B. *Fluctuations in population in relation to specific habitats and units of vegetation.*

1. Waste Land Communities:

An unused cinder dump (still smouldering beneath and with heated surface material) showed for the first three years after disuse increasing populations of the annuals *Amaranthus albus* L., *Chenopodium pumilio* R. Br., *Portulaca oleracea* L., and *Vulpia dertonensis* (All.) Volk., but over the subsequent three years the populations of these annuals decreased with the assumption of complete dominance of the perennial *Cynodon dactylon* (L.) Pers.

Littoral swamps in North Auckland and Hawke's Bay in process of reclamation show fluctuations in population numbers of the composite *Aster subulatus Michx.* and *Erigeron* sp. in the earlier stages.

2. Cultivated Land Communities:

The populations of *Juncus bufonius* L., *Polygonum persicaria* L., *Stachys arvensis* L., and *Veronica persica* Poir. in cultivated land in Wellington Province show marked fluctuations from season to season, being particularly large in wet seasons.

3. Permanent Crop Communities:

Medicago sativa L. (perennial) shows decrease in population, with increase of the annuals, *Bromus* spp., *Erodium* spp., *Vulpia* spp., and perennial *Agrostis tenuis* Sibth.

4. Grassland Associations:

Newly-sown artificial grassland often shows for one or more seasons significant populations of annuals as *Sisymbrium officinale* (L.) Scop, and biennial *Cirsium vulgare* (L.) Savi, which may fluctuate for a period, then disappear completely.

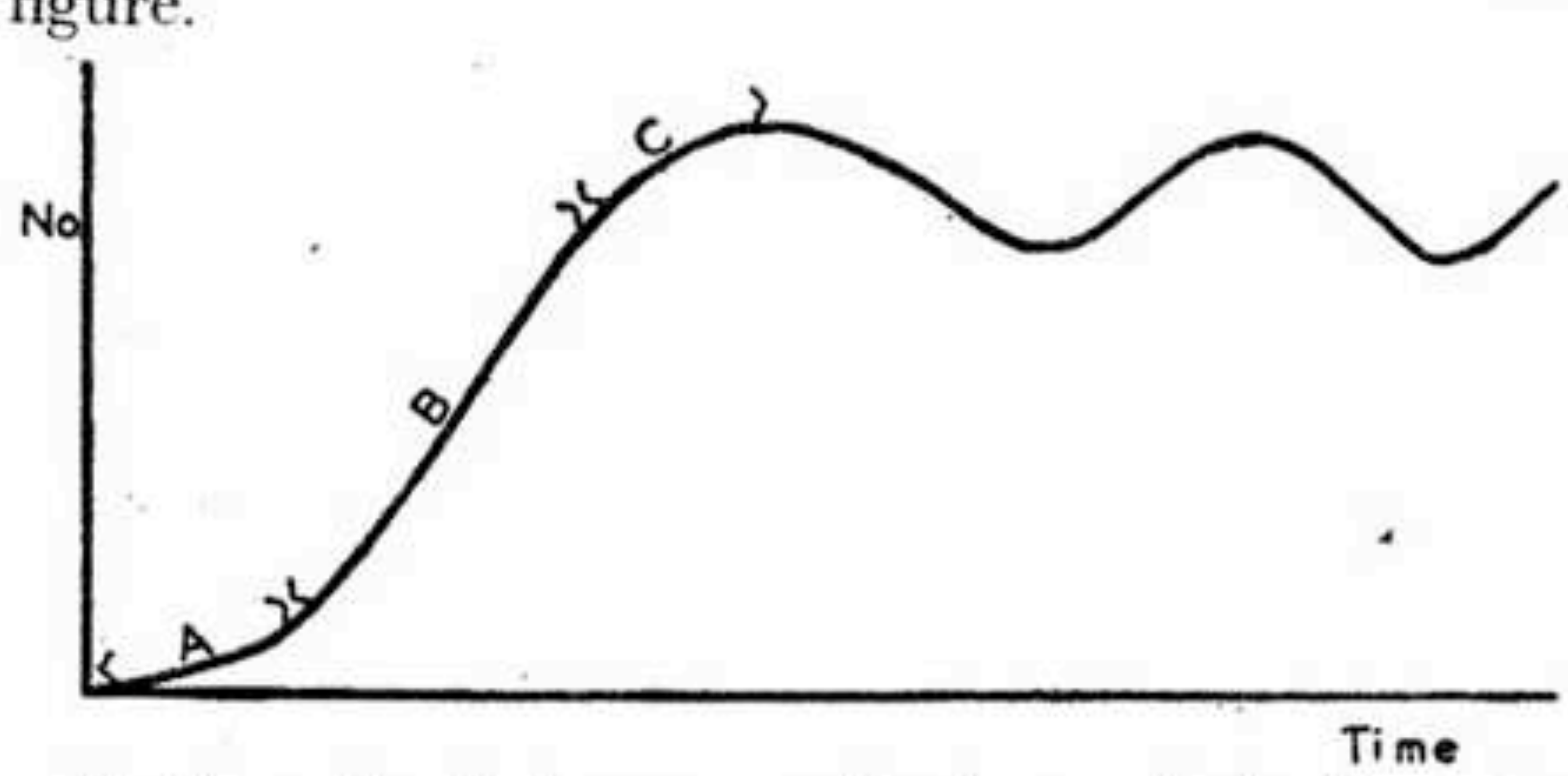
Population fluctuation involving change from species of perennial grass to other species of perennial grass is instanced with replacement of *Lolium perenne* L. etc. by species as *Agrostis tenuis* Sibth. and *Pennisetum clandestinum* Hochst.

Population Growth in Some Introduced Insects in New Zealand

Dr. W. Cottier

Whereas experimental patterns of population growth can be satisfactorily determined in the laboratory, their application under field conditions is not easy, although it has been done to a limited extent, e.g., Davidson in Australia on thrips in roses. This contribution is a rather general account of the progress of three newly-introduced species with observations on some factors considered to have influenced population growth.

In general the population growth curve of these introductions is shown in the following figure.



Section A of the curve is the period of establishment after which, under favourable environmental conditions, there is a period of rapid increase B, until numbers reach near stability at C, and thereafter attain an equilibrium in which there are numerous fluctuations. The pattern of the graph covered by periods A, B and C forms a sigmoid curve. Features of the growth patterns of the following three insects will be considered in relation to the curve.

1. The White Butterfly—*Pieris rapae* L.

Two specimens of the insect were recorded in New Zealand at Napier, Hawke's Bay, in March, 1930, *i.e.* A in figure. In the season 1931-32 there was a period of rapid increase, *i.e.* B in figure. when specimens were recorded 100-120 miles from the original points of discovery. As a result of abundant food sources and favourable climate, by 1932-33 numbers were immense, and the insect had spread as far north as Auckland. By the 1934-35 season the infestation of the North Island was complete. The insect was first recorded in the South Island in 1931-32, had covered the north-eastern area of the island as far south as Timaru. Spread was continuous and rapid, and by 1935-36 the invasion of the two islands was complete. The abundance of cruciferous crops and the lack of significant natural controlling factors allowed this enormous and rapid increase.

Before the butterfly had reached a state of equilibrium, *i.e.*, C, parasites were introduced and these very greatly reduced the population. The chalcid, *Pteromalus puparum* was first introduced in the summer of 1932-33. In the area of liberation a survey in the same season showed that 58 per cent. of 415 butterfly pupae collected were parasitised. With fresh liberations in 1933-34 surveys indicated that 89 per cent. of 5,396 butterfly pupae had been parasitised. At the end of the 1934-35 season 23,414 pupae from Manawatu, Hawke's Bay and Taranaki were 90 per cent. parasitised, and there was a remarkable decrease in the population of the butterfly.

The effect of the introduction of parasites has been to reduce the stable level of population from C to a considerably lower point. The history of the white butterfly in New Zealand is that of an insect that found physical conditions very suitable for its multiplication. The climate was favourable, there was an abundant food supply, and, in the absence of natural enemies, the population increased rapidly all over the country, but probably before an equilibrium could be established the introduction of parasites reduced this population to a very much lower level of fluctuating stability.

2. THE EUROPEAN WASP—*Vespula germanica* F.

This insect was first recorded in 1945 near Te Rapa where a wartime R.N.Z.A.F. store was located. It is thought that one or several hibernating queens were inadvertently brought out from Europe in packages. In that season only a few nests were recorded, whereas in the following season wasps were found in and around Hamilton, north to Huntly and south to Te Awamutu, and to a similar distance both east and west. The seasons 1944-46 represent period A in the figure. By 1947 wasps were recorded at Paeroa and further east and west with little spread southward. In 1948 boundaries of infestation were extended to Auckland, Whakatane, Taumarunui and Raglan. Infestation further increased and since 1948 wasps have spread over the North Island and into the Nelson and Marlborough provinces of the South Island, *i.e.* period B.

However, the growth of the wasp population was not entirely unrestricted because nests were intentionally destroyed and D.D.T., supplied free by the Department of Agriculture, was employed liberally. In 1951-52, however, wasp populations around Hamilton had noticeably decreased, while recent evidence suggests that in 1953 the numbers had increased. These variations may indicate that wasp populations in the vicinity of Hamilton reached equilibrium fairly rapidly, *i.e.*, 2-3 years after the initial period of establishment, followed by a great diminution in population (1951-52), with a rise again in 1953, but not to the 1949 level, indicating the period of fluctuating stability.

Possible factors contributing to these fluctuations have been suggested from time to time. The wholesale use of D.D.T. has already been mentioned. Fox-Wilson (1946) and Beirne (1944) suggest that wet springs inhibit the building of nests. It is possible that a mild winter may result in a lower establishment of queen wasps in the following spring, whereas a cold winter may produce a higher nest establishment in the following spring. This leads to the conjecture that wasps perhaps will be more active in southern districts which have colder winters. Other factors of the environment, *e.g.*, sudden heavy rains in the spring, flooding, etc., may account for population fluctuations.

3. THE GREEN VEGETABLE BUG—*Nezara viridula*

The first authentic record of this insect in New Zealand was at New Plymouth, Taranaki, in 1944, and, possibly because of climate, population growth was very slow, and after the initial record and survey was not featured as troublesome. The growth curve in this case was probably a smooth upward-trending curve. In 1946-47 however it appeared at Kawakawa in Northland. This was possibly a fresh introduction, but in view of a subsequent discovery at Te Kaha in Gisborne this supposition may be in doubt. In contradistinction to the experience in Taranaki, the bug population in Northland increased and spread rapidly. As the species is sub-tropical, being present in New Caledonia, Fiji and Australia, it is not surprising that it thrived in the warm climate of Northland. The population growth in this case probably took the sigmoid curve. By 1948 the insect had spread from Whangarei to North Cape. It should be mentioned that apart from a favourable climate, the great diversity of food plants in the north gave a great impetus to the growth of population. Apart from tomatoes and beans it has been found attacking such crops as sweet corn, maize, pumpkin and other cucurbits, silver beet, tree tomato, citrus, various weeds, and, it is said, grasses. The insect had spread as far as Warkworth in 1949, *i.e.* B in figure, to Auckland in 1950, and southwards, and since then, to all intents and purposes, has spread over the whole of the North Island. In 1951 it was recorded in Nelson and Blenheim, only reaching serious numbers in the latter district in this present (1954) season. Establishment in Nelson probably took the sigmoid curve.

In the summer of 1948-49 *Microphanurus basalis* Woll., an egg parasite, was introduced and liberated in several areas infested with the bug. Surveys have been carried out to determine whether the parasite has established, and at Paihia, Bay of Islands, in 1953 95 per cent. of egg rafts located in this area were parasitised. It would appear that the parasite has considerably reduced bug populations in Northland. However, the evidence is not completely satisfactory because the bug appears to be very sensitive to weather conditions, since attempts to discover egg masses in Auckland have been unrewarding during relatively poor summer seasons, and there is no evidence to show parasites are the cause of low population levels. The green vegetable bug is an example of an insect whose population growth is greatly influenced by temperature. Whereas it has been suggested that the wasp may do better in climates with a colder winter, it is suggested that the opposite may occur with this bug.

The aim of the author's sphere of activity is the control of insect pests, including the above three, and consequently population dynamics are incidental to the development of control measures. However, an attempt has been made, with, it is believed, some degree of success, to fit population growth to the sigmoid curve shown to represent growth in such laboratory systems as *Tribolium* in flour, *Drosophila* and yeast cells in laboratory culture.

Among insects, some of the salient features of population growth in newly introduced species that find the environment suitable are:—

1. The short period of adjustment to and establishment in the environment.
2. The rapidity with which the population increases under favourable conditions of food and climate.
3. The truly catastrophic destructive influence of effective natural enemies.
4. The sensitivity of population fluctuations to factors in the environment, *e.g.* climate.

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Do Newly Introduced Species Present A Separate Problem?

D. F. Hobbs

It is intended to suggest that there are grounds for the separate consideration of the dynamics of newly introduced species, and further, that there is a need for closer research interest in the dynamics of new populations. These aspects are dealt with in general terms.

There is little evidence in the literature to suggest that newly introduced species possess any special problems in population dynamics. In Allee's "Principles of Animal Ecology" and in recent studies by both Solomon (1949) and Haldane (1953) on natural regulation of animal populations, little distinction is made between indigenous and introduced populations, between human and other populations, or between, except in the case of Solomon, the test-tube populations of Gause and other workers and populations in a natural state. While it is not suggested that any serious student of populations could afford to limit his reading and thinking to populations of either type, it appears that there could be dangers in failing to appreciate certain differences which seem to warrant separate consideration of the dynamics of newly introduced populations. Some of the more important aspects are indicated in the table.

The following points arise from an examination of these differences.

1. Extinction of a native species within a short period is a rare thing, even where great changes of environment follow settlement of a new country by people of European races. The North American continent provides two or three instances of the extinction of birds under such circumstances and at least one of the near extinction of a mammal. Contraction of range