THE INTERACTION OF NATIVE AND INTRODUCED INSECT SPECIES IN NEW ZEALAND

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THE INTRODUCTION PERIOD

Initially, it is desirable to define the word "introduced" in terms of time. Most of the species which concern us are ones which have received assistance from man, but we must allow the possibility of recent introductions unaided in this manner.

The advent of the more recent spectacular introductions such as the white butterfly (*Pieris rapae* (L.)) and the European wasp (*Vespula germanica* (F.)) is clearly dated, but there is no definite information for most of the species which arrived last century. A hundred years ago, when quarantine was a relatively minor consideration, and traffic with our nearest neighbour, Australia, was quite considerable, it is not difficult to imagine many species being unwittingly introduced with plants and produce from that country. It will be recalled that much of this shipping arrived in northern parts, especially the Bay of Islands — a climate ideally suited to the reception and establishment of many Australian insects. Some species, now common to both countries, are shrub-loving ones with a poor capacity for flight. A number of these are now more plentiful here than in Australia, indicating a relative freedom from controlling agents, features strengthening the probability of their recent arrival.

The period with which we are mainly concerned in considering the interaction of native and introduced species thus began rather vigorously some 120 years ago with an accent on Australian migrants and has continued since, with decreasing emphasis on that source, controlled as best we can.

ESTIMATES OF OUR NATIVE AND INTRODUCED FAUNAS

Tillyard (1926) produced a census of order representation indicating clearly that the ultimate figures would prove far in excess of those for which there was at that time direct evidence. In many orders there are still formidable gaps. With some knowledge of the New Zealand fauna as a whole, and with the evidence arising from detailed studies in specific groups which are presented from time to time, it is possible, and pertinent here, to estimate the probable extent of our insect fauna. There are acknowledged pitfalls, for the final answer must depend in part upon the concept of the species, and our ability to discover them before they become extinct. Table 1 presents an estimation of our indigenous and recently introduced insect faunas.

The numbers of introduced species in the orders with relatively few world representatives, and in those which have freshwater larval stages and delicate weak-flying adults, are likely to be small, as in the Protura, Ephemeroptera, Odonata, Plecoptera, Strepsiptera, Neuroptera, Mecoptera, and Trichoptera. The converse will be the case in those orders which contain strong-flying insects, and great numbers of species, such as the Orthoptera, Hemiptera, Coleoptera, Hymenoptera, Diptera and Lepidoptera. Some species because of the small size of individuals, or close parasitic association with birds and mammals also lend themselves to introduction as in the Collembola, Psocoptera, Thysanopera, Anopleura and Siphonaptera.

In summing up the table of order representation, it appears that our native fauna may eventually be shown to number about 12,000 species and that our introduced species at present approach 1100. Whether or not new arrivals will balance the species which become extinct is debatable.

TABLE 1. *Estimated numbers of species in orders*

	Indigenous species	*Recently introduced species*
APTERYGOTA		
Thysanura (bristle-tails, silverfish)	10	2
Protura (minute soil insects)	2	1
Collembola	300	70
EXOPTERYGOTA		
Ephemeroptera (may-flies)	30	—
Odonata (dragon-flies)	20	—
Orthoptera (cockroaches, grasshoppers, crickets, etc.)	100	5
Isoptera (termites)	5	2
Dermaptera (earwigs)	5	2
Plecoptera (stone-flies)	30	—
Psocoptera (book-lice)	40	10
Anopleura (sucking-lice)	70	30
Thysanoptera (thrips)	10	20
Hemiptera (bugs)	700	100
ENDOPTERYGOTA		
Coleoptera (beetles)	6000	500
Strepsiptera	2	—
Hymenoptera (saw-flies, wasps, bees, ants)	600	50
Neuroptera (alder-flies, lacewings, ant lions, etc.)	20	2
Mecoptera (scorpion-flies)	1	—
Diptera (flies)	2500	200
Siphonaptera (fleas)	2	10
Trichoptera (caddis-flies)	70	—
Lepidoptera (butterflies, moths)	1500	100

A CLASSIFICATION OF POSSIBLE INTERACTIONS

No-one will dispute that we know very little about the interactions of any two species in this country — even in cases where parasites have been introduced to help control introduced pest species. In the absence of pertinent data it has been decided to discuss some of the possible interactions, indicating where they may well occur.

A classification of the diverse interactions is not easy. The introduced species may primarily be divided into those which decrease native faunas, and those which increase them. Introduced pest species may also invoke widespread general control measures thereby affecting associated species indirectly in either direction.

1. SPECIES REDUCING THE NATIVE INSECT FAUNA

A. *Entomophagous species*

These are the species which are completely dependent upon other insects for their survival. They tend to produce relatively more stable lower level populations, the stability itself being a factor favourable to their perpetuation. They may be broadly divided into two groups.

i. *Species more restricted in their hosts* are restricted to a single or to a few closely allied host species. They are the true parasites with life stages and histories tuned to those of the host. Most of the insect species introduced into the country to control injurious species, i.e. biological control agents, belong in this category. The more host-specific the parasite, the more unlikely it is to enter into

complexes with unforeseen results, a factor closely considered by those people with whom the decisions on introductions rest. The egg-parasite *Microphanurus basalis* Woll., which was introduced to help control the green vegetable bug (*Nezara viridula* (L.)), is an example. This genus of parasites is apparently restricted to the eggs of pentatomid bugs. There are a limited number of possible endemic hosts, the majority of which are apparently unaffected, but at least one of which is known to be parasitised.

ii. *Species less restricted in their hosts* assume the role of predators rather than parasites. They forage somewhat indiscriminately to obtain their general supplies of protein, and are best represented in the social species of Hymenoptera, although the Coleoptera (e.g. Staphylinidae) and Orthoptera (e.g. Phasmidae) include predatory species.

The European wasp (*Vespula germanica* F.) is an excellent example. The history of its inadvertent arrival and establishment about 1945 and subsequent wide distribution is well known (Thomas 1960). It produced an "explosion" typical of that shown by many newly introduced species. Large nests of unheard-of proportions were commonplace. The wasps are known to attack a large number of insects including blowflies, lepidopterous larvae, etc. There are few detailed ecological studies, however, of populations of species which have since become affected by the predations of this wasp and one is largely dependent upon opinions of reliable observers. There seems little doubt, however, that populations of Diptera and Lepidoptera have received a considerable set-back in many areas.

In 1948-49 (Cumber 1951) a study was made of the wasp *Polistes humilis* F. in

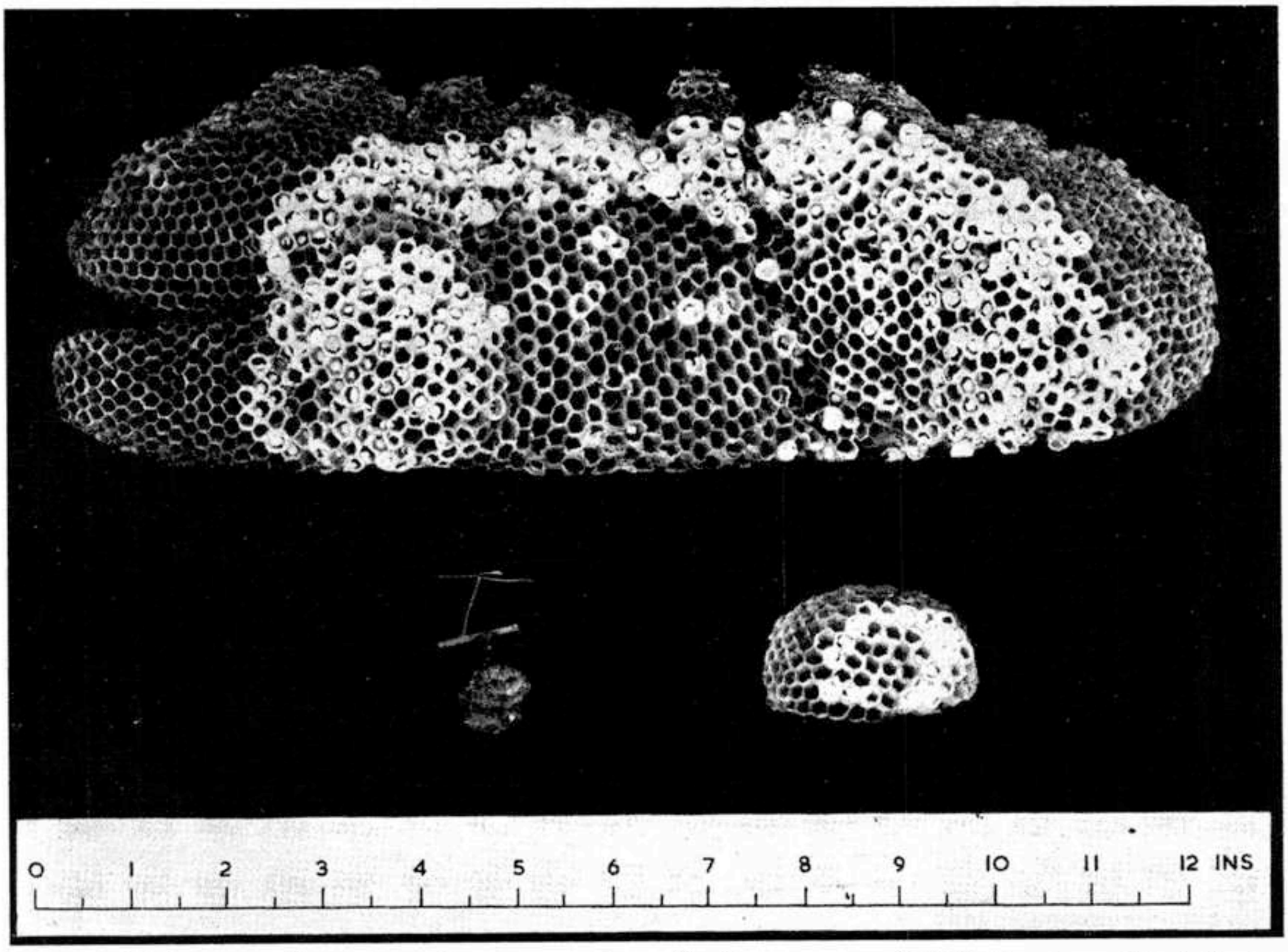

FIGURE 1. *Two small nests and an exceptionally large one of* Polistes humilis *taken at Paihia in the Bay of Islands in* 1948. (Photograph R. Blick.)

North Auckland areas. This species is not endemic, also occurring in Australia, but it has been in the country for a very long time and is present from North Cape to the vicinity of Tauranga. It is a social species which makes paper bell-shaped nests which are attached by single stalks to the walls of houses, posts, shrubs, etc. At the time of study this was a common species north of Whangarei, almost every coastal dwelling and flax bush in some areas having its quota of nests. Scrub-cutters engaged in summer contracts will vouch for its numbers. Nests almost one foot in width have been taken (Fig. 1). But this was before the arrival of the European wasp from the south.

The situation has since altered appreciably. Nests are now quite difficult to locate and the majority are considerably smaller than formerly. The two species come into very direct competition as their feeding habits are similar. The decline of *Polistes* is regarded as being primarily due to reductions in the numbers of lepidopterous larvae particularly favoured by that species as a source of protein for the brood. It is possible that there is direct predation by *Vespula* on the larvae in the *Polistes* nests, but there have been no observations of this. *Vespula* workers have been known to enter honey-bee hives, but apparently only in search of nectar. They have also been noted investigating the clay galleries of mason wasps (*Pison spinolae* Shuck.) which also appear to have declined in numbers recently.

General predators such as *Vespula* must have a very marked effect on endemic populations. The workers are extremely persistent as they forage amongst grass and vegetation in search of protein sources and sugary secretions. Honey-dew from blackened manuka trunks and the sticky substance of fungus diseased paspalum heads are much favoured. When more is known about the habits of *Vespula* in New Zealand and people have become accustomed to the nuisance, this species may become accepted as a very useful insect, but there may be lepidopterists who bemoan the near-extinction of some species.

B. *Non-entomophagous species*

The effect of introduced species on indigenous ones is clearly a matter of competition. The situation concerns mainly phytophagous species, but also saprophagous and xylophagous species.

i. *Species severely affecting specific plants or other media* represent the extreme in insect competition for food which is possible when introduced species arrive without their controlling agents. The recently arrived manuka scale (*Eriococcus orariensis* Hoy) is an example. It is well known that this scale has been responsible for the complete removal of manuka from considerable areas. Insects normally associated with, and in some cases restricted to manuka (*Leptospermum scoparium* Forst.) will have been wiped out from such areas. The elimination of the host plant is proving to be of a temporary nature, however, and recolonisation and re-establishment of the associated insect species is occurring.

On the saprophagous side, coprophagous species introduced to disperse dung rapidly, could come into severe competition with native species of flies which utilise this medium.

ii. *Species mildly affecting diverse plants and other media* include most of the non-entomophagous introduced species. For the most part, host materials suffer varying fortunes which must be reflected in the indigenous species normally associated with them. A typical phytophagous case is exemplified by the passion-vine hopper (*Scolypopa australis* Walk.). This Australian species is now found in amazing numbers on many shrubs and trees in northern areas, but is not so destructive as to threaten with extinction the native species with which it competes.

The effects of the introduced honey-bee may be considered here. The New Zealand fauna of solitary bees is not extensive by overseas standards. Nevertheless there are probably about 40 species, and these are completely dependent upon supplies of nectar and pollen. These have evolved in the absence of competition from the honey-bee, and often in association with specific plants. It is true that the great number of introduced plants provides perhaps the bulk of the honey-bee pollen and nectar, but the coverage of honey-bees, both as propagated and wild colonies, has provided a competi-

tion which may well be very severe for our solitary species.

II. SPECIES INCREASING THE NATIVE INSECT FAUNA

Complex situations may occur in which the introduction of one species results in the increase of another.

A. *Entomophagous species*

The conditions envisaged involve parasitic species.

The inadvertent introduction of hyperparasites could result in increases in the native fauna. Hyperparasites are those species which are themselves parasitic on parasites. For example many of our lepidopterous caterpillars are attacked by tachinid flies. These fly larvae are themselves often attacked by small hymenopterous parasites, some species of which could well prove to be introductions.

Another possibility arises where the introduced species proves to be an alternative host for endemic primary parasites. This may well occur in the case of introduced leaf-mining Diptera which are heavily parasitised by apparently endemic and now common species of Hymenoptera. The situation does not guarantee such an increase as other factors may come into play, but the possibility does exist.

B. *Phytophagous species*

Any introduced species which contributes to the death of shrubs and forest trees at least temporarily augments the supply of dead wood which is normally utilised by timber species. There is some evidence that the introduced saw-fly *Sirex juvencus* L. is responsible for at least hastening the death of unthrifty pine trees. This increase in dead pine wood favours the huhu beetle (*Prionoplus reticularis* White), and possibly other endemic species. Formerly the main host for *Prionoplus* was the native kahikatea or white pine.

C. *Species giving protection*

It is well known that ant species which attend homopterous insects such as aphids, coccids, etc. often confer advantages in the form of propagation, protection, and cleaning. The introduced Australian species *Iridomyrmex glaber* (Mayr.) comes within this category.

The advantages conferred on an endemic species by an introduced mimic may also be considered here. It is possible that the native pentatomid *Glaucias amyoti* (Dallas), which closely resembles the introduced green vegetable bug (*Nezara viridula* (L.)), has benefited by reduced bird predation in this manner. If both species are equally susceptible and in limited demand, then the swamping of one species by the other could also confer advantages on the originally less prolific endemic one.

III. SPECIES INVOKING GENERAL CONTROL MEASURES

This category involves both the above in some ways, as it does not necessarily involve a decrease in populations.

Control measures may be mechanical or chemical. In the mechanical field heavy stocking, and tillage to destroy and expose larval stages to bird predators will affect many species in addition to the one at which the operation was primarily aimed. The use of insecticides is also far from selective and results in varying fortunes for attendent insect faunas. Two introduced species which may be cited in these connections are the black beetle (*Heteronychus sanctae-helenae* Blanch.), a serious pasture pest, and the white-fringed beetle (*Graphognathus leucoloma* (Boheman)) which is proving a serious pest of crops. Whereas one species may be almost eliminated from an area, another less susceptible one may, however, receive a boost through the disappearance of its more susceptible controlling parasite species.

The interactions between introduced and native insects may be so involved that there is indeed little wonder that we have little detailed knowledge even of any two species. Many possible interactions may seem almost ludicrous when first suggested, but experience teaches us to welcome new ideas, and to content ourselves with studies of relatively limited aspects of ecological complexities knowing full well that the complete answer will never be within our grasp.

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INTERACTIONS BETWEEN NATIVE AND INTRODUCED EARTHWORMS

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There are three ways in which one group of animals may interact with another. They may (i) compete for food, (ii) compete for living space, or (iii) prey upon one another.

This paper discusses the taxonomic status and ecological preferences of the native and introduced earthworms and the extent to which they interact in these three ways.

Included in the native earthworms are about 170 species, all belonging to the family Megascolecidae. The introduced earthworms comprise 14 species of the family Lumbricidae and five species of the family Megascolecidae.

NATIVE EARTHWORMS

Two distinct subfamilies of Megascolecidae are found in New Zealand. In one subfamily (Acanthodrilinae) there are 17 New Zealand genera, of which 14 are confined to New Zealand, while in the other subfamily (Megascolecinae) there are 10 genera, none of which is peculiar to New Zealand. It is considered that both groups have been here for a long time. The Acanthodrilinae probably arrived in Mesozoic times and the Megascolecinae in early Tertiary times.

Many of the native species are highly specialised, morphologically, physiologically, and in their behaviour, to fit them for a very limited range of ecological conditions. They are primarily inhabitants of forest soils, and appear to have only recently spread into open country habitats.

In forest soils, three groups of native worms are recognisable on ecological grounds. Some inhabit leaf mould on the ground surface, some topsoil, and some subsoil. Leaf mould species move about among the plant debris and make no permanent burrows. They are mostly small in size, very active, and darkly pigmented. They feed on the leaf mould in which they live. Topsoil species make permanent burrows in the topsoil, leaving them only to forage for food in the leaf mould above. Apart from feeding on leaf mould, they apparently also continue burrowing to some extent throughout their lives, feeding on organic matter in the topsoil and extending their burrows laterally within the topsoil. They are larger than leaf mould species, and are not so active nor so darkly pigmented. Subsoil species make very extensive burrows, mainly in the subsoil, but occasionally coming up into the topsoil or even opening at the soil surface. They seem to feed mainly on the organic matter contained in subsoil and they make very extensive burrows, feeding on the soil as they move along. They are usually of large size, sluggish in their movements and unpigmented or very lightly pigmented.

INTRODUCED EARTHWORMS

There is no record of any deliberate introduction of Lumbricidae into New Zealand. All the species are of European origin and almost certainly came from Great Britain with the early settlers, probably within the