A C T A T H E R I O L O G I C A

VOL. 19, 1: 1—18. BIAŁOWIEŻA May, 1974

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Studies on the Food of Foxes*

[With 6 Tables & 3 Figs.]

The diet of foxes, *Vulpes vulpes* (Linnaeus, 1758) was estimated on the basis of analysis of approximately 1000 portions of faeces collected successively during three years. Estimation of the degree of different food constituent enabled assessment of the biomass of food consumed by these predators. Small rodents dominate in the diet of foxes (65.1%). Hares are less important (26.0%), while roe deer and birds are supplementary constituents. Among small rodents prevails *Microtus arvalis* (93.1%). It was shown that the availability of voles for foxes is a factor deciding on the diet of foxes. Estimates of year consumption of voles and hares by foxes are presented and the effect of these predators on the population of small rodents is discussed.

1. INTRODUCTION

The accurate estimate of predators diet, enabling demonstration of its seasonal quantitative and qualitative variability, is an important element of complex studies carried out by the Department of Agroecology of the Institute of Ecology at Turew on the function of predators in agrocenoses.

The foxes, *Vulpes vulpes* (Linnaeus, 1758), occupy a leading position in the investigated complex of predators (Ryszkowski, Goszczyński & Truszkowski, 1973), and hence they constitute a suitable object for studying mutual relationships between predators and prey. Several years studies on the composition of foxes food will also permit drawing conclusions on the role of these animals in agrocenoses and for hunting economy.

* Praca została wykonana w ramach problemu węzłowego: Ekologiczne efekty intensywnej uprawy roli.

2. STUDY AREA

The study area included 31 km^2 in the vicinity of the Department of Agroecology PAN in Turew ($\varphi=52°04'$ N, $\lambda=16°48'$ E), district Kościan. The forests, constituting the main habitat for foxes and the site of raising of young animals, occupy only a small part of this area (approx. 12%). Sandy soils in these forests permit an easy digging of burrows, or renewal of old burrows. Digging of burrows and raising young foxes is rather rare in areas devoid of forests (meadows, gravel pits, stacks, plantations). Cultivated fields dominate in the study area (80%) but they contain numerous field woods. Particularly important for foxes are cultures of alfa-alfa and meadows (16.1% of the area) due to the abundance of voles living in these habitats. A more accurate characteristics of the area was given by Ryszkowski *et al.* (1973).

3. ANALYSIS OF FAECES

The diet of foxes in the study area was estimated on living animals by the analysis of faeces.

3.1. Choice of the Method

The commonly employed method of presenting the results of faeces analysis as the frequency of occurrence of particular constituents (Errington, 1937; Gašev, 1965; Kasatkin, 1969; Johnson, 1970, and others) gives only approximative values. With a higher credibility this method may be used only in cases when the diet of predators consists of animals of similar size (Macpherson, 1969), but this is a rare phenomenon in the study area. In general, the frequency of occurrence of a given prey in the diet leads to overestimation of small animals, which may dominate in numbers but when calculate for biomass constitute a second rate or even accidental food. Moreover, this method does not take into consideration differences in digestibility of particular food constituents by foxes, as already emphasized by Scott (1941).

On account of the above objections a method proposed by Lockie (1959) was used for the diet estimation. In this method the weight of particular constituents separated from faeces is determined (*e.g.* remnants of small rodents, hares, etc.). By multiplying the weight of these undigested remnants by a suitable factor characterizing the digestibility of a given constituent (the ratio of consumed food weight to remnants weight in faeces) the consumed biomass can be calculated.

3.2. Food Tests

In these tests coefficients of digestibility were estimated for the foxes deriving from the study area and with the use of typical food constituents.

Preliminary analyses of faeces collected in the study area demonstrated that principal prey of foxes consists of small rodents, hares — *Lepus europaeus* (Pallas, 1778), birds (*Aves*) and roe deer — *Capreolus capreolus* (Linnaeus, 1758). Other food (insectivorous animals, plants and insects) occurs only sporadically and in small amounts so it does not play any significant role in the diet of foxes. For this reason food tests aimed at the finding out factors characterizing digestibility of a given constituent of the diet were limited to the four above mentioned types of food.

The foxes were kept in separate cages and supplied with a given amount of the examined food. Non-consumed remnants (fragments of the skin, intestines, feathers, etc.) were collected and weighed. The animals received food as a single dose or several times at daily intervals. Collecting of faeces was continued until third day after the last portion of food was consumed to ensure that all undigested remnants were excreted. During a few days before the experiment the foxes were fed with pig hearts not containing bones and fur. Also in the final stage of the test pig hearts were given to avoid starvation which might influence digestibility of the examined food constituents.

The tests were carried out on two adult foxes (♀ and ♂) and for young growing animals aged 3 to 10 months (3 ♀ and 1 ♂). Small rodents: *Microtus arvalis* (Pallas, 1779), *Clethrionomys glareolus* (Schreber, 1780), *Apodemus flavicollis* (Melchior, 1834), *Apodemus agrarius* (Pallas, 1771) were given as the whole. The rodents were of different body weight, including pregnant females. Hares and birds (hens and chickens of different body weight were used) were given either as the whole or after dividing in two parts. Roe deer were always suitably divided due to difficulties with obtaining this food. When the bodies of animals were divided each portion of meat contained similar amount of bones and fur or feathers.

The analysis of excrements was carried out according to Lockie (1959). The faeces collected separately for each test were washed on a sieve to separate fur, bones or feathers. The washed out undigested remnants were dried under radiators and then weighed.

3.3. Estimation of Digestibility Coefficients for Different Types of Food

The experimental tests demonstrated that small rodents are poorly digested by foxes (Table 1). This is related probably to the fact that the bodies of these animals contain large amounts of not digestible parts such as fur and bones. Birds, hares and roe deers are digested in a better degree (the amount of undigested remnants per unit of consumed food is smaller than in case of rodents). Roe deer is assimilated in the highest degree. This may be related to the fact that foxes consuming large animals discard at the beginning certain parts of the body (intestines, heads, lower parts of legs) and hence in the consumed portion the amount of bones and fur is relatively small. The same can be said of birds and hares in distinction to small rodents which are swallowed as a whole, often without being crushed in teeth.

Table 1

Digestibility of different types of food for the fox.

Type of food	Total wt. of consumed food	No. of tests	Mean wt. of undigested remnants (g) per kg of consumed food $\pm$ *S.D.*	*C.V.*
Small rodent	12.262	11	44.4±6.0	19
European hare	5.485	8	20.0±5.6	42
Bird	5.343	7	28.5±9.0	44
Roe deer	4.580	7	8.5±2.7	44

Table 2

Coefficients of digestibility (relation between weight of consumed food and weight of undigested remnants) of different types of food.

Type of food	Own data	After Lockie, (1959, 1961)
Small rodents	23	23
Lagomorphs	50	41 [1]
Birds	35	45—61 [2]
Roe deer	118	60

[1] Data for rabbits, [2] Extremely data for large and small birds.

The size of the prey and possiblity of consuming only some parts of it affect the digestibility even within the same type of food. This is shown by the coefficient of variability (*C.V.*), which is low for small rodents and much higher and similar for the remaining types of food (Table 1). The error of estimation of the mean weight of undigested remnants for a given number of tests is around 14% in case of small rodents and around 30% for the remaining three types of food. Of course the mean could be estimated more accurately by multiple determinations but this would not change the scatter of results in natural habitats.

The coefficients of digestibility obtained in my experiments for small rodents are identical with those reported by Lockie (1959, 1961) (Table 2). The results obtained for hare in this studies were wery similar to ones reported by Lockie, despite the fact that Lockie utilized in his experiments rabbits. Discrepancies in the case of roe deer are understandable since Lockie gave his estimations without carrying food tests. Lower estimates were obtained in the present study for birds.

4. MATERIAL UTILIZED FOR THE ESTIMATION OF DIET COMPOSITION

The faeces were systematically collected during the whole year in the vicinity of fox burrows and in the areas strongly penetrated by these predators. In winter the faeces were collected directly on fox tracks.

Three periods were distinguished in the feeding cycle of foxes: 1. Winter season with snow cover, characterized by reduced availability of

Table 3

Small rodents in the fox diet (estimated from teeth).

Species	No.	Mean wt. g	Consumed biomass, g	Per cent
Microtus arvalis	1089	18.4	20.038	93.1
Microtus oeconomus	4	19.0	76	0.4
Clethrionomys glareolus	14	19.0	266	1.2
Apodemus flavicollis	9	27.3	246	1.1
Apodemus agrarius	3	19.3	58	0.3
Apodemus sp.	24	23.3	559	2.6
Mus musculus	5	10.0	50	0.2
Arvicola terrestris	2	130.0	260	1.2

small rodents, depending on snow thickness and presence of ice. Foxes exert stronger pressure on the game. 2. Spring season including rearing of young foxes. 3. Summer-autumn season with abundance of small rodents, also due agricultural measures such as grass crop, harvest, ploughing.

The analysis of approximately 1000 portions of fox faeces during three consecutive years constituted the basis for estimation of the fox diet.

The collected faeces classified in appropriate season were analysed under a binocular eye-piece in order to separate the remnants into particular types of food. With a certain practice the separation of remnants is rather easy. In doubtful cases microscopic analysis according to Day

(1966) was carried out. The separated undigested remnants belonging to one group were rinsed on sieves, dried under a radiator and weighed. The consumed biomass was estimated by multiplying the weight of undigested remnants by the appropriate coefficient of digestibility (see 3.3, Table 2). After determination of the biomass in all groups of food their proportion in the fox diet was calculated.

Within small rodents the proportion of particular species was estimated on the basis of identification of teeth found in faeces (Table 3).

To complete the data on winter food the animals consumed by foxes were also noted. Additional data on the number of hares and penetration of the area by foxes were obtained during night tours of a car with a side headlight; this allowed observation of animals in the zone corresponding to the range of the readlight (cf. Ryszkowski *et al.*, 1973).

5. COMPOSITION OF THE DIET AND ITS SEASONAL CHANGES

When describing the diet of foxes during three years the published data on the proportion of hares and small rodents in the diet of these predators were also taken into consideration (Ryszkowski *et al.*, 1973). Moreover, other components of the diet, and seasons not mentioned in the cited above paper, were utilized here.

The data concerning density of the common vole in the same area (Ryszkowski *et al.*, 1973) were supplemented by unpublished materials (Truszkowski, in litt.).

5.1. Small Rodents

The proportion of common vole among all consumed rodents was estimated on the basis of teeth analysis (Table 3). This proportion is so high (93%) that consideration on small rodents in the diet of fox is limited in practice to this one species. Forest rodents (*A. flavicollis, A. agrarius* and *C. glareolus*) correspond to 5%. Their proportion may rise to 11% of all rodents at decreased density of *M. arvalis,* as it was in winter 1969/70 and spring 1970, or to 10% in summer and autumn 1972. On the other hand, in 1971 with a high number of *M. arvalis* consumption of forest rodents was reduced.

The increase in the population density of common vole observed in the studied area (Fig. 1), with the mass occurrence in summer and autumn 1971, is reflected by the change in proportion of this species in the fox diet (Fig. 2a). In two consecutive years of increase of the common vole population a parallel increase in the consumption of this species by foxes was observed. In autumn 1971 the share of the common vole in the fox diet reached 90%.

In the year cycle the consumption of voles by foxes is the highest in summer and autumn when density of voles reaches the maximum and hunting for them is facilitated by agricultural measures (crop of grass and alfa-alfa, harvest, ploughing). In 1972 at decreased density of the common vole its consumption by foxes was reduced, except summer and autumn when still remained high. This fact indicates the importance of agricultural measures as factors determining the availability

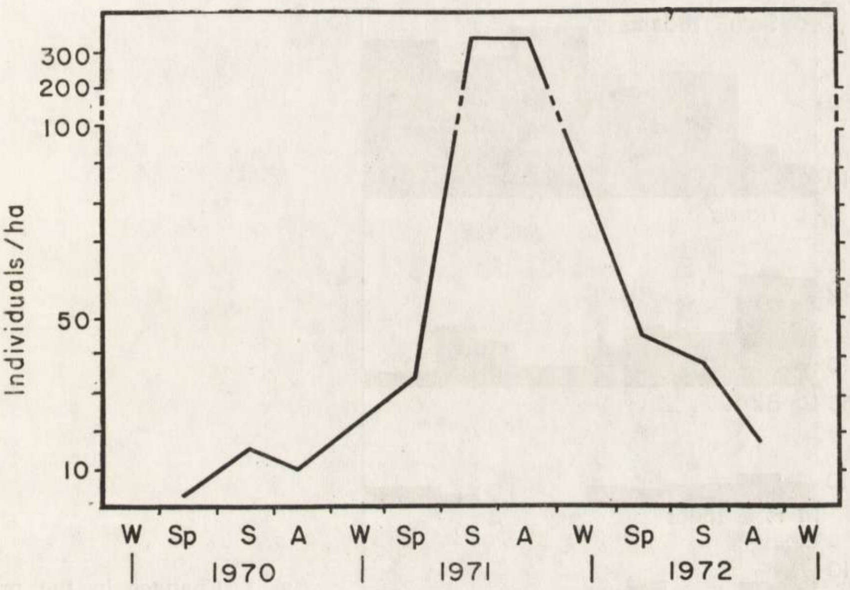

Fig. 1. Density of *M. arvalis* per average acreage of cultivated fields.

of voles for foxes. In winter seasons a decrease in the proportion of small rodents in the diet of foxes was always observed (Fig. 2a).

5.2. Lagomorpha

In a few places of the studied area the rabbit, *Oryctolagus cuniculus* (Linnaeus, 1758), occurs sporadically. In practice, however, this type of fox food is represented by hares, *Lepus europaeus*. In respect of the consumed biomass they constitute the second, after small rodents, source of food for foxes. Their proportion in the fox diet is smaller than of common vole, except winter 1969/70 and spring 1970, when they constituted as much as 50% of the food. In subsequent seasons a decreased consumption of hares by foxes was observed in parallel with increased consumption of small rodents. Augmented consumption of hares in spring 1972 was undoubtedly caused by reduced numbers of voles in this period.

In the year cycle the maximum of hares consumption falls for winter and spring. In the summer-autumn season the consumption of hares by foxes is very small. The employed method of diet estimation does not allow to decide in what extent dead hares are eaten by foxes. During winter trackings hares were found in 52 cases to be the food for foxes

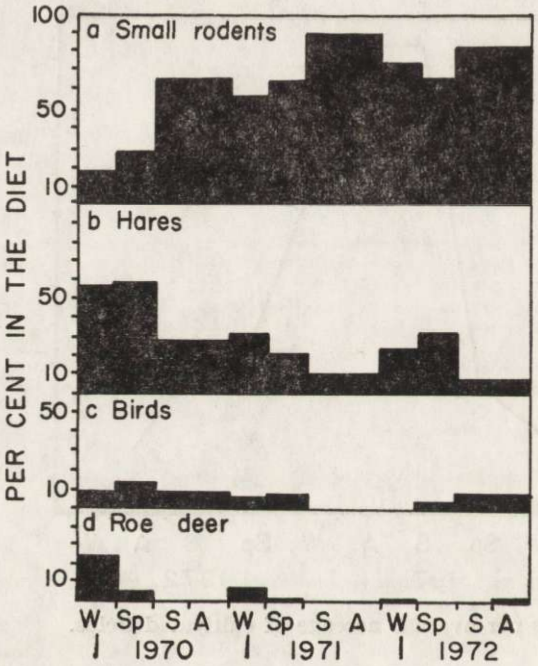

Fig. 2. Changes in the proportion of different food constituents in the diet of foxes.

but out of this figure only in 6 cases it was clear that foxes utilized dead animals. The carcasses of these dead hares were earlier observed in the terrain. In other 6 cases the trackings indicated that foxes attacked alive hares. In the remaining 40 cases it was not possible to establish whether consumed hares were earlier dead or not. Even the digged out remnants of hares from under the snow are difficult to be classified, since the predators may return to the prey.

5.3. Birds

Birds occur in the fox diet all the year round but in small amounts (maximum up to 12%) (Fig. 2c). Comparison of species (identification was based on legs and feathers collected on fox tracking and in the vicinity of burrows) indicates that large birds are preferred by foxes (Table 4).

Majority of pheasants (*Phasianus colchicus* Linnaeus, 1759) and partridges (*Perdix perdix* Linnaeus, 1759) derived from the winter 1969/70 which was very severe and prolonged, and this fact may influence the average picture. Increased consumption of birds was observed at low densities of common voles (years 1970 and 1972).

5.4. Roe Deer

The roe deer occurs in the diet of fox mainly in winter, and in smaller amounts in spring (Fig. 2d).

Table 4

Birds consumed by the fox (material from winter tracking and collected around burrows).

Species	No.	Mean wt. g	Consumed biomass, g	Per cent
Perdix perdix	9	430	3.870	17.2
Phasianus colchicus	5	1200	6.000	26.7
Gallus domesticus	5	1600	8.000	35.6
Vanellus vanellus	1	200	200	0.9
Columba palumbus	6	475	2.850	12.7
Columba livia	1	475	475	2.1
Alauda arvensis	1	40	40	0.2
Lanius exubitor	1	75	75	0.2
Sturnus vulgaris	1	80	80	0.4
Corvus frugilegus	1	300	300	1.3
Turdus merula	5	96	480	2.1
Parus major	1	20	20	0.1
Passer sp.	1	27	27	0.1
Emberiza citrinella	1	27	27	0.1
Total			22.444	99.7

Winter trackings indicate that foxes consume only dead animals. During three consecutive years no case was observed indicating that fox attacked alive roe deer. During inspection of the area in winter 1969/70 as many as 30 dead roe deer were found. In subsequent winters two and one dead roe deer were observed, respectively. The carcasses were utilized by foxes as easily available source of food. Changes in the proportion of roe deer in the diet of foxes in winter seasons correspond in approximation to the number of dead roe deer.

5.5. Other Food

In winter 1969/70 two shrews (*Sorex araneus* Linnaeus, 1758) were identified in the fox diet. In spring 1972 consumption of moles (*Talpa europaea* Linnaeus, 1758) was also noted. The ramaining observations derive from winter seasons when snow trackings enabled identification of the prey species. During three consecutive winters decaying carcasses were consumed by foxes. In two cases these were the remnants of a piglet and in one case remnants of unidentified large mammal (probably calf). In other two cases it was observed that foxes digged out hedgehogs (*Erinaceus europeaus* Linnaeus, 1758) from under the snow. The predators consumed only part of the hedgehog head.

6. IMPORTANCE OF PARTICULAR FOOD COMPONENTS IN THE DIET OF FOX AND FACTORS MODIFYING THE DIET

Three-year observations allow to conclude that small rodents represent the principal food for foxes in the studied area. They are the constant component of the diet independently of their population density. Hares are also constantly utilized by foxes but their share in the diet is lower

Table 5

Composition of the fox diet (1969—1972).

Type of food	Per cent
Small rodents	65.1
European hares	26·0
Birds	5.5
Roe deer	3.0
Insectivores	0.4
Total	100.0

than that of rodents. Birds and roe deers constitute only supplementing constituents of the diet (Table 5).

It appears that the availability of common voles (*M. arvalis*) is a factor decisive for the diet of foxes. Apart from the discussed above parallelism (see 5.1) on the changes of voles density and their proportion in the fox diet this is supported by the following data:

1. Constant numbers of hares in the studied area during several years (Z. Pielowski, pers. comm.) indicate that the decrease in the share of hares in the diet was not caused by their reduced numbers.

2. Relationship between the length of fox track falling for a definite area of the terrain (index of intensity penetration of the area by foxes) and frequency of burrowing in snow in order to find out rodents indicates that hunting for voles and not the density of hares is responsible for different penetration of the area by these predators (Table 6). Captures of rodents in various plantations are in agreement with the density of rodents in these habitats (Ryszkowski *et al.*, 1973) [1].

Despite the fact that changes in the density of rodents in particular years affect the proportion of rodents in the diet the relationship is not direct. It should be remembered that particular plantations are characterized by different voles density. Hence even at general low numbers of voles their density in some perennial plantations, such meadows and alfa-alfa cultures, is sufficient for fox hunting.

The availability of voles for foxes depends not only on the density of potential prey but also on its mobility, more or less developed system of corridors, degree of the soil cover by plants, and other similar factors. This was already mentioned (see 5.1) when discussing increased consumption of voles by foxes in the summer-autumn season: despite

Table 6

Length of fox track per unit of the area and density of hares and hunting for voles.

Plantation	No. of hares/km^2	Fox tracks, km/km^2/day	Hunting for voles in snow, no. of cases/km^2/day
Ploughings	3—13	4.5—5.3	7— 20
Meadows and alfa-alfa cultures	9—15	17.0—25.0	132—180
Winter corns	47—62	6.4— 7.6	15— 32

decreased density of voles in 1972 their share in the diet of foxes was still very high.

Climatic conditions may also significantly affect the availability of food for foxes. Thick snow cover, especially when frozen, makes difficult hunting for voles and facilitates hunting for small game and birds. In these seasons decaying carcasses of animals are often consumed.

The effect of climatic conditions was particularly marked in winter 1969/70. That winter was rather not typical for the study area since was characterized by a prolonged snow cover (93 days) of considerable

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[1]) Data on the penetration of the area by predators derive from the study of Ryszkowski *et al.* (1973).

thickness (around 20 cm, and in some periods even more), and by the temperature of winter months considerably below the many years mean (Fig. 3). The occurrence of so unfavourable climatic conditions caused mass death of game and deterioration of conditions of the remaining individuals. According to the estimates of the Research Station of Polish Hunting Association at Czempiń (9 km from the study area) winter death of roe deers amounted to 48%, hares to 25%, and pheasants and partridges to 75 and 60%, respectively (Pielowski, 1970). A considerable proportion of decaying carcasses (roe deer and probably also

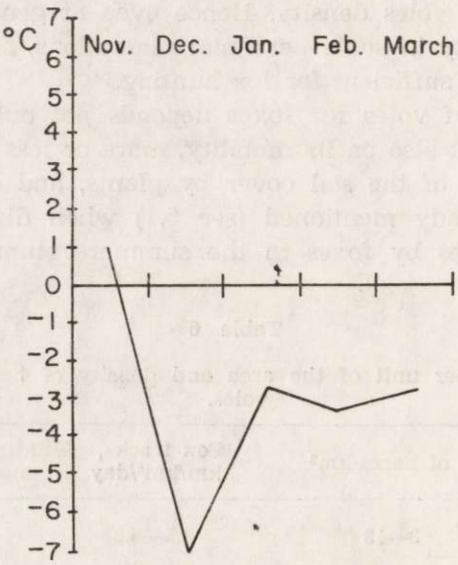

Fig. 3. Deviations of the mean monthly temperatures from the many year mean. Winter 1969/70 (the baseline corresponds to the values of the many year mean).

hares and birds) in the diet of foxes noted in this winter and following spring represents probably an exceptional phenomenon, even after taking into consideration very low numbers of rodents at that period.

7. DISCUSSION OF THE RESULTS AND ESTIMATION OF THE EFFECT OF FOXES ON POPULATIONS OF RODENTS AND GAME

The collected material derives from a small area (30—40 km²), hence any attempts of extrapolation of the obtained results should be treated with care. On the other hand, these observations limited to a small area allowed for simultaneous investigations of the diet and of the number of prey. Hence the estimates of the relationship between predator and prey are not encumbered with an error arising from addition of areas differing in numbers of both predator and prey.

The present study confirmed the fact, already noted by several authors (Errington, 1953; Lund, 1962; Scott & Klimstra, 1955), on the preferrence of rodents from *Microtus* genus by foxes. In the studied area *M. arvalis* constituted the basis of the fox diet. Similar conclusions were reached after analysis of stomach content of foxes deriving from the whole territory of Poland (Rzebik-Kowalska, 1972). The predominance of *M. arvalis* in the fox diet seems to be typical for the areas in which foxes and voles occur jointly (Barnovskaja & Kolosov, 1935; Atanasov, 1958; Kasatkin, 1969; Loskariev, 1970). Only exceptionally at low densities of rodents or epidemics among hares, when dead animals constitute available food, the proportion of voles is lower than of hares in the diet of foxes (Heptner *et al.*, 1967). A slightly different picture of the fox diet is typical for the areas in which rabbits constitute the available food. In such case consumption of rabbits exceeds that of voles (Southern & Watson, 1941; Lever, 1959; Korschgen, 1959), but in cases of a sudden fall of rabbit density, *e.g.* after myxomatosis, the voles begun to prevail in the fox diet (Lockie, 1956; Lever, 1959).

The proportion of voles in the fox diet changes in relation to abrupt changes in the numbers of these rodents. This is also confirmed by the results of other investigators (Scott, 1943; Pavlov & Kiris, 1956; Englund, 1965). In the years of low vole density and in winter, when availability of rodents to foxes is limited, foxes utilize more often other types of food. Hares constitute the principal vicarious food in the study area, while birds and roe deer (decaying carcasses) represent a supplementary source of food. The importance of vicarious food was emphasized by Korytkin (1968), who indicated that at increased freezing of snow cover foxes abandon snow burrowing and more often hunt for hares. Similar observations were made by Naumov (1961). Also Englund (1965) investigating the diet of foxes in Sweden found that at low densities of *M. agrestis* (species constituting the basis of fox diet there) the predators consume much more decaying carcasses or birds.

Knowing the diet of foxes and the numbers of their prey it was possible to estimate the effect of foxes on the populations of small rodents. The share of these predators in the total mortality of *M. arvalis* reached 39% at low densities of voles but decreased to 3.2% at the mass occurrence (Ryszkowski *et al.*, 1973). The pressure on the population of *M. arvalis*, *i.e.* the ratio of the number of individuals consumed by foxes to the number of potentially available voles, ranged from 23.6 to 2.8%, depending on voles density. Similiar changes were noted in the pressure of foxes on the populations of forest rodents (from 18.8 to 2.3%). Among the studied complex of predating birds and mammals the foxes constitute undoubtedly the most efficient hunters of rodents (Ryszkowski *et al.*, 1973).

Assuming the mean proportion of small rodents in the diet of foxes as obtained in the present study (65.1%), and the mean daily food requirement equal to 470 g (see Ryszkowski *et al.*, 1973) it may be calculated that one adult fox consumes during the year approximately 111 kg of rodents, which corresponds to over 5.5 thousand of individuals. If we assume that food requirement in a natural habitat is lower than estimated in laboratory conditions and equal to doubled resting metabolism (Odum, Connell & Davenport, 1962) then the daily food ratio for a fox weighing 4.5—5 kg amounts to 308—336 g. Hence the year consumption of rodents by one fox is equal to 73.2—79.8 kg, corresponding to 3.7—4.0 thousand of individuals. Rzebik-Kowalska (1972) estimated the year consumption of rodents by a fox as approximately 2700 individuals, stating at the same time the occurrence of considerable differences in the proportion of rodents in the diet of foxes from Southern and Northern Poland. Heptner *et al.* (1967) estimated the daily consumption by foxes, at food requirement equal to 300 g, as 15 voles, which gives ca 4500 individual in a year.

In the areas with the mass occurrence of *M. arvalis* even higher consumption of voles by foxes was noted. Seven years lasting investigations in the Ukraina demonstrated that the diet of foxes in this region consists almost exlusively of rodents (91.3%), common vole (*M. arvalis*) constituting 62 to 75% of the diet (Heptner *et al.*, 1967).

Many controversial views arised around the problem fox — hares. The study of Rzebik-Kowalska (1972) indicates that the hares and rabbits constitute up to 30% of the diet of foxes in Poland. A similar proportion of hares in the fox diet was also recorded in the studied area. The mean share of hares calculated on the basis of three winter seasons amounts to 37%. In spring consumption of hares remain on the same level (37.1% in the diet) but it decreases abruptly in summer and autumn (14.7%). The pressure of foxes for hares is hence high in winter and spring months. It should be remembered, however, that among consumed hares there are also dead individuals. The total winter reduction of hares population (diseases, predators, famine) ranges from 5 to 10%, but in winter 1969/70 it reached much higher value (Pielowski, 1968, 1970). The share of dead hares in the diet of foxes is probably also high in the growing season due to a high mortality among young hares caused by farm machines (Pielowski, 1971).

Assuming the mean annual share of hares in the fox diet as 26%, and food requirement as 470 g, the year consumption can be calculated as 44.6 kg per one fox. Assuming the daily food requirement as corresponding to doubled resting metabolism the year consumption is calculated as 28.2—31.9 kg of hares per one fox. Since no data are available on the proportion of young and old animals among consumed hares it was impossible to estimate the number of consumed individuals.

In the studied period it was not observed that the pressure of foxes reduced the number of hares.

The proportion of birds in the fox diet ranges from 0 to 12%. The data provided by Heptner *et al.* (1967) indicate increased consumption of birds at low population densities of voles; this was also found in the study area. A rather considerable proportion of pheasants and partridges arises probably from the fact that most of the estimated material derives from the winter 1969/70, when climatic conditions deviated from normal (see p. 8). Also the results of Rzebik-Kowalska (1972) indicate a non-significant role of birds in the diet of foxes, and particularly of partridges and pheasants.

Of course the function of foxes cannot be limited to removal of a definite number of prey. Eventual selectivity in respect of sex, age or weight of consumed animals should be also investigated. Sanitary function of foxes depending on the removal of ill or weakened individuals is not completely elucidated. It appears that only complex studies carried out in a few centres on the density and diet of foxes, as well as on the number of prey, will enable the estimation of optimal number of foxes from the standpoint of agriculture and hunting economy.

Acknowledgements: The foxes required for the tests were obtained from the Research Station at Czempiń. This station also provided some roe deer and hares utilized as food for foxes. Assistance of Dr. Z. Pielowski in these studies is gratefully acknowledged. Dr. K. Dobrowolski, Dr. Z. Bogucki and J. Truszkowski, M. Sc., identified species of birds consumed by foxes. The author expresses deep gratitude to them. I thank also Mrs. E. Nejman for the care of the tested foxes and Mrs. E. Jędroszkowiak who carried out some analyses of the collected material. I am very grateful to Dr. L. Ryszkowski and the staff of the Department of Agroecology at Turew for valuable suggestions concerning the manuscript of this study.

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Accepted, October 23, 1973.

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BADANIA NAD POKARMEM LISÓW

Streszczenie

W testach hodowlanych nad lisami określono współczynnik strawialności (stosunek ciężaru biomasy zjedzonej do ciężaru niestrawionych resztek w kale) dla różnych rodzajów pokarmu (Tabela 1 i 2). Wyodrębnienie z kału lisów szczątków zjedzonych ofiar i pomnożenie ciężaru niestrawionych resztek przez odpowiedni współczynnik strawialności daje ocenę zjedzonej biomasy. Wielokrotne powtórzenia testów pozwoliły określić błąd, który zależy głównie od sposobu wykorzystania przez lisy różnych rodzajów pokarmu.

Podstawą do zestawienia zmian diety lisów w ciągu 3 lat na terenach (powierzchnia ok. 31 km^2) graniczących z Zakładem Agroekologii IE PAN w Turwi była analiza ok. 1000 porcji kału.

Badania pokarmu lisów wskazują na dominującą rolę drobnych gryzoni w diecie lisa. Nornik zwyczajny stanowi 93% biomasy jedzonych gryzoni (Tabela 3). Zmiany liczebności tego gatunku ofiary wpływają na zmiany diety lisów (Ryc. 1 i 2a). W roku masowego pojawu nornika (1971) lisy odżywiały się prawie wyłącznie tym gryzoniem. Zające (Ryc. 2b) są stale wykorzystywane jako pokarm, ale ich udział w diecie jest znacznie mniejszy od udziału nornika. Przy wysokich stanach gryzoni lub w sezonach letnio-jesiennych, gdy dostępność nornika dla lisów na skutek zabiegów agrotechnicznych wzrasta, obserwowano obniżenie konsumpcji zajęcy przez lisy. Przyjęta metodyka nie pozwala na ustalenie w jakim stopniu lisy korzystają z padłych zajęcy jako pokarmu. Tropienia zimowe na śniegu wskazują na istnienie tego zjawiska. Ptaki i sarny (Ryc. 2c i 2d) stanowią uzupełniający składnik diety drapieżników. Wśród jedzonych ptaków przeważają gatunki większe (Tabela 4). Sarny są spożywane przez lisy głównie w sezonach zi-

mowych i wczesną wiosną w postaci padliny. Stwierdzono zwiększoną konsumpcję ptaków i saren w latach ubogich w drobne gryzonie.

Przeciętny udział drobnych gryzoni w diecie lisów jest na badanym terenie bardzo wysoki i sięga 65% (Tabela 5). Współzależność między zmianami zagęszczenia nornika na polach a udziałem tego gatunku w diecie oraz związek między intensywnością penetracji różnych środowisk przez lisy a wyłowem z tych terenów gryzoni (Tabela 6), wskazuje na to, że dostępność M. arvalis jest czynnikiem kształtującym dietę lisów.

Roczna konsumpcja gryzoni przez jednego lisa, zależnie od przyjętego zapotrzebowania pokarmowego, wynosi od 73 do 111 kg co odpowiada 3.7—5.5 tysiącom drobnych gryzoni. Roczna konsumpcja zajęcy (wliczając padlinę) waha się od 28 do 45 kg.