FOOD HABITS OF MID-WEST FOXES

By Paul L. Errington

The studies of the past five years (1929–1934) on the food habits of foxes in Wisconsin and Iowa have been conducted in response to a very evident need of sound information on this highly controversial subject. For while opinions abound—ranging to all extremes, one way or another—actual data have not been abundant, especially as to the status of foxes as predators upon game, poultry and stock.

Previous data include chiefly the results of stomach examinations on file at the U. S. Biological Survey, Washington, D. C., from the country at large, some from Virginia (Nelson, 1933), from New York and New England (Hamilton, 1935), and fecal analyses carried on at the University of Michigan (Dearborn, 1932).

This paper (No. J. 205, Iowa Agric. Exper. Station, Project no. 330) is based on data obtained from examination of stomachs of 236 Wisconsin and Iowa red foxes (*Vulpes fulva*) and gray foxes (*Urocyon cinereoargenteus*), collected items from 113 Iowa red fox breeding dens, and 1175 Iowa red fox spring and summer fecal samples. The 1933–1934 winter stomachs and the 1934 spring and summer den and fecal specimens on hand have not yet been examined, so the scope of this paper covers broadly the laboratory and field work of four winters, one spring, and the early part of one summer.

SOUTHERN WISCONSIN STOMACH ANALYSES

The Wisconsin stomachs were from animals killed by hunters, largely in Dane, Sauk, Columbia, and Iowa counties. These were collected so far as possible from areas kept under regular observation in connection with the Wisconsin Coöperative Quail Investigation (Errington, 1933a) or from equivalent environmental types. The 1929–1930 and 1931–1932 analyses were handled personally; those for 1930–1931 by the U. S. Biological Survey.

Of my own analyses, those for the first winter are least reliable, as they represent mainly winter food items noted from hasty examinations of stomach contents, often in the field. Allowances should also be made for certain natural imperfections in the results of stomach examination as well as for my own crudities in technique. Foods are differentially resistant to digestion or are retained in the stomach for variable periods of time; carrion is picked up here and there; ecological information relating to individual stomachs is usually absent. All these elements of uncertainty add to the difficulty of obtaining a fair understanding of the predaceous activities of the species.

RED FOX

Food items found in 25 of the 46 red fox stomachs, taken between December 14, 1929, and February 17, 1930 (21 stomachs were empty or otherwise unproductive of data): Cottontail (*Sylvilagus*), in 9; fox squirrel (*Sciurus niger rufiventer*), 1; meadow-mouse (*Microtus*) (a total of about 73), 19; deer mouse (*Peromyscus*), 1; unidentified mouse-like mammal, 2; unidentified mammalian carrion, 1; domestic chicken, 2; small unidentified feathers, 2; cartilage from a large bone, 1; eggshells (from garbage), 1.

Food in 10 of the 13 red fox stomachs, taken between October 26, 1930, and February

23, 1931: Cottontail, in 4; Norway rat (*Rattus norvegicus*), 1; meadow mouse (total of about 25), 8; deer mouse, 1; domestic chicken, 1; small bird, 1.

Food in 11 of the 14 red fox stomachs, taken between December 14, 1931, and February 3, 1932: Cottontail in 9; flying squirrel (*Glaucomys*), 1; meadow mouse, 1; deer mouse, 1; unidentified mouse-like mammal, 3; domestic chicken, 3; mass of dirt and feather butts, 1.

GRAY FOX

Food items found in 17 of the 28 gray fox stomachs, taken between December 15, 1929 and June 8, 1930: Pig skin (probably carrion), in 1; cottontail, 6; fox squirrel, 1; meadow mouse (total of about 64), 15; deer mouse, 3; unidentified mouse-like mammal, 4; unidentified mammal, 1; domestic chicken, 1; unidentified feather shafts, 1; snake (*Heterodon*), 1; apple, 3.

Food in 22 of the 39 gray fox stomachs taken between December 22, 1930, and March 17, 1931: Cottontail, in 15; fox squirrel, 1; woodchuck (?), 1; muskrat (*Ondatra*), 1; meadow mouse (total of about 19), 8; deer mouse, 2; unidentified mouse-like mammal, 1; blue jay (*Cyanocitta*), 1; quail (*Colinus*), badly digested foot, 1; apple, 2.

Food in 33 of the 44 gray fox stomachs taken between December 14, 1931, and February 16, 1932: Pig skin (probably carrion), in 1; cottontail, 29; meadow mouse (total of 17), 2; deer mice (total of 10), 3; unidentified mouse-like mammal, 1; unidentified mammal, 1; small bird, 1; domestic chicken, 6; ruffed grouse (*Bonasa*), (foot), 1; carrion, 1; grapes, 1; haws, 1; apple, 7.

Feces from the intestine of one gray fox showed buds, possibly the crop contents of another ruffed grouse.

The red fox in the Wisconsin observational areas preferred to hunt principally—not entirely—in plowing or stubble fields where meadow mice were most abundant; the gray fox was more of a hunter of brushy hills and gullies where rabbits and gallinaceous game were more likely to be found. The tabulations, however, do not show the differences in diet that a consideration of the hunting habits of the two species would lead one to expect. Though quail and ruffed grouse remains were found in gray fox stomachs only, it is plain enough that both species ate about what they could get.

Fruits, notably frozen apples, were eaten in varying quantities, and one red fox was shot when snooping about a garbage pile (stomach contents: Cottontail, egg shells, cartilage from end of a large bone, feather butts).

Carrion, particularly dead domestic chickens that farmers scatter over their fields with the manure, appeared to be quite acceptable throughout the winter months. I think it probable that most, or all, of the domestic chickens represented in the stomachs—usually by feet—were carrion, for live chickens were quite closely confined to farm yards at this season. With respect to carrion wild life, it is virtually impossible to say from stomach examination whether the creatures were killed and cached, to be eaten later, or were found dead in the first place. We can hardly say, either, into how many fox stomachs parts of a given small or medium-sized carcass, killed or carrion, will find its way before it is finally cleaned up.

The listed items reflect consistently the relative availability of prey. In 1929–30, when meadow mice were exceedingly abundant, they constituted staple diet; in 1930–31 the meadow mice had fallen off decidedly, and cottontails suffered more; in 1931–32, with rabbits easily available, the fox diet was predominately cottontail. During the first two seasons the composition of the diet fluctuated with the depth of snow on the ground, the foxes turning to rabbits whenever the snow afforded the smaller prey too much protection. Worthy of comment also was the conspicuous preponderance of comparatively slow prey in the fox diet; there was hardly any representation of animals that could be considered as swift.

IOWA STOMACH ANALYSES

The Iowa stomachs represent almost entirely specimens obtained from hunters during the winter of 1932–1933 by deputy wardens, especially J. C. Jago, John Holst, Jr., and A. F. Meier. Some June stomachs were also secured by Holst. Analyses were made by myself, with the aid of a fair reference collection.

All but 2 of the 52 stomachs were of red foxes, so the data may be conveniently lumped:

Food items found in 40 of the 50 red fox and 2 gray fox stomachs, taken between December 17, 1932 and June 13, 1933: Cottontail, in 27; fox squirrel, 1; Franklin ground squirrel (*Citellus franklinii*), 1; striped ground squirrel (*Citellus tridecemlineatus*), 2; meadow mouse, 27; deer mouse, 20; harvest mouse (*Reithrodontomys*), 1; unidentified mice, 2; skunk (including 1 identified as *Mephitis*), 2; short-tailed shrew (*Blarina*?), 1; unidentified mammal, 2; icterine bird, probably grackle, 1; ring-necked pheasant (*Phasianus colchicus torquatus*, including 1 probable small chick), 4; domestic chicken (only represented by traces in 5 and by probable carrion in 1), 7; unidentified birds, 3; much insect material, 3; much vegetation (green grass), 1.

Of the stomachs and intestines containing insects in quantity, one contained 102 heads of *Phyllophaga* (June beetle) larvae; another, 21 *Phyllophaga* and click beetle (*Melanotus*) larvae; and the last, 9 Lepidoptera larvae.

The domestic chickens represented in the stomachs from Iowa, where it is not the general practice to keep chickens closely confined in winter, probably are not carrion to so great an extent as those from Wisconsin. Feet of chickens and pheasants in stomachs, however, are notably indicative of carrion feeding, as field studies revealed a decided tendency on the part of foxes to bite off and swallow the frozen feet of carcasses encountered.

Nevertheless, it does not follow that some items, even though eaten as carrion, may not represent killed prey, as an example may illustrate. A fox was known to have killed a pheasant hen beside a highway and to have left it uneaten, perhaps frightened by traffic. The next night the carcass was visited by a fox that ate the feet. This shows how the behavior of a species may complicate immeasurably one's efforts to study with accuracy its food habits; feet of fox-killed pheasant carrion can not be distinguished in a stomach from feet of motor traffic victims.

Winter studies of quail on Iowa and Wisconsin observational areas disclosed a variable fox pressure on this species, the heaviest loss definitely traced to this cause being 4 of 177 birds in the course of the season. I believe it improbable that fox depredations upon adult vigorous bob-whites often exceed two or three percent of the wintering quail population except where the carrying capacity of the land for bob-whites is exceeded. If a vulnerably situated winter bob-white surplus is present, something tends to reduce it, irrespective of fox or other predator kinds and numbers (Errington, 1933 c; 1934). Therefore, whether the exposed excess is taken by foxes or by something else appears to be inconsequential.

DEN STUDIES

Apart from some rough notes (unpublished) on 3 South Dakota dens in 1921 and a few old Wisconsin dens in 1930–1931, I had acquired very little first-hand information as to spring food habits of foxes until 1932. In 1932, the Iowa Fish and Game Commission, coöperating with the State College, instructed its deputy wardens to gather material from the vicinity of occupied dens and made special assignments of picked wardens to assist in the studies. The careful coöperation of Supervisor of Game and Deputies, William Schuenke, and Wardens Ross W. Moses, John Holst, Jr., and A. F. Meier, was of particular value.

Practically all specimen material from dens, with the exception of rabbit remains, was examined by me either in the field or in the laboratory. The wardens, whenever possible, made notes on the number of rabbits and kept representative portions of other kinds of prey, to have identification confirmed. The listed items, then, truly represent the fox food refuse that was found outside of dens or in dens dug out, although, as will be shown later in this paper, they do not represent a true cross-section of fox food habits.

Food items found in and about 113 red fox dens in Iowa during spring and early summer, 1933: Two-months lamb, probably carrion, 1; small pigs (including 3 known to be carrion, as many of the others probably were), 19; cottontail (less than full number, as some wardens made no counts of individuals), 269; jack rabbit (*Lepus townsendii campanius*), 72; unidentified rabbits, 15; woodchuck, 4; fox squirrel, 5; Franklin ground squirrel (*Citellus franklinii*), 15; striped ground squirrels, 11; specimens reported as "gophers," 4; and "squirrels," 3, both probably ground squirrels; muskrat, 2; Norway rat, 1; pocket gopher (*Geomys*), 13; meadow mouse, 6; deer mouse, 55; specimens reported as "mice," 21; striped skunk (including 1 very small *Mephitis*), 4; weasel (*Mustela*), 5; spotted skunk (*Spilogale*), 2; mole (*Scalopus*), 7; *Blarina*, 2, small opossum (*Didelphis*), 1; crow (*Corvus brachyrhynchos*, probably killed by crow shooters), 8; Icterine birds (including 10 meadowlarks (*Sturnella*), 2 grackles (*Quiscalus*), and 1 red-winged blackbird (*Agelaius*), 15; robin (*Turdus migratorius*), 5; catbird (*Dumetella carolinensis*), 1; small passerine birds (including 1 house wren (*Troglodytes*), 1 short-billed marsh wren (*Cistothorus*), 2 horned larks (*Otocoris*)), 29; long-eared owl (*Asio wilsonianus*), 1; juvenile great horned owl (*Bubo virginianus*), 1; domestic pigeon, 2; mourning dove (*Zenaidura*) 8; domestic chicken (including at least 1 known to be carrion), 69; Guinea hen, 2; ring-necked pheasant (including 201 identified as hens and 98 as cocks), 314; Hungarian partridge (*Perdix perdix*), 8; bob-white, 1; American bittern (*Botaurus*), 1; Canada goose (*Branta canadensis*), 1; Pekin duck, 1; domestic mallard, 1; mallard (*Anas platyrhynchos*, including 2 believed to be semi-domesticated), 3; pintail drake (*Dafila acuta*), 1; blue-winged teal (*Querquedula discors*), 1.

It may be seen by checking over the items identified from dens that they constitute principally remains of medium-sized prey, i.e., rabbits, poultry, and miscellaneous species of comparable size. Small mammals notably—while strongly predominant in half or more of the feces—do not accumulate in very conspicuous numbers but are apparently eaten whole. On the other hand there is much tough or inedible material about the larger carcasses that the foxes do not clean up and which persists indefinitely, even for years.

A considerable amount of material seemingly is carried to dens with no very evident intention of using it for food. The fox pups frequently use for play purposes objects obviously unsuited for food, as blocks of wood, horse feces, and time-bleached bones from stock carcasses. Hard ear-corn may be used both for play and for food. All the weasel carcasses that I examined were putrid and entire. Pig and chicken carcasses picked up in the first place as desiccated carrion in winter or early spring were frequently deposited at the dens, to be left there uneaten.

Fragments of larger prey species, as well as wings of small birds and entire small mammals, were scattered about the outside of most dens. My casual impression is that examination of the outside litter gives nearly as reliable an index to the representation of foods as could be obtained through digging out of the dens. Dug out dens, though, in several cases yielded considerably more material than was evident at the surface.

ANALYSIS OF IOWA FOX DEN FECAL SAMPLES

Coincident with the gathering of prey refuse from the Iowa dens in 1933, fecal samples were taken. The feces could usually be picked up near the entrances of the dens or

about the periphery of the dirt mounds commonly present. Fecal samples totalling 1175 were obtained from 82 of the 113 dens, with lots ranging in size up to 119.

The entire collection of 1175 fecal samples was analyzed personally. The tedious and time-consuming nature of the job combined with the pressure of my other official duties, did not permit me to pay a great deal of attention to individual samples. Hence a certain amount of omission and questionable identification of items in the analyses may be taken for granted. I regard the determination of the common items, however, as furnishing a sufficiently correct analysis of the bulk of the fecal substance examined.

Species representation in 1175 Iowa red fox fecal samples, spring and early summer, 1933:

Feces containing mammal remains: Small pig bristles, 6; cottontail in quantity (represented by fur, 492, and by bones, 79), 505 total; more or less satisfactorily identified jack rabbit, 26; Leporidae, mainly unidentified juveniles, 141; woodchuck (?), 1; Franklin ground squirrel, 16; striped ground squirrel, 23; undertermined, probable ground squirrels, 17; meadow mouse in quantity (represented by fur, 499, and by bones, 191), 515 total; deer mouse (represented by probable fur, 85, and by bones, 65), 104 total; harvest mouse, 3; jumping mouse (*Zapus*), 3; house mouse, 1; Norway rat, 4; undertermined mice (represented by fur, 117, by bones, 32), 136 total; pocket gopher, 21; spotted skunk (*Spilogale*), 1; mole (*Scalopus*), 5; *Blarina* (?), 1; prominent unidentified mammal remains, 35; conspicuous unidentified bone fragments, 19.

Feces containing recognized bird remains, other than poultry and pheasants: Crow, 1; meadowlark, 15; grackle, 3; red-winged blackbird, 1; robin, 2; horned lark, 1; unidentified small birds, probably passerines, 31; flicker (*Colaptes*), 1; domestic pigeon, 1; mallard duck (probably tame), 1; bob-white, 9; Hungarian partridge, 1.

Feces containing representation mainly of poultry and pheasants:

(a) Fair determinations of domestic chickens: considerable quantities in 9 fecal samples; evident quantities in 5; traces in 2.

(b) Determinations of domestic chicken listed as possible or probable; considerable quantities in 4 fecal samples; evident in 4.

(c) Total listed representation of domestic chicken, including doubtfuls, 24.

(a′) Fair determinations of ring-necked pheasants: considerable quantities in 31 samples; evident, 14; trace, 5; by bones only, 4.

(b′) Possible or probable pheasant determinations: considerable quantities in 6; evident, 5; trace, 1.

(c′) Total listed representation of pheasants, including doubtfuls, 66.

Feces containing avian material, about 410 samples, included: Unidentified gallinaceous birds, 3; medium sized unidentified birds, 5; unidentified feathers in 248 samples (considerable quantities in 74; evident quantities in 97; traces in 77).

Miscellaneous fecal contents: Egg shells (including 2 probably of pheasant) in 5; piece of leather, 1; frog (*Rana*), 2; snake, 2; insects in 93 (large numbers in 29; moderate in 10, apparent representation in 54).

In addition to those arising from the short-comings of my own analytical technique, several further valid criticisms may be brought against these studies of feces. While the stomach examination method of research may not give us complete information about food habits and may be in need of interpretation, fecal analyses need to be supplemented and interpreted a great deal more.

Adult jackrabbit probably is not represented in the feces in anywhere near the proportions in which it is eaten, as the hide is tough and readily laid back from the edible portions of the carcass. Feathers of grown poultry, pheasants, or other large birds, although rarely eaten in bulk proportional to the size of the carcasses, are nevertheless taken rather freely; but digestive action has a way of wearing most of these feathers down to virtually unidentifiable shafts and butts. The more clean meat there is in the

diet, of course, the less identifiable material will show in the feces, which in many instances are little more than an amorphous mixture of dirt and gummy or hardened protein waste.

The irregular passage of food debris in the feces, too, needs always to be considered. We have not checked up this point experimentally with live animals, as Dearborn (1932, pp. 14–15) did with the mink, but the examination of some hundreds of mammalian predator stomach and intestinal contents, mainly of house cats and foxes, has emphasized its importance. Very frequently a residuum of long retained indigestible material is noted in a stomach along with foods of fresh or recent ingestion; this stomach residuum commonly contains such items as worn feather butts, teeth and claws, soles of feet, particles of gizzard lining, coarse hair, chicken leg scales, etc. Such materials are also found distributed throughout the length of the intestines, presumably passed in from the stomach, bit by bit, over variable periods of time.

When one considers the likelihood that resistent particles from a given individual of prey may be represented in feces for days, it becomes apparent that mere representation leads to the placing of excessive emphasis on certain prey types. Traces are important in *qualitative* food habit studies but the dangers of using them in *quantitative* work should not be overlooked. The danger of over-emphasizing traces is especially great in the organization of data from fecal samples found at dens; the activities of the pups break up and mix the feces so inextricably that the evidence is greatly obscured.

One lot of 10 fecal samples contained bob-white remains in 5, but a scrutiny of the analyses reveals how bone fragments from one bird might easily be spread through a large number of feces. One sample contained a quail femur end; the second, a left humerus end and fragments of both coracoids; the third, feathers and synsacrum fragments; the fourth, a right humerus, foot and sternum fragments; and the fifth, a maxilla and fragments of femur, sternum, and coracoid.

CORRELATION OF DEN STUDIES AND FECAL STUDIES

In view of the obvious short-comings of the sundry investigational techniques tried for foxes, it seems that the soundest procedure is to rely upon no single technique but use critically all of the methods available. For mid-west winter studies, it may be best to rely on stomach and fecal analysis in conjunction with field observation and ecological study of the animals preyed upon by foxes; during spring and early summer, a combined technique of den and fecal studies is desirable. For late summer and autumn no particular technique appears to be especially promising, though something may be learned from stomach analyses and from the examination of prey caches. Stomach analyses are doubtless best for general food habits research.

Let us inquire into the feasibility of correlating the spring and early summer den and fecal studies. Spring and early summer may be jointly regarded as a period when fox depredations upon prey species are accelerated by the growing requirements of pups in dens, and also a period when heavy pressure upon many prey populations is borne by breeding individuals. Hence this period probably has special biological significance.

The gross discrepancies in ratios of prey species evident at dens and their representation in feces are very apparent. Of 910 individuals of prey recorded for the 113 dens, 473 or 52 per cent were birds, whereas only 36 or 3 per cent of the 1175 fecal samples from the same dens consisted mainly of recognizable avian material. The fecal samples containing some recognizable avian material totalled about 410, or 34 per cent, of which only about 190 or 16 per cent contained any considerable amount. Mammalian material on the other hand comprised nearly all of the remaining 1139 or 97 per cent of the total fecal samples.

From table 1, we may see that relatively few species show comparable representation in both den débris and feces, namely: Cottontails, ground squirrels, white-footed mice,

pocket gophers, moles, and passerine birds. The birds are largely species the wings of which may be nipped off at the den and the rest eaten whole; the mammals are largely those of such size as to be entirely devoured, but of which some portions are apt to remain scattered about near the den. Exceptions are weasels, which are brought in and apparently not eaten, and meadow-mice which are well represented in feces but hardly at all in the den refuse. Domestic chickens appear more equally represented in

TABLE I

Comparison of incidence of prey species in 910 specimens at dens and in 1175 fecal samples

PREY	DEN REPRESENTATION	DEN SPECIMENS (PERCENTAGE)	FECAL REPRESENTATION	FECAL REPRESENTATION (PERCENTAGE)	INCIDENCE RATIO, DEN:FECES
Small pig	19	2.1	6	.51	4:1
Cottontail	269	29.6	505	43.0	3:4
Jackrabbit	72	7.9	26	2.2	4:1
Unidentified Leporidae	15	1.6	141	12.0	
Franklin ground squirrel	15	1.6	16	1.4	Citellus
Striped ground squirrel	11	1.2	23	2.0	1:1
Unidentified ground squirrel	7	.8	17	1.4	
Pocket gopher	13	1.4	21	1.8	1:1
Microtus sp.	6	.7	515	43.8	1:75
Peromyscus sp.	55	.6	104	9.0	2:3
Unidentified mice	21	2.2	143	12.2	
Norway rat	1	.1	4	.3	
Woodchuck	4	.4	1	.1	
Skunk	6	.7	1	.1	
Weasel	5	.6	0	.0	
Mole	7	.8	5	.7	2:1
Crow	8	.9	1	.1	
Meadowlark	10	1.1	15	1.3	Miscellaneous passerines and Icteridae
Icterine birds	5	.6	4	.3	
Miscellaneous passerines	29	3.2	34	2.9	1:1
Columbiformes	10	1.1	1	.1	
Hungarian partridge	8	.9	1	.1	
Bob-white	1	.1	9	.8	
Pheasant	314	34.5			
Total, including doubtful			66	5.8	6:1
Strong representation			37	3.2	11:1
Domestic chicken	69	7.6			
Total, including doubtfuls			24	2.0	4:1
Strong representation			13	1.1	7:1

den refuse and in feces than pheasants, though both birds are plainly over-represented at dens, as are jackrabbits and other rather large mammalian prey.

For small forms such as mice and passerine birds, which are swallowed whole or nearly whole, substantial representation in feces may mean approximately one individual. A tender young rabbit, on the other hand, if eaten entire, may furnish enough fur to be detected in many fecal samples. In the absence of data from feeding experiments, then, I doubt if attempts at correlating den-feces ratios would be worth while.

Data from a single typical den are sufficient to exemplify these difficulties. Den no. 93 had near it the remains of 1 small pig, 1 fox squirrel, 3 cottontails, 1 weasel, 2 crows, 1 domestic chicken, 3 pheasants, and 1 American bittern. Of 119 fecal samples collected at this den, 2 contained small pig; 31, cottontail; 1, jack rabbit; 2, unidentified Leporidae; 1, woodchuck; 1, ground squirrel; 1, pocket gopher; 2, Norway rat; 82, *Microtus*; 6, *Peromyscus*; 1, *Reithrodontomys*; 17, unidentified mice; 1, *Scalopus*; 1, *Blarina* (?); 3, unidentified mammals; 1, domestic chicken; 9, pheasant; 26, miscellaneous and unidentified birds in greater or less quantities.

GENERAL REMARKS ON FOX FOOD HABITS

Fox food habits seem to be dependent largely on availability of prey. Small mammals evidently constitute staple foods during the greater part of the year. The representation of other kinds of prey fluctuates according to seasons, weather conditions, abundance and vulnerability of prey populations, and with the experience of the fox. Young animals learning to hunt have to take what they can get.

The rare representation of *Microtus* at dens and its high occurrence in feces, compared with *Peromyscus*, may signify a preference on the part of foxes for meadow mice.

Foxes ordinarily do not kill large prey; grown domestic chickens, cock pheasants, woodchucks, and jackrabbits appear to represent the largest creatures that they care to attack. Of course, juveniles of larger animals may be vulnerable, but items such as the two-months lamb found at one den and the calf carcasses now and then reported can hardly be anything but carrion; there surely is a limit to what may be done by an animal weighing ten or twelve pounds and possessed of neither great ferocity nor exceptionally formidable dental equipment. A cured ham that some Iowa hunters retrieved from a fox den does not indicate that a fox killed a pig!

Doubtless much of the damage to pigs charged against foxes does not represent depredation at all, but carrion feeding. Two entire fresh pig carcasses picked up by one of the wardens at a fox den showed no traces of injury; bloodless tooth marks about the nose of each indicated that they had been cold when carried to the den. Other pigs were observed in such withered, dried condition that they must have been dead for weeks before having been picked up. Practically all of the really authentic cases of depredations were those in which foxes had preyed upon small pigs farrowed under semi-wild conditions or at considerable distances from buildings.

Likewise, a great deal of the widely advertised destructiveness of foxes to poultry proves upon investigation to be overdrawn. The interest of foxes in dead chickens thrown out in fields with manure has been touched upon. A certain amount of the chicken material found at dens is known not to represent killed prey. One farmer admitted to a warden checking up a complaint that the poultry debris about a den came mostly from chicken carcasses thrown out during the winter. In another instance a farmer had watched a fox carrying to its den a number of chicken carcasses which someone had dumped beside a highway.

Poultrymen may at times, however, have a real grievance against foxes. Aside from losses of an odd chicken now and then, depredations upon vulnerably situated flocks may be severe, especially when mid-summer family groups of foxes may raid farm yards. We have authenticated instances of as many as 160 chickens being killed in two mornings by a raiding fox family. Half grown turkeys may suffer heavy losses also.

The worst depredations occurred on farms which lacked a good dog, and on which extensive concealing vegetation allowed the foxes to sneak close to the buildings. Corn fields planted right up to the farm yards furnished excellent opportunities for unobserved approach and played a prominent part in a number of poultry massacres. All in all, the majority of severe depredations seem preventable, if only through the possession of an active dog.

Fox pressure upon game birds should perhaps be divided into a number of categories.

With respect to winter bob-white, fox pressure appears rather confined to that proportion of the population which the environment does not easily accommodate. Populations in excess of carrying capacity are vulnerable to predators, including foxes. Conversely, bob-white populations within or below environmental winter carrying capacity (as defined in terms of food and cover combinations or of covey territories) are, unless weakened by starvation, wounds, disease, or other causes, essentially secure against the usual types and densities of their natural enemy populations. Material depredation of foxes upon quail—at least in winter—may then be more properly regarded as a symptom of species vulnerability than a factor significantly influencing population levels (Errington, 1933 c; 1934).

The severity of depredations upon the introduced ring-necked pheasant presents questions which our available data do not answer. Specifically, does the fox pressure actually hold down pheasant population levels or does the preying largely mean only the removal of an exposed surplus, doomed anyway as in the case of quail surpluses? Unpublished data show a strong local vulnerability of the similarly alien Hungarian partridges. Exceptional vulnerability of another alien, the Norway rat, has also been noted (Errington, 1933 b; 1935).

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