that selection for modifiers for its typical expression was quickly effective. It is intended henceforth to interbreed all the Dominant-N sheep.

A fourth stock is Recessive-N. The first Recessive-N ram was the double grandson of a hairy ram bought in 1929 who, it seems safe to conclude, was either a homozygous Recessive-N sheep, or a carrier of the gene. With a rare exception, Recessive-N rams are horned, but the ewes have never grown horns. Non-N rams heterozygous for this gene often have small horns.

The most fundamental question in genetic analysis engaging attention in recent years is the relation between Dominant-N and Recessive-N. Rams well authenticated as Recessive-N, on being mated with ewes from outside sources, known to have been free from halo-hairs on the back, have sired several N-type lambs, and upon these rare N-type animals we have speculated freely.

The Dominant-N and Recessive-N genes have proved not to be allolomorphic. Recessive-N and Dominant-N were crossed. The Recessive-Dominant-N sheep so-produced have been mated with Recessive-N, and have given a good 3: 1 ratio. The interbreeding of Recessive-Dominant-N animals has produced several Non-N lambs, the number of N-type and Non-N not departing significantly from the 13: 3 ratio.

In 1948 it has been possible for the first time to breed from an N-type ram sired by a Recessive-N ram from an unrelated Non-N ewe, without halo-hairs on the back, from an ordinary Romney flock. This ram, mated himself with no-halo ewes from outside sources, has sired several N-type lambs. In the light of all the evidence the most likely explanation is that this ram is heterozygous both for the Recessive-N gene received from his sire, and for a dominigene, received from his dam, which brought to expression the single dose of the Recessive-N gene.

This experimental breeding with sheep, which has proved to have been along Mendelian lines from the outset, has taken a long time. At the beginning, six years elapsed before it was realized that a Dominant-N oligogene existed, and it is now six years since, following the recognition of the Recessive-N oligogene, a series of experiments was planned on the relation between these two genes. In twenty seasons some three thousand five hundred lambs have been bred.

This research has introduced the investigators to an array of phenomena and problems of Mendelism. These include the conditioning of the same characterization by independent genes; pleiotropy; sex-influenced inheritance; heterozygous expression, including failure of penetrance as well as poor expression; genetic analysis by direct examination; modifying factors including a dominigene; the mode of working of the gene; and dosage effects. A teacher of Genetics occupied with N-type sheep is liable to draw illustrations from them with undue frequency.

STUDIES ON THE ENTOZOA OF MAN IN NEW ZEALAND*

PART III.

A NOTE ON THE INCIDENCE OF *ENTEROBIUS VERMICULIS* (Linn.).

By L. R. Richardson and A. Elizabeth Clark, Victoria University College.

The larger entozoa of man held a prominent place in medicine prior to the demonstration of the pathological nature of some bacteria. The development of bacteriology directed attention away from the entozoa, and their study was largely neglected for many years. The past twenty years has seen a revival of researches on the entozoa. This work is showing that the long neglect of these animals has in no way impaired their success. Dr. Norman Stoll has recently brought together available data on the incidence of helminth infestation. In his address, "This Wormy World" (*J. Parasit.*, 33 [1], 1–18), he estimates the world incidence for several species as follows: 39 million infested with *Taenia saginata*; 457 million infested with hookworm; 355 million infested with *Ascaris*; and, tentatively, 209 million infested with *Enterobius*, the common pinworm of man.

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It is clear that there is need of a proper evaluation of the entozoa. They cannot be disregarded in the light of these figures. Infestations may not in all cases have the dramatic results of some bacterial or virus infections. The clinical entities of helminthiases range from patent and serious disease, as in trichinosis and ancylostomiasis, through a series of diminishing intensity to the apparent complete tolerance of seemingly non-pathogenic species such as *Trichuris* and *Enterobius*. The clinical significance of the latter species is not clear; but studies on them can contribute much to our understanding of helminthiases in general.

The development of the N.I.H. swab by Hall and his Institute has given a technique for the detection of *Enterobius* infestation with a high degree of certainty and with reasonable facility. The swab consists of a one-inch square of waterproof cellophane wrapped over the tip of a length of four millimeter glass rod. The rod is passed through a stopper and carried in a test-tube. The cellophane is lightly rubbed over the perianal region collecting any eggs which may be present on the mucous membrane. Six swabs are supplied for each individual, and used one swab on each of six successive days.

In the present study, so far a total of 852 swabs have been distributed to 142 individuals, and 521 swabs have been examined. The majority of these individuals have been contacted through the services of the Royal New Zealand Society for the Health of Women and Children. They are, for the most part, members of young families. The age range within the group is from three weeks to 42 years, with virtually a complete gap in the 16 to 20-year range.

The gross infestation rate is 55%, ranging from 45.5% for children of 0 to 3 years, up to 86% for children of 11 to 15 years of age. There is no indication of acquired immunity to the pinworm. Adults, 20 years to 40 years in age, are commonly infested. Swabs from 40 adults have shown 50% infested, with no indication of any distinction in incidence between the sexes. In gross consideration, the infestation rates of parents are on par with those of children. Juveniles from 0 years to 15 years show an overall infestation rate of 57%. Both parents are as prone to infestation as are children, and the parental group must be regarded as proven potential reservoirs.

Enterobius infestation in this group is familial in nature, and of the thirty-one families so far studied, 74% were found to be infested. Six of the eight negative families have less than four children. Completely negative families as a rule have children all under school age, while families containing children of school age have one or more members infested. An incidence increasing from 47% in families of three individuals to 73% in families of seven individuals is correlated with increasing infestation from the 0 to 3-year group, to the 11 to 15-year group, where in the latter infestation reaches an incidence of 86%, although the number in this group is still small.

The data accumulating in this study must be correlated with our knowledge of the biology of this worm for a clearer understanding of its success in the face of what is considered a reasonably hygienic mode of life such as is followed in modern urban surroundings.

It is essential to keep in mind that there is no evidence of multiplication of this worm within the host. The life-span of the adult is still unknown, but oviposition commences two to four weeks after initial infection. Reardon (*U.S. Publ. Health Rept.*, 53 [24], 978–983) has shown that the gravid worm carries 4,672 to 16,888 eggs. These are deposited chiefly on the perinaeum, develop to infectivity in six hours in this location, and transferred to clothing are widely distributed. The infective egg contains a larval stage. Eclosion of the larva has so far not been found possible until the egg has been exposed to air. In infested houses, 90% of dust samples from all rooms, taken from the floor, from furniture, and from ledges up to 9 ft. from the floor, contain ova. Under ordinary conditions, 30% survive at least six days. Ova resist fumigation even with hydrocyanic gas, but are remarkably susceptible to heat and low humidity.

Enterobius is a worm having a simple direct life-cycle coupled with a high rate of production of moderately resistant eggs. The eggs are distributed by the actions of the host. Each worm in the host intestine has been released from an ingested egg. Auto-infection is not only possible, but a prominent feature in prolonging infestation. After a latent period, the infested individual is a persistent source of infective eggs. The spread of infestation within the family group is linked with the continuance of infestation through reinfections and the absence of acquired immunity. These are important factors which contribute to the worm's success in maintaining its position even under present urban

ways of life. So far as present data shows, there is an increased incidence in families as the age of the children passes the school-entry level. School contact seems an important factor in the spread of infestation among family groups. This may have further significance.

Shope has shown (*J. Exp. Med.*, 73, 74, 77) that swine influenza is a combination of influenza bacteria and virus, that the virus is harboured in the larvae of lung-worms, where it can survive even up to three years, and can be perpetuated in this way from outbreak to outbreak. This can be coupled with the demonstrated transmission of the virus of equine swamp fever through strongylids, as an indication that there is room to consider helminths generally and nematodes in particular as potential vectors of virus and bacteria.

These findings apparently have not yet been carried over in the investigation of human diseases; but having in mind the variety of "children's diseases," their seasonal occurrence and other features in their epidemiology such as acquired immunity, it is clear that this is a field deserving of careful research. In such studies, *Enterobius* should be given careful consideration as a potential vector. It provides, with other entozoa, a potential pathway particularly suited to the transmission of virus from host to host. Whether important in that respect or not, *Enterobius* is of value in demonstrating the ease with which the intestinal fauna and flora can be transmitted from person to person. It demonstrates the inadequacy of our ordinary hygiene, and in its success shows the need for the encouragement of a very high order of individual hygiene. It is, in fact, a worm worthy of meticulous researches for its own sake and as a study in some aspects of the biology of man.

A RESUME OF INVESTIGATIONS ON NEMATODE PARASITISM IN SHEEP IN NEW ZEALAND

By J. H. TETLEY, Zoology Department, Massey Agricultural College.

GREATEST activity in the field of parasitology has taken place in those countries possessed of a large and varied vertebrate fauna. Perhaps, therefore, it is not surprising that in New Zealand, with its paucity of Amphibia, Reptilia, and Mammalia, the subject should have attracted little attention from zoologists. It is a matter for regret that, when host material was more readily available, the opportunity was not taken to study its parasitism, for our unique fauna might have provided knowledge, in this connection, of great interest to science.

Although this particular field for parasitological study has been almost lost to science, another field of economic importance has been created in New Zealand through the introduction of domestic animals. So far as sheep are concerned, following their introduction, flocks multiplied rapidly as the forest was converted to grassland and coincidentally the problem of parasitism developed, and for more than half a century has assumed considerable economic proportions. All the species of parasites were brought inadvertently with their hosts, either directly from Britain, or indirectly from there by way of Australia. Probably many of the species now found in this country arrived here with the early importations of sheep.

It appears strange that, though parasitism of sheep has been recognised as a major problem in New Zealand for two or three generations, and though attempts at control have been obviously inadequate, the study of the subject should have been neglected. There seems to have been no appreciation that it is only by understanding the factors which determine the pitch of parasite numbers that known anthelmintics can be applied to the limit of their potentiality, or that other methods of control can be devised.

In taking up the study of parasitism in sheep the writer has adopted a zoological, mainly ecological, approach, because such approach appeared most likely to contribute towards an understanding of the mechanism of the epidemiology of parasitism.

To begin with, a survey[1] was made of the parasites of sheep. Twenty-five species of nematodes were found, several of these being recorded from New Zealand for the first time. The range of species was similar to that found in sheep in other temperate countries. Since nematodes are so intimately associated with their hosts it is to be expected that they had no difficulty in accompanying