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Infestations of the brown rat (*Rattus norvegicus*) in drift mines of the British Isles

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INTRODUCTION

Infestations of the brown rat (*Rattus norvegicus*) have for long been common in many drift mines. Apart from damage to equipment by gnawing, rats transfer *Leptospira icterohaemorrhagiae* to man. The occurrence of Weil's disease amongst mineworkers has been reviewed by Jenkins & Sharp (1946); Broom (1951); Sharp (1953).

The drift mines of the British Isles are situated in Scotland, Northumberland, Durham, Yorkshire, Lancashire and South Wales and are distinguished from other coal mines by the fact that there is always connexion between the surface and underground by means of a tunnel, or drift, passing horizontally or inclined either up or down, although a vertical shaft is also present in some. They vary greatly in size, the smallest having less than 10 men employed both on the surface and underground and the surface installations consisting of one or two huts only, whilst a large mine may have up to 400 surface workers, over 1000 men underground and several acres of surface buildings.

Since 1953 determined attempts have been made to clear mines of rats. It has been observed that whilst some drift mines experienced continual rat infestations others have not been so troubled: it is proposed in the present study to refer to this as 'differential infestation' and it would appear from this that there may be certain features which influence infestation. Furthermore, both surface buildings and underground workings have been re-infested after clearance by poison treatments. In order to plan a scheme of control it is necessary to know the frequency of re-invasion and whether re-infestation of surface premises and underground takes place simultaneously.

The present work is an attempt to determine the factors assisting infestation and to study the rodent population, between poison treatments, in and around a typical drift mine.

NATIONAL DRIFT MINE SURVEY

Methods

In order to evaluate the features and infestation records of the drift mines of the British Isles questionnaires were sent to 562 pits. The information was recorded on punched cards to facilitate analysis.

Because of the lack of critical information on the number and size of infestations

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it has not been possible to assess infestation severity and frequency, only the presence or absence of infestations.

Drift mines have two separate working units, surface and underground, each with different numbers of men who may be separated by a considerable distance: it has thus been decided to treat the data from these two points of view rather than treat the pit as a whole. The following examinations of the data have been made:

(1) Initial analyses to observe the distribution of rat infested pits amongst the varying features under examination and at varying man-power levels.

(2) The apparent differences exhibited by pits in certain conditions have been tested by χ^2 tests from the following three viewpoints:

(*a*) A comparison of small and large pits under the various conditions recorded to test the effect of pit size on rat infestations.

(*b*) A comparison of small pits under different conditions with the total number of small pits.

(*c*) A similar comparison of large pits with the total number of large pits.

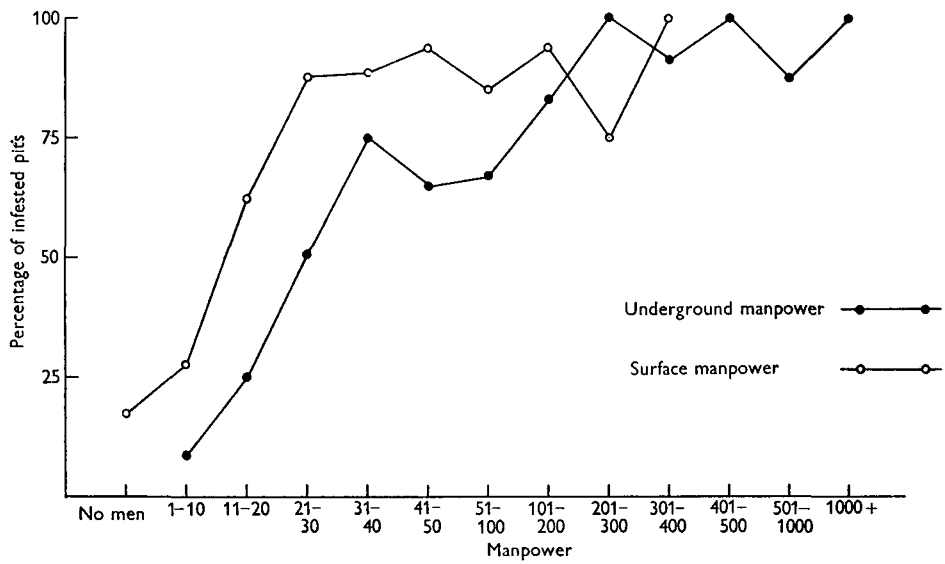

Fig. 1. Rat infestation and presence of men.

Results

Infestation frequency

Rat infestations have been recorded in 45% of the drift mines investigated.

Surface manpower

There is a close correlation between the number of surface workmen and the percentage of mines having rats at any particular man-power level. Fewer small mines than large mines are infested. (The term 'small' refers to mines with 10 or less surface and 20 underground men and 'large' to those with over 10 surface and 20 underground workmen) (see Fig. 1). In pits with ten or less surface workers fewer than 30% are infested, but above this level there is increased infestation, and over 80% of pits with more than 21 men have rats.

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Underground manpower

Of drift mines with less than 10 men underground only 9% have had rats. Twenty-five per cent of mines with between 11 and 20 men underground were infested. Above this level there is a sharp rise in the percentage of infested pits and of those with more than 200 men (91 in all) only four were rat free (see Fig. 1).

Type of area surrounding drift mines

Data have been collected on the type of countryside surrounding the mines within a half-mile diameter circle of which the mine is the centre. Five main types are seen: arable, woodland, urban, pasture and moorland.

A comparison of small pits with large pits reveals that in all cases there is a significant difference in infestation between the two.

Pits with small numbers of surface workmen and with urban surroundings have significantly greater infestation than the total number of small pits, whilst similar sized pits situated in moorland are on the borderline of significance at the 5% level, and at the 10% level there is a significant difference between them and the total number but in this case the infestation is less (see Table 1).

Table 1. *χ^2 analysis of drift mine infestation in different types of surroundings*

Type of surroundings	Comparison between small and large pits in different surroundings, *P*	Comparison between small pits in each type of area and the total number of small pits, *P*	Comparison between large pits in each type of area and the total number of large pits, *P*
Surface manpower			
Arable	< 0·001	0·50–0·10	0·10–0·05
Woodland	< 0·001	0·90–0·50	0·50–0·10
Urban	0·01–0·001	0·05–0·02	0·90–0·50
Pasture	< 0·001	0·50–0·10	0·90–0·50
Moorland	< 0·001	0·10–0·05	0·50–0·10
Underground manpower			
Arable	< 0·001	0·90–0·50	0·90–0·50
Woodland	< 0·001	0·50–0·10	0·50–0·10
Urban	< 0·001	0·10–0·05	0·50–0·10
Pasture	< 0·001	0·90–0·50	0·95–0·90
Moorland	< 0·001	0·90–0·50	0·50–0·10

Presence of rat concentration points

Features such as farms, refuse dumps, etc., where rat colonies often exist, have been recorded when they occur within the quarter-mile radius.

Small mines differ significantly in infestation from large ones whether rat concentration points are present or not. Large pits with rat concentration points in the vicinity show no significant differences when compared with all large pits. Small mines, however, when either surface or underground manpower is considered,

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have significantly greater infestation in the presence of rat concentration points than is found in all small mines. Table 2 illustrates the extent of the differences.

Presence of buildings

When buildings are present there is a significant difference in the infestation of small and large pits, $P < 0{\cdot}001$, but when there are no buildings, although the difference in infestation is significant it is less marked, P between 0·05 and 0·02.

Table 2. χ^2 *analysis of drift mine infestation in the presence and absence of points of rat concentration*

Presence or absence of rat concentration points	Comparison between small and large pits, P	Comparison between small pits with or without the presence of rat concentration points and the total number of small pits, P	Comparison between large pits with or without the presence of rat concentration points and the total number of large pits, P
Surface manpower			
No conc. points	< 0·001	0·10–0·05	0·90–0·50
Conc. points present	< 0·001	< 0·001	0·90–0·50
Underground manpower			
No conc. points	< 0·001	0·50–0·10	0·50–0·10
Conc. points present	< 0·001	0·05–0·02	0·10–0·05

Table 3. χ^2 *analysis of drift mine infestation in relation to presence of buildings*

Presence or absence of buildings	Comparison between small and large pits, P	Comparison between small pits in these conditions and the total number of small pits, P	Comparison between large pits in these conditions and the total number of large pits, P
Surface manpower			
Buildings present	< 0·001	0·70–0·50	0·99–0·98
No buildings	0·05–0·02	0·05–0·02	0·90–0·50
Underground manpower			
Buildings present	< 0·001	0·70–0·50	0·90–0·80
No buildings	0·05–0·02	0·50–0·10	0·10–0·05

When comparing the difference in infestation between small pits with or without buildings and the total number of small pits (Table 3) it is seen that there is a significant difference in the infestation of small pits (surface manpower) without buildings and the total, P between 0·05 and 0·02. Infestation is less than for the total. There is no difference at the 5 % level between large pits with or without buildings and the total, although at the 10 % level there is significantly less infestation of large pits (underground manpower) without buildings than in large pits generally.

Canteen and surface stables

Four groups of mines can be recognized in this section: those with canteen only, those with stable only, those with both canteen and stable, and those having neither.

There is a significant difference in infestation between large and small mines (both surface and underground manpower analyses). However, where there is a canteen present and where both canteen and stables are present, the difference is less marked.

When comparing small mines having the features under consideration with the total number of small mines it is seen that so far as surface manpower goes small pits with a canteen only, those with neither canteen nor stables, and those with both canteen and stables do not differ to any significant extent in the number infested from the infestation found in the total number of small pits. When stables only are present infestation is significantly higher than for the total.

Table 4. χ^2 *analysis of drift mine infestation in the presence or absence of canteen and stable*

Presence or absence of canteen and stable	Comparison between small and large pits, *P*	Comparison between small pits and the total number of small pits, *P*	Comparison between large pits and the total number of large pits, *P*
Surface manpower			
Canteen	0·05–0·02	0·99–0·98	0·90–0·50
Stable	< 0·001	0·05–0·02	0·50–0·10
Both	0·05–0·02	0·50–0·10	0·05–0·02
Neither	< 0·001	0·50–0·10	0·05–0·02
Underground manpower			
Canteen	0·02–0·01	0·50–0·10	0·50–0·10
Stable	< 0·001	0·05–0·02	0·50–0·10
Both	0·01–0·001	0·50–0·10	0·02–0·01
Neither	< 0·001	0·02–0·01	0·05–0·02

In the case of underground manpower when a canteen only or when both canteen and stables are present there is no difference in infestation between these pits and all small ones. On the other hand, pits with surface stables alone have significantly greater, and those with neither canteen nor surface stables, less, infestation than that for all small pits.

A similar comparison of large mines (surface manpower) reveals that those with either canteen or stable do not differ from the total. Mines with both canteen and stable have significantly more and those with neither, less, infestation than the total.

A very similar state of affairs to that of the surface analysis is seen when underground manpower is considered. Canteen and stables only appear to have no significance but there is greater infestation when both are present and less when both are absent (see Table 4).

Surface sanitation

The methods of sewage disposal on the surface vary considerably from water lavatories with the excreta passing to sewers or septic tanks (modern), to pits with earth lavatories and those where the excreta are deposited on the ground (primitive).

Most pits with modern sanitation are large ones and most of those with primitive methods of disposal are small.

There is a significant difference in infestation between large and small pits irrespective of the type of sanitation.

When comparing small mines having either type of sanitation with all small mines it is seen that those with modern sanitation have significantly greater infestation.

Table 5. *χ^2 analysis of drift mines infestation in relation to the type of surface sanitation*

Type of sanitation	Comparison between small and large pits, P	Comparison between small pits and the total number of small pits, P	Comparison between large pits and the total number of large pits, P
Surface manpower			
Modern sanitation	$<0\cdot001$	$<0\cdot001$	0·50–0·10
Primitive sanitation	$<0\cdot001$	0·50–0·10	0·05–0·02
Underground manpower			
Modern sanitation	$<0\cdot001$	$<0\cdot001$	0·50–0·10
Primitive sanitation	$<0\cdot001$	0·50–0·10	0·10–0·05

Table 6. *χ^2 analysis of drift mine infestation in the presence or absence of horses*

Presence or absence of horses	Comparison between small and large pits, P	Comparison between small pits and the total number of small pits, P	Comparison between large pits and the total number of large pits, P
Surface manpower			
Horses present	$<0\cdot001$	0·05–0·02	0·50–0·10
Horses absent	$<0\cdot001$	0·50–0·10	0·50–0·10
Underground manpower			
Horses present	$<0\cdot001$	0·50–0·10	0·05–0·02
Horses absent	$<0\cdot001$	0·90–0·50	0·50–0·10

Large mines (surface manpower only) with primitive sanitation have less rat infestation than all large mines (see Table 5). This apparent paradox is discussed later (p. 282).

Presence of horses

Whether horses are present or absent there is a significant difference in the infestation of large and small mines (see Table 6).

Small mines (surface manpower) with horses have higher infestation than all small mines, and large mines (underground manpower) with horses show similar results when compared with all large mines.

FIELD SURVEY OF SOUTH YORKSHIRE DRIFT MINES

Methods

Regular visits have been made to sixteen drift mines in South Yorkshire and surface and underground inspections carried out.

Results

Of the sixteen drift mines four have been rat free. These are the four smallest mines, none having more than 10 men on the surface. Underground, however, none of them can be classed as small since they have 27, 42, 77 and 136 men each. Apart from this low surface manpower the striking feature of these four mines in comparison with the other mines is the lack of surface buildings—at two of them there are only two huts near the adit, at the third and fourth two and three small brick buildings respectively. No materials were stored on the surface and both canteen and stables were absent.

The twelve large drift mines have all had rat infestations and continual treatments have been necessary in two of them. In contrast with the small mines the noticeable surface features are first the large number of men in the vicinity of the drift, and secondly the considerable area of buildings—in some cases covering several acres.

It is difficult to standardize precisely the extent of dilapidation of buildings and the amount of scrap material, the latter being a feature of most large mines and frequently remaining untouched for long periods. It has been observed, however, that the older type of mine buildings tend, with their often crumbling brickwork, buildings with underground basements, and lack of careful planning, to provide a greater amount of cover than the modern type, well lit and well built. When a new set of buildings has been added to an old mine it is noticeable that, when rats are present, the holes are more often in the older premises. Davis & Fales (1949) showed that in urban areas there is a positive correlation between density of the rat population and the proportion of dilapidated buildings.

None of the small mines has either canteen or surface stables. The only food other than natural material is the scraps thrown away by the men.

A canteen is present at all the large mines and, at a few, surface stables also, the latter, when infestations are present, acting as focal points. Food scraps from canteens are not always scrupulously placed inside rat proof containers but may be found on the ground. At two drift mines infestations were centred around the canteen, the rats living in heaps of scrap metal and earth banks alongside the canteen.

Underground there is, even in a small mine, unlimited cover for rats in the 'pack'—the shattered rock which is packed to form the sides of the roadways.

There is evidence from rat traces and poison baiting that rats underground follow the men quite closely for food. The distribution of men in a mine is such that most are at or near the coal face whilst the rest are in small groups at transfer and loading points.

In a small mine where distances between the groups of men are less it is common to find rat footprints between the groups, although they are mainly around the places where men congregate for meal breaks, but in large mines, where the groups of men are usually further apart, it is very rare to find rat traces between them.

Where ponies are present and grain is stored, infestation is usually heavy in the region of the underground stables.

In large mines with discrete working groups it is seldom that any feeding ('takes') from test baits or poison baits is seen in the long empty spaces between groups and it is usually restricted to the vicinity of the men. In a smaller mine where distances are less between groups some takes may be recorded in the inter-group roadways but again the majority are seen near groups of men. In the vicinity of stables takes are usually good.

STUDY OF RODENT POPULATION CHANGES AROUND A DRIFT MINE

The mine

A typical drift mine in South Yorkshire was selected for the work. Rats had been present both on the surface and underground for many years and recent poison treatments had only relieved the position temporarily. Of the 210 men at the mine 40 were surface workers and the rest worked underground.

The adit was situated 30 yards from the buildings amongst waste land used for timber storage. Since the adit is the point at which rats must enter to go underground an area was delineated which had the adit at its centre. The colliery buildings formed one side of the rough square (called 'pit top' section), and waste and agricultural land the other three (these are called 'copse', 'stream' and 'swamp' sections).

Methods

The technique of surplus baiting (Chitty, 1942, Chitty & Shorten, 1946) was employed to obtain measurements of relative population density. Dry whole wheat was used and in all places except a swampy area, where cast iron pipes were used, it was placed in shallow wooden trays. Points out of doors were protected from rain by strips of conveyor belting and points in the coal screening plant had to be similarly protected from the accumulation of coal dust. Corrections for moisture uptake by the wheat were made from test baits to which rodents had no access.

The census was carried out approximately every 3 months from October 1955 to February 1958. The term 'average daily take' refers to the period of steady feeding (usually 6 or 7 days) once the animals had overcome suspicion of the trays and become accustomed to the new food.

Results

Analysis of the separate areas

It is proposed to deal first of all with the copse, stream and swamp sections. The pit top section and the problems it raises will be reviewed last of all. Fig. 2 shows the population changes in the four areas.

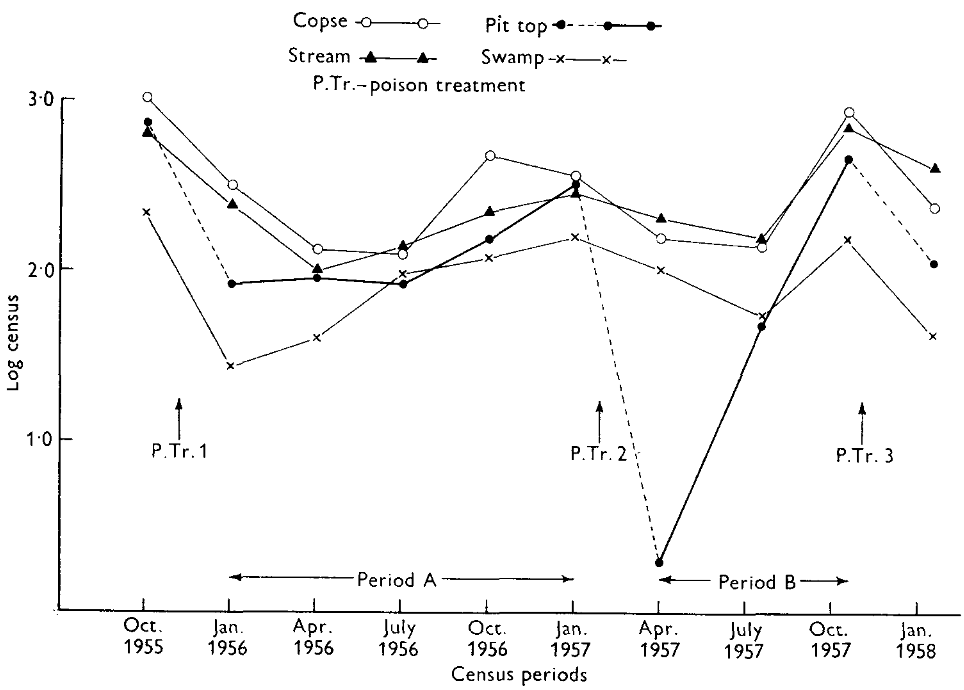

Fig. 2. Rodent population changes.

It is seen from Fig. 2 that at the time of the first census in October 1955 the populations in the copse, stream and swamp sections were greater, with one exception, than at any subsequent census. Three peaks are seen in the autumn and early winter of 1955, 1956 and 1957, and two low periods in the summer of 1956 and 1957.

Live trapping to ascertain the small mammals present showed that *Arvicola amphibius* (water vole), *Cleithronomys glareolus* (bank vole), *Apodemus sylvaticus* (long-tailed field-mouse) and *Sorex minutus* (pygmy shrew) were present. It was almost certain that *Rattus norvegicus* was not at any time present in either of these three areas during census periods. Dust tracing, trapping, the type of kibbling and droppings all indicated thus.

In the pit top buildings, with the exception of mice at a few points, the rodent population has been common rat throughout the period.

The effects of poisoning

Three poison treatments amongst the surface buildings and one underground have been carried out in the study period. The first surface treatment was in December 1955 simultaneously with an underground treatment. By the end of January 1956 it was apparent that the underground rat population had been exterminated completely and that the surface population had decreased considerably—the daily average wheat take was reduced by 88·6 %. Throughout the spring and summer there was little change in the feeding rate, but by January 1957 the feeding was approximately half of that at the October 1955 census. The second poison treatment was carried out in February 1957 and appeared to be completely successful, yet within 9 months the population was greater than just before the treatment. A third treatment took place in November 1957 and was completely successful, but by February 1958 a small number of rats was again present.

Growth of the population

Fig. 2 shows the growth of the rat population. There are two periods (A and B) between treatments in which the population shows an increase. At the first census period the daily average take of wheat was 734 g. In January 1956 (after poison) it was 84 g. This very small population remained constant throughout the summer months. By October 1956 the daily average was 158 g. and by January 1957, 337 g. After treatment 1 the population remained constant for 9 months. Fig. 2, in which population increase is plotted logarithmically (log census), shows that after a period of inertia the population is increasing slowly. Treatment no. 2, in February 1957, achieved 100 % success. Small takes in April were due to mice and birds but by August 1957 the daily takes of wheat were 48 g. About 6 months had elapsed before rats were present again. The November 1957 census revealed a daily average of 475 g. taken. In view of the very small populations studied in the present work no attempt has been made to estimate the rate of increase.

The treatment necessary after this census, although apparently successful, appeared in February 1958 to have accounted for only 75 % of the population, but in view of the evidence after poisoning it is believed that another smaller influx had taken place.

Infestation of underground workings

Despite the fact that rats succeeded in establishing themselves in the surface buildings twice in 2 years they were not present underground between December 1955 and February 1958.

DISCUSSION

The fact that there exists a greater proportion of infested pits amongst those with larger numbers of men than in small ones appears to indicate that there is some connexion between rats and men. It may well be that the rats, at any rate underground and in the absence of horse fodder, depend to a great extent upon the waste scraps thrown away by the men. It has been observed that rats appear to follow the men quite closely underground—in a large mine where discrete groups of men are separated by considerable distances the rat tracks are usually concentrated around the men. The cessation of a working face and removal of all men to a new district has, on one occasion, resulted in a movement of the rats with the men, presumably in the search for food. Furthermore, poison baits are taken well during the pit holiday weeks.

It seems likely that, in the absence of all other food supplies, the population of rats in a pit would be directly proportional to the number of men. It is known that sewer systems vary a great deal in their capacity to support rats. Bentley (1955) states that sewers which service markets, industrial canteens and restaurants often carry a high rat population. Chitty & Southern (1954) reported that in heavily bombed areas of London the proportion of rat-infested manholes was lower in areas where there was a lower proportion of houses still occupied by people than in less damaged districts.

Together with size of mine as indicated by the number of men goes the extent of pit-head buildings, the number of which correspond quite closely with the size of the pit in terms of manpower.

From the basic facts of a greater percentage of infested pits with more men present, and the converse, it is possible in the light of a study of the grade of organization and the dependence of rats for food upon the waste scraps of the men, providing no other sources are available, to regard the observed differential infestation as being controlled by food and shelter. In addition, however, it is seen that over and above this certain pits exhibit more infestation than others.

Pits in urban surroundings with small numbers of surface workmen have a greater proportion of infestation than all similar-sized pits. There is little information on the relative characteristics of different types of environment in their rat populations, but rats are commonly found in association with man and the shelter and food he provides. Urban areas are commonly infested so it would not be unreasonable to infer from this data that whilst small pits generally have low infestation rates those in urban surroundings could owe their higher infestation to the presence of buildings etc.

It is interesting, but only significant at the 10 % level, to observe that small pits in moorland areas have less infestation than average. The rat population of moorland is probably small and this may be reflected in the infestation.

It is apparent that mine buildings play some part in the infestation, for when small and large pits have no buildings the difference in infestation between them is not so great as when buildings are present. Also, small mines without buildings have significantly less infestation than is common for small mines in general.

It is suggested that the nature of the relationship of infestation and manpower is to some extent in the amount of food scraps thrown away by workmen. This source of food may not be the only one found since a canteen and surface stables are frequently present. The scraps thrown down by the men are in such cases augmented by waste food deposited in or around dustbins and spillage from grain stores and feeding troughs. It is seen that an increased proportion of infested pits occurs in the presence of canteens and stables, and it seems certain that this is in some measure due to the effect of auxiliary supplies of food. That an increase in the amount of available food can contribute to greater rat infestation has been demonstrated by Kirby (1945) who showed how the keeping of backyard poultry and rabbits in Norwich during the war increased rat infestation.

The seemingly anomalous state of affairs in which small pits with modern sanitation have a significantly higher rate of infestation than other small pits, whilst those with primitive methods do not, and also the fact that pits with primitive sanitation and large numbers of surface workmen have a significantly lower infestation than all other large pits is difficult to explain.

Small mines as a rule have few buildings and primitive sanitation but there are mines which have extra buildings attached for various reasons, e.g. the storage of a particular commodity for all mines in the area which entails extra workers not under the control of the mine in question. The extra men may warrant the provision of water lavatories and, together with extra buildings, be responsible for the increased infestation.

Large pits (surface manpower) with primitive sanitation have a significantly lower rate of infestation than all large pits. Unless this again is indicative of the grade of organization it is difficult to explain.

The presence of ponies appears to be correlated with increased infestation in certain classes of pit. This is no doubt a reflexion of the extra food available rather than the presence of ponies *per se*.

A field study of the drift mines of south Yorkshire reveals that there is a differential infestation. This is clearly correlated with the presence of men, as in the national survey, and it appears that the amount of pit-head buildings varies proportionately with the size of the pit in terms of manpower. This being so, then the lack of cover exhibited by the small mines in their surface premises is probably as important as the lack of food and may explain the differential infestation between large and small mines.

Whilst the older type of buildings favour rat habitation, the often extensive amounts of scrap material, when undisturbed, at old mines and particularly at large mines both new and old, have on several occasions been observed to harbour rats.

Orgain & Schein (1953) illustrated how, when garbage was sharply reduced, the rat population was eliminated within 6 months. Davis & Fales (1949) showed that in urban areas there is a positive correlation between the density of the rat population and the proportion of dilapidated buildings, and Davis (1951) showed how, in Baltimore, the improvement of sanitation caused a decline of the rat population in two blocks of 50 % and 75 % respectively.

The census study of a typical drift mine has shown how a rat population may be restored after poison treatments either by the breeding of survivors or the influx of rats from elsewhere. The first treatment consisted of a double poison strike which left a very small residual population. Twelve months later the population was still less than half the size of the pre-treatment population; an increase which can be accounted for by breeding alone. Barnett, Bathard & Spencer (1951) showed that after double or triple strikes in two English villages the rat population took more than a year to recover, and they suggested that it might be 2 years before the population had reached a maximum. In the present case this might also be true, but it was not possible to test it because the risk of underground infestation and consequently of Weil's disease limited such experimental work.

Whilst breeding alone could almost certainly account for the increase in period A the rats present in August and November 1957 had certainly come from outside the area since there were none present in April 1957. Despite a further successful treatment in November 1957 there was another smaller influx between then and February 1958.

Whilst the information is insufficient to state with any certainty that any seasonal movements of rats take place to buildings it does show that re-invasion of cleared areas can take place in a short space of time. Furthermore, despite the fact that rats have succeeded in establishing themselves on the surface twice in 2 years they have not been present underground since December 1955. There is reason to believe from this that careful control of rats in the pit-head buildings would result in preventing underground infestations since the only rats present in the area round the adit have been in pit buildings. The evidence from this survey supports the evidence of the national survey that the greater number of surface buildings and men in large mines is responsible for the increased prevalence of infestation when compared with small mines. The pit-head buildings constitute a suitable site where food and cover may be found, particularly when auxiliary food supplies are present and when situated in certain types of areas. Unless large-scale rat control is practised then clearance of pit-head buildings may be followed quickly by re-invasions so that continual watch must be essential in order to prevent a build up. At certain trouble spots the use of permanent poison-baiting points may be desirable, but in the long run the position must depend on the vigilance of trained operators.

SUMMARY

Questionnaire survey of the drift mines of the British Isles revealed that the presence or absence of rat infestations could be related to the size of the mine in terms of manpower, large mines being more commonly infested than small ones. In addition, various features of drift mines and their surroundings, i.e. the presence of urban areas, nearby rat concentration points, canteen and surface stables, horses, the absence of buildings and the type of surface sanitation are all related to infestation. Field survey has shown that the extent of dilapidation and piling of waste material assists infestation. It has also indicated that the greater infestation of pits with large numbers of workmen is due to some extent to the extra cover provided by the greater number of surface buildings, these being few or lacking altogether in small pits.

At a mine at which changes in the rat population were studied it was seen that unsuccessful poisoning could leave a breeding nucleus of rats, but that there could also be a speedy re-invasion even after successful poison treatments. Whilst the surface rat population in the buildings of this mine was controlled there were no underground infestations. It appears, therefore, that regular inspection and control of surface infestations should in most cases prevent underground infestation.

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