, which can cause rapid degradation of damp logs and will damage damp sawn timber, is not a problem in properly managed forests, where it is an important agent in speeding the breakdown of waste logs and slash. Old pine forests acquire a rich native beetle litter fauna if there are adjoining areas of native forest. This fauna speeds the breakdown of the pine litter, a process which is much slower in pine forests isolated from native forests sources. Regrettably, all the fauna is lost on clear-felling and burning.

BEETLES OF INDIGENOUS FORESTS

The beetle fauna of indigenous forests is incredibly rich compared with even the oldest and most diverse exotic forests. Native bush has a much greater diversity of beetle habitats: many more species of trees, shrubs, herbs, lianes, epiphytes, parasites, ferns, fungi, bryophytes, lichens, algae, slime moulds, invertebrate prey. There is a greater diversity of litter, rotten logs, twigs, bark, birds nests, galls, soil, streams.

There are few plant species which some beetle does not eat, although it may have to wait until the plant dies. Lycopods and psilopods seem to be virtually immune to insect attack, suggesting that the surviving members of these ancient groups must have evolved very effective chemical defenses. Some ferns are also relatively immune, but some gymnosperms and angiosperms are attacked by numerous insects, including beetles.

Most plant-feeding beetles fall into the "Phytophaga" (superfamilies CHRYSOMELOIDEA and CURCULIONOIDEA), some of which have

already been mentioned. Longhorn beetles (CERAMBYCIDAE) bore into live and dead wood. Leaf beetles (CHRYSOMELIDAE) feed (at least as adults) mostly on the leaves of higher plants. *Adoxia vulgaris*, with almost white elytra and yellow to brown prothorax, is abundant on flowering composites, especially rangiora *Brachyglottis repanda*, in spring.

Many weevils (CURCULIONIDAE) live both as larvae and adults in leaf litter or dead wood on the ground. Others bore in living or dead wood. Several genera have larvae which bore in green stems, flower buds or fruit, or mine leaves of native trees and shrubs. Some of these species are in the genus *Peristoreus*, adults of which are small weevils with a long, narrow, curved rostrum, often beaten out of their host plants.

The ANOBIIDAE are another group of borers, either in dead wood or in hard woody bracket fungi. *Hadrobregmus magnus* (Fig. 2i) has been found in rimu stumps, and also in damp timber in buildings. The smaller (3.5 mm) introduced house borer *Anobium punctatum* is abundant in untreated timber and furniture in older Auckland houses.

Beetles of diverse families live in the dead rachides of various tree ferns, especially *Cyathea dealbata* and *C. medullaris*. Adults tend to be long and thin, an adaptation to movment between the longitudinal fibres of the rachides, e.g. *Hapalips prolixus* (Fig. 3d), *Rhizonium antiquum* (Fig. 3h).

Logs and dead branches in various stages of decay are inhabited by beetles of many different families, especially as larvae. Some CURCULIONIDAE and CERAMBYCIDAE have already been mentioned. Larvae of OEDEMERIDAE will be found in logs on the seashore as well as in forest. *Thelyphassa lineata* (Fig. 4c) is a common species in forest logs when still reasonably sound, a habitat where larvae of *Ceratognathus parrianus* (Fig. 2a) also occur. Larvae of *Mordella antarctica* (Fig. 4e) are in much more decayed logs, but the adults are found on flowers.

RHIPIPHORIDAE include beetles overseas which are unquestionably parasitic on various other insects. New Zealand rhipiphorid larvae are found in rotten logs, but the evidence so far suggests that they may be predators on woodborers such as the huhu, rather than actual parasites. *Rhipistena lugubris* (Fig. 4d) occurs in the Auckland area: the antennal processes are much shorter in the female. Larvae of *Bothrideres* apear to be true parasitoids on pupae of wood borers.

Rhyzodiastes proprius (Fig. 1a) and other RHYSODIDAE live in rotten logs both as adults and larvae. All stages of *Dryocora howitti* (Fig. 4b) live in logs which have reached the stage of decay when the wood has broken up into blocks, and is usually red in colour. The very flat adults and larvae live in the crevices between the blocks.

The subcortical habitat is a favourable one for beetles, especially when the bark has loosened somewhat. Certain beetles and their larvae are very flat to facilitate progress between the bark and the trunk, branch or log, e.g. various CUCUJIDAE and *Diagrypnodes wakefieldi* (Fig. 4a). Others move in when the subcortical cavity is larger, e.g. *Pristoderus antarcticus* (Fig. 3g), both adults and larvae of which feed on subcortical moulds. Also occurring under bark during the day are adults of *Leperina brouni* and *L. nigrosparsa* (Fig. 3b), but they emerge on favourable nights to feed on the bark surface (possibly on algae rather than the bark itself). Their larvae are predators on subcortical larvae and woodborers, as are larvae of the related families CLERIDAE and MELYRIDAE.

Thallis polita (Fig. 3e) is an example of a number of beetles of diverse families which feed on the larger fungi (in this case, *Hericium coralloides*). Dead Polyporaceae are almost always inhabited by *Cis*, and often by various other beetles such as *Brouniphylax* spp. and *Cyphanobium illustre*. Fungus weevils (ANTHRIBIDAE) feed on moulds and mould spores on dead plant material.

Leaf litter in native forest is extraordinarily rich in beetles of several families, in fact many genera are hardly ever found anywhere else. This applies to almost all SCYDMAENIDAE, PSELAPHIDAE (e.g. *Sagola laminata*, Fig. 1g) MEROPHYSIIDAE (e.g. *Holoparamecus tenuis*, Fig. 3f, and various COLYDIIDAE, TENEBRIONIDAE (*Edalus*, *Periatrum*), terrestrial HYDROPHILIDAE and several genera of weevils. In addition to beetles which live permanently in leaf litter, others pupate there, and others shelter there during inclement weather. Larvae of CANTHARIDAE are predators on other leaf litter dwellers, but adults (e.g. *Asilis fulvithorax*, Fig. 2g) are found on flowers and apparently feed on pollen (along with a diverse assemblage of other beetles with very various larval habits).

New Zealand has several groups of insects which are normally aquatic, which here are partly or completely terrestrial. Adults and larvae of DRYOPIDAE live here in rather damp leaf litter. The common Auckland species is *Parnida agrestis* (Fig. 2e). Most SCIRTIDAE (= HELODIDAE) are aquatic as larvae, but that of *Veronatus tricostellus* (Fig. 1i) lives in damp soil in native forest. Larvae of various other SCIRTIDAE develop in rain water in the axils of *Collospermum* and similar monocots.

The commonest soil-inhabiting larvae in Auckland forests are those of the green mumu chafer *Stethaspis longicornis*, and the yellow spotted chafer *Odontria xanthosticta*. These larvae are quite similar to large grass grubs, but can be distinguished by patterns of setae and spines on the last abdominal sternite. The adults fly at and shortly after dusk, especially in late spring and early summer. *Stethaspis longicornis* is large (20 mm) and bright green; *Odontria xanthosticta* is smaller (13

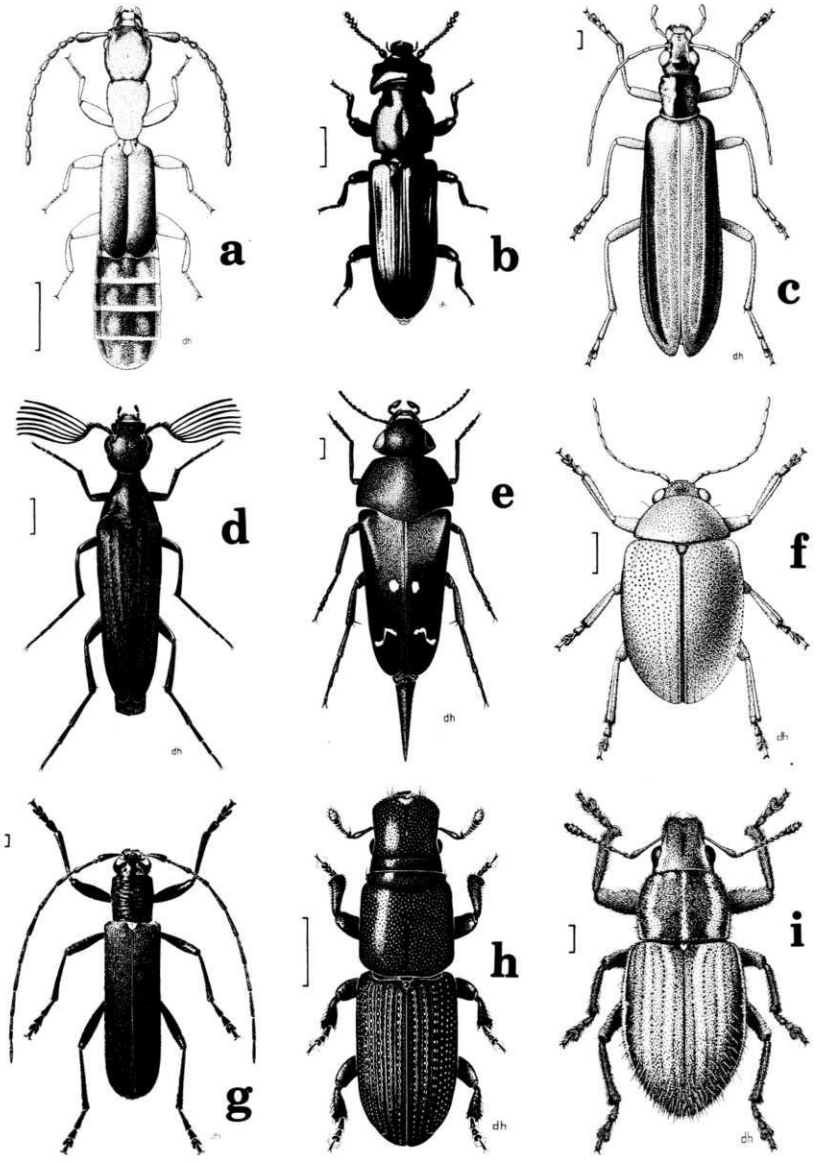

Fig. 4. (a) *Diagrypnodes wakefieldi* (INOPEPLIDAE); (b) *Dryocora howitti* (PROSTOMIDAE); (c) *Thelyphassa lineata* (OEDEMERIDAE); (d) *Rhipistena lugubris* (RHIPIPHORIDAE); (e) *Mordella antarctica* (MORDELLIDAE); (f) *Eucolaspis brunneus* (CHRYSOMELIDAE); (g) *Oemona hirta* (CERAMBYCIDAE); (h) *Xenocnema spinipes* (CURCULIONIDAE); (i) *Graphognathus leucoloma* (CURCULIONIDAE). **Bar = 1 mm.**

mm) and velvet brown with rather inconspicuous yellow spots. Given (1952) and Hoy and Given (1952) give detailed descriptions of adults and larvae of these and other chafers.

Wireworm larvae of various ELATERIDAE live in forest soils, along with larvae of CARABIDAE and STAPHYLINIDAE. Some of the wireworms, especially *Ctenicera* spp., are root feeders, but the others are all predators. A few small (1.5 mm) carabid adults live in soil: the almost blind *Nesamblyops subcaecus* occurs in the Auckland area.

WATER BEETLES

There are relatively few water beetles in the Auckland area. Diving beetles (DYTISCIDAE) are voracious predators, which live in ponds, stagnant streams, and reed beds around small lakes. The commonest species in the Auckland area are *Rhantus pulverosus* (11 mm) and *Liodessus plicatus* (2.7 mm, Fig. 1e). Adults breath air, and when in water, have to come to the surface frequently to replenish the air bubble, which is held on the ventral surface, posteriorly, and extends into the subelytral cavity. Larvae are fully aquatic.

A few HYDROPHILIDAE are true water beetles, living in small ponds. *Enochrus tritus* (Fig. 1d) is the commonest Auckland species.

In streams, beetles are generally much less common than the more familiar caddis, mayfly and stonefly larvae. Larvae of riffle beetles (ELMIDAE) live in stony streams, and adults (e.g. *Hydora picea*, Fig. 2d) may be seen under water or just out of it in early summer. Cascade beetles (HYDRAENIDAE) are much smaller (less than 1.5 mm) and live amongst decaying leaves at the edge of stony streams. *Byrrhocryptus* spp. (PTILODACTYLIDAE), whose larvae live in sand or mud on the margins of small streams, seem to be quite rare. All these beetles seem to be restricted to streams in native forest, and vanish when the forest is removed.Some larvae of SCIRTIDAE may be found in seepages and small streams.

BEETLES OF NESTS AND STORED PRODUCTS

This may seem to be a strange association, until it is realised that most beetles associated with stored products originally lived in nests of birds or mammals. Spider beetles (PTINIDAE) include such species as the Australian spider beetle *Ptinus tectus*, which, in addition to infesting a wide variety of stored foods, has been found in sparrow's nests. *Ptinus speciosus* (Fig. 3a) is a colourful native species whose larval habits are unknown.

Probably the commonest beetle infesting stored foods in Auckland is the drugstore beetle *Stegobium paniceum*. It has been known to bore into almost anything, including aspirin and other drugs.

Stored grains are infested mostly by weevils of the genus *Sitophilus*, and CUCUJIDAE of the genus *Oryzaephilus*. Wholemeal flour is sometimes invaded by flour beetles (*Tribolium castaneum* and *T. confusum*). Adults and larvae of the lesser mealworm *Alphitobius diaperinus* are common in deep litter of poultry houses, and have also been found in a sparrow's nest.

The hide beetle *Dermestes maculatus* infests hides, and is also common in carcasses in the later stages of decomposition. Hide beetles are used by osteologists for cleaning skeletons of vertebrates. Final instar hide beetle larvae like to make their pupal chambers in solid material such as wood, and they can seriously weaken structural timbers (they have been responsible for the partial collapse of at least one fellmongery in the Auckland area).

The varied carpet beetle *Anthrenus verbasci* has acquired a taste for wool, and can severely damage untreated woollen carpets and clothing. It is also the most serious threat to inadequately protected insect collections, which are rapidly reduced to piles of dust if left untreated.

Native DERMESTIDAE (e.g. *Trogoderma maestum*, Fig. 2h) are found mostly in association with nesting sea birds, or in dry subcortical habitats, where they apparently feed on the remains of dead arthropods.

RESEARCH ON BEETLES

There is tremendous scope for research on beetles in the Auckland area. Taxonomically there are still many problems to be solved, but these need to be tackled on a countrywide basis, and require constant access to a major reference collection. In the related field of life history studies, much can be done with quite simple equipment. Larvae of relatively few beetles occurring in the Auckland area have been associated with adults. Many beetles are quite easy to rear from larvae, and many larvae are quite easy to breed from adults, provided they are given frequent care. Changes and transformations should be carefully noted, and duplicate larvae and exuviae as well as adult beetles should be suitably fixed and preserved for future taxonomic study. Techniques for preserving and handling specimens will be found in Walker and Crosby (1979): PEA is the best fixative for beetle larvae. Much other useful information is included in Ramsay and Singh (1982).

Although we know something of the general ecology of many Auckland beetles, there are many others of which we know almost nothing. For example, we know that one specimen of the rare false darkling beetle *Arthopus brouni* was found in dead wood at Titirangi on 25 March 1968 (and that a few other specimens were found in the Wellington area in September and November). There is very little that can be inferred about the ecology and life history of this species from these data. Its rarity suggests fairly specialised habitat requirements,

which are completely unknown.

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Appendix I. List of families of beetles occurring in the Auckland area, genera mentioned in the text, and some other genera likely to be encountered in the Auckland area. * = illustrated.

SUBORDER ADEPHAGA

RHYSODIDAE -*Kupea, Rhyzodiastes**; CARABIDAE - *Ctenognathus**, *Demetrida, Maoritrechus, Mecyclothorax, Mecodema, Nesamblyops, Notagonum, Rhytisternus, Scopodes*; CICINDELIDAE - *Neocicindela**; DYTISCIDAE - *Liodessus**, *Rhantus.*

SUBORDER POLYPHAGA

Superfamily Hydrophiloidea
HYDRAENIDAE - *Orchymontia*; HYDROPHILIDAE - *Cercyon, Enochrus*, Rygmodus.*

Superfamily Histeroidea
HISTERIDAE - *Carcinops, Reichardtia*, Saprinus.*

Superfamily Staphylinoidea
PTILIIDAE - *Acrotrichus, Ptenidium;* LEIODIDAE (=ANISOTOMIDAE) - *Colon, Paracatops, Zeagyrtodes;* SILPHIDAE - *Necrophilus;* SCYDMAENIDAE - *Adrastia, Scydmaenus;* SCAPHIDIIDAE - *Baeosilpha, Scaphisoma;* STAPHYLINIDAE - *Atheta, Cafius*, Creophilus, Philonthus, Thamiaraea, Thyreocephalus, Xantholinus;* PSELAPHIDAE - *Dalma, Sagola*.*

Superfamily Scarabaeoidea
LUCANIDAE - *Ceratognathus*, Lissotes;* TROGIDAE - *Trox;* SCARABAEIDAE - *Ataenius, Aphodius, Costelytra*, Heteronychus*, Odontria, Pericoptus, Pyronota, Stethaspis.*

Superfamily Eucinetoidea
CLAMBIDAE - *Clambus;* EUCINETIDAE - *Cryptomera;* SCIRTIDAE (=HELODIDAE) - *Atopida, Cyphanus, Cyphon, Veronatus*.*

Superfamily Byrrhoidea
BYRRHIDAE - *Epichorius, Synorthus.*

Superfamily Dryopoidea
PTILODACTYLIDAE - *Byrrhocryptus;* LIMNICHIDAE - *Hyphalus;* DRYOPIDAE - *Parnida*;* ELMIDAE - *Hydora*.*

Superfamily Elateroidea
ELATERIDAE - *Agrypnus, Conoderus, Ctenicera, Lomemus, Ochosternus, Protelater, Thoramus*;* EUCNEMIDAE - *Neocharis, Talerax.*

Superfamily Cantharoidea
CANTHARIDAE - *Asilis*;* LYCIDAE - *Metriorhynchus.*

Superfamily Dermestoidea
NOSODENDRIDAE - *Nosodendron;* DERMESTIDAE - *Anthrenus, Dermestes, Trogoderma*.*

Superfamily Bostrichoidea
ANOBIIDAE - *Anobium, Cyphanobium, Hadrobregmus*, Stegobium;* PTINIDAE - *Ptinus*;* LYCTIDAE - *Lyctus.*

Superfamily Cleroidea
PELTIDAE - *Rentonellum, Rentonium;* TROGOSSITIDAE - *Leperina*, Tenebroides;* CLERIDAE - *Phymatophaea, Paupris;* PHYCOSECIDAE - *Phycosecis*;* MELYRIDAE - *Arthracanthus, Dasytes, Halyles.*

Superfamily Cucujoidea (Clavicornia)
NITIDULIDAE - *Carpophilus, Epuraea, Soronia;* RHIZOPHAGIDAE - *Monotoma;* CUCUJIDAE (Incl. SILVANIDAE) - *Brontopriscus, Cryptamorpha, Cryptolestes,*

Oryzaephilus; CRYPTOPHAGIDAE - *"Cryptophagus", Salltius;* LANGURIIDAE - *Hapalips*, Loberus;* EROTYLIDAE - *Cryptodacne, Thallis*;* PHALACRIDAE - *Phalacrus;* CERYLIDAE - *Euxestus, Philothermus;* CORYLOPHIDAE - *Arthrolips, Corylophodes, Holopsis;* COCCINELLIDAE - *Adoxellus, Coccinella, Orcus, "Scymnus", Stethorus;* MEROPHYSIIDAE - *Holoparamecus*;* LATHRIDIIDAE - *Aridius, Cortinicara, Enicmus.*

Superfamily Tenebrionoidea (Heteromera)

CIIDAE - *Cis;* COLYDIIDAE - *Bitoma, Bothrideres, Enarsus, Pristoderus*, Pycnomerus, Rhizonium*, Tarphiomimus;* MYCETOPHAGIDAE - *"Triphyllus", Typhaea;* ARCHEOCRYPTICIDAE - *Archeocrypticus;* ZOPHERIDAE - *Arthopus, Brouniphylax, Syrphetodes;* TENEBRIONIDAE - *Actizeta, Alphitobius, Artystona, Chaerodes, Edalus, Menimus, Mimopeus*, Periatrum Tanychilus, Tenebrio, Tribolium;* INOPEPLIDAE - *Diagrypnodes*;* PROSTOMIDAE - *Dryocora*;* SALPINGIDAE - *Salpingus;* PYROCHROIDAE - *Techmessa;* MELANDRYIDAE - *Hylobia;* SCRAPTIIDAE - *Nothotelus;* MORDELLIDAE - *Mordella*, Zeamordella;* RHIPIPHORIDAE - *Rhipistena*;* OEDEMERIDAE - *Parisopalpus, Thelyphassa*;* ANTHICIDAE - *Anthicus, Cotes, Macratia;* EUGLENIDAE (=ADERIDAE) - *"Xylophilus".*

Superfamily Chrysomeloidea

CERAMBYCIDAE - *Ambeodontus, Navomorpha, Oemona*, Prionoplus, Somatidia, Stenellipsis, Xylotoles;* BRUCHIDAE - *Acanthoscelides;* CHRYSOMELIDAE - *Adoxia, Eucolaspis*, Paropsis, Pleuraltica.*

Superfamily Curculionoidea

NEMONYCHIDAE - *Rhinorhynchus;* ANTHRIBIDAE - *"Anthribus", Exilis;* BELIDAE - *Pachyura;* PROTERHINIDAE - *Aglycyderes;* BRENTIDAE - *Lasiorrhynchus;* APIONIDAE - *Apion, Neocyba;* CURCULIONIDAE - *Asynonychus, Graphognathus*, Irenimus, Listroderes, Listronotus, Peristoreus, Platypus, Psepholax, Scolopterus, Xenocnema*, Xyleborus.*

GEOLOGY