DANISH REVIEW OF GAME BIOLOGY Vol. 8 no. 3

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by
BIRGER JENSEN

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Author's address: Mag. scient. Birger Jensen
Game Biology Station, Kalø,
8410 Rønde, Denmark

Introduction

In 1965 the Game Biology Station began a project of catching and ear-tagging foxes *(Vulpes vulpes* L.), as part of a research-program into the biology of the species (JENSEN 1968, 1969). The main purpose of this marking was to obtain information on the movements of foxes. Such information was important in planning and executing the fox control campaign which has existed in southern Jutland since 1964, the purpose of which is to prevent the spread of rabies further northward into Denmark. The marking campaign was as a whole completed in 1969. In this paper only the methods used and results concerning the movements of foxes will be discussed. Associated features such as age distribution and turnover in the fox population will be discussed elsewhere.

During the 5-year period of the study approximately 500 foxes were marked, and this was mainly due to the excellent efforts of FRODE PEDERSEN (1965–67), FINN JENSEN (1967–68) and ARNULF ARNESEN (1968–69), all now game advisers. With a few exceptions, all tagging was carried out by these three persons. In addition, contact was made with a large number of landowners and owners of shooting rights, who permitted the capture and release of foxes on their land, and who often helped in capturing foxes. Finally a debt is due to the many sportsmen who supplied information on fate of the ear-tagged foxes, or delivered the foxes for further studies on e.g. age criteria.

Material and methods

During the period 1965–1971, 484 foxes were captured, marked, and immediately released at the place of capture (Table 1). In addition, during the same period 26 foxes were captured and marked, and released after different intervals of time at different distances from where they were captured. This latter group is considered in a special section, p. 13.

Experience rapidly proved that it was most advantageous to capture and mark foxes while they were still cubs. The

	Adults – *Voksne*				Cubs – *Hvalpe*				Age? – *Alder?*				Total			
	♂	♀	Sex?	Total	♂	♀	Sex?	Total	♂	♀	Sex?	Total	♂	♀	Sex?	Total
1965					14	17		31					14	17		31
1966		1		1	37	25	4	66					37	26	4	67
1967					35	41		76	2	1		3	37	42		79
1968	1	3		4	51	53	1	105	2			2	54	56	1	111
1969		11		11	101	68		169	1	2		3	102	81		183
1970					3	1		4					3	1		4
1971					5	4		9					5	4		9
Total	1	15		16	246	209	5	460	5	3		8	252	227	5	484

Table 1. The number of foxes marked and released at the same place.
Tabel 1. Antal ræve mærket og frigivet på mærkningsstedet.

work involved in capturing adult foxes was relatively large in relation to the results, whereas the marking of cubs only occupied about 6 weeks in the early summer. In addition, the marking of cubs was preferable as the age of the animals was known.

CAPTURE OF CUBS

460 cubs were marked and immediately released at the same place (Table 1, Fig. 1). 321 of these were dug out from natural earths, 64 were taken in artificial earths, and 66 were taken in pitfalls in front of earths. The remaining 9 were captured by chance by various methods, e.g. captured manually in front of an earth.

In later years, a dachshund was used in digging out cubs from natural earths. It was sent into the earth on a lead, and when it reached the cubs it began to bark. The lead was then tightened so that the dog could not reach the cubs, and by listening at the surface, the dog could be localized and the cubs dug out. This method could only be used when the earth complex was not too large or deep. The terrain and soil of Denmark are generally favourable for digging out fox cubs, but in spite of this many practical problems arose in connection with the work. In addition to planning, the work of 1–2 men was required for over a month each year, and travelling of about 5,000 km. each year.

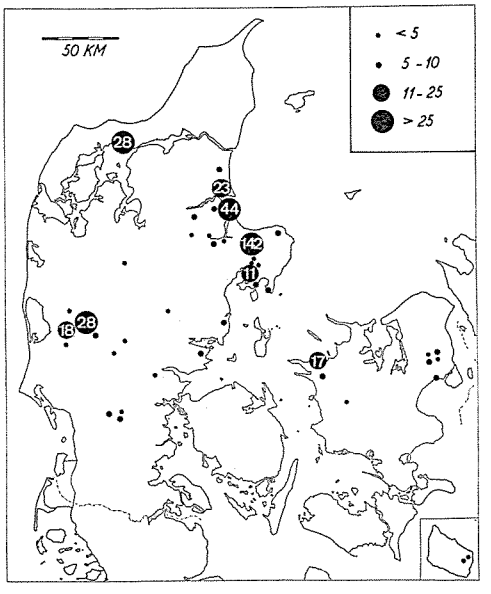

Fig. 1. Localities at which 460 fox cubs were marked during the years 1965–1971.

Fig. 1. Lokalitet for mærkning af 460 rævehvalpe i 1965–1971.

The cubs were marked from the last week of April until the middle of June (April 44 animals, May 364, and June 52). On being tagged over 400 of the cubs weighed between 1 and 3 kg.

In general, foxes moved from the earth complex in which they were captured and released, and in some cases tagged cubs were recaptured at earths situated from a hundred metres to 3 km. from where they were originally captured. It is quite normal for a litter of cubs to be moved and often this is apparently not caused by disturbance. The marking campaign does not appear to have caused any special risk to the cubs.

CAPTURE OF ADULT FOXES

Many different methods of capturing adult foxes were tried, but the amount of work and expense in building and inspecting traps was too great in relation to the results achieved. In addition, it was impossible to prevent other animals

such as dogs, cats, badgers, hares, buzzards and magpies entering and activating the traps. Attempts to force the foxes out of their earths with various methods were also unsatisfactory. Only 16 adult foxes were marked, of which 15 were females taken together with their cubs (Table 1). In addition 8 foxes were captured and marked during the winter, when they could not be determined to age (Table 1).

TAGGING, AND LOSS OF EAR-TAGS

Foxes were marked by affixing a metal tag to each ear (Fig. 2). On recovery information was obtained on whether a fox still bore both tags, and on their position, and in many cases the fox was acquired for investigation.

Normally the tags did not cause the fox any irritation, and traces of infection around the tag were only observed in a few cases. In marking small cubs it was important to place the tag near the edge of the ear to allow for growth of the ear.

By using two ear-tags on each fox, it was discovered that there was a loss of tags. In fox cubs in captivity the loss was observed to be especially due to the cubs biting each other's tags so that they opened out. It was very uncommon to observe that an ear bore traces of a tag having been pulled out. In the beginning two identical aluminium tags were used, and later we experimented by using one aluminium tag and one press-stud tag (Fig. 2). However the latter proved unsuitable, and since then two tags of the same shape as the aluminium tags, but made of the harder monel metal, have been used (supplied by I. Ö. Mekaniska, Bankeryd, Sverige).

Though the problem of tag loss in the red fox has been mentioned by some authors (LUND 1967, MARCSTRÖM 1968) only FAIRLEY (1969) seems to have made any calculations. He found from a total of 14 adults and 33 cubs recaptured that the probable number of adults losing both tags (lost recoveries) was 0.20 and cubs 0.22.

Some data illustrating the tag loss in the present material is given in Table 2. Only foxes tagged as cubs and recovered in their first year of life have been considered here.

FAIRLEY (1969) calculated the number of foxes recaught with both tags missing from the formula:

$$N_3 = \frac{N_2^2}{4N_1} \quad (1)$$

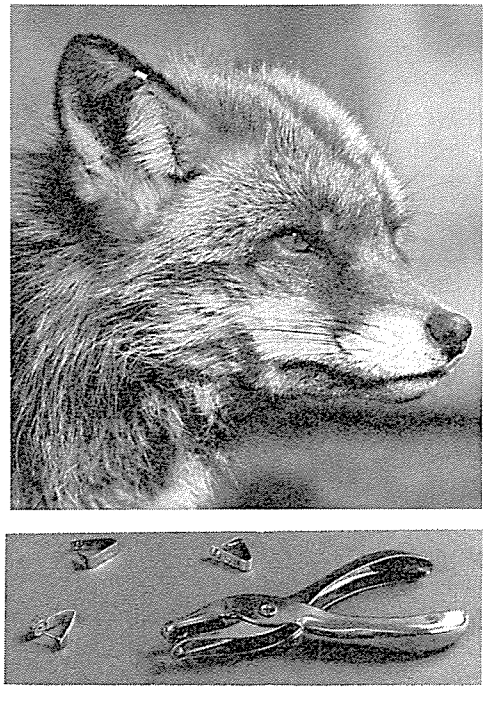

Fig. 2. An ear-tagged fox, and the kinds of tags used and the pliers for affixing them.

Fig. 2. Øremærket ræv og de anvendte mærketyper samt tangen til påsætning af klipsene.

and the probability of any tag being lost from the formula:

$$\hat{p} = \frac{N_2 + 2N_3}{2\,(N_1 + N_2 + N_3)} \quad (2)$$

Where N_1 is the number of foxes recaught with both tags intact,
N_2 is the number of foxes recaught with one tag missing,
N_3 is the number of foxes recaught with both tags missing.

When two tags of different kind have been applied formula (1) can be extended to:

$$N_4 = \frac{N_2 \times N_3}{N_1} \quad (3)$$

Where N_1 is the number of foxes recaught with both tags intact,
N_2 is the number of foxes recaught with one kind of tag missing,
N_3 is the number of foxes recaught with the other kind of tag missing,
N_4 is the number of foxes recaught with both tags missing.

The probability of any aluminium tag or any monel tag being lost from a cub during its first year of life was 21.3 % and 5.1 % respectively. The monel tag therefore proved to be the best.

There seems to be an increase in the loss of tags with increasing age of the fox at recovery but only for the groups given in Table 2 are the data available satisfactory for calculations. However the total number of recoveries lost in this project because of loss of ear-tags has been estimated to only a few percent of the total number of recoveries.

LORD (1956) found a comparable loss of ear-tags in the gray fox *(Urocyon cinereo-argenteus)*. Of 100 foxes marked with two ear-tags, 33 were recovered and of these 10 had lost one of their tags. Calculated as above this gives 1.1 lost recovery and a probability of any tag being lost of 18 %.

It is thus evident that more than a single tag should always be used. In using only one tag, some recoveries will become unobtainable, and it will also be impossible to calculate the number of tags lost and make a correction for this. This latter factor is very important in appraising the recovery percentage in different studies and in calculations of mortality. When data does not include information on the kind of tag used, the value stated for percentage recovery should not be relied upon, e.g. in consideration of the shooting pressure in the area in question.

	Kind of tags used *Anvendte mærketyper*					
Number tagged *Antal mærkede*	2 Al	117	2 Mo	177	1 Al+1 Mo	92
Number recovered *Antal genmeldt*	2 Al	24	2 Mo	47	1 Al+1 Mo	26
	1 Al	13	1 Mo	5	1 Al	1
					1 Mo	8
	Total	37	Total	52	Total	35
Loss of recoveries *Mistede genmeldinger*	1.76		0.13		0.31	

Table 2. Examples of tag loss for two different kinds of tags and for a combination of them. Only foxes tagged as cubs and recovered in their first year of life have been considered. Al denotes tags of aluminium, Mo tags of monel.

Tabel 2. Eksempler på mærketab ved brug af to forskellige mærketyper og en kombination af disse. Kun ræve mærket som hvalpe og genmeldt i første leveår er medtaget. Al betyder mærker af aluminium, Mo mærker af monel.

PERCENTAGE RECOVERY

The number of recoveries in different age classes of foxes tagged as cubs is given in Table 3. Foxes recovered before the end of February in the year following their birth are classified as < 1 year, those recovered after that but before the end of February in the second year are classified as 1–2 year, etc. The percentage recovery varies somewhat from year to year and from place to place. Per September 1 1972 202 (44 %) of the 460 tagged cubs have been reported and by the time when further recoveries can no longer be expected, the total percentage reported will be just over 45 %.

24 foxes were marked as full grown during 1966–69, and by September 1 1972 15 of these (63 %) had been reported.

The percentage recovery reported represents the minimum number of marked foxes which again have passed through human hands. As mentioned on p. 6, loss of tags has probably caused that a few percent of the recoveries have not been recorded. In addition, it is probable that a few sportsmen who shot tagged foxes have not reported them, in spite of the fact that a reward of 50 Danish crowns is paid for a recovery, as announced in shooting magazines and the daily press. Further the ear-tags are not conspicuous and may easily be overlooked, especially if the fox is not skinned, or is even left out in the field. Finally, some foxes which are shot are not found and some are crippled and die later without being found. From experience with recovery records, it is probable that the last three factors have some effects, but it is not possible to estimate their importance on the percentage recovery.

Years of tagging *Mærkningsår*	Tagged *Mærket*	Recovered *Genmeldt*	Age class *Aldersklasse*
1965–71	460	140 (30 %)	<1 year/*år*
1965–70	451	39 (8 %)	1–2 year/*år*
1965–69	447	15 (3 %)	2–3 year/*år*
1965–68	278	3 (1 %)	3–4 year/*år*

Table 3. Recoveries in different age classes of foxes tagged as cubs.

Tabel 3. Genmeldinger i de forskellige aldersklasser af ræve mærket som hvalpe.

Recoveries of foxes marked as cubs

460 foxes were marked as cubs and immediately released at the point of capture (Table 1), and of these 202 (44 %) were recovered by September 1 1972. These recoveries have an advantage over recoveries of foxes marked as adults, as the age of the cubs on recovery is known. However, in considering the movements of foxes, it should be born in mind that no direct knowledge is available on the time at which a fox arrives at its point of recovery or how it reaches there. Neither can it be ascertained whether a fox which is recovered was passing through the area or had settled at the place of recovery.

CAUSES OF MORTALITY

With a few exceptions information was available on the cause of death for the 202 foxes recovered. The absolutely dominant recovery factor was shooting, as

177 (88 %) were shot, while 15 (7 %) were killed in accidents and 10 (5 %) were found dead from unknown reasons (but not from shooting, as they did not contain lead-shots).

The most direct kind of fox-shooting is at the earth itself and a total of 35 animals (17 %) were shot in this way. Approximately 50 animals (25 %) were taken in forms of shooting such as beating, in which several kinds of game are expected, including fox. A comparable number, 45 (22 %), were taken in shoots, which mainly covered fields and other open country, where the presence of foxes is generally less expected. About 30 (15 %) were shot by chance during shooting for a particular species, e.g. 12 during deer-stalking, 9 in pigeon shooting, 4 in duck-shoots. 15 (7 %) were shot incidentally, e.g. during dog-training, at rubbish dumps, in henhouses, pheasantries, or on returning from a shoot etc.

10 foxes (5 %) were found killed by motor vehicles. Of these, 7 cubs or young foxes were killed during June–December, and 3 were 1-year old. One cub and one adult female fox was killed by a harvester and one cub injured by a flail mower. Two cubs of 2.1 and 2.5 kg. were killed by dogs in June.

The above review only considers the different causes of death for the 44 % of the marked cubs which have been recovered. Some of the remaining cubs are still alive, but for more than half of the cubs, nothing will ever be known of their fate. However, it is accepted that only a small proportion of these have, or will be found, by humans.

THE TIME OF RECOVERY

The distribution of recoveries over the months of the year is given in Tables 4 and 5, for animals recovered in their first year or recovered later, respectively. In general, the results reflect the course of fox-shooting through the year, but two factors should be emphasized.

During 1965–67 foxes could legally be shot throughout the year, but with the Game Law of June 1967, the shooting season was limited to June 16–February 29. However, protection during the breeding period does not completely hinder the shooting of adult foxes. Furthermore, during the protected period it is permitted to destroy earths as long as the young are also killed. This latter point is taken advantage of by some sportsmen but does not affect the results in Table 4, as cubs were only marked in areas where the owners of the shooting rights had agreed that they should be left undisturbed until they could leave the earth and fend for themselves.

In addition, the seasonal distribution of the recoveries should be compared with the mortality causes described above. For instance, shooting at earth is done almost exclusively during the winter, and 32 of the 35 animals shot at earths were recovered during the period November–February (November 6, December 10, January 9, February 7). The many recoveries during October and November reflect the intensive shooting activity which occurs in these months especially, on such species as roe deer, hare, pheasant and partridge, and in which foxes are also shot. A more detailed description of the age and sex distribution of the shooting yield of foxes during the year will be given elsewhere.

Distance *Afstand*	Month of recovery – *Genmeldingsmåned*																							
	Month?		June		July		Aug.		Sept.		Oct.		Nov.		Dec.		Jan.		Feb.		Total			
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂+♀
< 5 km.		1	4	1	6	3	7	4	5	3	13	10	5	6	2	6	3	7		4	45	45	90
5–14 km.													5	3	3	1	5	1	3		16	5	21
15–25 km.											2		1		2	1			2	2	7	3	10
> 25 km.									1		3	2	3	1	5		2			2	14	5	19
Total ♂ & ♀	0	1	4	1	6	3	7	4	6	3	18	12	14	10	12	8	10	8	5	8	82	58	140
Total ♂ + ♀	1		5		9		11		9		30		24		20		18		13		140		

Table 4. The time and distance of recovery of 140 foxes marked as cubs and recovered during their first year of life.

Tabel 4. Genmeldingsafstand og -måned for 140 ræve, mærket som hvalpe og genmeldt i deres første leveår.

THE DISTANCE OF RECOVERY

The distance of recovery of foxes aged less than or more than one year during each month is given in Tables 4 and 5 respectively.

It is seen from Table 4 that up to and including the month of September, all cubs and young foxes with one exception were recovered at a distance of less than 5 km. from the point of marking. However, one recovery at 50 km. on September 28 and two recoveries at 20 km. and 35 km. on October 1 indicate that dispersal of young foxes over greater distances already begins in September. From October until the end of the year, a steadily increasing percentage are recovered from greater distances. In October 28 % of the male foxes and 17 % of the females were recovered 5 km. or more away from the point of marking. For November–December, the corresponding figures are 73 % and 34 %, and for January–February 80 % and 31 %.

Comparing the distances of recovery of foxes less than one year old in January and February (Table 4) with those for all foxes recovered of more than one year of age (Table 5), the distribution is seen to be almost the same. For male and female foxes of more than one year, 81 % and 35 % respectively were recovered at a distance of 5 km. or more from the point of marking, which are about the same values as those found for the corresponding sexes of less than one year of age in January and February (80 % and 31 % respectively). This indicates that no further dispersal of importance takes place in the young foxes, after they begin to breed for the first time in January at about 10 months of age.

As is explained above, there is a considerable difference in the degree of dispersal of young male and female foxes (Table 4). This is illustrated graphically for all recoveries by September 1 1972 in Fig. 3, in which the cumulative number of recoveries at 5 km. intervals is shown. For example a total of

Distance *Afstand*	Month of recovery – *Genmeldingsmåned*																											
	March		April		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.		Jan.		Feb.		Total			
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂+♀
< 5 km.		1				2	1	1		1		1	1	2		2		6	2		1	1	1	3	6	20	26
5–14 km.							2	2	3	1	1			1	4		1	1	1	1	3		1	1	16	7	23
15–25 km.			1				1	1		1					1		1			1		1	1		5	4	9
> 25 km.			1		1								1		1										4	0	4
Total ♂ & ♀	0	1	2	0	1	2	4	4	3	3	1	1	2	3	6	2	2	7	3	2	4	2	3	4	31	31	62
Total ♂ + ♀	1		2		3		8		6		2		5		8		9		5		6		7		62		

Table 5. The time and distance of recovery of 62 foxes marked as cubs and recovered after their first year.

Tabel 5. Genmeldingsafstand og -måned for 62 ræve, mærket som hvalpe og genmeldt efter første leveår.

55 % of the males were recovered less than 5 km. from the point of marking, whereas the corresponding value for females was 78 %. Although females show lesser tendency to disperse there are cases where females have moved just as far as those males which moved furthest away. A total of 5 of the 202 foxes recovered moved further than 50 km. away from the point of marking, and of these, three males covered 55, 92 and 110 km., while two females covered 112 and 140 km. All were shot during their first year of life, the three males in December of the year in which they were marked, and the two females in February of the following year.

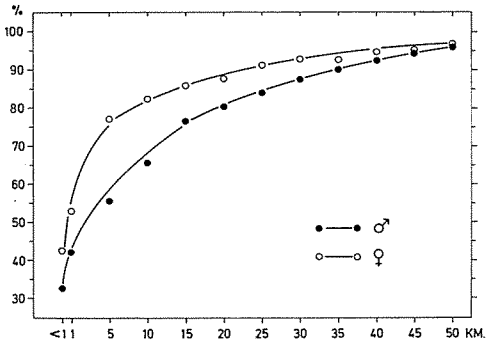

Fig. 3. The percentage proportion of foxes less than one year of age, recovered at different distances from the point of marking.

Fig. 3. Procentdelen af ræve under 1 år gamle, der er genmeldt indenfor forskellig afstand fra mærkningsstedet.

All recoveries from 5 km. or more during the first year of life are illustrated in Fig. 4 and the map provides an immediate impression of the relatively large distances covered by occasional individuals. Although it is not known to what extent foxes follow a particular direction, the actual number of kilometres covered certainly exceeds the straight-line distance given by a considerable amount. Furthermore, the two foxes which moved southwards from western Jutland to southern Jutland and Schleswig (North Germany) prove that the streams in Denmark do not form a barrier to their movements, the foxes having swum over or else crossed a bridge.

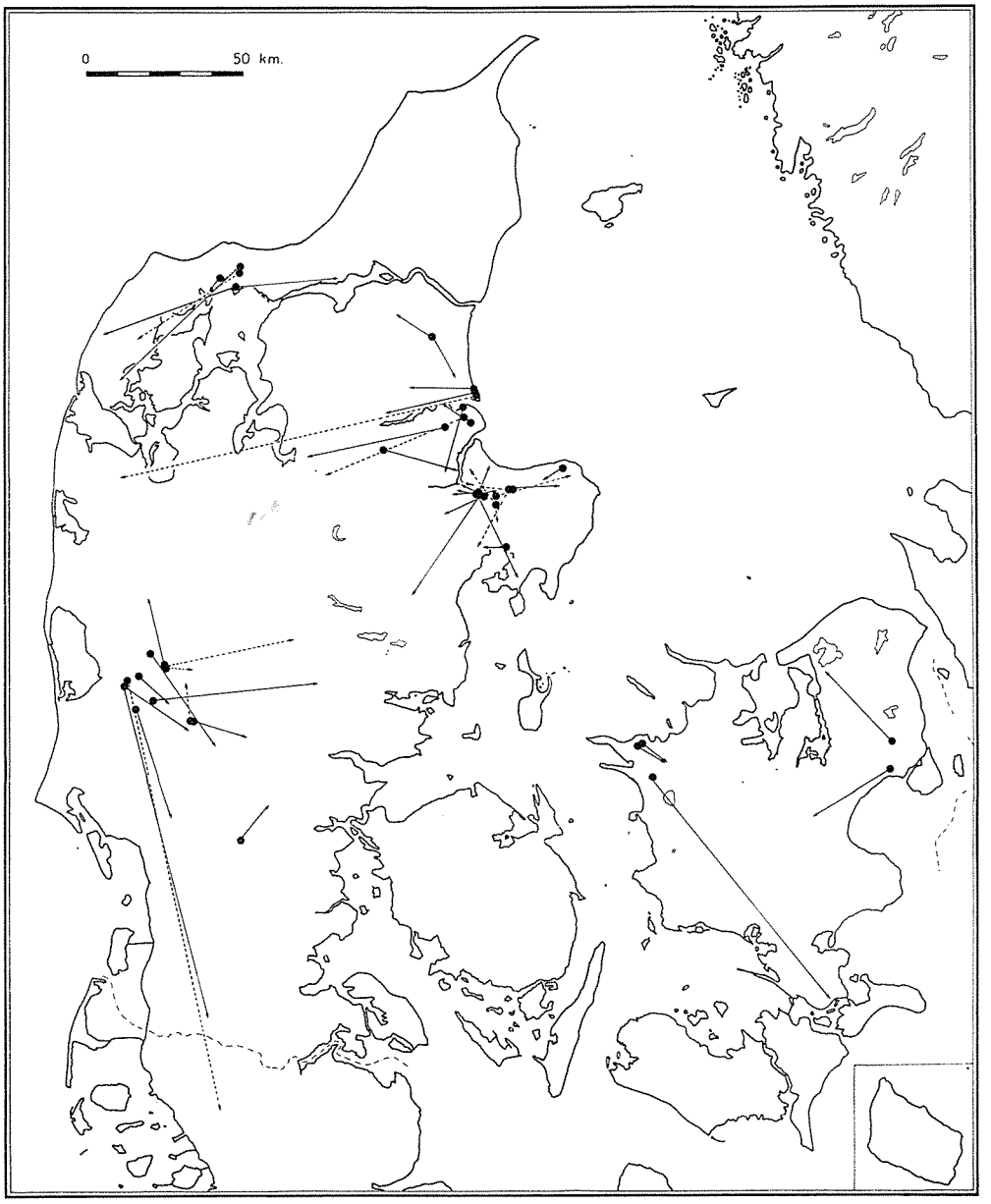

Fig. 4. Recoveries of foxes in their first year which moved 5 km. or more away from the point of marking.

Fig. 4. Genmeldinger i første leveår af ræve, der har fjernet sig 5 km eller mere fra mærkningsstedet.

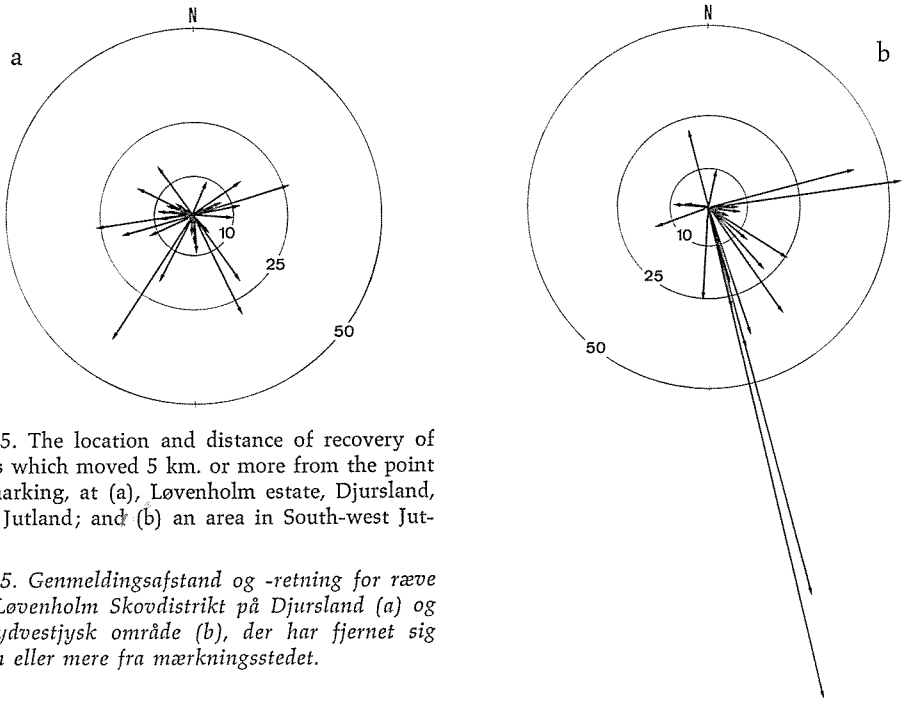

Fig. 5. The location and distance of recovery of foxes which moved 5 km. or more from the point of marking, at (a), Løvenholm estate, Djursland, East Jutland; and (b) an area in South-west Jutland.

Fig. 5. Genmeldingsafstand og -retning for ræve fra Løvenholm Skovdistrikt på Djursland (a) og et sydvestjysk område (b), der har fjernet sig 5 km eller mere fra mærkningsstedet.

It is altogether only possible to obtain a superficial idea of the movements of foxes from recoveries of ear-tagged animals. A better idea of details in movement patterns will certainly be obtained by telemetric investigations in the future.

In some cases the topography of the land may have affected the direction and distance of movement; for example, it is possible that a fox stops its movements on reaching the coast, or that it changes direction. There were only sufficient recoveries from two areas to allow comparison of the results. Distances of recovery of 5 km. or more are shown in Fig. 5a for 25 cubs marked on Løvenholm estate, Djursland, East Jutland. The corresponding data on 21 cubs marked in an area of South-west Jutland are shown in Fig. 5b.

A total of 61 of the cubs marked at Løvenholm have been recovered, and 36 of these (59 %) were recovered at less than 5 km. from the point of marking. Similarly 32 of the cubs marked in the South-west Jutland area have been recovered, but only 11 (34 %) of these were recovered at less than 5 km. from the point of marking. This noticeable tendency towards a greater dispersal in the foxes of western Jutland is also evident in distances of more than 5 km. (Figs. 5a, 5b). Furthermore, it is striking that whereas the foxes at Løvenholm disperse in a fairly uniform radial manner from the forest area, there are relatively many recoveries from the south-eastern sector of foxes in South-west Jutland. Amongst other factors, those of age and sex distribution, shooting pressure, topography, and possible differences in population density could all affect the direction of migration and the distance covered. At the same time shooting pressure could also affect re-

covery rates in different sectors. However, it is at present not possible to emphasize any particular factor on the basis of the data available. The example given here was chosen to illustrate the danger of making generalizations from the data obtained in a single area, and also to illustrate that certain variations exist which might be investigated more closely in the event of sufficient data being available.

Recoveries of foxes marked as adults

As explained previously, only a few adult foxes were marked (Table 1). One adult male fox was marked on May 20 1968, and shot on June 3 of that year, about 2 km. from the point of marking. A total of 15 females were marked during May and June; these animals were all obtained during the capture and marking of cubs. 9 of these females (60 %) were recovered by September 1 1972. All of the females were shot, 8 of them at a distance of up to 4 km. from the point of marking and one at a distance of 11 km. 6 of the animals were recovered in the same year that they were marked, 2 in the following year and one after the duration of two years.

In addition, a female which was marked as a cub on May 13 1966 was recovered in March 1968 about 2 km. distant from the point of marking, and it was shot on November 8 1968 at the same artificial earth at which it was recorded in spring.

8 foxes were captured and marked during the period November–March (Table 1), when it was not possible to determine whether the animals were juveniles or adults. 3 males and 2 females of this group were recovered by September 1 1972, and were shot at a distance of up to 4½ km. from the point of marking. Of these 4 were recovered in the same year as they were marked, and one in the following year.

Thus, of a total of 24 foxes which were marked during 1966–69 as full grown, 15 (63 %) were recovered by September 1 1972. Only one of these animals was found at a distance of more than 5 km. It is not possible to form any final conclusions on the basis of the few data available, but in general adult foxes do not seem normally to leave the area in which they have already settled and reproduced.

Recoveries of foxes transported before release

On a few occasions, it was not possible to release marked foxes at the point of marking. 26 foxes were involved and 11 of these were recovered. However, only a few of the cases will be described here.

Two female foxes which had cubs were marked in April 1967. One was transported about 25 km. from northern Djursland to Kalø where it was released, and in February 1969 it was taken in a trap and its tag recorded, a few hundred yards from the point of release. The other was released at Borris in western Jutland about 6 km. south of the place at which it was captured. In January 1969 it was shot about 8 km. north-

west of the release point and 4 km. west of the point at which it was originally captured.

PHILLIPS & MECH (1970) mention an adult female fox, which was captured on November 15 in Iowa, U.S.A., released the same day 36 miles (56 km.) to the south-west, and captured 12 days later less than 1/4 mile from its original place of capture. In contrast, MARCSTRÖM (1968) did not find any tendency to return to the place of capture in 35 foxes recovered, after they were transported distances from a few to over 100 km. However, a considerable number of these animals were marked while young in July–September, at which time no strong association with the home area would be expected.

On May 16 1967, 5 cubs were dug out in Vendsyssel (North Jutland), and kept in captivity until July 10, when they were released together in Hestehave Forest at Kalø. The litter was a late one, as the cubs only weighed about 1/2 kg. on capture. On being released in July, they all weighed about 3 kg. In December of that year, a female from this litter was shot 1/2 km. from the point of release, while in January 1968 a second female was shot 1 km. from the release point and a male shot 5 km. to the east. In February a third female was shot just under 1 km. away from the point of release. The last of the 5 cubs was a male and it has not been recovered.

10 cubs from different litters were dug out during May 1967 at different places in Jutland. They were kept in captivity until June 10, when they were released together at Borris in West Jutland. Only one of these animals, a female, has been recovered; it was shot at a poultry farm on June 26, 4 km. away from the release point. On release the cubs weighed about 2 1/2 kg., and the animal recovered was the heaviest of them all at 2.7 kg.

Furthermore a male cub of almost 3 kg. was released at Borris on June 1, 50 km. distant from where it was captured, and recovered in October of the same year about 7 km. away from the point of release. However, a cub of 2 kg. which was captured in a hen-house in Djursland and released nearby has not been recovered.

The above examples of cubs which have not been in contact with their parents after being tagged indicate that fox cubs are able to fend for themselves if they weigh about 3 kg. at the age of 2–3 months. Most cubs will have reached this weight by the beginning of the open season for foxes in Denmark on June 16, but if a female fox with cubs is shot before July 1, there is some risk that the cubs will not survive. For comparison it can be mentioned that ERRINGTON & BERRY (1937) reported that of 236 cubs which were released in Iowa, U.S.A. as »three-fourths grown« in May and early June, only 17 (7.2 %) were recovered. The majority of the cubs released were presumably too small to fend for themselves.

Discussion

The results of the marking of foxes in Denmark are in general agreement with the results obtained in studies in other countries (JENSEN 1968). However, a closer comparison is made more difficult by the fact that in most cases not very much data is available from literature, and that the information given on age

Country *Land*	No. marked *Antal mærkede*	No. recovered *Antal genmeldt*	% recovery *% genmeldt*	Categories marked *Kategorier mærkede*	Source of information *Kilde*
EUROPE					
Norway	62	14	23	cubs, subad., ad.	LUND 1967
Sweden	163	59	36	cubs, subad., ad.	MARCSTRÖM 1968
Ukrainian SSSR	126	26	21	cubs	TCHERIKOVA 1955
Germany	?	50			BEHRENDT 1955
Denmark	24	15	63	subad., ad.	This study
	460	202	44	cubs	
Netherlands	98	22	20	cubs	VAN HAAFTEN 1970
UK (Wales)	21	8	38	cubs	LLOYD 1968
Ireland	55	21	38	subad., ad.	FAIRLEY 1969 & 1970
	63	37	59	cubs	
NORTH AMERICA					
Iowa	236		7	cubs	ERRINGTON & BERRY 1937
Iowa and Illinois	926	367	40	899 cubs, 27 ad.	PHILLIPS et al. 1972
New York	120		33		SHELDON 1950 & 1953
Michigan	37		54		ARNOLD & SCHOFIELD 1956
North Dakota	179	44	25		DONAHOO 1962

Table 6. Markings and recoveries of red foxes.

Tabel 6. Mærkninger og genmeldinger af ræve.

and sex, numbers and time of release and recovery, and whether transportation was involved, is scanty and incomplete (Table 6). The results of this study will therefore mainly be discussed in relation to the rabies problem.

The greatest variation from one study to another is apparently to be found in the percentage recovery, which ranges from 20 % to 63 %. However, it must be remembered that in most cases the proportion of tags lost is unknown, and that some of the data has been published while further recoveries might still be expected. In addition, the percentage recovery is affected by the degree of interest shown by the populace, and by the amount of publicity the study has been given.

As most of the foxes recovered were shot, the percentage recovery no doubt very much reflects the shooting pressure in the different areas. On average this appears to be high, which certainly explains a good deal of the fact that bonus systems for foxes killed have not generally led to the intended reduction in the fox population. In many places, fox shooting is carried out so intensively that no considerable increase would be caused by the operation of a bonus system. It should be emphasized at the same time that although the percentage recovery in Denmark is among the highest found, the annual yield of foxes shot has doubled over the last 25 years from about 25,000 to over 50,000 (STRANDGAARD 1967). This indicates that the fox population has been able to expand in spite of the high and increasing shooting pressure.

The movements of foxes are important in two ways for the control of rabies; firstly, it is necessary to know

how far an infected fox can transmit the disease, and secondly to what extent immigration into areas in which the fox population has been reduced can occur, and at what time of year it may be expected.

With regard to transmission of the disease, marking of foxes in Denmark indicated that less than 1/4 of the fox cubs recovered moved more than 15 km. from their birthplace, although a small proportion moved over 100 km. away (Fig. 3). Presuming that a rabies-infected fox behaves in the same way as a healthy one, there is a theoretical possibility that a single animal could transmit the disease over a distance of 100 km. The risk can however only be a small one, as it requires that one of the few foxes which cover a great distance becomes infected just before or during its travels, and that the disease does not break out and stop the fox. In practice it has also been found that a rabies epizootic normally spreads by about 25–50 km. annually without sudden increases (cf. TOMA & ANDRAL 1970).

With regard to immigration into areas containing reduced populations of foxes, it is generally due to say that immigration of young foxes can occur from the beginning of October, and that it normally ceases round New Year. However, the immigration of adult foxes is negligible in terms of control measures.

No foxes were marked in or immediately north of the area in southern Jutland in which intensive fox control has been carried out for some years, by various means, particularly gassing the earths. The lower fox population density in the control area might be expected to cause the foxes outside the control area not to disperse more or less radially, but instead to migrate into the less-densely occupied area. However, only those foxes which frequent the limit of the thinly populated area become acquainted with and are attracted to the improved habitat conditions there. In addition, the control work has also shown that immigration is mainly into the narrow margin of the control area close to areas with higher population densities of foxes. For example the uneven dispersal of foxes in western Jutland, illustrated in Fig. 5b, can hardly be connected with the control efforts in southern Jutland. Only the two foxes which migrated furthest came into the control zone 75 km. to the south in which the fox population had been considerably reduced, and one of them moved 35 km. into the zone, while the other traversed it, a distance of 40 km.

It can also be emphasized that the further foxes move from the point of marking, the relatively larger the area over which they disperse. Thus while the 90 foxes (64 %) recovered during their first year of life less than 5 km. from the point of marking disperse over a circle with an area of about 80 km², the 21 foxes (15 %) which moved 5–14 km. away disperse over an annulus with an area of about 625 km²., and the 10 foxes (7 %) which moved 15–25 km. away disperse over an annulus with an area about 1250 km². Thus the density of recoveries in the 5–14 and 15–25 km. annulus is only about 1/30 and 1/150 respectively of the density inside the 5 km. limit.

In Fig. 6, the percentage proportion of the total number of recoveries which occur within different distances can be read off from the solid line. For instance, 72 % are recovered within a distance of 10 km. or less from the point of marking, and 91 % within a distance of 25 km. or less.

It was previously mentioned (p. 10)

that young male foxes on average disperse further than young females, and thus the curve describing the total dispersal of the population will be dependent on the sex distribution of the population. Of 455 cubs marked 54 % were males; of 140 foxes recovered in their first year 58 % were males, and of 62 of more than one year of age recovered, 50 % were males. There thus appears to be a slight excess of males.

Curves are also given in Fig. 6 for the distance of recovery of 140 foxes recovered in their first year, and 62 foxes recovered subsequently. As would be expected, there are relatively fewer recoveries from distance up to 10 km. of foxes more than one year of age than of those in their first year of life. Unexpectedly enough, on the other hand relatively more foxes less than one year of age were recovered from distances of over 25 km. For example, of the 140 animals of less than 1 year, 18 (13 %) were recovered from distances of more than 25 km., whereas only 1 animal (2 %) of the 62 of more than 1 year of age was recovered at this distance. It is difficult to account for this, but perhaps the risks connected with movement over longer distances are so great that few foxes survive for more than a year. The dispersal of the total population is therefore also dependent on the age distribution of the population and consequently on the shooting pressure.

The greatest source of uncertainty in considering dispersal in a fox population does not however lie in such factors as age and sex distribution in the population. It is rather to be found in the question of the fate which overtakes half of the marked cubs, which are never recovered. It is theoretically possible that they all die while young and before leaving their place of birth, or that they all migrate and completely avoid coming into contact with humans. The real explanation no doubt lies somewhere in between these two extremes; however, in relation to the control of foxes the problem about the possible movements is not important. In all events, from the solid line curve in Fig. 6 it is possible to estimate the increase or decrease in the percentage of the fox population affected, if the width of the control zone is increased or decreased.

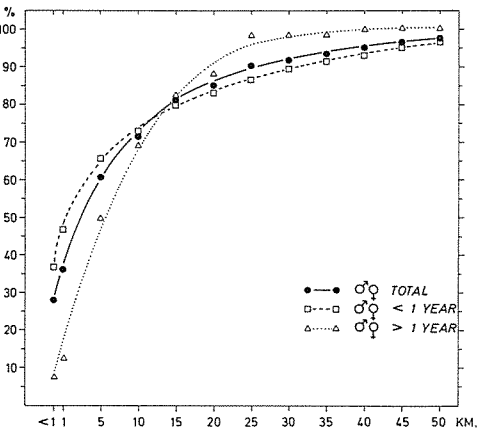

Fig. 6. The percentage proportion of foxes recovered at different distances from the point of marking.

Fig. 6. Procentdelen af ræve, genmeldt indenfor forskellig afstand fra mærkningsstedet.

Dansk resumé

Rævens vandringer i Danmark belyst ved øremærkning

I årene 1965–1971 blev der forskellige steder i Danmark mærket i alt 484 ræve, der straks efter fangst og mærkning blev frigivet på fangststedet (fig. 1, tabel 1).

460 af rævene blev mærket som hvalpe, og de fleste af disse blev gravet ud i maj måned og vejede 1–3 kg.

Ved mærkningen benyttedes forskellige typer øremærker (fig. 2). Da rævene altid fik et mærke i hvert øre, var det muligt ud fra genmeldinger af mærkede dyr at få et indtryk af mærketabet. Mærkerne af klips-typen var bedre end mærket af trykknap-typen, og den hårde klips af monel var bedre end den blødere af aluminium. Af monel-mærkerne var der kun et tab på nogle få procent, og det kan beregnes, at i alt nogle få procent genmeldinger ikke er blevet registreret, fordi rævene havde mistet begge øremærker.

Af de 460 mærkede hvalpe er der pr. 1. september 1972 genmeldt 202 (44%), og der kan kun yderligere ventes et par procent genmeldinger, da genmeldingsprocenten falder stærkt med stigende alder (tabel 3). Der er f. eks. genmeldt 30 % af de mærkede hvalpe i 1. leveår, men kun 1 % er blevet genmeldt som 3–4 år gamle. Af 24 ræve mærket som voksne i 1966–1969 er der pr. 1. september 1972 genmeldt 15 (63 %).

88 % af de genmeldte ræve er skudt, mens 7 % er omkommet ved uheld f. eks. trafikdræbt, og 5 % er fundet døde af ukendt årsag. Blandt de skudte ræve er 17 % nedlagt ved gravjagt, ca. 25 % ved klap-, tryk- og drivjagt, ca. 22 % ved anden jagt på flere vildtarter, ca. 15 % tilfældigt under jagt på en bestemt vildtart f. eks. under bukkejagt, duejagt eller andetræk, og 7 % er ikke skudt under egentlig jagt, men nedlagt i hønsehus, ved opdræt, under hundetræning o.s.v. Betydningen af den almindelige jagtlige aktivitet for genmeldingen af ræve viser sig også i disses fordeling på årets måneder (tabel 4 og 5). Særlig udpræget er det store antal unge ræve, der genmeldes i oktober og november, mens genmeldingerne af ræve over 1 år er mere jævnt fordelt over året.

Genmeldingsprocenterne giver kun et minimumstal for, hvor mange af de mærkede ræve der kommer i menneskehænder. Enkelte ræve har tabt øremærkerne, og man kan overse mærkerne på den døde ræv, og i nogle tilfælde bliver der nok ikke indsendt oplysninger om, at der er skudt eller fundet en mærket ræv.

Genmeldingsafstandene i de enkelte måneder viser, at unge ræve sidst i september kan begynde at forlade egnen, hvor de er født, og i løbet af efterårsmånederne stiger den gennemsnitlige genmeldingsafstand (tabel 4). I januar–februar synes der ikke at ske væsentlig yderligere spredning af de unge ræve. Genmeldingsafstanden for ræve over 1 år (tabel 5) fordeler sig omtrent som genmeldingsafstandene for de knap 1 år gamle ræve, og det tyder sammen med de få genmeldinger, der foreligger af ræve mærket som voksne, på, at disse ikke forlader den egn, hvor de har slået sig ned, for at yngle første gang som 1-årige.

Gennemgående foretager hanrævene de største vandringer (fig. 4), men af 5 ræve genmeldt over 50 km fra mærkningsstedet, havde 3 hanner tilbagelagt 55, 92 og 110 km, mens 2 hunræve havde fjernet sig henholdsvis 112 og 140 km fra mærkningsstedet. Sådanne lange vandringer er dog undtagelser, idet 85% af hunrævene og 75 % af hanrævene under 1 år er genmeldt mindre end 15 km fra mærkningsstedet (fig. 3).

Den samlede spredning, der foregår i en rævebestand, afhænger af alders- og kønsfordelingen i bestanden (fig. 3 og 6), men der synes også at gøre sig lokale forskelle gældende, som måske kan skyldes forhold i terræn, bestandstæthed eller jagttryk (fig. 5).

Резюме на русском языке

Кочевание лисицы *(Vulpes vulpes* L.) в Дании, выясненное при помощи пометки на ушах

С 1965 по 1971 г. в разных местах Дании было помечено общим числом 484 лисицы, немедленно после поимки и пометки выпущенных на свободу на месте ловли (фиг. 1, табл. 1). 460 лисиц были помечены, будучи молодыми, и большинство их было вырыто из нор в мае месяце. Вес их составлял от 1 до 3 кг.

Для пометки применялись разные типы меток на ушах (фиг. 2). Так как лисиц всегда снабжали меткой на каждом ухе, по сообщениям о помеченных животных было возможно составить себе мнение о потере меток. Метки в виде скрепок оказались более целесообразными, чем метки кнопочного типа, а жесткие скрепки из монель-металла лучше более мягких скрепок из алюминия. Потери меток из монель-металла составляли только немного процентов, и можно вычислить, что только немногие из сообщений не были зарегистрированы вследствие потери лисицами меток с обоих ушей.

Из 460 помеченных молодых лисиц, до 1 сентября 1972 г. были получены сообщения о 202 (44%), и в дальнейшем можно ожидать только около 2% добавочных сообщений, так как процент сообщений по мере старения лисиц резко понижается (табл. 3). Например, получены сообщения о 30% помеченных молодых лисиц в течение первого года их жизни, но только об 1% получены сообщения по достижении 3–4 летнего возраста. Из 24 лисиц, в 1966–1969 г. помеченных взрослыми, до 1 сентября 1972 г. получены сообщения о 15 особях (63%).

88% из лисиц, о которых получены сообщения, были застрелены, 7% погибли от несчастных случаев, напр. убиты автомашинами, а 5% найдены мертвыми по неизвестным причинам. Из застреленных лисиц, 17% были убиты при охоте на лисиц в норах, прибл. 25% при облавах или травлях, прибл. 22% при других родах охоты на дичь нескольких видов, прибл. 15% были убиты случайно во время охоты на определенный другой вид дичи, напр. косуль, голубей или уток, а 7% не были убиты собственно на охоте, а в курятниках, на участках, где разводятся фазаны или другие виды птиц, или в связи с дрессировкой собак и т. п. Значение общей охотничей деятельности для сообщений о лисицах отражается также и в распределении по месяцам года (табл. 4 и 5). Особенно значительно количество молодых лисиц, о которых получаются сообщения в октябре и ноябре, между тем как сообщения о лисицах старше 1 года более равномерно распределены по всему году.

Проценты сообщений дают указание только о минимуме количества лисиц, попадающих в человеческие руки. Некоторые из лисиц потеряли метки с ушей, на убитой лисице метки можно не заметить, а в некоторых случаях может быть не послано сообщение о том, что была убита или найдена помеченная лисица.

Расстояния, с которых в отдельные месяцы получены сообщения, указывают на то, что молодые лисицы в конце сентября способны уходить из местности, в которой они родились, и в течение осенних месяцев увеличиваются расстояния, с которых приходят сообщения (табл. 4). В январе-феврале кажется, что молодые лисицы дальше уже не рассеиваются. Расстояния, с которых получаются сообщения о лисицах старше одного года (табл. 5), распределяются приблизительно так же, как расстояния сообщений о лисицах почти однолетнего возраста, и вместе с небольшим числом сообщений, имеющихся о лисицах, помеченных взрослыми, это является признаком того, что они не оставляют местности, в которой они поселились однолетками чтобы впервые размножиться.

В общем, самые далекие странствования предпринимаются самцами лисицы (фиг. 4), но из 5 лисиц, о которых сообщения получены с расстояний более 50 км от места пометки, 3 самца прошли 55, 92 и 110 км, между тем как 2 самки удалились на соответственно 112 и 140 км от места пометки. Однако, такие далекие странствования являются исключениями, так как о 85% из самок и 75% из самцов моложе 1 года получены сообщения с расстояний менее 15 км от места пометки.

Общее рассеивание, происходящее в популяции лисицы, зависит от ее распределения по

полу и возрасту (фиг. 3 и 6), но кажется, что состоят и местные разницы, могущие объясняться условиями местной топографии, плотностью популяции или интенсивностью охоты (фиг. 5).

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