The Inland Distribution of *Mus decumanus*.

It appears that, notwithstanding many statements to the contrary, *Mus decumanus* does not occur in India except in seaports. This statement may be proved, in the future, to be erroneous, but all the evidence of this inquiry is in favour of the view that the grey rat has not established itself in any part of the interior of the peninsula. Certain writers relate how this rat passes up the great rivers by means of country boats to establish itself in riverside towns, and it has even been stated that it is fast replacing the indigenous rat in India. Allahabad and Cawnpore are situated on the banks of the Ganges at points where the river is navigable for country boats; in both of these cities many thousands of rats were caught, but not one *Mus decumanus* was among them. It is impossible that they could have been overlooked, for in both places the officers in charge of the operations paid great attention to the question of the species caught, and *Mus decumanus* can be easily distinguished from *Mus rattus*.

Other Observations bearing on the Question of Plague Dissemination.

It has been sufficiently shown that the species *Mus rattus* is the common house rat throughout the whole peninsula of India, that it occurs intimately associated with man in every place (with the single exception of Quetta) in which it has been looked for. The fact of its absence from Quetta is doubtful and requires confirmation (see page 33). If it could be shown that this species is rare in or absent from Quetta, the cause of its absence should be carefully sought for as it might have a direct bearing on plague prevention. It has been shown that, in any town, rats of this species show individual differences from one another, and that in certain places they show slight racial differences; so that although it is often impossible to say whether a particular rat was native to Tellicherri or Amritsar, it would be easy to identify a group of fifty rats from either place. In certain instances, however, individuals could be identified. For example, single rats from Kashmir, Amritsar and Katmandu could be almost always identified at a glance. In spite of this the fact remains that any of a small collection of house rats from Adelaide in Australia can be "matched" exactly, by searching among large numbers of the rats of Calcutta, Bombay, Cawnpore or many other large towns on the plains of India. In colour they can be matched as closely as two threads in the same skein of coloured silk. In proportions of body and skull the similarities are not less than those indicated by this comparison. Therefore it seems that there is no reason why a rat should not wander freely, in or out of the country, and intermingle with the rats of places far removed from its own birth-place, without being recognised as an interloper. However, all the evidence that can be obtained shows that rats do not wander freely, that they rarely move from village to village of an Indian rural district, and that

they even confine themselves to particular houses or groups of houses, and are much given to breeding within the family circle.

To obtain sure evidence about such a question is a matter of some difficulty. It might be obtained experimentally by means of marked rats. Fortunately cases have occurred in which Nature has herself provided the mark. Captain Davys has contributed a good example from the Amritsar district, and pointed out its significance. Among a mixed collection of *Mus rattus* from any large Indian town there is often a small number of white-bellied ones. Among the large number of rats which we received from the Punjab was a small sprinkling of such forms, and it was definitely ascertained by the sender that out of sixty-nine villages, in which rats had been collected, only three provided these white-bellied forms, and that they made up about ten per cent. of the total rats of those villages. Whether we regard the white-bellied forms as a separate race or not, there is clearly not much intercourse between the rats of those villages.

Two other cases have been already described which show conclusively that a group of rats may identify itself with certain adjoining houses. The first of these is the case in which ten black mole-rats were caught in two adjoining houses in Rangoon during three nights, and no other kind of rat was caught at the time in those houses, although black mole-rats are very rare indeed. This shows that a "family group" may establish itself within very narrow limits, keeping without those limits all others who are not of the group. A precisely similar case was recorded from Naini Tal where the house rats found on a part of Ayapata Hill could always be distinguished from those which dwelt at either end of the lake, although the three places were separated by less than a mile. It may be objected that these examples do not constitute fair evidence in favour of the view that the rats of one species in a town do not freely intermingle, because in these cases the rats have been marked off by their peculiarities from the majority, and held themselves aloof.

While watching large numbers of rats brought in by townsfolk, the observer is compelled to recognise that the rats of any one species are split up into a great number of "family groups" or clans, each with its own limited domain. If, for example, at a collecting station rats of the long-tailed kind are superficially examined and set aside, the accumulation, which consists perhaps of some hundreds of individuals, has a truly heterogeneous appearance; some few of its constituents are black or nearly so, a few are pure white below, others are white below with a grey breast stripe. Among them there is much variation in size. The length of one may be 150 mm., the length of another 200 mm., both being obviously adult. Tail length will vary from 105 % to 135 % of length. In respect to length or tail length, the rats can be laid out side by side in an unbroken series, the mediocre in both respects being in the majority. In respect to colour it is much more difficult to arrange them in an unbroken series. The collection will perhaps

contain one or two pure black rats and four or five others of a blackish tone which show a variable mixture of brown hairs; but one cannot find, when dealing with hundreds, every shade between a black rat and a light brown one. Similarly, one cannot arrange a satisfactory series between the white-bellied type and the commoner brown-bellied type, although some of the former have coloured breast stripes of variable breadth and some of the latter are very light in colour.

The collection is truly heterogeneous in appearance, although, in a broad sense, it consists of animals of one species. The individuals composing it have been brought in batches of two or three together, by the townsfolk. It is often noticeable that the individuals of any one batch very closely resemble one another. Thus the melanotic and semi-melanotic rats would probably all be brought in by one man. Another man would bring unusually large rats, a third would bring four or five white-bellied rats with relatively short tails, some with breast stripes, others without. The members of the separate batches often show a likeness to one another. This can only be explained by the fact that the members of each batch were usually taken together from a single house, the likeness being a true "family likeness." By the word "family" is meant a small localized group whose members are given to inbreeding. These observations point to the conclusion that the rats of one species in a town are divided into a number of groups which hold little intercourse with one another.

Experimental evidence of a more certain nature could be obtained by successively capturing, marking, releasing, and after an interval recapturing a large number of rats. It might be predicted that the recapture would take place in all cases in the same house that the capture and marking was effected. Such experiments could probably be carried out without much difficulty. The rats should be caught in a trap, anæsthetized lightly by placing the traps in a closed box containing chloroform, and removed from the trap while unconscious. They might be marked by branding the tail or piercing the ears. Recovery from chloroform in rats takes place with certainty, and often with most disconcerting quickness. The accidental scars which are present on so many rats might lead to some confusion, but a system of marking by metal rings and number plates would probably prove unsatisfactory. To recapture the rats it would be probably necessary to use spring jaw traps of which there are many effective patterns. Such experiments would give direct evidence of the movements of rats in a town or village which would be of value in any consideration of the means of plague dissemination.

APPENDIX II.

QUESTIONS OF BIOLOGICAL INTEREST.

The Government's measures against rats have afforded a unique opportunity of studying large numbers of closely related