

Although this does not represent the complete picture, it should be apparent from the above discussion that a clearer definition of the present state of imbalance in this particular drainage is needed and that the "practical conservation problem" is not simply due to the presence of deer and chamois as was supposed in the initial stages of this study. Future research may explore the extent to which hare and sheep contribute to the state

of imbalance existing in this watershed, and the extent to which each of the several species competes with the others for living requirements. The foregoing discussion emphasizes the need to define the problem areas in relation to an ecological situation which includes human interests. As shown, the synthesizing approach using data from several components of the ecosystem may facilitate such a definition.

Insects Attacking Tussock

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Tussock is defined as any tussock species on which the insects recorded were known to feed, but unless otherwise stated, the tussocks referred to are *Festuca novaezelandiae*, *Poa caespitosa*, and *P. colensoi*, at altitudes ranging from 1,500-4,500 feet. Data are confined strictly to tussock itself, and do not include inter-tussock vegetation.

Earlier literature indicated that only 9 insects—all larvae of Lepidoptera—were known to feed on tussock; in addition the adults of 22 further species of Lepidoptera were recorded as being common on tussock, and a further 47 species were found on native grasses in tussock areas. The term "native grasses" has been used apparently in many cases as a general name to include the above three tussock species. In 1940 the list of insects definitely attacking tussock was extended to include a species of *Odontria* feeding on roots, and the caterpillars of the three moths *Persectania ewingi*, *Leucania toroneura* and *L. acontistis*. In 1945 grass grubs were recorded as damaging tussock. There are records of only 13 species of insects that definitely eat one or more of the three tussock species mentioned above, and an almost unlimited number of tussock-zone moths whose larvae may be able to eat tussock.

The following insects were actually seen to feed on tussock, or contained tussock fragments on dissection; they have been divided into Leaf-eating insects, of which 23 species were recorded, and Root-feeders, comprising 10 species.

1. LEAF-EATING INSECTS:

- Argyrophenga antipodum* Dbld.
(Nymphalidae)
Crambus simplex Butl. (Pyralidae)
Crambus flexuosellus Dbld. "
Crambus spp. (2)
Persectania ewingi Westwd. (Noctuidae)
Persectania disjungens, Walk. "
Leucania acontistis Meyr. "
Leucania phaula Meyr. "
Leucania semivittata Walk. "
Agrotis ypsilon Rott. "
Oxycanus spp. (2) (Hepialidae)
Orophora unicolor Butl. (Psychidae)
Locusta migratoroides Reich.
(Oedipodinae)
Phaulacridium marginale Walk.
(Acridiinae)
Brachaspis collinus Hutt. "
Mealybug (1) (Margarodinae)
Thrips (2)
Dictyotus caenosus
Hudsona anceps
Mysius huttoni
Odontria sp.
Pyronota sp.

2. ROOT-FEEDERS:

- Costelytra zealandica* White
(Melolonthidae)
Chlorochiton convexa Given "
Pyronota "
Odontria striata White "
Odontria spp. (5) "
Weevils (2)
Elaterids (3)
Tipulids (3)

Oxycaenus spp. (2)
Mealybug (1)

DAMAGE BY DIFFERENT ORDERS OF INSECTS

Lepidoptera occurred in greatest numbers in tussock, causing most damage to leaves over the ten-year period of observations. Of the 12 species involved, most damage was done by members of the genera *Crambus*, *Persectania*, and *Leucania*.

Coleoptera. Though 8 species of Melolonthid adults have been collected within tussock, only two species were actually seen eating leaves, and their overall influence as leaf feeders was negligible. On the other hand Melolonthid larvae feeding on roots caused sufficient damage to permit grazing stock to pull up whole tussock plants.

Orthoptera. The three members of this order made very little impression on tussock growth.

Hemiptera. These insects are sap-feeders, and no definite evidence was collected to show that they were of primary importance, though sometimes present in large numbers.

Thysanoptera. The two species of thrips came into the same category as the Hemiptera so far as assessing damage is concerned.

Diptera. Three species of Tipulid larvae were sometimes relatively common in areas of high soil moisture or organic matter.

OVERALL DAMAGE

With the exception of a relatively few caterpillars and grass grubs, no noticeable damage can be attributed to insects. Their combined influence, however, is another matter, and it is hardly necessary to point out that 41 different species of insects, often all occurring in the same area, must reduce the vigour of tussock to some extent at certain stages of growth.

Of the insects that caused most damage, not one was free from parasites or predators, and it is considered that this factor was responsible for maintaining insect populations at a level where influence on tussock was not of major concern. In small localised areas there were occasional seasons of severe damage till the parasite-host rela-

tionship reached the normal balance. Furthermore, Melolonthid larvae are cannibalistic, keeping normal populations per tussock at a more or less constant maximum of 6-8 larvae.

Leaf-eating insects are considered beneficial rather than harmful. Individual tussock plants tend to die out in the centre, this having the effect of "pushing" the growing portion outwards in a ring, leaving dead leafage in the centre. Most insect damage to leaves occurs to centres of plants. Whether or not the tendency to die out in the centre is a natural feature of tussock development, the final effect is to produce a central decaying portion of leaf mould which forms an excellent seed-bed for germination of seed from the parent plant.

Root-eating insects—particularly Melolonthid larvae—undoubtedly reduce the vigour of tussock. Populations as high as 47 larvae under a single tussock were recorded, and counts of 3-8 per plant were not uncommon averages. The main effect of these insects is to reduce length and number of roots so that tussock cannot utilise plant nutrients at a depth greater than 2-4in., a fact particularly important in dry periods.

The movement of ground-inhabiting insects through the soil tends to make the top 3in. open and crumbly. This permits frost action to lift root-damaged tussock plants in areas where high populations of Melolonthids build up to damaging levels. It is responsible also for accelerated wind erosion round margins of tussocks, and, of course, in inter-tussock areas, where root-feeding insects cause more damage than under tussocks themselves.

Over the 10-year period of the present studies, there has been no heavy infestation by any of the insects recorded. Many insects feed on tussock, a few do periodic local damage, but the overall damage is not severe. A small series of experiments shows, however, that there is a definite difference between plots treated with insecticides and untreated areas, indicating that the overall effect of insects on tussock cannot be ignored. It is suggested that an entomologist be placed on any committee appointed to consider tussock welfare.