

AN ABSTRACT OF THE THESIS OF

Frank W. Stanton ----- for the M S in Fish & Game
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Title DOUGLAS'S GROUND SQUIRREL AS A PREDATOR UPON

UPLAND GAME BIRD NESTS ON THE SOAP CREEK EXPERI-

MENTAL AREA IN OREGON

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(Major Professor)

A field investigation was made during the 1940 nesting season in the Willamette Valley, Oregon, to determine whether the Douglas's ground squirrel, Citellus beecheyi douglasii, is a factor in nesting losses of pheasants and quail. Incidental data was gathered on the general food habits of this squirrel, and on predation by some other species.

A valley quail nest apparently destroyed by a Douglas's ground squirrel in Oregon was the only record of predation by this animal found in the literature. Some other species of the genus Citellus have been known to prey on birds' eggs.

One hundred dummy pheasant and bobwhite nests, with a small steel trap at each, were placed on an area of about 2,000 acres. Eighty per cent of these sets were

destroyed by predators even though, on the average, nests were exposed for less than one-half the normal period of incubation for the species. Forty-three sets caught seventy squirrels and direct evidence remained of twenty others. About half of the sets were raided more than once. Eggs were eaten in seven instances, and stolen in 27, by the squirrels. Nests located in the proximity of squirrel burrows were particularly susceptible to destruction. There were no indications that the size of clutches or naturalness of the habitat for birds were factors in nest destruction. Predation was most severe in grass cover and on crop land. There was an indication that fence rows are particularly dangerous locations from the standpoint of predation.

Stomach analyses were made on 204 Douglas's ground squirrels. Pheasant egg shells were found in the stomachs of three squirrels trapped at the dummy nests. The average per cent, by volume, of food items in the stomachs analyzed were: green leaves, 37.2; grain, 22.7; apple, 12.2; weed seeds, 11.9; miscellaneous vegetation, 8.0; fruits, 5.2; animal matter, 1.5; other, 1.3. There was a close correlation in the foods of the squirrels and upland game birds in this area.

Eight squirrels were kept under observation in captivity for a total of 136 animal-days. Five well-fed penned individuals ate one or more pheasant or bobwhite eggs, total 11 eggs, and three ignored them.

One squirrel was observed, in the field, to carry off a bobwhite egg; but eggs were not always eaten when found by them. Digger-squirrels have been known to steal domestic chicken eggs, and young chicks.

Other predatory animals caught at the dummy nests were: 22 skunks, 4 long-tailed jays, 2 house cats, 2 brown rats, 1 coast jay, and 1 gray fox. At least 16 of the skunks had eaten eggs, as had both kinds of jays, and one of the cats.

The Douglas's ground squirrel is one of the most destructive rodents to agriculture in this farming region, and need for its control is generally recognized. Cooperation of the wildlife interests with agriculturists is believed to be the best approach to the control of this predatory and crop destroying species. Seasonal control of the skunk is recommended.

DOUGLAS'S GROUND SQUIRREL AS A PREDATOR.
UPON UPLAND GAME BIRD NESTS ON THE
SOAP CREEK EXPERIMENTAL AREA IN
OREGON

by

FRANK WEBSTER STANTON

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APPROVED:

[REDACTED]

Professor of Fish and Game Management

In Charge of Major

[REDACTED]

Chairman of School Graduate Committee

[REDACTED]

Chairman of State College Graduate Council

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DOUGLAS'S GROUND SQUIRREL AS A PREDATOR UPON UPLAND GAME
BIRD NESTS ON THE SOAP CREEK EXPERIMENTAL AREA IN OREGON

INTRODUCTION

Objectives

This report is the result of a field investigation made during the 1940 upland game bird nesting season in the Willamette Valley, Oregon, to determine whether the Douglas's ground squirrel, Citellus beecheyi douglasii Richardson, is a factor in nesting losses of the ring-necked pheasant, Phasianus colchicus torquatus Gmelin, and the bobwhite quail, Colinus virginianus virginianus (Linnaeus), and if so, to arrive at some approximation of its importance. Incidental data has been gathered on the general food habits of this squirrel, and on predation by some other species.

The predatory nature of many ground squirrels is commonly recognized, but relatively little study has been made of this problem. Although a closely related form of squirrel has received considerable attention in California regarding its status in relation to the valley quail, Lophortyx californica, no specific data was known to exist concerning predation on pheasant nests by this species.

This study was financed by the Oregon Cooperative Wildlife Research Unit* and was under the supervision of Mr. Arthur S. Einarsen, Associate Biologist, United States Fish and Wildlife Service.

The Experimental Area

The experimental work was practically confined to the Soap Creek Experimental and Demonstration Area managed by the Unit. It is located about ten miles north of Corvallis, in Benton and Polk Counties, Oregon. Approximately 5,000 acres of it is general farming land on the valley floor and is good pheasant and quail range. The cover is estimated to be about 55 per cent cultivated crops, 30 per cent pastures, and 15 per cent woodlots or brushy creek bottoms. The area exists as many small units divided by fence rows grown up to rose, ** blackberry, poison oak, hawthorn, and similar plants. The woodlots are composed principally of such hardwoods as ash, oak, and maple. Crop plants are chiefly small grains, vetch, peas, and clover. In this region of mild

* Cooperators include: United States Fish and Wildlife Service, Oregon State College, Oregon State Game Commission, and the American Wildlife Institute.

** Common and scientific names of all plants mentioned are listed on page 72.

winters there is ordinarily a yearlong abundance of food and cover for the birds. This area has been closed to hunting for the past four years, and certain predatory species of birds and mammals have been controlled during the same period. Douglas's is the only ground squirrel found in this locality. They are sporadically poisoned and hunted by most of the resident farmers, but persist almost throughout the region, being most abundant on pasture slopes at the foothills of the Coast Range.

A few specimens were collected for stomach analyses from surrounding localities, as noted under that heading. All nest studies were conducted on the Soap Creek area.

The Douglas's Ground Squirrel

The following excerpts, selected from a number of articles, together with some personal observations, summarizes the more pertinent facts about the Douglas's ground squirrel, locally known as the gray digger.

According to Bailey (2:144) this rodent is:

"As large or larger than the eastern gray squirrel; ears about as long; tail long and bushy but less full and spreading than in the tree squirrels....."

Howell (14:152) says that the Douglas's ground squirrel is closely related to beecheyi, differing chiefly in having a large black patch on the foreback; but Grinnell and Dixon (9:644) state that,



Fig. 1
Douglas's ground squirrel



Fig. 2
Excellent ground squirrel habitat.
Soap Creek Experimental area

"Although the differences are not great, they are evident and should be recognized in economic work, for they not only concern color, but apparently also habitat and food preferences."

Gabrielson (8:6) gives the length of an adult male as from 17 to 19 inches. One particularly large male measured during the present study was: 10.5 inches from tip of nose to base of tail, and 8.5 inches along the length of the tail vertebrae.

The distribution of this form as given by Howell (14:151) is:

"Western Oregon and northern California, from the Columbia River Valley south nearly to San Francisco Bay, Calif.; east to the Deschutes River Valley, Oreg.; Lake City, Calif.; and a line reaching from the latter point to Eagle Lake, Lyonsville, Magalia, and Nelson; from there southward occurring only west of the Sacramento River. "

It is reported to be spreading into eastern Oregon and Washington. Its range nowhere overlaps that of the Beechey squirrel.

Bailey (2:145) says:

"They are most abundant in the dry interior Upper Sonoran valleys but are scattered well over the more open parts of humid Transition valleys, not usually ranging high in the mountains nor entering heavily timbered areas."

Gabrielson (8:6) says of their habitat:

"The animals do not go far into the heavy timber but prefer the open glades, rocky or bushy hillsides, fence rows, cut-over lands, and similar places. They have a tendency to congregate in colonies, but this is not so con-

Spicuous as in other species. Particularly in the foothills the great majority of the individuals seem to congregate on the south and east slopes. Such slopes, with a scattered growth of oak or brush, are ideal digger country in Oregon."

Grinnell and Dixon (9:644) writing about California conditions state that douglasii never reaches the great numbers that characterize beecheyi. But even though they are nowhere so very numerous as compared with certain other rodents, their predilection for clearings brings them into economic prominence locally.

They excavate their own burrows, usually on a slope but not infrequently in level fields. The entrance is often hidden by thickets, brush piles, and other cover. Well beaten trails lead to neighboring dens or favorite feeding places. Judging by the excavations made during this study, there seems to be at least two types of burrows - simple shallow runways without nests, and the deeper, ramifying kind that leads to a nest cavity at some depth below the surface.

As to their period of inactivity, Bailey(2:145) says:

"In late autumn these squirrels become very fat and apparently hibernate for 4 or 5 months during the coldest weather, which generally includes November and February. But this period varies locally with the weather, the amount of fat accumulated, and the age, the smaller young of the year being the latest to enter winter quarters."

Local observations for 1939-1940 were: last observed on October 31; and first reported out on January 15. They were commonly seen on the area after January 29. These two days in January were clear and warm, while most of the intervening period was cloudy and cold with rains and one sleet storm. A few individuals may come out on clear, warm days throughout the winter, but none were observed or heard of in 1939-1940 between the dates given.

Edge (4:192) says:

"Its activities are strictly diurnal....during its most active season the squirrel spends 75% of its time in its burrow.....The maximum number of squirrels for the year are in evidence the latter part of June, when the young are beginning to spend considerable time outside the burrow."

Regarding the breeding habits, Edge (3:194) says that the majority of young appear to be born about the middle of April, and probably appear above ground about the seventh or eighth week and begin foraging. The first young observed during this study was on May 24 when a pup caught one measuring only about eight inches in total length. Its stomach was full of green vegetation. The largest number of young caught at one burrow was five; however, two adult females (and one male) were taken at the same hole. The average number of young trapped from four dens at which only one female was caught, was four.

The sex ratio for 224 squirrels caught was: adults, 39 males and 32 females; young, 72 males and 81 females; totals 111 males to 113 females.

Grinnell and Dixon (9:630, 644), writing about the Beechey squirrel state that the general tendency is for the squirrels to increase on uncultivated land where they are least molested through human agency and from there they spread out and invade nearby cultivated fields. Emigrations in search of food are usually less than a mile in extent. General observations indicate that this tendency may be applied to the Douglas's squirrel. Their statement following has been noted commonly in the behavior of the local race:

"In foraging for seed pods, grain or fruits, the ground squirrel does not usually eat the food on the spot where it is gathered, but he stuffs it into his capacious cheek pouches or else, if it is too large for this, carries it in his mouth nipped between the incisor teeth. He then repairs to some point of vantage such as a rock pile or to the mound at the entrance of the burrow."

Edge (5:959) says that predatory enemies take a heavy toll of the ground squirrels. He mentions the red-tail hawk, raven, crow, rattlesnake, gopher snake, cat, dog, and skunk which probably only get a few of the young and those in shallow burrows. Species of lesser or of unknown importance include the coyote, fox, wildcat, weasel, badger and golden eagle.

On July 22, a young red-tailed hawk was surprised while eating a trapped gray digger. The hawk had apparently killed the animal. On August 19, fox droppings were noted which contained cascara seeds and gray digger hair.

Grinnell and Dixon (9:649) say of the Douglas's ground squirrel that every few years there is a great reduction in its numbers.

Edge (4:193) estimates the maximum life span of this rodent to be 5 or 6 years.

The gray digger is probably the most prone of all the ground squirrels to climb, and is frequently seen in trees, on top of telephone poles, old buildings, and such places. A number of authorities state that whenever a ground squirrel senses danger while up in a tree it "always" or "invariably" starts for the ground. The inevitable exception was observed on June 14, in an orchard, when a young digger squirrel, come upon suddenly, ran out of the tall grass and went up a tree for some 10 or 15 feet, where it was easily shot. On several occasions adult animals were noted trying to escape detection, when surprised in an apple tree, by lying motionless against a limb or in a crotch. The great majority, however, run for the nearest burrow and do not stop at the entrance for a last look, but disappear in great haste.

LITERATURE SURVEY

In providing a background for the present study, an attempt was made to review all literature pertaining to predation on birds' eggs by the Douglas's and California ground squirrels, and the following information was secured.

Several references were found relating to the digger squirrel's fondness for flesh; traps baited with meat and set for carnivores often attracting them (Grinnell and Dixon, 9; Bailey, 2).

Only one reference has been found relating to the Douglas's ground squirrel as a nest destroyer. Horn (11:743; also mentioned in 12 and 13) makes the following statement:

"A valley quail nest kept under observation near Amity, Yamhill County, Oregon, in June, 1922, was found empty and the shell fragments were seen about the mounds of Douglas squirrels nearby. One egg also was found in a cache made by the squirrels."

More information is available about the California, or Beechey, ground squirrel, Citellus beecheyi beecheyi, a closely related sub-species in California.

Stephens (19:66) writes that, "Eggs of poultry and wild birds are relished."

Grinnell and Dixon (9:626) who cite the preceding statement, comment as follows:

"We have heard considerable testimony from ranchers to the effect that individual ground squirrels in different localities have learned to raid henneries, so that the above statement is not exceptional."

According to Grinnell and Storer (10:166), a former resident in Yosemite Valley, Mr. E.W. Baker, says this rodent,

".....is not averse to stealing young birds. He has seen a California Ground Squirrel carry off a young Western Robin, and he has received report of their capturing young chickens in yards on the floor of the Valley."

Horn (11:743) quotes the following observation by Frank E. Dunn, county forester of Santa Barbara County, California, as published by Kellogg (15):

"In late April, 1925, in company with a forest guard, we noted a male squirrel carrying eggs from a quail nest in the Oso Canyon in the Santa Ynez District of Santa Barbara National Forest. We watched this squirrel take 6 eggs from a nest containing 19 eggs, and after the 6 had been taken we shot the squirrel."

Of ninety quail nests studied by Glading (Horn, 13:4) in California, thirty were destroyed by ground squirrels. Horn says,

"In this limited investigation it was found that ground squirrels destroyed as many nests as all other native predators combined."

Emlen and Glading (7:41) state that,

"On May 17, 1937, a California Ground Squirrel (Citellus beecheyi) was caught in the act of robbing the nest of a Valley Quail (Lophortyx californica vallicola) on the San Joaquin Experimental Range in the Sierra Nevada foothills about 20 miles east of Madera, California."

This clutch of 16 eggs was being incubated at the time, and both the male and female fought the squirrel. The hen was especially active. "The bird in her excitement, mounted the squirrel's back and clung tenaciously as the latter spun around trying to shake her off." Each time the squirrel was repulsed or left with an egg, the female returned to the nest. Each time the squirrel returned, the birds fought it, and pursued it for eight or ten feet from the nest. The squirrel ate the eggs about thirty feet away. It returned and successfully took an egg on three occasions, and was repulsed once. Two of its trips were just nine minutes apart. Investigation after the third trip disclosed eight eggs left, and four days later these were all gone. The nest structure was not molested or broken. A number of other quail nests showed evidence of a similar fate.

Horn (12:58) says:

"The California digger squirrel, or Beechey ground squirrel (Citellus beecheyi beecheyi) and its close relative the Douglas ground squirrel (Citellus beecheyi douglasii), are suspected of eating enough eggs to actually hold down the population of quail on areas where these squirrels are numerous. The following observations over a period of years strongly indicate this possibility and show the need for careful, detailed field study of the question."

Horn continues with the Oregon observation previously quoted. Then a statement that during May 1935 in Santa Clara County, California, a quail nest containing nine eggs was robbed. He states that:

"Shell fragments of quail eggs were found at a rock outcropping in a Beecheyi ground squirrel colony close by. One egg was found in a surface cache made by the squirrels. So far as could be determined from shell fragments, four eggs had been eaten."

At about the same time and place, a Beechey ground squirrel was observed robbing a mourning dove nest in a blue oak tree. It came across the nest probably by accident, ate one egg, and carried the other away in its mouth.

In the spring and summer of 1929, following a poison campaign which reduced the squirrel population to one per cent of its former concentration of 20 to 25 per acre, ".....there was a very noticeable increase in the number of young quail following that nesting season." One excellent quail habitat on this same ranch, but where squirrels are still present in large numbers, did not show as rapid an increase in quail.

Horn (12:58-60) concludes that:

"From these instances it is strongly indicated that they (ground squirrels) are a factor influencing the density of quail populations. Whether similar results would be obtained under different habitat conditions is at present unknown."

Only one reference has been found regarding predation by ground squirrels on pheasants. The following quotation from Moore (16) concerns the Columbian ground squirrel, Citellus columbianus columbianus:

"Shells of China pheasant eggs were found in the stomach of a specimen taken at Moiese, Montana. In 1930 the state game farm at Lapwai, Idaho, estimated 1,500 pheasants ranging in age from three days to six weeks were killed and partly eaten by this squirrel. In digging out the squirrel dens, in addition to the young pheasants, meadow larks and bull bats were reported found."

DUMMY NEST STUDY

The Sets

In order to obtain specific data regarding nesting losses due to Douglas's ground squirrels, one hundred dummy nests were constructed at scattered locations on approximately 2,000 acres of the Soap Creek area, figures 3 and 4. Eighty-six of these were pheasant, and fourteen were bobwhite nests. Eggs of these species were secured from the Oregon State Game Farm near Corvallis and from wild, deserted nests. Sets were made to imitate wild nests as closely as possible considering the varied environmental conditions in which they were purposely placed. A small steel trap was placed at each nest. The surroundings were left as natural as possible, and due precautions were taken whenever the sets were visited. A detailed record was kept for each set and it included the following items which were considered as possibly influencing predation: time of season; distance from nest to nearest digger burrow; value of the location as a game bird habitat; number of eggs in the clutch; and the type and degree of cover at the nest. These sets were in operation from April 25 to August 25, except for a ten day period in early June. This period corresponds closely with the local nesting



Fig. 3
Bobwhite dummy nest. Set 44.
July 7, 1940.



Fig. 4
Pheasant dummy nest. Set 42.
July 7, 1940.



Fig. 5
Douglas's ground squirrel caught
at set 44. (Fig. 3).
July 10, 1940.



Fig. 6
Douglas's ground squirrel caught at Set 42
(Fig. 4)
Vegetation trampled. (Note egg near base of
post.)

July 20, 1940

season. Individual sets remained in place from one to thirty-six days, average twelve, or for a total of 1204 trap-days.

Results

Results were recorded as to date; species and sex of individuals caught; direct evidence such as hair or claws left in sprung traps, or whether there was a lack of such evidence; and finally, the condition of the eggs - whether eaten, stolen, or untouched. A stomach analysis was made of most individuals caught, especially if the eggs had been molested.

Of the 100 sets, 80 in all were disturbed at some time. Of the latter, 59 caught and held some predatory species of bird or mammal, including the gray digger; eight others contained direct evidence such as claw or hairs; ten more were sprung, but no incriminating evidence remained; and at three other nests eggs only were disturbed. Many of these sets made repeated catches. The species, and total numbers of individuals caught are given in table I.

Table I. A summary of predatory species caught at dummy nests.

Species	Number of sets raided	Number of individuals caught
Douglas's ground squirrel	43	70
Skunk (<u>Mephitis occidentalis</u>)	21	22
Long-tailed jay (<u>Aphelocoma californica</u>)	3	4
House cat (<u>Felis catus</u>)	2	2
Brown rat (<u>Rattus norvegicus</u>)	1	2
Coast jay (<u>Cyanocitta stelleri</u>)	1	1
Gray fox (<u>Urocyon cinereoargenteus</u>)	1	1

Direct evidence in addition to the catches listed above include, for the squirrel: toe or claw remains in trap, 14; and hair, six; for a total of 90 individuals definitely identified. And, for the skunk, hair was identified at one trap, and eggs eaten in characteristic skunk manner at another, making a total of 24 skunks identified.

Seventy-one traps were sprung without sufficient evidence remaining to determine the cause. These are disregarded in following calculations.

Of the 100 sets, eggs were molested in some manner at 58, stolen from 42, and eaten at 34. If repeated raids at the same set are counted then, 152 missing eggs were noted on 76 inspection visits, and a total of 126 eggs were eaten on 46 occasions. Table II shows the condition of the eggs at the time when these 124 definitely identified individuals were caught.



Fig. 7
Douglas's ground squirrel
and pheasant egg



Fig. 8
Set 49. Typical nest destruction by skunk
Shells also found in stomach. July 16, 1940.

Table II. Summary of the condition of eggs at time of trapping 124 known predators.

Species	Recovered in stomach	Eaten, not recovered	Some stolen	Intact or broken
Douglas's ground squirrel	3	4	27	56
Striped skunk	13	3	4	4
Long-tailed jay	0	2	1	1
Coast jay	0	1	0	0
House cat	0	1	0	1
Gray fox	0	0	1	0
Brown rat	0	1(?)	0	1

Eighty per cent of the one hundred dummy nests were visited by some species of predatory animal even though, on the average, nests were exposed for less than one-half the normal period of incubation for the species. Fifty-two per cent of these were raided more than once, some as often as eight and ten times. Such nests were restocked with eggs between visits, and made to look as natural as possible. In one instance, set 35, two squirrels were taken from the same nest-set during the day following its construction. A young skunk destroyed the nest four days later. On one of the few occasions when two traps were placed at one nest, set 61, a measure induced by the fact that a skunk had already made two successful raids, two digger squirrels were caught at the same time. A skunk was caught there the next day.

Following are a few nest histories selected to show the occasional intensity of predation. These occurred in spite of the fact that control measures have been carried on for four years.

Set 7. Made on 5/6, six feet from a digger burrow in an open pasture.

- 5/8 Trap sprung; all 6 eggs gone. Reset with 4 eggs.
- 5/9 Trap sprung; 3 eggs gone. Reset with 1 egg.
- 5/11 Trap sprung; egg remained. Reset.
- 5/17 Gray digger caught; egg gone. Reset, blind.
- 5/18 Trap sprung; Reset with 2 eggs.
- 5/20 Gray digger caught; eggs eaten, not recovered. Reset with 2 eggs.
- 5/21 Young skunk caught; eggs gone. Not reset.

Set 12. Made on 5/11, probably 6 to 8 feet from a digger burrow, and at the edge of a brush patch.

- 5/15 Gray digger caught; 1 of the 2 eggs gone. Reset.
- 5/20 Trap sprung; eggs intact. Reset 2 eggs.
- 5/21 Trap sprung; shell of one egg found nearby. Reset.
- 5/23 Gray digger caught; eggs gone. Reset 1 egg.
- 5/24 Trap sprung; egg intact. Reset.
- 5/28 Trap sprung; egg intact. Reset.
- 5/30 Young skunk caught; egg in stomach. Not reset.

Set 25. Made 6/13, 3 to 4 feet from a digger burrow, located in heavy grass.

- 6/14 Gray digger caught; eggs intact. Reset.
- 6/17 Gray digger caught; eggs intact. Reset.
- 6/18 Gray digger caught; eggs intact. Reset.
- 6/21 Gray digger caught; 1 egg, and 1 shell remained.
- 6/24 Gray digger caught; egg intact. Not reset.

Set 39. Made 6/25, 6 feet from a burrow, in a pasture near some deserted buildings. Bobwhite eggs were used.

- 6/25 Gray digger caught; eggs intact. Reset.
- 6/26 Gray digger caught; eggs intact. Reset.
- 6/27 Trap sprung; eggs intact. Reset.
- 6/28 Gray digger caught; eggs crushed. Reset.
- 6/30 Removed set.

Set 74. Made 7/31, 6 feet from a burrow, in heavy grass at the edge of an oat field.

- 8/2 Brown rat caught; 1 of 8 eggs eaten, not recovered.
- 8/3 Brown rat caught; eggs intact. Reset.
- 8/5 Digger claw in trap. Reset.
- 8/6 Digger hair in trap; eggs moved around. Reset.
- 8/7 Gray digger caught; 1 of 7 eggs gone. Reset.
- 8/8 Trap sprung; eggs intact.

8/9 Gray digger caught; eggs intact. Reset.
 8/10 Gray digger caught; eggs intact. Reset.
 8/15 Feral house cat caught; eggs intact. Reset.
 8/22 Digger claws in trap; eggs intact. Reset.
 8/25 Removed set.

Set 87. Made 8/8, no burrow nearby, located in mowed pea field.

8/9 Trap sprung, held digger toe; eggs intact. Reset.
 8/10 Trap sprung; 2 of 5 eggs gone. Reset with 3 eggs.
 8/11 Trap sprung; 1 egg moved some distance. Reset.
 8/12 Digger hair in trap; 2 of 3 eggs gone, 1 recovered about 5 feet away. Reset.
 8/13 Gray digger caught; eggs intact. Reset.
 8/14 Young skunk caught; 1 of 2 eggs bitten. Not reset.

Set 93. Made 8/10, nearest burrow at least 50 feet away, set in harvested field.

8/11 Gray digger caught; eggs intact. Reset.
 8/12 Gray digger caught; 3 of 4 eggs gone, 1 eaten. One shell found about 10 feet away. Small black feathers in intestine. Reset at one partly eaten egg.
 8/13 Gray digger caught; egg gone. Reset with 3 eggs.
 8/18 Only 2 eggs remain.
 8/20 Digger claw in trap; eggs intact. Reset.
 8/21 Gray digger caught; both eggs gone. Reset
 4 eggs.
 8/25 Gray digger caught; eggs intact. Not reset.

Set 94. Made 8/12, ten feet from burrow in harvested field.

8/14 Gray digger caught; all 4 eggs intact. Reset.
 8/16 Gray digger caught; eggs intact. Reset.
 8/17 Digger hair in trap; eggs intact. Reset.
 8/18 Digger claw and hair in trap; eggs intact. Reset.
 8/22 Trap wire broken, trap gone; eggs intact. Reset.
 8/25 Gray digger caught; eggs intact. Not reset.

The largest number of predators caught at dummy nests on any one day was six. With twelve traps in opera-

tions on May 20, the catch consisted of two skunks, two jays, and two gray diggers. On June 25, four of these ground squirrels were taken at eleven nest sets. Three skunks and two diggers were trapped, on July 26, at five of the seventeen sets in operation. August 14 yielded two skunks and three ground squirrels from a total of twenty-six traps. Five gray diggers, the most taken in one day, and one skunk were caught on August 25 when seventeen traps were set.

Although nearly three out of every four individuals caught were gray diggers, egg shells were actually recovered from only three stomachs. Following are the complete case records of these sets.

Case 1

Set 35

Date set - 6/24

Location - in wheat field, 10 feet from edge. Field is adjacent to timber and brush (Figure 2).

Cover - moderately good stand of wheat, being broken down by diggers.

From digger burrows - about 50 feet

Eggs set - 3 pheasant.

Game bird habitat - good.

Results -

6/25 Gray digger caught, young female. One egg missing; not recovered in stomach which was half full of wheat.

6/25 (same day) Gray digger caught, young male. One of the two eggs partly eaten. Stomach full of wheat, trace of blackberry, and EGG SHELL AND MEMBRANES. Shell also in intestines. Saved the shells. Reset with one egg.

6/29 Skunk caught, small female. Egg intact. Stomach empty. Reset.

6/30 Removed the set.

Case 2

Set 45

Date set - 7/9

Location - Same field as set 35 (Figure 2).

Cover - as for Set 35.

From digger burrows - at least 25 to 30 yards

Eggs set - 4 pheasant

Game bird habitat - very good

Results -

7/16 Gray digger caught, young female. Two eggs unbroken, two broken into and eaten, with bits of shell scattered about. Stomach, 3/4 full, contained 85% wheat, 10% blackberry, a trace of seeds, and 5% EGG SHELL AND MEMBRANES. Saved stomach contents. Photographed damaged nest (Figure 9).

7/20 Removed the set.

Case 3

Set 63

Date set - 7/22

Location - fencerow along county road.

Cover - heavy grass strip between road and a cultivated field.

From digger burrows - none located, but believed to be in the neighborhood.

Eggs set - 10 pheasant

Game bird habitat - very good

Results -

7/28 Gray digger caught. Eggs intact. Stomach empty. Reset.

7/30 Feral house cat caught. Three eggs eaten, but little shell broken. No shell found in stomach or intestines, but remains of a small bird were found. Reset 7 eggs.

8/5 Eggs all eaten, with large hole in side of each believed to be work of skunk. Trap not sprung. Reset 5 eggs.

8/7 One of five eggs eaten; predator undetermined. Trap not sprung. Reset with 4 eggs.

8/8 Gray digger caught, young female. Two eggs broken and eaten, one missing, and one intact. Stomach half-full; 80% green seeds, 10% cas-cara seeds, 10% green vegetation, trace of grain, and EGG SHELL. Collected broken egg shells and stomach contents. Reset 3 eggs.

8/9 Trap sprung. Eggs intact. Reset.

8/20 Removed the set.



Fig. 9
Dummy pheasant nest destroyed by Douglas's
ground squirrel. Shell found in
stomach. Set 45. July 16, 1940.



Fig. 10
Douglas's ground squirrel eating pheasant
egg.

In addition to the three foregoing records, there were the following occasions when these squirrels almost certainly ate eggs at a nest. One set of six pheasant eggs located in light grass cover under an oak tree, and only six feet from the nearest burrow, had been raided on five different dates. Some or all of the eggs had been stolen on four of these occasions, and one squirrel was caught. On May 20, a second gray digger was trapped, and only the broken shells of two eggs remained. The stomach was empty. On June 21, the fourth young one was taken at another pheasant nest situated in heavy grass along a fence row. One egg remained intact but the other was represented by an empty shell. Only green vegetation was identified in the stomach. At another set along a fence row, and some thirty feet from the nearest known burrow, a young digger was trapped on July 22. Two of the six pheasant eggs were broken into as if eaten; but no shell was detected in the stomach. Another of these squirrels was caught on August 14, at a pheasant nest in a harvested grain field. This set was at least fifty feet from the nearest den. One partly eaten egg remained at the nest, the shell of one egg was found about ten feet away, and the two others had disappeared. The stomach was empty. In each of these

cases the condition of the shells indicated that the eggs had been eaten rather than merely broken or crushed. Eggs belonging in this latter category were also recorded from time to time. It should be recognized that stomach analyses reveal only an individual's last meal. For adequate material with which to make accurate identifications the analysis must be undertaken shortly after the meal was eaten. This was not always done, for the traps were visited only once or twice a day.

Many of the squirrels must have been caught before reaching the eggs, and once trapped they immediately concentrate on escape. According to the record, this probably happened to fifty-four or 60 per cent of the individuals caught.

Another reason for so few stomachs from trapped animals containing egg shells is the gray digger's habit of removing the eggs, singly, from the nest rather than eating them on the spot. This may account for twenty-one cases when an animal was trapped at a nest from which some eggs were missing without a trace remaining, while others were still intact. These squirrels apparently were caught on their second, third, or subsequent trips. The following are a few examples il-

lustrating this habit. On August 18, a gray digger was caught at a pheasant nest of four eggs. Two eggs remained intact, one was missing, and the broken shell of the fourth was found some feet away. A more convincing incident occurred on August 16, when a dummy nest of five bobwhite eggs, located about twenty feet from a digger squirrel's burrow, lost four eggs. They were recorded as "disappeared", and the remains of the set were left as found. On the following day, the broken shells of four bobwhite eggs were found mixed with some freshly removed soil at the entrance to the nearby digger burrow. On several other occasions, also, these ground squirrels were trapped at nests and a missing egg was found, broken, some distance away. None were ever actually observed carrying a pheasant egg, but they have been seen eating them, figure 10. On one occasion a squirrel was seen to approach and carry off a bobwhite egg placed near a den for observation purposes. The animal returned into the hole before it could be collected for detailed examination of its method of egg carrying. Eggs were stolen from nests in 49 instances without the predator leaving a clue. How many of these records should be attributed to the Douglas's ground squirrel, can only be conjectured.

In some cases the egg appeared to have been dropped, but not eaten. Attention is called to figure 7, which illustrates the comparative size of the pheasant egg and the squirrel, and which might cause some question as to the ability of so small an animal to carry such an object in its mouth. It would not be surprising to learn that the small young squirrels are unable to get the necessary grip on the smooth, firm shell. The adults, however, have been known to carry a domestic hen's egg, according to several reports to be cited under "general observations". Examination of several pheasant eggs carried or eaten by gray diggers revealed that these animals pierce the shell on opposite sides with their long incisors. Such marks, quite naturally, were not found on eggs eaten by non-rodent predatory species observed during this study. Figure 12 shows typical remains of some pheasant eggs eaten by Douglas's ground squirrels.

No significant difference was found in the results whether pheasant or bobwhite eggs were used for the dummy nests, as is shown in table III. Data on a number of items which varied from set to set were carefully recorded in order to determine the possibility that one or more of them might prove to be of importance.

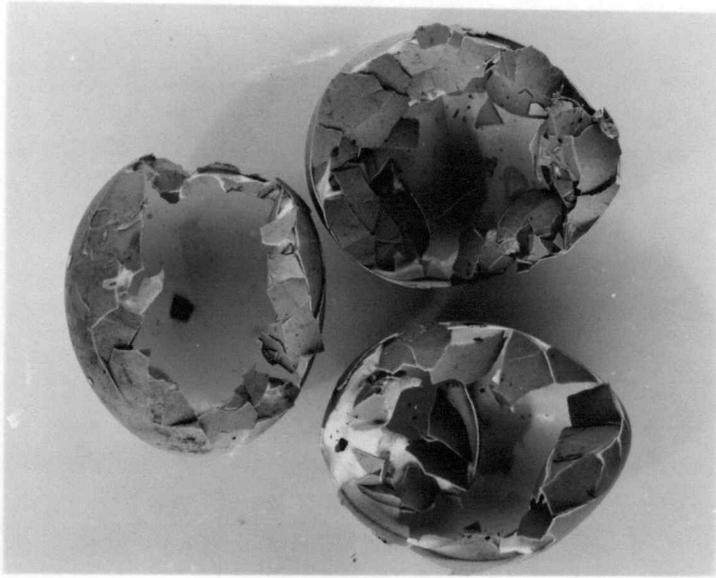


Fig. 11
Pheasant eggs eaten by skunks
Sets 49, 61, 86

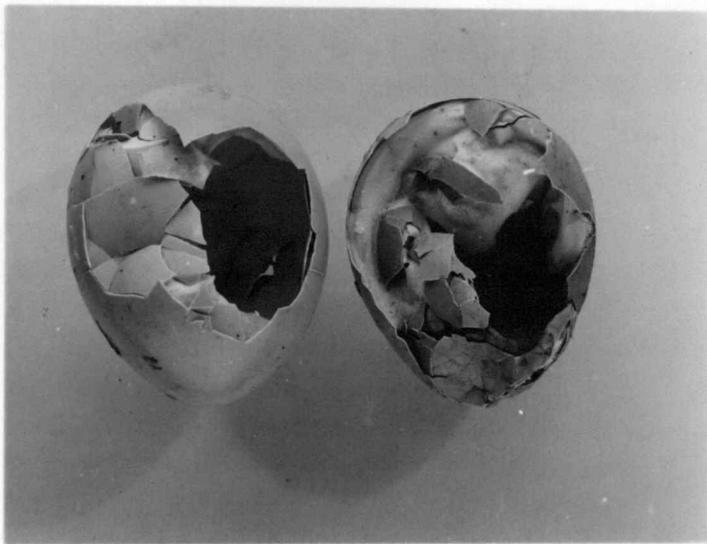


Fig. 12
Pheasant eggs eaten by Douglas's
ground squirrel at Set 63. Shell
found in stomach.

Table III. Comparison of results at pheasant and bobwhite sets

Trap-days	Pheasant, 1078			Bobwhite, 126		
	Number	Number* T-D	%	Number	Number T-D	%
Diggers caught	80	7.4		10	7.9	
Sets catching diggers	44		51	7		50
Instances of set molesta- tion	194	18		24	19	

These items were: time of season, distance of set from nearest digger-squirrel burrow, the rating of the locality as a game bird habitat, the number of eggs in the set, and the type and density of cover. Table IV gives existing conditions at the time and place of capture of each Douglas's ground squirrel. Only individuals actually killed or those leaving positive evidence are included. This is followed by tables V to IX showing the significance, if any, of these items.

* For purposes of comparison, an "efficiency" figure, obtained by dividing the number of individuals or instances by the trap-days (total number of days that all traps concerned were set), is believed to be the most significant. This value has been multiplied by 100 for convenient use.

Table IV. Data on 51 sets that caught 90 Douglas's ground squirrels.

Set number	Month set	Feet from den	Bird habitat	Number of eggs	Cover	Condition of eggs
5	May	25'	Excell.	3	Mod. grass	2 missing
6	May	6	Excell.	1	Mod. grass	Intact
7	May	6	Poor	2	Lt. grass	2 gone
7	May	6	Poor	2	Lt. grass	2 eaten **
8	May	6	Excell.	1	Hy. grass	Intact
9	May	6-10	V. Good	4	Mod. grass	3 gone
9	May	6-10	V. Good	2	Mod. grass	2 gone
9	May	6-10	V. Good	3	Mod. grass	3 gone
9	May	6-10	V. Good	3	Mod. grass	1 gone
12	May	6- 8	Fair	2	Mod. brush	1 gone
12	May	6- 8	Fair	2	Mod. brush	2 gone
16	May	?	V. Good	3	Hy. grass	2 gone
16	June	?	V. Good	1	Hy. grass	Intact
16	July	?	V. Good	1	Hy. grass	Intact
17	May	3	Fair	1	Lt. grass	Intact
20	May	?	Good	1	Med. grass	Gone
25	June	3-4	Excell.	2	Hy. grass	Intact
25	June	3-4	Excell.	2	Hy. grass	Intact
25	June	3-4	Excell.	2	Hy. grass	Intact
25	June	3-4	Excell.	2	Hy. grass	1 eaten **
25	June	3-4	Excell.	1	Hy. grass	Intact
28	June	?	V. Good	5*	Hy. grass	Intact
28	June	?	V. Good	5*	Hy. grass	5 gone
30	June	?	V. Good	3	Mod. brush	Intact
31	June	?	V. Good	1*	Hy. brush	Intact
32	June	6	Fair	1	Lt. grass	Intact
33	June	4	Fair	1	Hy. brush	Gone
35	June	50	Good	3	Mod. cult.	1 gone
35	June	50	Good	2	Mod. cult.	1 EATEN
36	June	50	Good	3	Mod. cult.	Intact

Table IV. (Continued) Data on 51 sets that caught 90 Douglas's ground squirrels.

Set number	Month set	Feet from den	Bird habitat	Number of eggs	Cover	Condition of eggs
39	June	6	Poor	2*	Mod. grass	Intact
39	June	6	Poor	2*	Mod. grass	Intact
39	June	6	Poor	2*	Mod. grass	Broken
40	July	?	Excell.	3	Hy. brush	3 gone
42	July	?	Good	6	Hy. cult.	Moved some
42	July	?	Good	6	Hy. cult.	1 gone, 3 broken
44	July	?	V. Good	6*	Hy. grass	Intact
45	July	?	V. Good	4	Mod. cult.	2 EATEN
50	July	?	V. Good	5	Hy. grass	Intact
50	July	?	V. Good	5	Hy. grass	Intact
56	July	30	V. Good	6	Mod. grass	2 eaten **
57	July	30?	V. Good	4	Mod. grass	1 gone
58	July	50	V. Good	10	Hy. grass	Intact
59	July	?	V. Good	10	Hy. grass	Intact
61	Aug.	?	Excell.	5	Hy. grass	Intact
63	July	?	V. Good	10	Hy. grass	Intact
63	Aug.	?	V. Good	4	Hy. grass	2 EATEN, 1 gone
64	July	?	Excell.	4*	Mod. brush	1 gone
65	July	?	Excell.	10	Hy. grass	Intact
69	July	?	Good	12	Hy. grass	Intact
69	July	?	Good	12	Hy. grass	3 broken
70	July	6-8	Good	12	Hy. cult.	Intact
71	Aug.	?	V. Good	6	Hy. grass	Intact
73	Aug.	?	Excell.	4	Hy. herb.	1 gone, 1 broken
74	Aug.	6'	V. Good	7	Hy. grass	Intact
74	Aug.	6	V. Good	7	Hy. grass	Intact
74	Aug.	6	V. Good	7	Hy. grass	1 gone
74	Aug.	6	V. Good	6	Hy. grass	Intact
74	Aug.	6	V. Good	6	Hy. grass	Intact
74	Aug.	6	V. Good	6	Hy. grass	Intact

Table IV. (Continued) Data on 51 sets that caught 90 Douglas's ground squirrels.

Set	Month set	Feet from den	Bird habitat	Number of eggs	Cover	Condition of eggs
75	Aug.	?	Excell.	8	Hy. grass	Intact
76	Aug.	?	Excell.	8	Mod. grass	Intact
78	Aug.	20	V. Good	6	Hy. herbs	Intact
78	Aug.	20	V. Good	6	Hy. herbs	1 gone?
82	Aug.	?	V. Good	4	Hy. herbs	1 broken
83	Aug.	5	V. Good	3	Hy. cult.	Intact
84	Aug.	?	Good	5	Hy. herbs	1 gone
85	Aug.	?	Good	4	Hy. herbs	Intact
86	Aug.	?	Good	4	Mod. cult.	Intact
86	Aug.	?	Good	4	Mod. cult.	Intact
86	Aug.	?	Good	4	Mod. cult.	Intact
87	Aug.	?	Good	5	Mod. cult.	Intact
87	Aug.	?	Good	3	Mod. cult.	1 gone, 1 broken
87	Aug.	?	Good	2	Mod. cult.	Intact
89	Aug.	?	Excell.	4	Hy. brush	1 gone, 1 broken
93	Aug.	50	Good	4	Mod. cult.	Intact
93	Aug.	50	Good	4	Mod. cult.	1 eaten**, 2 gone
93	Aug.	50	Good	1	Mod. cult.	Gone
93	Aug.	50	Good	2	Mod. cult.	Intact
93	Aug.	50	Good	2	Mod. cult.	2 gone
93	Aug.	50	Good	4	Mod. cult.	Intact
94	Aug.	10	Good	4	Mod. cult.	Intact
94	Aug.	10	Good	4	Mod. cult.	Intact
94	Aug.	10	Good	4	Mod. cult.	Intact
94	Aug.	10	Good	4	Mod. cult.	Intact
94	Aug.	10	Good	4	Mod. cult.	Intact
94	Aug.	10	Good	4	Mod. cult.	Intact
95	Aug.	20	Good	5*	Mod. cult.	3 broken
98	Aug.	?	Good	3*	Hy. herb	2 gone, 1 broken
99	Aug.	?	Good	4	Mod. cult.	Intact
99	Aug.	?	Good	4	Mod. cult.	Intact

* Bobwhite

** Not recovered

Table V. Relationship of ground squirrel predation to time of season.

Date	No. of sets*	Trap-days	Sets catching diggers per cent	No. of diggers caught	Number trap-days
Apr.	4	14	0.0	0	0.0
May	19	251	47.4	16	6.4
June	23	153	43.5	18	11.8
July	35	310	42.9	18	5.8
Aug.	37	476	54.1	38	8.0

* Sets in operation during any part of month.

Table VI. Relationship of ground squirrel predation to distance from nearest den entrance.

Distance in feet	No. of sets	Trap-days	Sets catching diggers per cent	No. of diggers caught	Number trap-days
0 - 10	17	211	76.5	29	13.7
10 - 100	26	300	38.5	21	7.0
Over 100 or unknown	57	693	49.1	40	5.8

Table VII. Relationship of ground squirrel predation to the value of a location as a bird habitat.

Habitat*	No. of sets	Trap-days	Sets catching diggers per cent	No. of diggers caught	Number trap-days
Poor	5	60	40.0	5	8.3
Fair	9	101	44.4	5	5.0
Good	29	312	51.7	32	12.6
Very good	28	382	64.3	32	8.4
Excellent	29	349	41.4	16	4.6

*Based on personal judgement and familiarity with the area.

Table VIII. Relationship of ground squirrel predation to the size of nests.

No. of eggs	No. of sets	Trap-days	Sets catching diggers per cent	No. of diggers caught	Number trap-days
1	20	103	50.0	11	10.7
2	27	167	29.6	16	9.6
3	32	179	31.3	11	6.1
4	29	210	48.3	22	10.5
5	25	223	24.0	8	3.6
6	14	129	42.8	10	7.8
7	5	30	20.0	3	10.0
8	3	36	66.6	2	5.6
9	2	7	0.0	0	0.0
10	8	88	50.0	4	4.5
12	5	32	40.0	3	9.4

Table IX. Relationship of ground squirrel predation to the type and density of cover

Cover	No. of sets	Trap-days	Sets catching diggers per cent	No. of diggers caught	Number trap-days
Lt. grass	6	48	50	4	8.3
Mod. grass	10	107	80	13	12.1
Hy. grass	23	333	61	30	9.0
Moder. herb	3	46	0	0	0.0
Hy. herb	13	168	54	7	4.2
Mod. brush	9	108	33	4	3.7
Hy. brush	9	71	55	4	5.6
Moder. cult.	19	202	47	24	11.9
Hy. cult.	7	106	43	4	3.8
Lt. burn	1	15	0	0	0.0

Application of Pearson's Chi-square test to the above tables gave the following results:

Table	χ^2	Degree of freedom	Probability	Interpretation
V	7.067	4	$.10 \leq P \leq .20$	Not signif.
VI	14.994	2	$P < .01$	Significant
VII	5.355	4	$.20 \leq P \leq .30$	Not signif.
VIII	13.127	10	$.20 \leq P \leq .30$	Not signif.
IX	22.538	9	$P < .01$	Significant

Analysis of results

The fact that the field study was carried on through only one nesting season, and on a limited area, should be considered when evaluating these results. It is realized that these tables are based upon insufficient data to be regarded as conclusive, but the figures shown here may prove sufficiently indicative to stimulate further investigation.

Table V presents the relationship of squirrel predation to the time of season. Data for April is insufficient for dependable analysis and may be entirely disregarded. The per cent of sets catching these ground squirrels during the other four months is remarkably close, indicating, perhaps, that the animals are evenly scattered on the area. Since the young are just appearing above ground in June, it is the season of greatest populations. The table tends to indicate that June is the most active month for nest-raiding squirrels, but this can not be stated as a fact because statistical analysis shows the figures to be inconclusive.

Table VI shows the relationship of squirrel predation to distance from their nearest den entrance. As

might be expected of an animal having such a short cruising radius from a definite home site, nests located in the proximity of burrows are particularly susceptible to destruction. Three-fourths, 76 per cent, of the nests located within 10 feet of a den were raided as compared to an average of about 45 per cent for nests at a greater distance. All such dens were not definitely known to have been in use at the time. On the basis of the number of times raided per given number of days exposed, the nests within 10 feet may be judged twice as vulnerable as any others. They also caught nearly one-third of all the squirrels taken. Although many of the 40 individuals caught at undetermined distances from dens probably had come less than 100 feet, it is common knowledge that gray diggers may travel several times that far in search of food.

Table VII shows the relationship of predation to the existing estimated value of the nest location as an upland bird habitat, considering especially the known concentration of birds actually using the immediate area. There are, probably, too few sets located in poor and fair habitats to secure significant results. Why the excellent habitat group should appear so comparatively favorable was, at first, not clear. With about the same

number of traps set for the average number of days, the per cent making a catch appears noticeably lower than for the good and very good sites. Checking the original notes disclosed that the remaining excellent habitat sets were all at unknown distances from the nearest burrows and had been raided somewhat more severely from other predators. When including all sets molested by any cause, the following percentages were revealed: good, 76; very good, 79; excellent, 76. There is nothing in the table to indicate that the digger squirrels locate nests with any more regularity in poor or in good nesting cover.

Table VIII shows the relationship of predation to number of eggs in the nest. The many categories with the resulting small figures for each, preclude any satisfactory analysis. The large number of sets as well as their concentration at the lower figures is partly due to re-baiting partially destroyed sets with the eggs remaining, and to other nests from which part of the eggs had been stolen but the set remained in operation. The table tends to show that whether small or large, nests are found with equal frequency.

Table IX shows the relationship of predation to the type and density of cover. The terms grass, herbs, and brush indicate the predominant vegetative growth-form.

Cultivation (cult.) is self-explanatory. The degree of cover as expressed by light, moderate, and heavy is a general estimate based on personal judgement. Figure 2 pictures cover considered moderate; and that in figure 3 was listed as heavy. This table indicates particularly heavy predation in all grass cover and in moderately dense cultivated stands. When these items are condensed into larger groups as in table X, the figures become more significant.

Table X Relationship of ground squirrel predation to the type and density of cover. Table IX condensed.

Cover	No. of sets	Trap- days	Sets catching diggers	No. caught	Number T-D	Sets molested (total)
			%			%
Grass	39	488	67	47	9.6	89
Herbs	16	214	37	7	3.3	63
Brush	18	179	39	8	4.5	67
Cult.	26	308	46	28	9.1	77
Light	7	63	43	4	6.4	100
Moder.	41	463	49	41	8.9	78
Heavy	52	678	54	45	6.6	79

Table X illustrates more clearly than the preceding one that nests in grass cover had a considerably higher percentage of destruction than those in weeds or brush. Cultivated land ranks somewhere in between these, but closely approaches the grass habitat in danger due to squirrel predation. Sets on cultivated land were

practically confined to fields of grain and legumes in various stages of growth or following the harvest. Sets were usually less than 100 feet into the field. That this comparatively low degree of destruction by gray diggers in the herbs and brush was not due to other predatory species discovering the sets first is shown by the figures for the total per cent of sets molested. Since the figures in this column are relatively the same as those showing loss due to squirrels alone, there was no disproportionate predation by other species. Although the nests in moderate cover appear to have been found more quickly than those in heavier cover, eventually about the same percentage of sets were raided in each group. Although only seven nests were placed in light cover, it is perhaps worth mentioning that all of them were destroyed.

There is an indication, at least, that nest damage due to predation is more severe in cover along fence rows. Of the 80 sets molested by any cause, 47, 89 per cent, of those along fence rows and 33, 70 per cent, of all others were destroyed. Thirty or 57 per cent, and 21 or 45 per cent respectively were by gray diggers.

STOMACH ANALYSES

A routine field analysis of digestive tracts was made of individuals taken in traps at the dummy nests. In addition, gray diggers were shot or trapped as opportunity afforded during seven months of their active season. Most of these individuals were collected at random on the experimental area, but some are from the surrounding countryside. All are from Benton, Polk, or Linn Counties. A total of 234 squirrel stomachs were examined, thirty of which were empty. Pheasant eggs, the primary object of the analyses, were positively identified in three gray digger (and 13 skunk) stomachs, from specimens caught at dummy nests. No evidence of egg eating was discovered in any animals not trapped at nests. This does not necessarily imply that such predation does not take place, for it is necessary to examine the stomach shortly after the nest has been raided. Large numbers of specimens might be expected to yield but little evidence even though predation was of widespread occurrence. The ground squirrel's usual procedure is to remove eggs, one at a time, and carry them some distance away before eating, or storing them in their burrows.

It should be emphasized that all analyses were conducted in the field and that all percentage estimates are

approximate. Due care was taken to insure accurate identifications, but no attempt was made to carry all determinations to species.

Foods Eaten

Tables XI and XII list all the food items found in the 204 stomachs analyzed. About 80 per cent of these were secured on the Soap Creek Experimental Area, 12 per cent on Wood's Creek in the central part of Benton County, and a few in other parts of Benton, Polk, and Linn Counties, all within 20 miles of the area.

Table XI. Food of Douglas's ground squirrel. The average per cent by volume, and the occurrence by number and per cent of all food items in 204 stomachs analyzed.

ITEMS	VOLUME	OCCURRENCE	
	per cent	number	per cent
GREENS			
Leaves and stems.....	37.2	155	76.0
Clover flowers.....	0.5	1	0.5
Composite flowers.....	0.4	4	2.0
FRUITS			
Apple.....	12.2	40	19.6
Blackberry.....	1.9	23	11.3
Serviceberry.....	0.7	6	3.0
Hawthorn.....	0.4	2	1.0
Berries (undetermined)..	1.8	11	5.4
Fruits (undetermined)..	0.4	1	0.5
SEEDS			
Tarweed.....	8.3	34	16.7
Acorns.....	2.2	9	4.4
Grasses.....	0.7	6	3.0
Hazel.....	0.4	1	0.5
Cascara.....	0.1	2	1.0
Weeds (undetermined)..	3.6	26	12.7
BERRIES AND SEEDS			
(undetermined).....	0.4	4	2.0
CULTIVATED CROPS			
Wheat.....	10.9	28	13.7
Oats.....	3.9	12	5.9
Vetch.....	0.8	4	2.0
Peas.....	0.8	3	1.5
Grain (undetermined)..	7.9	39	19.1
STRAW.....	0.5	2	1.0
ROOTS or BULBS.....	0.3	5	2.5
VEGETABLE MATTER			
(undetermined).....	0.9	4	2.0
ANIMAL MATTER.....	1.5	28	13.7
UNIDENTIFIED.....	1.1	7	3.4
SOIL.....	0.2	2	1.0
	<u>100.0</u>		

While these findings can only be applied with certainty to the locality studied, it is believed that the Douglas's ground squirrel's food habits are similar over much of its surrounding range in the Willamette Valley.

Table XII. Analysis of the animal matter in 28 stomachs, as reported in table XI.

ITEM	OCCURRENCE	PERIOD OF USE
Eggs, pheasant	3	June, July, Aug.
Mammals, flesh and hair	6	June, July, Aug.
Hair, unidentified	3	June
Feathers (1 blackbird; 1?)	2	June, Aug.
Insects (grasshoppers, and larvae mainly)	14	July

The eggs listed in table XII, as previously indicated were all from dummy nests. The mammal remains from three stomachs were identified as gray digger and all three were taken the same day from among the seven animals shot in Linn County. The other samples may also have been from this species, but this is uncertain. The average per cent of animal matter in these six stomachs was 35, and the range from 2 to 75 per cent of the total contents.

Table XIII is a classification of the same food material according to use by months. Of the 204 stomachs, green vegetation - leaves, stems, flowers - of various weeds was the most important food in spring and early summer, and was of major importance during every month studied. Acorns were utilized shortly before the animals

hibernated and again upon emerging in the early spring. Ground squirrels were seldom found on cultivated areas early in the season, but were concentrated on the warmer slopes covered with grass and scattered brush and trees - principally oaks. Grain became important in the diet during June, and use of weed seeds and berries were at their peak. By July, a variety of items were taken, of which, the leading ones were green vegetation, grain, apples, and weed seeds. Apples led in per cent by volume during August, and were followed by green plants and grains.

On July 17, a digger-squirrel was approached in an open pasture. It was excessively heavy, and as it made no attempt to run, was easily collected. Upon examination the stomach and intestines were found to be greatly distended by the following contents: 75 per cent, by volume, of hawthorn berries, 25 per cent flower heads from an unidentified Compositae, three cutworms, and a grasshopper. The measurements of the stomach were: circumference, 6 inches; length, $2\frac{1}{2}$ inches; and width, 2 inches. This was by far the largest of the many stomachs examined.

Table XIII. Stomach analysis of 204 Douglas's ground squirrel stomachs by months showing volume by per cent and occurrence in numbers of individuals.

Items	Oct.		Mar.		May		June		July		Aug.		Sept.	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Stomachs analyzed	3		7		7		78		72		33		4	
GREENS														
Leaves and stems	3	51.5	7	58.0	6	79.0	58	42.0	56	31.6	24	25.8	1	20.0
Clover flowers					1	14.0								
Composite flowers							3	0.8	1	0.4				
FRUITS														
Apple									21	16.0	18	37.5	1	25.0
Blackberry							13	3.0	7	1.2	3	2.3		
Serviceberry									6	1.9				
Hawthorn									2	1.1				
Berries(undetermined)							6	3.2	5	1.5				
Fruits (undetermined)									1	1.0				
SEEDS														
Tarweed							19	14.3	10	7.3	5	22.3		
Acorns	1	31.5	6	42.0	2	7.0								
Grasses							3	1.2	3	0.6				
Hazel									1	1.2				
Cascara									1	0.1	1	0.3		
Weeds(undetermined)							16	7.4	6	0.6	4	3.0		
BERRIES and SEEDS														
(undetermined)							4	1.0						

Table XIII. (Continued) - Stomach analysis of 204 Douglas's ground squirrel stomachs by months showing volume by per cent and occurrence in numbers of individuals.

Items	Oct.		Mar.		May		June		July		Aug.		Sept.	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
CULTIVATED CROPS														
Wheat							22	22.7	6	6.3				
Oats	1	17.0							9	9.2	2	2.7		
Vetch									2	0.2	1	1.2	1	25.0
Peas											1	1.5	2	30.0
Grains(undetermined)							5	2.0	20	13.6	14	14.7		
STRAW														
							1	0.4	1	1.1				
ROOTS or BULBS														
									3	0.2	2	1.6		
VEGETABLE MATTER (undetermined)														
							1	0.4	2	1.1	1	2.0		
ANIMAL MATTER														
							6	1.0	18	2.3	3	2.1		
UNIDENTIFIED														
							1	0.6	5	1.5	1	1.8		
SOIL														
											2	1.2		

Cheek Pouch Analyses

Cheek pouches of these digger-squirrels have at one time or another during this study been found to contain seeds of wheat, oats, barley, vetch, peas, grass and fruit of apple.

On July 11, an old male was shot after it had been observed for some minutes feeding in a stubble field. His cheek pouches contained: on one side, 344 vetch seed, 20 oat grains, and one cherry pit; and on the other side, 307 vetch seed, plus some oats; and the mouth cavity itself held about 50 more vetch.

On July 12, another adult male was taken while feeding in an unharvested field of vetch and oats. Its full pouches contained 551 vetch seed and 187 grains of oats.

Crop Destruction

The following quotations are presented to show the extent to which these ground squirrels normally remove the available food crops.

Grinnell and Dixon (9:629) say:

"It is believed by us that two ounces of green forage or one-half ounce of dry grain is an average stomach-full for an average-sized California ground squirrel and that two stomach-fulls represent a day's ration."

Shaw (17) working in Washington with the Columbian ground squirrel which he says is probably representative of the genus (18:250), has made the follow-

ing statement:

"Computing the amount of destruction on the basis of a normal 130 day season, one young or one brooding squirrel will destroy 51 pounds of grain in the ordinary active season for squirrels."

These estimates may be too conservative when applied to the large, local gray digger.

According to Gabrielson (8:6):

"This is the only ground squirrel found in the state that habitually stores food to last through the winter, and this fact, together with its long period of activity, combines to make this species one of the most destructive. The individuals do more damage than those of any other species,..."

Comparison of Food Habits

It may not be amiss to point out here that some of the leading food items in the squirrel's diet are also staple foods of the local upland game birds.

Edge (5:949) working on the Douglas's ground squirrel in Oregon found that weed seeds were very effective in baiting traps. He says:

"The effectiveness of these shows a definite competition for feed between the squirrels and other forms.....In the spring this food material consisted of succulent grasses, leaves of velvet grass (Notholcus lanatus), certain cheats, clover, filaree and false dandelion; and later in the year the heads and seeds of the false dandelion, plantain, lupine, rose, filaree, tarweed, St. John's wort, fireweed, oats, wheat, barley and the

like as well as acorns, hazelnuts, walnuts, cherry and prune pits....A number of seed eating birds like the mourning dove and some of the sparrows offer considerable competition (to the gray digger) for food, but this does not appear to be serious under average conditions. ...The squirrel gets ahead of some of these transient visitors by being continually on location and getting the seeds even before some are mature."

The following information appears to be the best available on the food of local game birds, and is included here for purposes of comparison.

Allen (1:64), working at Oregon State College, found that 87 per cent of the volume of 51 pheasant stomach contents consisted of plant food. Thirty-two per cent of this was crop or weed seed and the following are among a list of the 30 most numerous: wheat, wild blackberry, sweet clover, barley, oats, hawthorn, tarweed, common vetch, seven species of grass seeds, including Bromus; and at least ten other species of weed seeds.

Einarsen (6:8,10,11) writing of Oregon, says, "The best plants for providing quail food are those that yield a crop of small seeds, including such legumes as red and alsike clovers." Of the tarweed, he says, "...the Chinese pheasants and quail gorge themselves with its seeds." Apple fruits, "...provide a great source of food during the critical winter days." Wild rose fruits

are most important.

One pheasant and three quail stomachs examined on the area during, but incidental to, this study during July and August contained the following items listed in the approximate order of abundance of their volumes: Animal matter, mainly insects; seeds of brome grass, wheat, vetch, oats, peas, tarweed, and unidentified weeds; green leaves, blackberries, and apple fruits.

Reference to table 10 will show that green vegetation, cultivated grains, apples, and tarweed lead in per cent of occurrence and total 80 per cent of the volume of the gray digger's food. Weed seeds and blackberries add another five per cent. All of these items are known game bird foods. In fact, a check of the limited information given above discloses a surprisingly close correlation in the food items of the two groups.

How much food competition actually exists between the squirrels and the game birds is not known. Probably during ordinary years it is of little consequence; however, it seems quite possible that with lean years and large populations the gray diggers could become a serious factor in the depletion of the bird's food supply.

OBSERVATIONS ON CAPTIVE DOUGLAS'S GROUND SQUIRRELS

As a further check upon the egg eating propensities of the gray digger, and incidentally, to substantiate the stomach analysis data, eight individuals were taken in box traps and kept under observation in wire cages. They were caught at various times during July and August, and held for periods ranging from four to 38 days each. Only one animal was placed in a cage except in one instance where, due to lack of space, two squirrels were caged together. A record of all food eaten or refused by them was maintained for a period of 136 animal-days. Both pheasant and bobwhite eggs were available to the squirrels throughout most of the study.

Foods Eaten

Table XIV lists, in the approximate order of preference by these penned animals, the kinds of fruits or seeds eaten.

It will be noted that all items listed in table XIV were not fed to all individuals, but this was merely a matter of chance. Some of the food recorded here as eaten was in reality partly stored by some individuals in their cages. This was particularly true for wheat and vetch. Several kinds of green weed plants were of-

Table XIV. Fruits and seeds eaten by captive Douglas's ground squirrels.

Items	Animals	Rations	Per cent eaten	
	accepting per cent	offered	Rations per cent	Volume per cent
Wheat	100	26	100	100
Vetch	100	11	100	95
Oats	100	13	100	90
Blackberry, wild	100	16	100	75
Walnut, English	100	6	100	90
Serviceberry	100	1	100	25
Filbert	100	9	90	75
Cascara	100	9	90	65
Plum, cultivated	100	7	70	60
Tarweed	100	5	80	40
Hazelnut	100	2	50	50
Hawthorn	100	4	75	20
Rose, wild	40	9	20	10
Acorns, green	25	6	15	6

ferred and eaten. Apples were always a favorite food. Grasshoppers were eaten whenever available. Three dead white-footed mice (Peromyscus) were offered to different squirrels but were always ignored. Some unnatural foods such as lettuce, raisins, bread, sugar, and honey were relished.

Egg Eating

Pheasant and bobwhite eggs placed in the cages received quite different treatment from different squirrels as the following record shows.

- Case 1. Young, sex undetermined.
 Captive 10 days, July 21 to July 30.
 Pheasant egg offered July 30, not eaten.
 Escaped same day that egg was first made available.

- Case 2. Young female
 Captive 38 days, July 31 to September 6.
 Pheasant egg offered August 2 was not disturbed until August 26. On this date the egg was removed from the cage and a small hole pierced through the shell with a piece of wire. The egg was replaced, and upon the next inspection a few hours later only the shell remained, figure 14.
 Pheasant egg offered September 4, with hole in shell as described above, was not eaten.
- Bobwhite egg offered August 2 was eaten on August 5, figure 13.
 Bobwhite egg offered August 5 was eaten on August 17.
 Bobwhite egg offered September 4 was eaten on September 5 or 6.
- Case 3. Young female
 Captive 4 days, August 3 to August 6
 Pheasant egg offered August 6 was not eaten.
 Two Bobwhite eggs offered August 3, not eaten.
 Bobwhite egg offered August 6, not eaten.
- Case 4. Young female
 Captive 24 days, August 7 to August 30
 Pheasant egg offered August 7, not eaten.
 Pheasant egg offered August 18; shell pierced August 26, not eaten.
 Bobwhite egg offered August 7, eaten August 8.
 Bobwhite egg offered August 9, crushed August 11.
 Bobwhite egg offered August 11, eaten August 15.
 Bobwhite egg offered August 16, not eaten (?)
- Case 5 and 6. Young females. In same cage.
 Captive 17 days, August 10 to August 27.
 Pheasant egg offered August 11, shell pierced August 26 and eaten same day.
 Pheasant egg offered August 26, not eaten.
 Bobwhite egg offered August 11, eaten August 13.
 Bobwhite egg offered August 13, not eaten.

- Case 7. Adult male
 Captive 14 days, August 27 to September 9.
 Pheasant egg offered August 27, not eaten.
 Pheasant egg offered August 30, eaten September 4.
 Pheasant egg offered September 4, with hole pierced in shell, not eaten.
 Bobwhite egg offered September 4, not eaten.
- Case 8. Adult male.
 Captive 12 days, August 29 to September 9
 Pheasant egg offered August 30, not eaten.
 Pheasant egg offered September 4, with hole pierced in shell, eaten September 6.
 Bobwhite egg offered September 4, eaten September 5.

Table XV summarizes the information regarding the eggs offered to captive squirrels.

Table XV. The fate of eggs offered captive Douglas's ground squirrels.

Eggs	Gray diggers	Eggs eaten		Eggs not eaten	
		shell intact	shell pierced	shell intact	shell pierced
	adult(2)	1	1	2	1
Pheasant	young(6)	0	2	4	2
	adult(2)	1	-	1	-
Bobwhite	young(6)	6	-	6	-

Squirrel number two, like some of the others, had both kinds of eggs available at the same time. This

animal ate the first bobwhite egg three days after it was placed in the cage, another remained twelve days before it was eaten. During all this time a pheasant egg was unmolested; but on August 26, the twenty-fourth day, a hole was made through the shell. This was done by reaching into the cage with a wire, and producing an opening about one-eighth of an inch in diameter. A single drop of the egg contents appeared on the shell. As soon as things quieted down the digger began moving about, and apparently smelling the egg she looked it over. Immediately she began breaking off bits of the shell at the spot punctured, and eating the egg. The squirrel was accidentally frightened off several times, but always returned within a few minutes and continued eating into the egg. This individual had been very well fed at all times, and had eaten wheat, apple, cracker, and raisins already this same morning - some of it just previous to finding the egg. Other food was still available in the cage at that time. An hour or two later the egg had been almost entirely eaten, and the hole had been enlarged to about the size of a dime. Later, when the two kinds of eggs were again offered, the bobwhite egg was eaten within a day or two, but the pheasant egg, even with a hole through its shell,

was not eaten. Another squirrel, captive only four days, refused all eggs. The two young kept in one cage ate half of both kinds of eggs given them. One pheasant egg had been undisturbed for over two weeks when it was pierced with a wire as described previously. Upon inspection a few hours later, the egg was found to have been eaten clean, with a large hole in it, as illustrated in figure 14. Of the two captive adults, one individual ate a perfect egg and refused another, the second digger ignored the intact egg in his cage. When a hole was made through the shells, one squirrel ate his, and the other did not. One digger ate a bobwhite egg and one refused.

Such unpredictable behavior is difficult to analyze. During the experiments an effort had been made to eliminate situations which might influence the results. At no time were any of the animals starved into eating the eggs. They were normally fed at least three times a day. Fresh apples, a favorite food, were always available and apparently, with occasional rations of other fruits, berries, and green stuffs, supplied the necessary moisture. The cages were small enough so that there was no possibility of an egg being overlooked. So far as was known, all eggs were in similar condition, for freshly culled eggs were obtained from the Corvallis State Game Farm.



Fig. 13
Bobwhite eggs eaten by captive
Douglas's ground squirrels



Fig. 14
Pheasant eggs eaten by captive
Douglas's ground squirrels

Comparison of figures 12 and 14 show that eggs eaten by the captives have more shell gnawed away than those eaten under more natural conditions. Whether there is any particular significance to this, such as an attempt to correct a diet deficiency, is not known. This seems unlikely since all shells were eaten to about the same extent. Furthermore, one individual ate an egg on the very next day following its capture, while some others did not do so for six and eight days. Once, in the field, at a spot where some pheasant eggs had been eaten previously, a gray digger was observed to twice pick up a large piece of shell and gnaw on it. The fact that in two cases pheasant eggs unmolested for two and three weeks were eaten shortly after the shell was penetrated may indicate either, that the animal had been unable to open the egg, or perhaps that it responded to the senses of taste or smell. Although the young animals were almost the size of adults, it may be significant that none of the former ate any pheasant egg so long as the shell was intact, but one of the adults did take such an egg. In two out of four cases, however, when the shells were pierced, young diggers almost immediately ate the eggs. Contrary evidence may be taken from the dummy nest studies. Here, all three of the squirrels which were proved to have eaten

pheasant eggs were young animals caught at earlier dates than any of the penned animals; and the eggs they ate were believed to have been intact. The smaller bobwhite eggs were consumed with equal facility by both age groups. Of the seven individuals offered bobwhite eggs, three did not eat them. Five eggs available for a total of 58 egg-days were unmolested, one other was crushed, but uneaten.

Incidental Observations

One captive digger-squirrel (case 2) was particularly clean about its cage and always deposited its droppings in one corner. Alongside of this it cached a considerable store of grain. It also constructed a large nest with bits pulled from a burlap sack used to shade the cage. This individual always seemed smarter and more tame than any other captive. It was the only one to ever cross a cage to take food offered through the wire meshes. Most individuals remained wild and afraid, and would not eat when being observed by anyone near the cages.

The same squirrel (case 2) was offered some water on August 30 for the first time in a month. The water was "tasted", but it did not drink any, nor was it even known to show any further interest in water. This individual had been living on much moist food. Another digger which had been without water for two weeks of captivity was fed

only on dry graham crackers for two days, and then was given a container of water. This squirrel began lapping the water almost immediately. The water was then removed and the diet of dry crackers continued for another day. Then, when water was again offered, the digger took four drinks within five minutes, lapping for perhaps ten seconds on each occasion.

These ground squirrels were very adept at opening vetch pods; removing wheat grains from the seed heads, leaving the latter otherwise intact; and at gnawing into such hard shelled nuts as filberts, walnuts, and hazelnuts.

GENERAL OBSERVATIONS

Personal Observations

Some of the general observations made during the course of these investigations may properly be introduced at this point.

By mid-June the gray diggers were causing considerable damage to certain wheat fields. Figure 2, upon close inspection, illustrates a corner of one such field. The damage extended about 100 yards along the margin, but was only about 10 yards wide. On June 21 and again on June 24, a squirrel was trapped at a burrow entrance fifty paced yards from the nearest point of the wheat field. Stomach analyses proved that both of these individuals had eaten their fill of wheat grains.

On June 26 an adult female squirrel was found to have eaten a stomach full of red berries, but no such fruit could be located in this open pasture although the surrounding area was searched for a distance of at least 100 yards.

On one occasion, during a period of observation, a squirrel was observed to walk into a trap baited with bobwhite eggs. This set, under observation, was located near an old lumber pile. The animal repeated a particular cry which immediately brought six other diggers into

view and all stood erect on elevated points looking at the captive. Some approached closer for a better look, but shortly all returned underground or paid no further attention.

On June 14, a pheasant egg was placed on a pile of boards under which a family of ground squirrels was known to live. Soon a young one appeared and saw the egg. At first it seemed frightened, then it cautiously approached sniffing of the strange object. It repeated this from three different directions. After four approaches, it went away satisfied, and never molested the egg in any way.

In another instance, on August 22, pheasant eggs were being watched near some burrows. One squirrel which had appeared to be feeding on roots, finally found the eggs. It rolled, pawed, and played around with one for perhaps five or ten minutes, and had moved it about two feet, when taking alarm it ran into a burrow. The egg had not been broken, nor was any attempt made to carry off or eat it. The others all were in place.

Few wild game bird nests were located during the season. Only a bobwhite nest was known to have been destroyed by a predator, but the evidence did not permit its identification.

Observations by others

Conversations with local residents disclosed some interesting observations made by them. A dozen farmers were asked for their opinion regarding predation by gray diggers on game bird nests. Seven of them had no ideas on the matter, three thought it was doubtful, and two suspected the squirrels would eat eggs; but none could recall any personal observations, or accounts of others. Four farmers, however, did claim that these animals would steal chicken eggs. One man related that his week old chicks had been gradually disappearing. He caught one digger, but the loss continued. Finally, he moved the hen house and found beneath it the remains of some chicks near the entrance to a burrow. He trapped another squirrel at the den and had no further losses of that kind. One man who did not suspect the squirrels, based his statement on the fact that a hen had set only six feet from a ground squirrel hole, and raised a brood. Another said they do not seem to molest bantam chicks hatched in fields. One farmer complained that gray diggers caused some damage by digging his potatoes. Another told of a cache of two and one-half gallons of filbert nuts made by these squirrels.

Employees at the Corvallis State Game Farm said that a few years ago a digger-squirrel was observed in a pen from which pheasant eggs had been disappearing. On one occasion, they killed a gray digger that was seen carrying a domestic hen's egg. It had been taking hen's eggs for some time. They said, also, that diggers will take young chickens. It is believed that some losses of young pheasants in the field rearing pens have been due to these animals, but no specific data was available.

NOTES ON OTHER PREDATORY SPECIES

Although the dummy nest study was primarily concerned with predation by the Douglas's ground squirrel, any small animals attracted by the eggs were equally liable to capture. An occasional innocent individual might, perhaps, be taken accidentally. Since only steel traps of the smallest size were used, larger animals such as dogs and foxes would not be expected to remain captive. Throughout the study, many traps were sprung, but were empty when visited; and the eggs were sometimes disturbed. Many such instances could be due to the activities of the smaller species, including the digger-squirrels, but lack of evidence prevented identification. Set number 62 well illustrates this point. It was constructed on July 22 in heavy grass cover along a fence row bordering a cultivated field. No ground squirrels were known to be occupying the immediate vicinity. This nest of ten pheasant eggs had the following recorded history.

- 8/2 Trap sprung. Reset.
- 8/3 Trap sprung. Reset. (The trap, on both days was pulled out to the full length of chain)
- 8/4 Trap sprung. Two eggs missing, and one of those remaining was broken. Reset.
- 8/6 Trap sprung. All eggs smashed, eaten, and widely scattered over a six foot diameter. Reset as found.
- 8/7 Set 5 more eggs.
- 8/12 Removed set. Nothing further had disturbed it.

The Soap Creek area has been trapped in the past by local farm boys, and since becoming a study refuge, four years ago, predator control has been maintained. During the winter preceeding this study, 21 skunks were removed from that part of the area later used for the dummy nest study (about three sections of land), and others were taken from adjoining areas. In spite of this control work, 24 skunks, including two based on direct evidence, visited 21 of the 100 nests. Three of these were bobwhite, and 18 were pheasant nests. The eggs were recorded as eaten in 16 cases, and questionable or missing in four. All stomachs were not analyzed; but of the 20 that were, 13 or 65 per cent, positively contained egg shells. At each of the three bobwhite sets, the eggs were recovered from the skunk. They were always eaten whole; and the crushed shells, even in the intestines, were found mostly in one piece. The skunk usually had totally destroyed a nest, and eaten all the eggs on the spot. Pheasant eggs are not eaten whole, but are characteristically crushed with in-rolled edges, as illustrated in figure 11. This species was taken quite regularly throughout the study. The cover types at the raided nest locations were about equally divided, except for sets in brush habitats. These

latter made only three catches. Materials, other than eggs, found upon analysis of 12 skunk stomachs occurred as follows:

Straw	6
Grasshoppers	3
Douglas fir needles	2
Twigs	1
Grass	1
Blackberries	1
Unidentified vegetation	1
Unidentified larvae (grubs)	1
Beetles	1
Wasps	1
Jackrabbit fur *	1
Flesh and hair (gray digger?)	1

Two feral house cats were caught raiding these nests. In one case the eggs were still intact, but in the other, three of ten pheasant eggs had been eaten. No shell was recovered in the stomach, but approximately enough fragments were found lying on the ground to account for the shell particles removed from the eggs. Incidentally, the remains of a small song bird were present in the stomach. The stomach of the other cat was empty.

Two brown, or Norway, rats raided the same set located in heavy grass at the edge of an oat field one-
* old carcass nearby

quarter mile from the nearest buildings. In one instance the eggs were intact; but in the other, one of eight pheasant eggs had been eaten. Bits of shell remained on the ground, but none were found in the rat. This same set (74) was raided by digger-squirrels at least six times and once by a cat.

One small gray fox was held at a nest situated in heavy grass cover. The nest was entirely demolished due to the animal's efforts to escape, and two pheasant eggs were missing. The animal was not killed, and it can not be definitely stated that the fox ate the eggs. This species is not uncommon on the area.

Five jays of two species (table I) were caught while raiding three different dummy pheasant nests. All known predation by these birds occurred during the few weeks between May 14 and June 3. At set number 1 in moderately heavy herbaceous cover, on May 18, two of the three eggs had holes pecked through the shells, but the contents were not eaten. The other egg was gone. Two days later a long-tailed jay was taken at the nest. A partly eaten coast jay was found at one nest located in light cover. The eggs were gone, but a shell was found nearby - probably the work of a second animal. Within a week, a long-tailed jay raided this rebuilt set, and two eggs were missing. At the third location, at the edge of

an oat field, and in heavy cover, two long-tailed jays were caught a few days apart. The eggs were intact in one case; but in the other, one of the two eggs had been broken into. Analyses of the digestive tracts were not always made, but so little shell was removed from the eggs it is doubtful whether any was swallowed. None was found in those instances when examination was made.

SUMMARY

A field investigation was made during the 1940 nesting season in the Willamette Valley, Oregon, to determine whether the Douglas's ground squirrel is a factor in nesting losses of pheasants and quail. Incidental data was gathered on the general food habits of this squirrel, and on predation by some other species.

The study was financed by the Oregon Cooperative Wildlife Research Unit which is under the leadership of Mr. Arthur S. Einarsen.

The experimental area was located in a general farming region about ten miles north of Corvallis.

The Douglas's ground squirrel ranges in inland valleys of western Oregon, and northern California. Its populations are less concentrated than are those of the California ground squirrel, which it closely resembles, but their predilection for clearings brings them into economic prominence locally.

A valley quail nest apparently destroyed by a Douglas's ground squirrel in Oregon was the only record of predation by this animal found in the literature. The fact is well established that valley quail nests are destroyed by the beechey ground squirrel in California.

During the present study, one hundred dummy pheasant and bobwhite quail nests, with a small steel trap at each, were placed on an area of approximately 2,000 acres. Sets remained in place for an average of twelve days each, during the period of April 25 to August 25.

Eighty per cent of these sets were disturbed by some predator even though, on the average, nests were exposed for less than one-half the normal period of incubation for the species. Forty-three sets caught seventy squirrels, and direct evidence remained of twenty others. Fifty-two per cent of the sets were raided more than once. Nearly three out of every four predators caught were squirrels. Eggs were eaten in seven instances, and stolen in 27, by the squirrels. Bobwhite and pheasant nests were raided without apparent preference.

Digger squirrels were not proved to be most active in any one month, but such a tendency is indicated for June. Nests located in the proximity of squirrel burrows were particularly susceptible to destruction. There was no indication that gray diggers locate nests with any more regularity in poor or in good nesting cover. Nests, whether small or large, were found with equal frequency. Nests in grass cover suffered a

considerably higher percentage of destruction than those in weeds or brush. Cultivated lands rank close behind grassland in this respect. Although the nests in moderate cover appear to have been found more quickly than those in heavy cover, eventually about the same percentage of sets were raided in each group. All seven sets in light cover were destroyed by predators. Nests along fencerows were robbed by ground squirrels and skunks more frequently than nests in other locations.

Stomach analyses were made on 204 Douglas's ground squirrels. Pheasant egg shells were found in the stomachs of three squirrels trapped at dummy nests; but none were found in any animals not taken at such nests. The average per cent, by volume, of food items in the stomachs analyzed were: green leaves, 37.2; grain, 22.7; apple, 12.2; weed seeds, 11.9; miscellaneous vegetation, 8.0; fruits, 5.2; animal matter, 1.5; other, 1.3. The leading food items by frequency of occurrence in the stomachs analyzed were, in descending order of importance: green leaves, weed seeds, apple, wheat, animal matter, blackberry, oats, and acorns. Animal matter eaten consisted principally of grasshoppers, insect larvae, ground squirrels, and feathers. There was

a close correlation in the foods of the squirrels and upland game birds in this area.

Eight squirrels were kept under observation in captivity for a total of 136 animal-days. Five well-fed penned individuals ate one or more eggs, total 11 eggs, and three ignored them.

Eggs were not always eaten when found by the squirrels. One squirrel was observed to carry off a bobwhite egg. They have been known to carry off domestic chicken eggs, and young chicks.

Other predators caught at dummy nests were: 22 skunks, 4 long-tailed jays, 2 house cats, 2 brown rats, 1 coast jay, and 1 gray fox. At least 16 of the skunks had eaten eggs, as had both kinds of jays, and one of the cats.

CONCLUSIONS

The conclusions, based upon this study, are as follows:

1. The Douglas's ground squirrel, in Oregon will eat the eggs of the pheasant and bobwhite quail, and therefore is definitely a factor in nesting losses of these game birds in this locality.
2. The intensity of these depredations is of considerable importance. The squirrels are active throughout the nesting season, and find a large percentage of nests.
3. They may eat the eggs at the nests or, more regularly, carry off single eggs. In the latter case they evicently make repeated return visits.
4. Observations and feeding experiments both show that only certain individuals eat eggs. Apparently a taste for them is acquired. At times, a known "egg-eater" will ignore eggs.
5. Nest raiding is not proved to be greatest in any one month.
6. Nests located in the proximity of squirrel burrows are particularly susceptible to destruction.
7. The degree of predation is not influenced by the naturalness of the habitat for birds.

8. The size of the clutch is apparently not a factor in the probability of its discovery by a predatory animal.

9. Nests located in grass or cultivated crop cover are more likely to be destroyed than those in weeds or brush.

10. There is some indication that nests along fence rows are particularly vulnerable to predation.

11. In this area the food of the Douglas's ground squirrel is composed of many items also used by pheasants and quail, and it is possible that under certain circumstances the birds would be inimically affected by this competition.

12. The Douglas's ground squirrel is one of the most destructive rodents to agriculture in this farming region, and need for its control is generally recognized. Cooperation of the wildlife interests with agriculturists is the best approach to the control of this predatory and crop destroying species.

13. Several other local predatory species are known to raid game bird nests. Of these, the striped skunk is by far the most destructive. Seasonal control of their numbers is recommended.

COMMON AND SCIENTIFIC NAMES OF PLANTS MENTIONED
IN TEXT AND TABLES

Apple, cultivated.....	<u>Malus</u> sp.
Ash, Oregon.....	<u>Fraxinus oregona</u>
Barley, cultivated.....	<u>Hordeum vulgare</u>
Blackberry.....	<u>Rubus</u> spp.
Brome grass.....	<u>Bromus</u> sp.
Cascara.....	<u>Rhamnus purshiana</u>
Clover, red.....	<u>Trifolium pratense</u>
Clover, sweet.....	<u>Melilotus</u> sp.
Filbert.....	<u>Corylus Avellana</u> (?)
Hawthorn, black.....	<u>Crataegus douglasii</u>
Hazel, California.....	<u>Corylus californica</u>
Maple, Oregon.....	<u>Acer macrophyllum</u>
Oak, Oregon white.....	<u>Quercus garryana</u>
Oats, cultivated.....	<u>Avena sativa</u>
Peas, cultivated.....	<u>Pisum sativum</u>
Plum, cultivated.....	<u>Prunus</u> sp.
Poison oak.....	<u>Rhus diversiloba</u>
Rose, wild.....	<u>Rosa</u> sp.
Serviceberry.....	<u>Amelanchier florida</u>
Tarweed, Chilean.....	<u>Madia sativa</u>
Vetch.....	<u>Vicia</u> sp.
Walnut, English.....	<u>Juglans regia</u>
Wheat, cultivated.....	<u>Triticum aestivum</u>

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