THE COMPARATIVE SURVIVAL OF NINE DIFFERENT GROUPS OF JUVENILE RING-NECKED PHEASANTS ON ELIZA ISLAND, WASHINGTON

by

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INTRODUCTION

This report presents the results of a comparative summer survival study of one group of wild juvenile ring-necked pheasants and eight groups of artificially propagated juvenile ring-necked pheasants on Eliza Island, Washington, from July 20, 1951 to October 1, 1951. Each of the nine groups differed either in age composition or in method of rearing. All of the pheasants used in the study were of the Chinese ring-necked strain, Phasianus colchicus (Gmelin). Control of predators was not attempted in this study. This was the ninth in a series of experiments that have been conducted on Eliza Island by the Oregon Cooperative Wildlife Research Unit[1] under the direction of Mr. Arthur S. Einarsen, biologist, United States Fish and Wildlife Service. These studies have been concerned with the determination of certain biological factors in the life history of the ring-necked pheasant to be utilized for the better management of this bird, primarily in the states of Oregon and Washington.

Of the earlier studies, four were conducted in the summer months to determine nesting and production trends of adult game farm pheasants. The first study, in 1947, attempted to determine

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1/ United States Fish and Wildlife Service, Oregon State Game Commission, Washington State Game Commission, Oregon State College, Oregon Agricultural Experiment Station, Agricultural Research Foundation, and Wildlife Management Institute, cooperating.

the feasibility of liberating mature game farm hens after they had laid complements of eggs at the game farm. A total of 100 hens and 10 cocks were used. Predator control was not attempted. The hens produced 25 successful nests, a total hatch of 127 eggs, and an average clutch of 5.1 eggs per nest. Only 22 per cent of the young survived, and the total population decreased 39 per cent from the original population of 110 birds. The hens, which had already spent most of their reproductive energy, did not produce normal clutches of eggs. The low survival of offspring was attributed to the high population density which resulted in an unusual amount of chick mortality from cannibalism, desertion by hens, and other factors (Scott, 1947).

The second study, in 1948, was conducted with only half the numbers used in the 1947 study, a total of 50 hens and 5 cocks. The hens used, however, had not laid eggs at the game farm prior to the time they were released. Predator control was not attempted. Nesting results included: 15 successful nests, 137 eggs hatched, and an average clutch of 11.2 eggs per nest. Fall harvest results indicated that 72.3 per cent of the offspring had survived and that the total pheasant population had increased 69 per cent from the original population of 55 birds. Hens had laid normal complements of eggs and the high survival of young pheasants was attributed to the more normal population density (Salter, 1948).

The third study, in 1949, was a repetition of that in 1947 using the same number of hens and cocks. Procedure differed, however,

in that an attempt was made to control predators. A total of 44 successful nests, 211 hatched eggs, and an average clutch of 6.3 eggs was produced. Only 23.7 per cent of the young survived. The total population increase was only 1.8 per cent, or 2 birds more than the original release of 110 birds. Results were similar to those in the 1947 study, a low average number of eggs per clutch, and a high mortality of young as a result of excessive population density. Predator control was apparently of little value in decreasing the total pheasant mortality (Hoffman, 1949).

The 1950 study was a repetition of the 1948 study, using the same number of birds, procedure differing only in that predator control was practiced. The hens laid an average clutch of 11.8 eggs per nest and 251 eggs were hatched. A total of 44 per cent of the offspring survived. The increase in population, 63 per cent, was similar to that in the 1948 study. Once again the high survival of young was attributed to the more normal population density (Hansen, 1950).

The 1951 study on Eliza Island was the initial attempt thereon to evaluate the survival of juvenile game farm pheasants. It may therefore prove helpful to discuss some of the important issues that prompted this study.

Oregon and Washington Game Commission game bird farms currently produce and liberate far more juvenile than adult pheasants. The incentive for doing so is obviously governed by the demands of production economy. This fact is made clear in the following state-

ment (11,p.66) from the 1951 annual report of the Oregon State Game Commission:

> "Oregon's game farms are designed for the production and release of young pheasants for they do not have adequate pens to hold large numbers of mature birds. The hens used for laying are now held until the following spring and some cocks are liberated for the gun, particularly on public shooting grounds. In 1950, Oregon liberated 70,183 pheasants at a net cost of $123,376.18, 60,071 of which were juveniles. The average cost per bird was $1.76. Birds eight weeks of age released in the summer cost $1.66 per bird, adult cocks in October, $2.33 per bird, and adult hens in the spring, $3.13 per bird. Obviously, the cost of producing juveniles is far more economical."

Evaluations of pheasant liberations should also take into consideration such factors as subsequent survival and carry-over of brood stock, which determine the numbers of cocks that may be harvested. In these respects, it has become increasingly evident that liberations of juvenile pheasants are far more costly in relation to numbers of cocks returned to the hunter's bag than liberations of either adult cocks in the fall or adult hens in the spring.

According to statistical analysis of accumulated data concerning production costs, natural productivity, seasonal mortality, and hunting returns of pheasants in Oregon by the Oregon State Game Commission, the cost of each cock harvested during the first two seasons following liberation is: $18.44 per cock for August liberations of eight week old pen-reared birds, $8.94 per cock for spring liberations of mature hens, and $4.50 per cock for in-season liberations of mature cocks on public shooting grounds (11,p.76).

Table 1 demonstrates how the above-mentioned costs were derived. The data are based upon theoretical liberations of 100 eight weeks old pen-reared birds, 100 adult game farm hens, and 100 adult game farm cocks, each bird costing $1.66, $3.13, and $2.33 respectively to produce. Data concerning natural productivity and seasonal mortality were derived from studies on Eliza Island; Summer Lake, Oregon; and on public shooting grounds in Oregon. Seasonal bag returns were obtained from the statistics of the Oregon State Game Commission. The juvenile birds were assumed to have consisted of an equal number of both sexes at the time of release, 50 per cent of which were mortalities before the first hunting season. Summer mortality for the adult hens was 72 per cent. For each hen released, however, two offspring were produced, the progeny being equal as to sex. Subsequent data were the same for both the juveniles and the adult hens. Of the remaining cocks, 20 per cent were harvested during the first hunting season. The mortality of the balance was differential as to sex, 36 per cent of the cocks and 60 per cent of the hens during the winter; and during the second summer, 50 per cent of the cocks and 72 per cent of the hens that had survived the winter. For each hen that survived the winter, two offspring were produced, the total number of young being equal as to sex. The second season harvest of the cock balance was the same as that of first, 20 per cent. Corresponding figures for the adult cock liberation were: first season harvest, 60 per cent;

Table 1

Computed Costs of Cocks Harvested During the First Two Seasons Following Original Liberations of Eight Weeks Old Juvenile, Adult Hen, and Adult Cock Ring-Necked Pheasants2

August liberation of 100 eight weeks old pen-reared birds @ $1.66 per bird: $166.00

	Cocks	Hens
Total numbers of birds liberated (equal sex ratio)	50	50
Fall balance (50% summer loss)	25	25
First season harvest (20% cocks)	-6	0
Winter loss (36% cocks; 60% hens)	-7	-15
Spring balance	12	10
Production (2 offspring per hen)	10	10
Summer loss (50% cocks; 72% hens)	-6	-7
Fall balance	16	13
Second season harvest (20% cocks)	3	
TOTAL HARVEST (two seasons) - 9 cocks @ $166.00:	$18.44 per cock	

March liberation of 100 mature hens @ $3.13 per bird: $313.00

	Cocks	Hens
Total number of birds liberated	100	100
Production (2 offspring per hen)	100	100
Summer loss (72% of adult hens)	0	-72
Fall balance	100	128
First fall harvest (20% cocks)	-20	0
Winter loss (36% cocks; 60% hens)	-29	-79
Spring balance	51	49
Production (2 offspring per hen)	49	49
Summer loss (50% cocks; 72% hens)	-25	-35
Fall balance	75	63
Second season harvest (20% cocks)	15	
TOTAL HARVEST (two seasons) - 35 cocks @ $313.00:	$8.94 per bird	

October liberation of 100 mature cocks on public hunting grounds @ $2.33 per bird: $233.00. Maintenance of 200 acres: $50.00

	Cocks
Total numbers of birds liberated	100
First season harvest (60% cocks)	-60
Winter and summer loss (68% cocks)	-27
Balance (second season)	13
Second season harvest (23% cocks)	3
TOTAL HARVEST (two seasons) - 63 cocks @ $283.00:	$4.50 per cock

2/ Oregon State Game Commission figures (11, p.76).

first winter and second summer mortality, 68 per cent; and second season harvest; 23 per cent.

The data in Table 1 serves to illustrate the significance of survival and carry-over of brood stock in relation to returns during the first and second seasons. Not all pheasant liberations are expected to give a good second season return of cocks, however. Adult cocks, for instance, are often released on heavily hunted areas merely to satisfy the demands of the hunter. In such cases, the birds are expendable. Juveniles and adult hens, on the other hand, are liberated to provide a supply of harvestable cocks from one year to the next. For this purpose, according to the data in Table 1, the juvenile birds are a much poorer investment. They are subject to high losses of both sexes during the first summer, thus greatly reducing the number of available cocks for the first hunting season. With a high loss of the already diminished number of hens during the first winter, there are few hens left by the following spring to perpetuate the stock.

If a substantial reduction in the first summer's mortality were attained, there might be some justification for liberating juvenile game farm pheasants. It was this objective, primarily, that prompted the 1951 study on Eliza Island.

Although Oregon and Washington game farms employ several techniques in rearing juvenile pheasants, insufficient data exist as regards the survival of these birds in natural environments. Artificially propagated pheasants are of two major categories:

field-reared and pen-reared. Field-reared birds are hatched and brooded by domestic hens confined to small brooder coops placed in a natural environment. The chicks may enter or leave the coops at will and thus are enabled to become self sufficient. Pen-reared birds, on the other hand, originate from eggs hatched either by domestic hens or by incubators, the former being brooded by the same hens and the latter by means of artificial heat. After being brooded the chicks are placed in communal pens and fed prepared rations.

There is reason to believe that each method of rearing may affect the physiology or behavior of the birds, upon the nature of which their survival after liberation is dependent. For example, field-reared birds which have had previous access to natural foods, experiences with some of the natural hazards, and unrestricted freedom of movement would be expected to be better qualified, both physically and psychologically, for survival than pen-reared birds lacking the same opportunities. Bump (1, p.506), in reference to ruffed grouse, Bonasa umbellus umbellus (Linnaeus), reared on game farms in northeastern United States, and which may also apply to game farm pheasants, stated:

> "Assuming that grouse are placed in suitable habitats, certain other considerations exercise a strong influence upon their survival. Notable among these are the source and experience of the birds, their age, and their physical condition upon liberation. Success in dodging enemies, in finding food and shelter, in nesting and producing a brood depends upon these points. Of course, the inherent adaptability of the bird to new surroundings is all important."

In reference to age upon release, Bump (1, p.507) has this to say:

> "Most game birds raised in captivity seem to adapt themselves best to a new environment at a relatively early age."

The experiment under discussion was designed to evaluate the survival of six to ten weeks old pheasants reared by techniques used on Oregon and Washington State Game Commission game farms in relation to the survival of wild-reared birds of similar age classification. The nine groups of pheasants used in the study consisted of: (1) units of six and eight weeks old hen-hatched, hen-brooded, field-reared birds that prior to release, had been confined to a large enclosure under conditions which simulated a natural environment; (2) one unit of six weeks old hen-hatched, hen-brooded, field-reared birds that prior to release, had been raised in a natural environment and not confined to an enclosure; (3) units of six, eight, and ten weeks old incubator-hatched, electric-brooded, pen-reared birds; (4) one unit of eight weeks old incubator-hatched, steam-brooded, pen-reared birds; (5) one unit of eight weeks old hen-hatched, hen-brooded, pen-reared birds, and (6) one unit of wild-reared juvenile birds, the offspring of five adult hens which had been released on the island in the spring of 1951.

Procedures used in liberating the juvenile game farm birds on the island were similar to those generally followed by Oregon Game Commission personnel in restocking pheasant habitat. They were handled, transported, and immediately released in the natural environment of the island. This type of release, in which no

allowance is made for the birds to become adjusted to their new environment, is known as the "violent" method of liberation. In the "gentle" method, the birds are allowed to escape gradually from the crates, are liberated near natural food and shelter, and supplementary food may be placed around the site of release. Many game management reports cite incidents wherein significant numbers of juvenile game farm birds died following liberation by the "violent" method. Although this is a common phenomenon, its cause has not been definitely determined. Hence, the term "liberation shock" is generally used to denote mortality of this type. Anticipating that such an event would take place in this study, it was a preconceived objective to determine the nature of "liberation shock" and its significance as a mortality factor.

The contents of this report are divided into five main sections. The first section, "The Area", discusses the historical, biological, and climatic conditions of the study area. The second section, "Procedure", deals with the origin of the birds used in the study, the liberations, the methods and problems of the field study, and the harvest. In the third section, "Observations", such things as nesting, behavior of the birds, dispersal, and food conditions are discussed. Under "Results", mortality and survival are covered. The last section, "Analysis of Results", summarizes the study and brings into focus the more important findings.

THE AREA

History of the Island

Eliza Island was discovered by Lt. Francisco de Eliza, an early Spanish explorer, in 1791 and was named in his honor in 1841. Near the turn of the twentieth century the island was used as a chicken farm. In 1907, it was bought by Pacific American Fisheries Incorporated to be used as a base for salmon fishing operations. In connection with this fishery, the island was intensively developed to handle boats and other equipment and a reduction plant was put into operation to reduce fish offal into fertilizer. During the fishing season, several hundred people lived and worked on the island. When fish traps were banned in the year 1934, the island lost a great deal of its value to the company, but continued to function on a minor scale until a fire swept the island in 1938. Following the fire, the island was uninhabited except for the presence of a single caretaker.

In 1941, in order to save the island's vegetation, a semi-domestic herd of Columbian black-tailed deer was removed from the island and an overabundant population of domestic rabbits was poisoned. In 1942, a second fire swept the island leaving but a few of the remaining buildings standing. During World War II the island was used as a base for bombing practice by the United States Navy.

In 1947, the island was leased to the Oregon Cooperative Wildlife Research Unit by Pacific American Fisheries Incorporated

to be used as an experimental area for pheasant research. The island has been devoted to these studies to the present date.

Physical Description

Eliza Island is situated in the northern part of Puget Sound approximately ten miles southwest of the city of Bellingham, Washington. This island is on the southeastern fringe of the San Juan archipelago. The San Juan Islands are formed by the tops of a submerged mountain range and the main volume of water entering Puget Sound through the Straits of Juan de Fuca at flood tide passes through the various channels between these islands and flows northward in the Straits of Georgia.

The island is surrounded by a considerable expanse of water, thus making it suitable for conducting controlled experiments with pheasants. Bellingham Bay, which lies to the north and east, separates Eliza from the mainland by distances varying from three to ten miles. The nearest body of land to the south is Vendovi Island, about two miles away. To the west, a channel of water approximately one mile in width separates Eliza from the rocky and formidable Lummi Island, which has a maximum elevation of approximately 1900 feet above sea level.

Eliza Island, compared to Lummi, is relatively low in elevation. The land mass has a triangular shaped profile with deeply indented bays on the north and south shores, Figure 1. Approximately 159 acres, two-thirds of which are wooded, are contained within the three mile perimeter of the island.

Figure 1. View of Eliza Island from Lummi Island. Non-timbered area on the island is known as the "central flat". The "west point" of the island is in the foreground.

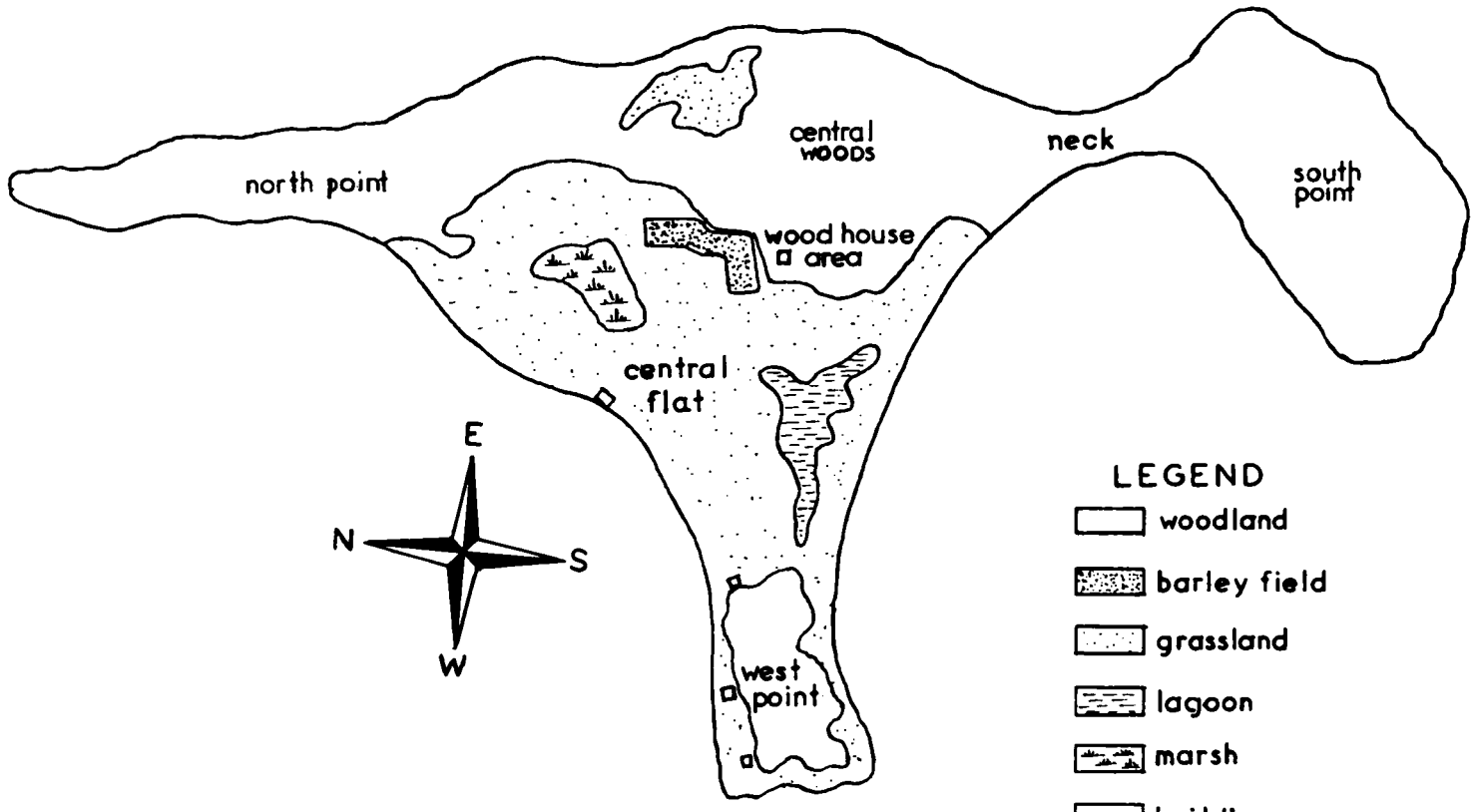

Figure 2.

MAP OF ELIZA ISLAND, WASHINGTON

The soil of the low central flat area, Figure 1, is composed of sea deposited gravel, intermixed with mollusc shells, and is relatively infertile. A dike has formed above the general level of this area adjacent to the sea and a brackish lagoon exists along the southern border. The only other body of water on the island is a fresh water marsh-type lagoon, Figure 2, in the northern portion of the central flat. Extending westward from the central flat area is a narrow, wooded ridge, Figure 1, about 20 feet above sea level, which terminates in a rocky escarpment.

The land to the east of the central flat is composed of more fertile glacial drift soils and rises gradually to form an elevated ridge, Figure 1, extending in a north and south direction. This ridge has a general elevation of 40 feet above sea level and reaches a maximum elevation of 60 feet above sea level on the southern extremity of the island. The southern extension of the island is sharply constricted at one point, Figure 2, where sea erosion is occurring. This is known as the "neck" of the island. The northern extremity of the island gradually tapers to a narrow point and is terminated by rocky ledges. Steep earth banks extend along the eastern shore and rocky cliffs surround the southern tip of the island.

As it exists today, Eliza Island appears to have been formed by sandspits which linked two former islands in recent geological time. The two former islands apparently were: (1) the elongated ridge forming the eastern section of the island, and (2) the

elevated western extremity of the island. The low central flat area appears to be a result of accumulated deposits of the sandspits that connected these two islands.

The terms "west point", "north point", "south point", and "central flat" seem appropriate for designating the general areas of the island and will be used in the text for reference.

Animal Associates

One interesting feature of the island's ecology is the absence of any resident form of mammal, with the exception of a small species of bat, Myotis. A variety of birds, however, occur on Eliza Island.

Common on the ocean are many sea inhabiting birds, such as: murres, murrelets, guillemots, gulls, grebes, cormorants, black brant geese, and diving ducks (scoters, scaups, goldeneyes, buffleheads, and harlequins). Included among the larger birds on the island are the bald eagle, Haliaeetus leucocephalus (Linnaeus); great blue heron, Ardea herodeus fannini Chapman; western pileated woodpecker, Ceophloeus pileatus picinus (Bangs); northwestern crow, Corvus branchyrhynchos caurinus (Baird); and several species of surface feeding ducks, Anatinae. Several species of hawks and owls are also found on the island. These are present in greatest abundance in the late summer and early fall when in migration. During the summer an occasional western red-tailed hawk, Buteo jamaicensis calurus Cassin; Cooper's hawk, Accipiter cooperii

(Bonaparte); or sharp-shinned hawk, Accipiter striatus perobscurus Snyder; is observed. During the late summer these same predators become increasingly abundant. In addition are found numerous marsh hawks, Circus cyaneus hudsonicus (Linnaeus); sparrow hawks, Falco sparverius phalaena (Lesson); and an occasional long-eared owl, Asio otus tuftsi Godfrey. In October and November, dusky horned owls, Bubo viginianus saturatus Ridgway; and duck hawks, Falco peregrinus pealei Ridgway; appear. Among the lower vertebrates on the island are numerous garter snakes, Thamnophis; toads, Bufo; and lizards, Gerrhonotus.

Botanical Description

Eliza Island's plant communities may be described by subdividing the island into several general areas: the "central flat", "west point", "central woods", "wood house area", "north point", "south point", and the "neck". These areas are designated in Figure 2. A list of the plants referred to may be found in the "Appendix".

The west point is a wooded area consisting primarily of second growth Douglas fir, Pseudotsuga taxifolia Britton; and vine maple, Acer circinatum Pursh; with understory thickets of red flowering currant, Ribes sanguineum Pursh; ocean spray, Holodiscus discolor Maxim.; and western serviceberry, Amelanchier anlnifolia Nuttall. An opening in the forest cover exists at the western extremity of the island. This area is covered with sprawling mats of American

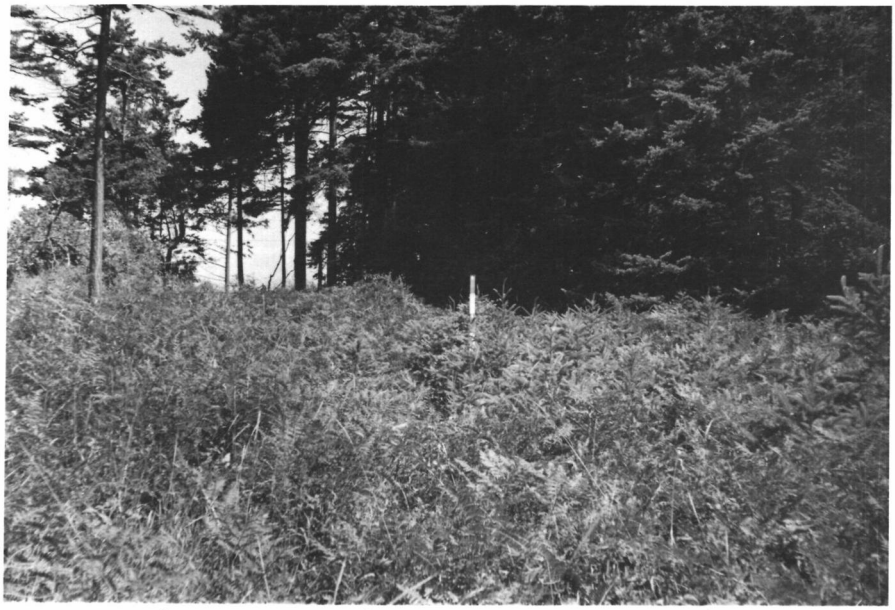

Figure 3. One of several clearings on the western extremity of the island. This clearing contains a dense stand of bracken fern.

Figure 4. View of vegetative cover on the "central flat". Plants consist of wire-rush and grasses.

vetch, Vicia americana Muhl.; and contains a moderate stand of orchard grass, Dactylis glomerata Linnaeus; as well as, several species of wild lily, i.e., Camassia leichtlinii (Baker) Watson. Small irregularly shapes fields containing dense stands of orchard grass, salal, Gaultheria shallon Pursh; bracken fern, Pteridium aquilinum pubescens Underwood; and young Douglas fir trees extend into the north and south sides of this wooded tract, Figure 3.

The vegetative cover of the central flat is composed of low-growing herbaceous plants. Surrounding the lagoon are two broad bands of emergent vegetation. The first band is a mixture of goose-grass, Salicornia ambigua Michx.; and saltgrass, Distichlis spicata (Linnaeus) Greene; which is carpetlike in appearance, Figure 5; whereas, the second band of vegetation consists mainly of wire rush, Juncus balticus Willdenow, Figure 4. This plant extends into numerous swales about the flat and along a drainage ditch to a marsh where it forms the perimeter of a marsh community made up of American bulrush, Scirpus validus Vahl; three-square bulrush, Scirpus americana Pers.; common cattail, Typha latifolia Linnaeus; marsh pea, Lathyrus palustris Linnaeus; and common horsetail, Equisetum arvense Linnaeus, Figure 6. South of the lagoon, low sprawling mats of beach pea, Lathyrus maritimus (Linnaeus) Bigelow, are found. Sparse vegetation which includes such plants as downy bromegrass, Bromus tectorum Linnaeus; Italian ryegrass, Lolium multiflorum Lam.; and scattered clumps of alfalfa, Medicago sativa

Figure 5. Perimeter vegetation of the lagoon (saltgrass and goosegrass). Southern extremity of island can be seen in background.

Figure 6. View of the marsh from the "central woods" area. Typical pheasant habitat of eastern portion of island in the foreground.

Figure 7. Pheasant habitat adjacent to woodland borders on eastern sector of island.

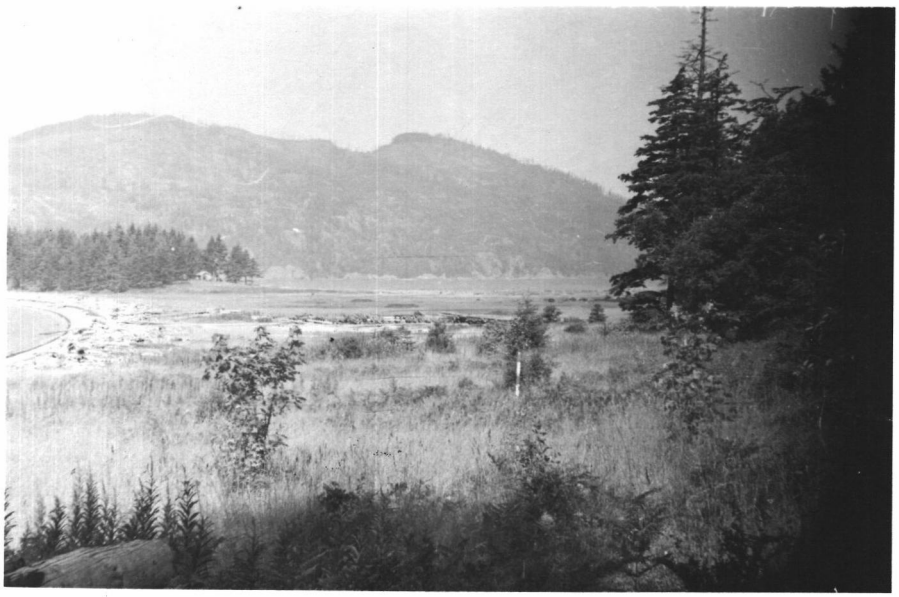

Figure 8. View of central flat and western extremity of the island from a clearing south of the "woodhouse" area. Lummi Island in the background.

Figure 9. Two-acre barley field adjacent to the central woods. This field was cultivated and seeded in the spring of 1951.

Linnaeus, exist on the gravelly soils to the north of the lagoon. Small Douglas fir trees, buffalo berry bushes, Shepherdia canadensis Nuttall; and stunted wild cherry trees, Prunus emarginata (Douglas) Walp., grow in the extreme northern part of the flat.

To the east of the central flat are the more fertile open slopes of the island, Figures 6, 7, and 8. These fields contain rank growths of orchard grass, bracken fern, and common thistle, Cirsium lanceolatum (Linnaeus) Scop.; and well spaced thickets of Himalaya berry, Rubus thyrsanthus Focke; and red alder, Alnus rubra Bongard. On the border of the central woods is a two-acre field containing cultivated barley, Hordeum vulgare Linnaeus, Figure 9. This field was planted in the spring of 1951 in an attempt to simulate conditions found on agricultural lands. Former cultivated fields on the open slopes of the island contain remnant stands of red clover, Trifolium pratense Linnaeus; alfalfa, and hairy vetch, Vicia villosa Linnaeus.

The vegetative cover of the wood house area consists of a mixture of Douglas fir, red alder, and vine maple. In this area occur numerous small clearings containing thickets of thimbleberry, Rubus parviflorus Nuttall; Himalaya berry, and red alder. Associated with the understory of this woods are tall stands of nettle, Urtica lyallii Watson; and prickly lettuce, Lactuca scariola Linnaeus.

The north point woods consists of second growth Douglas fir interspersed with red alder and vine maple. Nearer the extremity of

this extension of the island where the woods are more open, the ground is covered with bedstraw, Galium aparine Linnaeus; and starflower, Trientalis latifolia Hook. The central part of this woods is more dense. Found here are shoulder-high stands of nettle and much fallen timber.

A two-acre field of alfalfa and an open grove of mature bigleaf maple, Acer macrophyllum Pursh; and red alder exists between the north point woods and the central woods. Beneath and bordering this grove of trees are thickets of Himalaya berry and dense stands of orchard and canary grass, Phalaris arundinacea Linnaeus.

The major portion of the central woods is a uniform stand of second growth Douglas fir, in the understory of which only a few plants exist. Tall ranks of nettle, however, grow in the southern sector where these woods are more open in character.

The area about the neck of the island contains such deciduous trees as red alder, wild cherry, and vine maple. Dense thickets of willow, Salix sp. Linnaeus, ocean spray, and fireweed, Epilobium angustifolium Linnaeus, however, make this area a brush-type habitat.

An old growth stand of Douglas fir exists in the central portion of the southern extremity of the island. Between this stand and the steep eastern banks arising from the ocean there is a broad strip of salal, bracken fern, and giant vetch, Vicia gigantea Hook. Low wind-swept thickets of Douglas fir grow on the banks above the eastern and southern shoreline of this part of the island.

Climatic Conditions

Although Eliza Island is located within the Pacific coast rain belt, the annual rainfall seldom exceeds 20 inches per year. This is partly due to the fact that the island lies in the rain shadow of some of the San Juan Islands. Periodic storms and frequent drizzling rains occur in the fall and winter, but the period from spring to early fall is generally characterized by warm and sunny weather. The moderating influence of the ocean causes summer temperatures to be lower and winter temperatures to be higher than corresponding inland temperatures on the same latitude. These temperatures are nearly similar to those found in some of the lowland pheasant habitats of western Washington and Oregon, however.

Weather data were collected throughout the study. The rainfall was measured three times daily on a standard rain gauge. Temperatures were recorded on a thermograph. Table 2 presents the monthly temperature and precipitation trends during the study. The general velocity of the wind was low to moderate during the summer, and the prevailing wind direction was from the southwest. Occasional cloudy days occurred in the spring, but sunny weather was the rule during the summer months, the period with which this study was primarily concerned.

Table 2

Temperature and Precipitation Trends on Eliza Island, Washington Between April 10 and November 31, 1951

Explanation of Table: Average daily maximum and minimum temperatures in degrees Fahrenheit; precipitation in inches per month (with the exception of April.

Month	Temperature		Precipitation
	Average daily high	Average daily low	
April (10-30)	54.50	47.30	.15
May	59.93	49.93	1.95
June	64.53	55.20	.33
July	68.10	54.87	.08
August	68.71	57.38	.40
September	61.93	53.90	1.88
October	54.38	48.10	4.33
November	50.56	43.26	2.55

Between the first day of June and the last day of August, only .81 inches of rain was recorded on the island. The average daily maximum temperature was 67.1° F. During this period much of the herbaceous vegetation on the island withered and some of the leaves on deciduous trees fell to the ground. Water in the marsh disappeared completely and the lagoon was reduced to a very small pool. Even the usual springs on Lummi Island dwindled to mere trickles and devastating fires occurred in mainland forests.

PROCEDURE

History of Birds

The wild juvenile pheasants used in this study were reared in the natural environment of the island during the spring of 1951. They were the progeny of 5 adult hen pheasants and 2 adult cock pheasants that were released on the island on April 10, 1951. Although it would have been more desirable to liberate a known number of wild birds, there was no practical means of acquiring birds of this type. Since the wild offspring ranged free upon the island from the time of hatching, they could not be banded for identification, nor could their numbers be accurately determined. The wild juveniles were distinguishable from all other pheasants used in the study by the fact that they were the only birds not banded.

The eight groups of game farm reared juvenile pheasants were released on the island on July 20, 1951. Each of the groups contained 20 individuals, making a total of 160 birds. Since they still retained juvenile plumage at the time of release, the sex of the juvenile game farm birds was not known at the beginning of the study. Of the eight groups, five came from the Washington State Game Commission game farm at Whidbey Island, Washington, and three came from Oregon State Game Commission game farms in Oregon. In being transported to the island on the same days that they were released, the birds from Oregon were 12 hours enroute, as compared with two hours enroute for the birds from Washington. The

essential data concerning the varying ages, methods of rearing, and origins of these birds are listed in Table 3. Since the abbreviated methods of rearing approach self explanation, they will be used hereafter in the text when referring to specific classes of birds.

Table 3

A Listing of the Groups of Juvenile Game Farm Pheasants Used in the Comparative Survival Study on Eliza Island in 1951

Number of birds liberated	Age (weeks)	Method of Rearing	Origin
20	6	Hen-hatched, hen-brooded, field-reared (enclosure)	Whidbey Island,* Washington
20	8	Hen-hatched, hen-brooded, field-reared (enclosure)	Whidbey Island,* Washington
20	6	Hen-hatched, hen-brooded, open field-reared	E.E. Wilson ** Game Management Area, Oregon
20	6	Incubator-hatched, electric-brooded, pen-reared	Whidbey Island,* Washington
20	8	Incubator-hatched, electric-brooded, pen-reared	Whidbey Island,* Washington
20	10	Incubator-hatched, electric-brooded, pen-reared	Whidbey Island,* Washington
20	8	Incubator-hatched, steam-brooded, pen-reared	Corvallis Game** Farm, Oregon
20	8	Hen-hatched, hen-brooded, pen-reared	Corvallis Game** Farm, Oregon

* Washington State Game Commission game farm
** Oregon State Game Commission game farm

The pheasants reared by hen-hatched, hen-brooded, field-reared (enclosure) and incubator-hatched, electric-brooded, pen-reared

methods were divided into equal sized groups of different age composition. The former consisted of two groups, six and eight weeks of age; and the latter, three groups, six, eight, and ten weeks of age. In order to clarify the methods of rearing listed in Table 3, they will be discussed separately.

a. Hen-hatched, hen-brooded, field-reared (enclosure) units

In this method of rearing the eggs were hatched and the chicks were brooded by domestic hens confined to small coops from which the chicks could leave or enter at will. The coops were located in a large enclosure within which was vegetation simulating that in a natural environment. This system enables the chicks to become adjusted to semi-wild conditions.

b. Hen-hatched, hen-brooded, open field-reared unit

The method used in rearing these birds differed from that in (a) in that the chicks were reared in a natural environment and were not restricted to an enclosure.

c. Incubator-hatched, electric-brooded, pen-reared units

In this method the eggs were hatched and the chicks were brooded in electrically heated incubators and brooders. After being brooded the chicks were placed in outdoor pens and fed prepared foods.

d. Incubator-hatched, steam-brooded, pen-reared unit

These birds were reared in essentially the same manner as those in (c) with the exception that brooding was

accomplished by steam heat.

e. Hen-hatched, hen-brooded, pen-reared unit

In this method the eggs were hatched and the chicks were brooded by domestic hens, but the chicks were confined to pens and fed prepared foods.

Liberations

Adult game farm breeding stock. The seven adult game farm birds used for the production of the wild juvenile pheasants were shipped to the island on March 20, 1951, and were held in a pen for liberation at a later date. On April 10, 1951, when conditions for nesting were suitable, an aluminum identification band was secured to one leg of each of these birds. To serve as an aid in identifying the adult birds in the field, small plastic tags of varying distinctive colors were attached to the back of the neck of each with small surgical clips, Figure 10. During the early morning hours the birds were crated, moved to the eastern portion of the island, and released near optimum natural food and cover.

Juvenile game farm birds. The juvenile game farm birds arrived on the island at 6 p.m. on July 20, 1951, each group being contained in a separate crate. Consecutively numbered aluminum wing bands had been secured to both wings of each of these birds at the various game farms from which they originated. Although each crate contained 22 birds, only 20 were liberated for the study. The two extra birds were to be used as replacements in the event of injury

or mortality. To prevent losses, it was necessary to liberate the birds as soon as possible, for some birds had been confined to the crates for 12 hours. The crates were therefore placed aboard a tractor drawn sled and moved to a roadway bisecting the central flat area of the island. Starting at one end of this road, the crates were placed at intervals, and after removing the two surplus birds from each, the doors were opened. Most of the birds flew out and landed short distances away from the crates. All of the 160 birds released appeared to be in good condition; therefore, the 16 surplus birds were destroyed before they could escape. The immediate area in which these birds were liberated was considered to be either marginal or poor pheasant habitat, the vegetation consisting mainly of saltgrass, wire-rush, and other low-growing herbaceous plants. Optimum food and shelter conditions existed within a few hundred feet of the site of release, however. Thus, an opportunity existed to determine how well the birds would adjust themselves when liberated in adverse habitat adjacent to optimum habitat.

Field Methods

The pheasant population was under observation from the time that the adult birds were liberated on April 10, 1951, to the beginning of pheasant harvesting operations on October 1, 1951. The amount of time and effort devoted to observation on any given day varied with the different phases of the study and with other existing conditions.

Figure 10. Plastic neck tag attached to the neck of an adult cock. These tags were used to identify the adult birds in the field.

Figure 11. A pheasant nest showing "pipping lines" on hatched eggs.

Two general techniques were employed to obtain information about the pheasants. The first was called "quartering", which consisted of walking along a strip of ground about 50 feet in width in a series of sharp angles from one side to the other, returning on adjacent strips in the same manner. The second method was termed "random" searching, the principle consisting of traversing selected habitat by different routes of travel on successive trips. Habitual and natural routes were avoided and areas that might normally have been neglected by reason of their density of vegetation or rough terrain were scrutinized with particular care. In both of these methods of search, slow deliberate movement and intense visual concentration were most effective.

The first of two phases of field study included the period between April 10 and July 20, 1951. This phase was concerned with the determination of adult hen nesting success and an estimate of the total number of wild offspring. An attempt to locate nests was made in April while the vegetation was still low but was discontinued when harassment by the searcher caused two hens to desert their nests. Subsequent field observations were conducted in such a manner as to allow the hens to nest without being molested.

On June 1, the first brood was observed and subsequent field searches were devoted to the task of locating nests and broods. When nests were discovered they were carefully examined in order to determine the number of hatched and unhatched eggs. Only eggs that showed definite "pipping" lines, Figure 11, were counted as hatched

eggs. When broods were encountered, attempts were made to flush the entire group, and counts were made in flight. To determine total numbers, an effort was made to locate and count as many different broods on each trip as possible.

The second phase of the observation period, from July 20 to October 1, 1951, was primarily concerned with determination of mortality. Field searches commenced immediately after the liberation of the juvenile game farm birds on July 20 to determine losses from "liberation shock". The recovery of several dead birds in the vicinity of the release site stimulated a thorough search to be made of this area which continued for several weeks. The density of the saltgrass and wire-rush vegetation, however, prevented finding all dead birds regardless of what method of search might have been employed. A young Laborador retriever, with a keen sense of smell, was most effective in this endeavor. Outlying areas were searched with the aid of the dog in an attempt to locate birds that might have died in places remote from the liberation site. All dead pheasants were examined for possible evidence of the cause of mortality. The time of death was estimated by the degree of body decomposition.

Of the following characteristics, one or more were used to determine the sex of dead or captured juvenile birds. Males: (1) white markings of the primary wing feathers not continuous across the rachis; (2) indications of male plumage; (3) small but distinct spurs on the legs. Females: (1) white markings of the primary

wing feathers continuous across the rachis; (2) distinctive brown plumage; (3) no spurs on the legs.

An influx of migrating avian predators in August and September resulted in increased losses of pheasants from predation. These mortalities were invariably caused by Cooper's hawks. In looking for hawk kills, widespread examination of the island proved to be a waste of time and effort. Nearly all of the kills occurred along the border of the woods on the eastern side of the island. This area was searched each morning in an attempt to locate pheasants that had been recently killed. Although this method was helpful, the high frequency of predation prevented finding many of the pheasant kills before the carcasses were devoured and scattered about by the predators. The removal of wing bands by the predators became a problem in attempting to identify the victims and the scattered portions of various kills within a given area was misleading as to the actual number of predations that had occurred. The latter hours of the days were devoted to the time-consuming task required to locate and correlate these lost and misleading portions of evidence.

Several pheasants that had been killed and eaten by predators could not be identified as to the specific group in which they belonged. The skeletal and feather remains, however, indicated that they were juvenile birds. If the victims were game farm birds, the wing bands had either been removed at or near the scene of kill and could not be found, or else the bands had been carried away on

portions of the carcass by the predators. In these cases, the evidence was not sufficient to determine whether the birds were of wild or of game farm origin. It was necessary to list such kills as "undetermined" juvenile mortalities.

The Harvest

By October 1, 1951, the juvenile pheasants were between 16 and 20 weeks of age and had been subject to decimation from various factors for a total of 70 days. From the standpoint of survival, the most critical period of their life was over and the study was terminated. By removing the remaining birds from the island and checking them against the numbers released, accurate survival figures were obtained.

To accomplish removal of the remaining birds, live-trapping was first attempted. A total of three traps was erected in strategic locations and kept in operation between October 1 and October 13, 1951. The birds were removed from the traps twice daily and placed in holding pens. On November 3, 1951, a controlled hunt was conducted on the island in an attempt to remove the birds that had not been live-trapped. Persons taking part in this hunt included conservation officials and biologists from Oregon, Washington, and British Columbia. Although the hunt lasted most of one day, only 22 pheasants were recovered. Mr. Wayne Bohl, resident graduate student, removed the remainder of the birds by hunting daily until December 22, 1951, when the last bird was shot. Searches for pheasants that might

either have died from gun-shot wounds or have been killed by predators during the harvest were continued through the winter months. Three birds were recovered by hunting and eight birds were recovered as mortalities from predation after the controlled hunt on November 3.

OBSERVATIONS

Food and Water

From plant collections, at least 167 species of plants are known to be indigenous to Eliza Island, and food-habit studies of pheasants harvested thereon indicate that many of these plants are utilized by the birds for sustenance. Of the grasses, which provide a major source of food, mainly in the form of seeds, there are 20 or more species. Insects of several types are also abundant.

Although observations of pheasant feeding habits were limited, there was no evidence indicating a scarcity of sustaining natural food items. In the early spring the adult pheasants were frequently seen feeding upon newly sprouted barley. Later, many decayed logs which harbored quantities of sowbugs were picked apart by young pheasants, apparently to obtain these insects. The succulent green leaves of alfalfa were a favorite food item, and salal berries were found in the crop of a dead bird. The major item of food consumed by the pheasants was grain obtained from a barley field, Figure 9. Large flocks of pheasants foraged in this field throughout the summer. Himalaya berries, which were abundant on the eastern side of the island, were also heavily utilized by the birds.

When fresh water became scarce in August because of drought conditions, an effort was made to determine whether the pheasants were in need of this substance. Pans of water were placed in two areas frequented by pheasants and fine sand was spread about each

so that the tracks of any birds approaching could be detected. Observations were also made in the soft border mud along the shoreline of the fresh water lagoon. It was apparent that the birds obtained sufficient water from succulent vegetation for they did not utilize water from either the pans or the lagoon.

Reproductive Activities of Adult Birds

The seven adult game farm birds, consisting of five hens and two cocks, that were liberated on April 10, 1951, soon established areas in which they proceeded with reproductive activities. At this time, however, a third cock was present on the island. This cock had survived the winter study of 1950-51 and was not detected until April 21. Each of the three cocks resided in a rather well defined territory during the breeding phase. The territory of the cock that survived the winter study included the wood house area and its adjacent fields, and that of one of the released cocks, the fields and thickets bordering the north point woods. All of the five hens remained and nested within the territories of these two cocks. The third cock stayed on the western extremity of the island and apparently did not participate in mating activities.

Although the hens commenced to lay eggs within a few days after release, most of their time was spent away from the nests when not laying eggs. During this period, small groups containing a single cock accompanied by from one to three hens were frequently observed in the fields bordering the central woods. By April 22, the

hens commenced to incubate and were seen less frequently. The cocks, however, continued to strut about the open fields. In early June, the broods had hatched and the hens were wandering about the fields and thickets with their chicks. The cocks then retired into the seclusion of the woods and were rarely observed during the remainder of the study.

On May 26, a territorial dispute was witnessed when two cocks were observed strutting belligerently before one another on the central flat. After approximately 15 minutes of arrogant bluffing and attempted intimidation, one of the cocks reluctantly retreated toward the west point woods.

A most interesting phenomenon concerned the crowing activities of the cocks. It is commonly assumed that most male pheasants express themselves by crowing during the spring breeding phase. Neither of the two cocks situated on the eastern sector of the island did so during this study, despite the fact that they were in possession of all five hens. The cock on the western extension of the island, however, that took no part in mating, crowed persistently from the day it was released until June 21, at which time the chicks were well developed.

Nesting Success

The adult hens commenced to nest within a few days after being liberated on April 10. This was indicated by the discovery of two nests early in the study. The first nest, already containing four

eggs, was located on April 16. The second nest, also containing four eggs, was discovered on April 18. The intervention of a human observer during the egg laying period, however, caused the hens to desert both of these nests.

Although care was taken thereafter to avoid nesting hens, two hens were accidentally discovered while they were incubating clutches of eggs. The first hen, which was not disturbed at the time, was sitting on a nest when observed on May 8. Then on May 11 another hen was flushed from a nest containing 11 unhatched eggs. Eggs in both of these nests had hatched when examined on June 1. The former, which was probably a renest, contained three hatched and four unhatched eggs. The latter contained ten hatched eggs and one unhatched.

On May 11 the carcass of an adult hen that had recently been killed by a Cooper's hawk was discovered. Since hen pheasants generally require approximately 40 days to lay and hatch a clutch of eggs (8, p.148), this bird could not have produced a brood for it had been in the field only 30 days since its release on April 10.

A third nest containing 11 hatched and two unhatched eggs was located on July 22. Although the possibility of the presence of a fourth successful nest existed, an additional nest was not discovered during the study. In the three successful nests that were located, however, a total of 31 eggs was laid, 24 of which were hatched.

Wild Broods

The wild juvenile pheasants were under observation from the time of hatching in early June until the time that the juvenile game farm birds were liberated on July 20. Subsequent to the latter date, the wild birds could not be distinguished from the game farm birds by observation.

The accumulated observations of the wild-reared pheasants provided many indications that these birds, as a group, possessed the qualities necessary for optimum survival in a natural environment. Apparently indirectly responsible for the acquisition of some of these traits were the hens, whose habits of preservation, both for themselves and for their progeny, were, it seems, assimilated by the offspring through the close association that existed between broods and hens. The wild broods were intact and accompanied by the hens for approximately six to seven weeks from the time of hatching. When a family group was encountered, the hen would give a warning "cluck" at which signal the chicks immediately dispersed and hid, quietly and motionless, beneath the vegetation. Later, the hen returned, gathered up the chicks, and led them to a safer locality. The hens also guided their young to favorite feeding areas. These areas were seldom located far from protective escape cover.

As supporting testimony to the observable wariness of the wild juveniles, only one of these birds was known to be a victim of predation. This is noteworthy in view of the fact that 33 pheasants were killed by predators between April 10, when the adult pheasants

were released, and December 22, when the last bird, also of wild origin, was removed from the island. The one wild pheasant killed by a predator was a five weeks old cock.

The difficulties experienced while attempting to count the wild birds provided additional evidence as to the elusiveness of these birds. Brood counts ranged from a minimum of one to a maximum eight and could not, therefore, be considered reliable data. The young birds remained concealed and evasive to the extent that only two broods were ever observed on a single day. Consequently, only 20 separate broods were observed prior to July 20.

The wild broods ranged on a limited portion of the island, in the untilled fields and about the woodland borders east of the central flat. Since brood home ranges overlapped in this area, the different broods could not be distinguished by territorial aspects. Neither could they be recognized by hen identification, for the hens had lost their neck tags earlier in the study. These difficulties made it impossible to obtain an accurate count of the wild birds. A total of approximately 20 wild-reared offspring was estimated to have been present on July 20, the beginning of the study.

Juvenile Game Farm Birds

The behavior exhibited by the juvenile game farm pheasants indicated that these birds were, in general, less suitable for survival in a natural environment than were the wild birds. This statement, of course, applies to the juvenile game farm birds as a

composite group, for the various units of birds could not be distinguished in the field. The undesirable traits of these birds were particularly obvious during the days following their liberation.

On July 21, the day after release, it was evident that the juvenile game farm birds had not made a satisfactory adjustment to their new environment. During the entire day the majority of birds wandered about the central flat. Only a few birds ventured into the fields and thickets east of the central flat or into the woods on the west point of the island. The behavior of the birds seemed to reflect their game farm origin. Indifference to the presence of a human observer was one example. Instead of running swiftly away when stalked, they skulked along the ground only a short distance in advance. Those concealed in the short but dense vegetation of the flat could nearly be stepped upon before attempting to escape. On several occasions such hiding birds were nearly touched. A general reluctance to flush was obvious and flights were unusually short. Some birds experienced difficulties in flushing from dense cover, becoming momentarily trapped by the vegetation. Only slight improvements to this pattern of behavior were discernable for approximately ten days after the liberation of the juvenile game farm birds. Had they been present, wild or domestic predators undoubtedly could have killed large numbers of these birds. At the time, however, avian predators were not present on the island and the only dog thereon was confined to keep it from killing pheasants.

By August many of the juvenile game farm birds were residing in the fields and thickets to the east of the central flat. At the same time they had become more wary, more adept in flying, and were utilizing cover to better advantage. Nevertheless, the effects of game farm origin were still evident. For example, an eight weeks old hen-hatched, hen-brooded, pen-reared bird that had become trapped in a tangle of old wire was discovered on August 2. This bird appeared to be unharmed and was therefore released. Then on August 8, a small group of birds was seen feeding on waste grain near a chicken house. Either the same or other groups of birds continued to feed here during the rest of the month. Between the dates of August 5 and 13, several birds were captured within a garden enclosed with fish netting on all four sides. Entry had been made through the open top. These birds consisted of: two, 6 weeks old, and one, 8 weeks old hen-hatched, hen-brooded, field-reared (enclosure) birds, plus one, 6 weeks and one, 8 weeks old incubator-hatched, electric-brooded, pen-reared birds. On August 12, an 8 weeks old hen-hatched, hen-brooded, pen-reared bird was released from an old hawk trap into which it had unwittingly entered.

During the months of August and September the vicinity of the barley field and wood house area was the center of pheasant concentration. Groups of juvenile game farm birds ranging from 10 to 50 in numbers were commonly observed in this area, either feeding in the barley field, Figure 9, or resting in the adjacent woodlands and thickets. Only a few birds used the untilled fields

to the north and east of the marsh, Figure 7. Considerable numbers of birds, however, spent the greater part of their time in the swales about the central flat and a few sought the dense thickets on the western extension of the island. Although small numbers of birds ventured as far as the neck of the island, only a few individual pheasants were observed in the understory of the coniferous woods extending along the eastern sector.

In the 1950 summer study on Eliza Island, the pheasant population was obviously more widely distributed about the island and the coniferous woodlands harbored large numbers of pheasants. The 1950 population, however, was comprised mainly of wild-reared birds (31 adults and 111 offspring) at the time of harvest in October (3, unpublished).

The juvenile game farm birds commenced to disperse in early October and thereafter were observed on the extremities of the island. This inclination to spread was further indicated on October 27 when a cock was seen poised on a bluff at the west end of the island with the apparent intention of leaving the island. After a short flight over the ocean, the bird realized the futility of its attempt and returned to the island.

RESULTS

Losses From Liberation Shock

In the days following the liberation of the juvenile game farm pheasants, a considerable number of these birds were recovered as mortalities caused by some obscure factor and others were observed to be in an adverse physical condition. This phenomenon, which was a consequence of the release of the birds into a new environment, will be referred to as "liberation shock" hereafter in the text. A total of 23, or 14.4 per cent of the juvenile game farm birds were known to have died following release.

The first evidence of this type of mortality was revealed when three birds died after they had been recovered from peculiar situations on July 22, the second day after release. The first was a ten weeks old incubator-hatched, electric-brooded, pen-reared bird that had probably flown into the lagoon for it was inextricably mired up to its breast in the soft border mud. This bird, wet and exhausted from its ordeal, died within a few hours after being placed in a pen to recover. Although death may have resulted from exposure and exhaustion, "liberation shock" was thought to have been a contributing factor. The second bird was standing in the surf at the edge of the ocean when it was discovered. Though not wet, the bird was evidently weak and died later in a pen where it had been placed for possible recovery. This was also a ten weeks old incubator-hatched, electric-brooded, pen-reared bird. The third

bird was standing upon a rocky reef approximately 100 feet offshore when it was first observed. As the incoming tide rose, the bird was forced off the rock and flew to shore where it was captured after a brief chase. Examination indicated that this was an eight weeks old incubator-hatched, electric-brooded, pen-reared bird, and although it appeared to be weak, it was released. The carcass of this bird was found on July 24 only a short distance from the site of capture.

Most of the "liberation shock" mortalities were discovered between July 25 and July 31, 1951. In this period 12 decomposed and maggot infested carcasses of juvenile game farm birds were found. Figures 11 and 12 show two of these mortalities. The condition of these 12 carcasses indicated that death had occurred within a day or two after the liberation. Also found at this time were three birds that had died on the sixth or seventh day after being released. Two of these birds, one an eight weeks hen-hatched, hen-brooded, pen-reared bird, and the other a ten weeks old incubator-hatched, electric-brooded, pen-reared bird, were emaciated and their crops were empty. The third, of the six weeks old hen-hatched, hen-brooded, open field-reared class, appeared to be normal in weight and its crop contained many salal berries.

The remainder of the "liberation shock" mortalities were discovered later in the study. Although each of these carcasses was thoroughly decomposed, it could only be assumed that death had occurred near the time of release.

A total of 15 of the mortalities attributed to "liberation shock" were recovered on the central flat. Of these, eight were found in the wire-rush and saltgrass vegetation within a few hundred feet of the liberation site. The remainder were recovered either from the western extremity of the island or from the area east of the central flat.

The number and percentage of "liberation shock" mortality in each group of juvenile game farm birds is included in Table 4. The data show that each group sustained some loss of birds from this factor but that the numbers varied from one to seven. The six weeks old incubator-hatched, electric-brooded, pen-reared and six weeks old hen-hatched, hen-brooded, open field-reared groups suffered the highest losses, 35 per cent (7 birds) and 25 per cent (5 birds) respectively. Mortality from "liberation shock" ranged from 5 to 15 per cent (1 to 3 birds) in the other six groups.

Between July 21 and 30, six birds were captured in the area of release that were in a weak and listless condition, Figure 15. This was assumed to be a symptom of "liberation shock". These birds consisted of: three, 8 weeks and one, 10 weeks old incubator-hatched, electric-brooded, pen-reared birds, plus two, 6 weeks old hen-hatched, hen-brooded, field-reared (enclosure) birds. Three of the pen-reared birds did not survive to the end of the study. The first was killed by a Cooper's hawk in August, the second died of "liberation shock" within four days after it had been captured, and the fate of the third was not determined.

Figure 12. One of the juvenile game farm birds that died from "liberation shock". This bird died in a dense growth of wire-rush.

Figure 13. A typical "liberation shock" mortality. This bird died a day or two after liberation.

Figure 14. One of three "liberation shock" mortalities that occurred about one week after liberation.

Figure 15. A weak and listless juvenile game farm bird sitting in a dense growth of saltgrass. Several birds were observed to be in this condition which was assumed to be a symptom of "liberation shock".

Losses From Predation

Predation on the pheasant population was sporadic and insignificant until the sudden influx of migrating avian predators in early August, the impact of which resulted in the loss of 23 pheasants by Cooper's hawks before the end of the study on October 1, 1951. As far as could be determined this was the only predator that managed to kill pheasants during this study. In addition, ten pheasants were killed by avian predators before and after the study. Thus, a total of 33 pheasants were victims of predation during the time that pheasants were present on the island.

Only an occasional predator was observed on the island before August. Accordingly, the wild-reared birds were relatively safe from being preyed upon for approximately 60 days from the time of hatching. The juvenile game farm birds, however, had only been in the field for two weeks when predation suddenly became intense. The numbers of pheasants that were killed by predators during five day periods throughout the experiment are shown in Figure 16. In that most of the kills were discovered within a few days after they occurred, the data adequately express the seasonal variation of avian predation.

With the exception of the remains of two kills on the neck of the island, all of the Cooper's hawk kills recovered during the study were located in the area of highest pheasant density: about the wood house area and barley field.

Figure 16

RECOVERY OF PHEASANT MORTALITIES BY FIVE DAY PERIODS

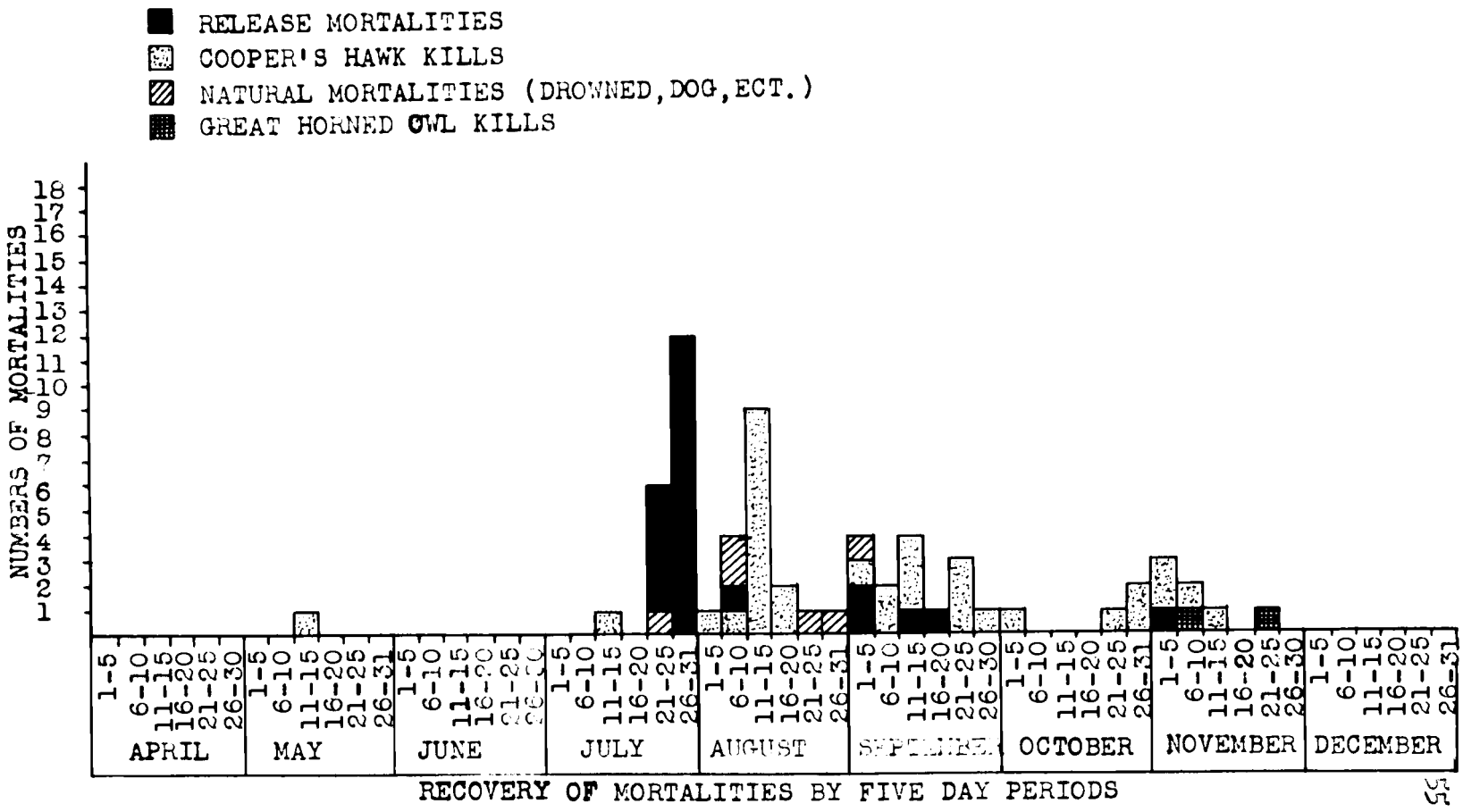

Figure 17. An immature Cooper's hawk that was captured at the pheasant kill shown in Figure 18. This species of hawk killed 31 pheasants during the time that pheasants used in this study were on the island.

Figure 18. A typical Cooper's hawk kill. This pheasant had been placed on top of a stump by the predator.

Figure 19. Remains of a typical Cooper's hawk pheasant kill. Note that the large bones have not been broken.

Cooper's hawks, secretive by nature, searched for pheasants about the woodland borders and thickets. Once this hawk secured a victim the carcass was usually dragged to some nearby place of concealment. Sometimes the pheasant was consumed near the scene of kill, but more often it was dissected and the parts carried away to a secluded area. One typical habit was that of placing the carcass upon some low elevation such as a stump, Figures 17 and 18. A Cooper's hawk could consume only about a handful of flesh at any one feeding and a half-grown pheasant generally provided sustenance for two or three days. Digestion is so rapid in this hawk, however, that excreta is passed from the cloaca in a forceful stream. These droppings existed as numerous bold, white streaks in the vicinity of kills and served as diagnostic evidence in the absence of the predator.

Observations of many Cooper's hawk kills demonstrated that this raptor has a characteristic method of eating its prey. Before any flesh is eaten the feathers are invariably plucked away from that portion to be consumed. An entry is first made in the abdomen to obtain the viscera. The intestines and gizzard, however, are usually discarded. Next, the neck, breast, wings, and legs are consumed, leaving the bones cleanly stripped of flesh. The smaller bones may be broken but the larger ones remain intact. Figure 19 shows the remains of a pheasant that was eaten by this predator.

Although Cooper's hawks were responsible for all of the kills recovered, they were not the only raptor present on the island. The

larger red-tailed hawks, and the smaller sharp-shinned hawks were also present during the study. The former were evidently either too slow or not inclined to kill pheasants, and the latter confined their predations to the smaller song birds. Marsh hawks were frequent visitors for brief periods in the early fall and although several were observed to sweep and hover over pheasants they did not manage to kill any of the birds.

The data concerning known mortality from predation in the nine groups of juvenile birds between July 20 and October 1 is included in Table 4. The percentage of predation in each group of game farm juveniles was computed from the number of birds that supposedly remained after initial losses from "liberation shock" (the difference between the number of initial losses recovered and the number released). For comparative purposes, these figures are subject to error, for some of the birds in each group could not be accounted for in the survival computations (Table 8). In many groups, however, the number of birds unaccounted for was low, and the proportions of mortality between these groups in Table 4 are probably near similar to the actual proportions. The outstanding feature of these data is the high percentage of predation in the six weeks old incubator-hatched, electric-brooded, pen-reared group, 46 percent (6 birds), as compared with from 0 to 11.7 (2 birds) per cent in the other eight groups of juvenile birds. That the high loss from predation paralleled the high loss from "liberation shock" (7 birds) in the above six weeks old pen-reared group, is equally significant. On the other hand, the six weeks old hen-hatched,

hen-brooded, open field-reared group, which also sustained high losses from "liberation shock" (5 birds), had only one known victim of predation. In the other six groups of game farm birds, the lower losses from "liberation shock" (from 1 to 3 birds) tended to have been paralleled by similar low losses from predation (from 0 to 2 birds), according to the number of mortalities recovered. The fact that six of the game farm groups show at least two birds lost from predation as compared with none for the wild group also tends to be significant. The eight weeks old incubator-hatched, electric-brooded, pen-reared group which shows no losses from predation, however, had five birds unaccounted for (Table 8), some of which were undoubtedly mortalities from predation.

Losses From Other Factors

A total of six mortalities occurred during the study that were not caused by "liberation shock" or predation.

The first, a six weeks old incubator-hatched, electric-brooded, pen-reared bird, was killed by a dog on the fifth day after its release. This death provided additional evidence as to the vulnerability of this group of birds.

The second, a wild-reared hen, was killed by a dog on August 8. An examination of the bird revealed no evidence of disease or injury. In that it was unusual for a dog to catch wild pheasants, this bird probably had some physiological defect.

Table 4

Known Mortality in the Nine Groups of Juvenile Pheasants Between July 20 and October 1, 1951

Class of Birds	Age in weeks	Number liberated	Number of birds lost from "liberation shock"	Number of birds remaining after losses from "liberation shock"	Per cent mortality from "liberation shock"	Number of birds killed by predators (Cooper's hawks)	Per cent mortality from predation*	Number of birds lost from other factors	Total number of pheasant mortalities	Per cent of known mortality
HH-HB-FR(E)	6	20	1	19	5	2	10.5	0	3	15.0
HH-HB-FR(E)	8	20	1	19	5	2	10.5	0	3	15.0
HH-HB-FR(O)	6	20	5	15	25	1	6.6	2	8	40.0
IH-EB-PR	6	20	7	13	35	6	46.0	1	14	70.0
IH-EB-PR	8	20	1	19	5	0	.0	0	1	5.0
IH-EB-PR	10	20	3	17	15	2	11.7	0	5	25.0
IH-SB-PR	8	20	3	17	15	2	11.7	0	5	25.0
HH-HB-PR	8	20	2	18	10	2	11.0	1	5	25.0
Totals: game farm juveniles		160	23	137	14.4	17	12.4	4	44	27.5
Wild Juveniles						0		2		
Undetermined Juveniles						6				

* Percentage of predation for the juvenile game farm birds was computed from the numbers of birds remaining after the initial losses from "liberation shock".

Key to abbreviations of classes:

HH-HB-FR(E) - hen-hatched, hen-brooded, field-reared (enclosure)
HH-HB-FR(O) - hen-hatched, hen-brooded, open field-reared
IH-EB-PR - incubator-hatched, electric-brooded, pen-reared
IH-SB-PR - incubator-hatched, steam-brooded, pen-reared
HH-HB-PR - hen-hatched, hen-brooded, pen-reared

The third, another wild-reared hen, died from some undetermined factor. This bird had not been dead more than a day when its carcass was discovered on August 9. Upon examining the bird there was no evidence of disease or injury.

The fourth, a six weeks old hen-hatched, hen-brooded, open field-reared bird, was flushed from the northern extremity of the island, and after expending its energy, landed in the ocean and drowned before a rescue could be made. This incident occurred on August 24.

The fifth, an eight weeks old hen-hatched, hen-brooded, pen-reared bird, apparently blundered into a shallow, concealed well and drowned. When the carcass of this bird was discovered on August 29, it was badly decomposed, indicating that the accident had occurred early in the study.

The sixth, a six weeks old hen-hatched, hen-brooded, open field-reared bird, died of a severely scalped head while attempting to escape from a live-trap in which it was captured on September 2. This trap had been erected to determine by capture and band examination the origins of a small group of birds that were feeding daily about a chicken house on the island.

Harvest Returns

In Table 5, the numbers of juvenile game farm, wild-reared juvenile, and adult game farm pheasant survivors that were collected by live-trapping or hunting, or that were recovered as predations

after October 1, 1951, are listed and expressed as percentages of the total numbers collected by all three methods. A total of eight pheasants were known to have been killed by predators during the harvest, six of which could not be identified as to proper group of origin. Of these eight kills, six were by Cooper's hawks and two were by great horned owls.

Table 5

Numbers and Percentages of Juvenile Game Farm, Wild-Reared Juvenile, and Adult Pheasant Survivors that were Collected by Trapping, Shooting, and as Predations

Class of Birds	Total Harvested	Live Trapped		Shot		Killed by Predators	
		Number	Percent	Number	Percent	Number	Percent
Juvenile (game farm)	94	78	83.0	14	14.9	2	2.1
Juvenile (wild-reared)	19	9	47.4	10	52.6	0	-
Adult (game farm)	3	2	66.7	1	33.3	0	-
Juvenile (undetermined)	6					6	-
Total (all classes)	122	89	72.9	25	20.5	8	6.6

The data in Table 5 show that 89 or 72.9 per cent of the 122 pheasant survivors in this study were live-trapped. This was considered to be an unusually high trapping return in comparison with trapping returns of the former island studies. Furthermore, these birds were recovered in the brief period between October 1 and 13. An examination of the data in Table 5, however, show that 78 or 83 per cent of the 94 juvenile game farm survivors and only 9 or

47.4 per cent of the 19 wild-reared survivors were trapped. These figures indicate that the juvenile game farm birds were more easily live-trapped than were the wild-reared birds.

Trapping returns from a surviving pheasant population consisting of 31 adult birds and 111 wild-reared juvenile birds in the 1950 summer study on Eliza Island were much lower than those of the 1951 study. In the 1950 study, 53.1 per cent of the wild juveniles were live-trapped as compared with 25.8 per cent for the adult birds (3, unpublished). These figures likewise indicate that wild-reared juveniles are not easily live-trapped.

The question arose as to whether the juvenile game farm birds in the 1951 study were less wary of the traps than the wild birds, or merely responding to a previously acquired habit of feeding when lured into the traps by grain bait. Observations in the 1950 study demonstrated that wild-reared birds were equally attracted to grain food. However, many of these birds were trap-shy, ate only the grain outside the traps, and refused to enter the more heavily baited interior.

Weights

The weights of the juvenile pheasants, which were recorded at the time of harvest, may perhaps be used as indices of the general physical condition of the survivors. The average weights of the survivors in the nine groups of juvenile birds, as shown in Table 6, do not vary significantly and are similar to the average weights of a large number of wild-reared juvenile survivors in the 1948 study,

Table 6

Pheasant Weights in Pounds and Ounces Recorded
Between October 2, and December 22, 1951

	Age in weeks	Number of cocks weighed	Average weight of cocks	Lowest cock weight	Highest cock weight	Number of hens weighed	Average weight of hens	Lowest hen weight	Highest hen weight
HH-HB-FR(E)	6	4	2- 9	2- 8	2-10	8	1-13	1-10	2- 0
HH-HB-FR(E)	8	8	2-10	2- 6	2-13	4	2- 0	1-15	2- 1
HH-HB-FR(O)	6	5	2-12	2- 8	3- 1	5	1-12	1-11	1-15
IH-EB-PR	6	2	2- 5	2- 1	2- 9	1	2- 0	2- 0	2- 0
IH-EB-PR	8	4	2-10	2- 8	2-11	9	1-15	1-12	2- 2
IH-EB-PR	10	5	2-11	2- 8	2-14	7	1-15	1-12	2- 2
IH-SB-PR	8	5	2-10	2- 7	2-12	6	1-14	1-13	2- 0
HH-HB-PR	8	5	2-14	2-11	3- 5	8	1-14	1-13	2- 0
Wild-reared	?	10	2-15	2- 9	3- 4	5	2- 0	1-14	2- 3

Key to classes:

HH-HB-FR(E) - hen-hatched, hen-brooded, field-reared (enclosure)
HH-HB-FR(O) - hen-hatched, hen-brooded, open field-reared
IH-EB-PR - incubator-hatched, electric-brooded, pen-reared
IH-SB-PR - incubator-hatched, steam-brooded, pen-reared
HH-HB-PR - hen-hatched, hen-brooded, pen-reared

which are as follows: 2 lbs. 12 oz. for males, and 2 lbs. 0 oz. for females (9, p.62). It seems worthy of mention, however, that one of the surviving six weeks old incubator-hatched, electric-brooded, pen-reared birds weighed five ounces less than any of the other 47 cocks weighed. The higher average weight of the wild-reared birds may have been due to the fact that the majority of these birds were weighed in November when they were harvested by hunting; whereas, the majority of the juvenile game farm birds were weighed in early October when harvested by trapping.

Sex Ratios

Data concerning the sex ratios of the birds used in this study are listed in Table 7. The numbers of cocks and hens recovered in each group of juvenile birds are listed in the column "Total number of birds recovered". Because some of the birds were either not recovered or non-identified mortalities, information in this column does not provide complete data regarding sex ratios at the beginning of the study. The figures tend to indicate, however, that mortality in the juvenile game farm birds was not differential as to sex.

Data for the wild-reared birds, however, show that the surviving cocks far outnumbered the surviving hens, 14 and 5 respectively. On the basis that the wild birds consisted of a normal (equal) sex ratio at the time of hatching, these figures indicate there was a significantly greater mortality of hens than of cocks. In the former studies on Eliza Island, approximately equal numbers of the

Table 7

Data Concerning Sex Ratios of the Pheasants
Used in the 1951 Study on Eliza Island

Class of birds	Age in weeks	Number of birds released	Total number of birds recovered (mortalities and survivors)		Number of mortalities recovered		Number of survivors recovered	
			F*	M**	F	M	F	M
Hen-hatched, hen-brooded, field-reared (enclosure)	6	20	13	5	3	0	10	5
Hen-hatched, hen-brooded, field-reared (enclosure)	8	20	7	9	3	0	4	9
Hen-hatched, hen-brooded, open field-reared	6	20	8	10	3	5	5	5
Incubator-hatched, electric-brooded, pen-reared	6	20	8	9	7	7	1	2
Incubator-hatched, electric-brooded, pen-reared	8	20	10	5	0	1	10	4
Incubator-hatched, electric-brooded, pen-reared	10	20	11	7	3	2	8	5
Incubator-hatched, steam-brooded, pen-reared	8	20	11	6	4	1	7	5
Hen-hatched, hen-brooded, pen-reared	8	20	10	9	1	4	9	5
Totals - game farm juveniles		160	78	60	24	20	54	40
Undetermined juveniles			6	6	6	6		
Wild-reared juveniles			7	14	2	0	5	14
Adult game farm (3 males; 5 females)		8	2	3	1	1	1	2

*F (female)
**M (male)

wild-reared juvenile cocks and hens survived. Fall survival data for the wild-reared pheasants in these studies are as follows: 1947, 16 cocks and 12 hens (10, p.78); 1948, 39 cocks and 44 hens (9, p.61); 1949, 26 cocks and 24 hens (5, p.61); 1950, 52 cocks and 59 hens (3, unpublished).

Survival

The data concerning comparisons of mortality and survival in each group of pheasants are listed in Table 8. Groups are here listed in the order of decreasing survival ratios. With the exception of the wild-reared birds, the figures include the numbers of birds in each group that could not be accounted for when the known numbers of survivors and mortalities were checked against the numbers of birds released. A total of 22 juvenile game farm birds could not be definitely accounted for. It should be noted in Tables 4 and 5, however, that 12 juvenile pheasants which were killed by avian predators could not be identified as to specific group of origin. In view of the fact that the juvenile game farm birds were obviously far more susceptible to predation, most of these 12 undetermined birds were probably of game farm, rather than of wild origin. The fates of the other ten or more juvenile game farm pheasants remain unknown. These were most likely undiscovered mortalities caused by "liberation shock", accidents, predation, or wounds inflicted during hunting procedures. It was also possible that a few birds flew off the island.

Table 8

Comparisons of Mortality and Survival in the Nine Groups of Juvenile Pheasants and One Group of Adult Pheasants for the 1951 Study on Eliza Island, Washington

Class of birds	Age in weeks	Number of birds released	Number of mortalities recovered	Per cent of known mortality	Number of birds unaccounted for	Total number of mortalities**	Per cent of mortality**	Number of survivors recovered	Per cent of survival
Wild juveniles	?	21*	2	9.5	?	2	9.5	19	90.5
HH-HB-FR(E)	6	20	3	15.0	2	5	25.0	15	75.0
IH-EB-PR	8	20	1	5.0	5	6	30.0	14	70.0
HH-HB-PR	8	20	5	25.0	1	6	30.0	14	70.0
HH-HB-FR(E)	8	20	3	15.0	4	7	35.0	13	65.0
IH-EB-PR	10	20	5	25.0	2	7	35.0	13	65.0
IH-SB-PR	8	20	5	25.0	3	8	40.0	12	60.0
HH-HB-FR(O)	6	20	8	40.0	2	10	50.0	10	50.0
IH-FB-PR	6	20	14	70.0	3	17	85.0	3	15.0
Totals: Juvenile game farm birds		160	44	27.5	22	66	41.3	94	58.7
Undetermined juveniles		6						6	
Adult game farm birds		8	2	25.0	3	5	62.5	3	37.5

* The sum of 19 survivors plus 2 known mortalities (the number of wild-reared pheasants was not known at the beginning of the study).

** Unaccounted for birds included as mortalities.

Key to abbreviations of classes:

HH-HB-FR(E) - hen-hatched, hen-brooded, field-reared (enclosure)
IH-EB-PR - incubator-hatched, electric-brooded, pen-reared
HH-HB-PR - hen-hatched, hen-brooded, pen-reared
IH-SB-PR - incubator-hatched, steam-brooded, pen-reared
HH-HB-FR(O) - hen-hatched, hen-brooded, open field-reared

Survival in Table 8 consists only of those birds that were accounted for after September 30, 1951. Accordingly, any pheasants which could not be accounted for after this date would distort the results. For example, the six unidentified pheasants that were killed by predators during the harvest, Table 5, were survivors, but could not be listed as such. That these six birds automatically became mortalities in Table 8, points out an inherent and unavoidable defect in the experiment.

An examination of Table 8 shows that survival varied in the nine groups of juvenile pheasants. As might be expected, the wild-reared group had the highest survival ratio, 90.5 per cent. This percentage of survival may not be real, however, for the number of wild birds that were present at the beginning of the study was not known. The original number of these birds was assumed to be 21, the sum of the 2 mortalities and the 19 survivors recovered in the field.

The rate of survival exceeded the rate of mortality in six of the juvenile game farm groups. These groups consisted of: (1) the eight and ten weeks old incubator-hatched, electric-brooded, pen-reared birds; (2) the eight weeks old hen-hatched, hen-brooded, pen-reared birds; (3) the eight weeks old incubator-hatched, steam-brooded, pen-reared birds; and (4) the six and eight weeks old hen-hatched, hen-brooded, field-reared (enclosure) birds. Survival ratios ranged from 60 to 75 per cent in these six groups and therefore did not vary significantly. Only one of the groups had a survival

of 75 per cent, however, this being the six weeks old hen-hatched, hen-brooded, field-reared (enclosure) birds. It is noteworthy that there was little difference in survival between the six and eight weeks old field-reared (enclosure) birds and the three classes of eight and ten weeks old pen-reared birds.

Although the six weeks old hen-hatched, hen-brooded, open field-reared birds were preconditioned to a natural environment, only 50 per cent survived. Survival in the six weeks old incubator-hatched, electric-brooded, pen-reared group, however, was much lower, 15 per cent; this being the lowest survival ratio shown by any group in the study. Only three of these birds survived out of the original 20 released.

In order to ascertain whether survival was influenced by variations in vitality that might have been results of age, the survival ratios of those birds reared by the same methods but differing in age should be compared. Of the pheasants reared by the hen-hatched, hen-brooded, field-reared (enclosure) method, 15 of the six weeks old birds survived, and 13 of the eight weeks old birds. In this class, survival was slightly higher for the younger birds. Of the pheasants reared by the incubator-hatched, electric-brooded, pen-reared method, 13 of the ten weeks old birds survived, 14 of the eight weeks old birds, and only 3 of the six weeks old birds. In this more artificial method of rearing there seems to be a definite age limitation, for the six weeks old birds were highly deficient in survival powers in comparison with the eight and ten weeks old birds.

The two groups of six weeks old field-reared birds, one reared in an enclosure and the other in an open field, though both of the same age and almost similar as regards method in which reared, survived in significantly different numbers, 15 and 10 birds respectively. The lower survival of the open field-reared group, as shown in Table 4, was mainly a result of much higher losses from "liberation shock", losses from predation being nearly similar for both groups.

The question arose as to whether the 19 wild juvenile survivors were produced from the three nests, which contained 24 hatched eggs, discovered during the study. This would result in a 79.2 per cent survival of offspring. Although this percentage of survival is considerably higher than the average figure for wild-reared juveniles, it is not unreasonable, for 72.3 per cent of the wild offspring survived in the 1948 study on Eliza Island. It seems more likely, however, that a fourth nest existed, which was overlooked in the observations. On this assumption, the average surviving ratio was 4.75 birds per nest, and the percentage of survival would be lowered to a more normal figure.

ANALYSIS OF RESULTS

Before attempting to analyze the findings, it would be well to consider some of the limitations of the experiment. Although such a study at first might appear to be rudimentary, one should realize that the survival of a pheasant population is determined by the complex mechanism of many interrelated and interacting factors. Because these factors are generally inconspicuous and indirectly manifested by gross consequences, any attempt to determine the influence of any one factor on survival would be an imposing problem. This problem is of greater magnitude when attempting to ascertain the influences of such obscure physical or psychological differences as might result from age or method of rearing, particularly among many units of birds which differ in these respects. Difficulties might even be encountered with the more obvious phenomena concerning mortality. In this study, for example, it was impossible either to recover or to identify all of the pheasant mortalities, and the cause of an important limiting factor, "liberation shock", was not determined. Neither can a positive explanation be given for the variable losses from "liberation shock" and predation. Furthermore, some of the surviving birds that were killed by predators could not be identified and therefore could not be included as survivors. The validity of the quantitative measurements of mortality and survival must be tempered by reason since they were derived from small units of pheasants. These small units were necessary in order not to exceed the carrying-capacity of

the island. As will be seen later, the fact that the physical condition of the juvenile game farm birds was not known at the beginning of the study may be another important limitation. The physical condition of these birds could not have been successfully measured, however.

In view of these limitations, comparative survival studies of a similar nature will be conducted on Eliza Island in the summers of 1952 and 1953. Although the results of the present study are not conclusive, an analysis of the findings may prove helpful for comparison with future studies related to the same problem.

Even a casual diagnosis of the results would indicate that an interpretation of the results cannot be realized to its fullest extent by comparing the measurements of survival. The nature and consequences of mortality are of particular importance, and the following discussions shall adhere closely to this subject. However, since the quantitative data concerning mortality are incomplete, any reference to these data are subject to question. The possibility of error for the measurements of mortality is equal to the respective number of birds that could not be accounted for (Table 8). In many cases, undoubtedly, the recovery of mortalities was nearly proportional to the numbers that actually occurred.

The perplexing nature and effects of mortality from "liberation shock" should be examined first. Losses from this factor did not occur among the mature game farm pheasants liberated twice yearly between 1947 and 1950 on Eliza Island. Since all classes of juvenile

game farm birds in this study sustained losses from "liberation shock", it would seem that release soon results in a lowering of resistance sufficient to cause the death of some birds. Unfortunately, the findings do not suggest any possible cause for this initial lowering of resistance. Buss's studies in Wisconsin concerning juvenile pheasants (2, pp.86-99), however, demonstrated that such factors as handling (transportation), "violent" release, segregation, strange environment, and strange foods separately retarded the rate of weight increase following release. For instance, pen-reared birds (21 weeks old) forced to subsist entirely on wild foods lost seven times as much weight in five days time as those which were offered prepared foods in addition to wild foods. Furthermore, these studies showed that weight retardation, survival, and ultimate weight were parallel. In summarizing, Buss commented:

> "It is likely that all factors which influence pheasants physically prior to, during, and soon after release manifest their influence in one way or another on survival. Any pernicious physiological influence probably has a permanent effect. Propagation diets that do not allow pheasants to become accustomed to insect and plant foods may cause death to those birds released on a strange range before they learn to eat the new foods upon which they are forced to subsist."

The above hypothesis concerning diet, however, does not appear to be a suitable explanation for those deaths attributed to "liberation shock". For instance, it would theoretically apply only to the pen-reared birds. The second highest losses from this factor, five birds, occurred in the six weeks old open field-reared group which was accustomed to wild foods. Pheasant losses ranged from one to three in numbers in four out of the five groups of pen-reared birds which

were not accustomed to natural foods. Furthermore, most of these deaths occurred within a day or two after release. It seems unlikely that fasting alone could affect vital processes to an extent sufficient to cause death in this period of time. It is not meant to infer that nutritional deficiencies were not involved, however. Several possibilities to this effect could be presented. For instance, it was possible that the stresses of liberation might have caused the birds to abstain from eating, the effects of which, together with other pernicious influences, might have resulted in a lowering of vitality sufficient to cause death, particularly to birds of subnormal vitality.

There was no correlation between mortality from "liberation shock" and duration of transportation. In fact, the six weeks old incubator-hatched, electric-brooded, pen-reared group, which was only two hours enroute, had the highest losses, seven birds; and the six and eight weeks old hen-hatched, hen-brooded, field-reared (enclosure) groups, which were 12 hours enroute, had the lowest losses, one bird each.

Although such factors as those found by Buss probably caused debilitating effects upon the birds in this study, the ability to resist these effects, and later, to escape predators was undoubtedly dependent upon their physical condition. An outstanding example of this is the six weeks old incubator-hatched, electric-brooded, pen-reared group. It will be recalled that this group suffered an initial high loss from "liberation shock" and a subsequent high loss from predation, seven and six birds respectively. The high losses

from "liberation shock" indicated that many of these birds had acquired a poor physical condition either before or soon after release. That a large number of these birds were killed by predators out of the comparatively smaller number available after the initial losses from "liberation shock", is likewise significant. Whereas six of the 13 available birds in this group were killed by predators, only from zero to two of the 15 to 21 available birds in the other eight groups were killed. In order to evaluate the role of predation in the six weeks old incubator-hatched, electric-brooded, pen-reared group it would be well to examine its effects in relation to a fundamental principle which was concisely stated by Leopold (7, p.242):

> ".....depredations may clearly be a result of an exercise of hunting skill by the predator, and escape a result of the skill or fitness of the game."

According to the above principle, the birds in this group were selectively culled out by predators for one or both of two reasons, either because they were in poor physical condition, or because they were less wary of predators than the other groups of birds. Since there was no logical reason why the six weeks old incubator-hatched, electric-brooded, pen-reared birds should have been less wary than the other groups of pen-reared birds, all of which had comparatively low losses from predation, it seems most likely that the survivors of "liberation shock" in this group had some obscure physiological defect. The fact that predators continued to cull out these birds indicated that this defect was of a permanent nature and perhaps

conditioned by their age. Thus, it seems as though the majority of these birds were permanently impaired, "liberation shock" eliminating the weaker birds first, and predators being the ultimate executioners of many of the remainder.

The six weeks old hen-hatched, hen-brooded, open field-reared group, which also sustained high losses from "liberation shock", five birds, lost only one bird from predation. This would suggest that the birds which died following release were of subnormal vitality, and that the remainder were vigorous.

The fact that the six weeks old incubator-hatched, electric-brooded, pen-reared and hen-hatched, hen-brooded, open field-reared groups also had the lowest rates of survival, 15 per cent (3 birds) and 50 per cent (10 birds) respectively, tends to indicate that this age may, in some cases, be a limiting factor. This seems to have been particularly true of the six weeks old incubator-hatched, electric-brooded pen-reared group, for the eight and ten weeks old birds of the same class and from the same game farm had much higher rates of survival, 70 per cent (14 birds) and 65 per cent (13 birds) respectively. However, the fact that the six weeks old hen-hatched, hen-brooded, field-reared (enclosure) group had the highest rate of survival, 75 per cent (15 birds), and a better survival than the eight weeks old birds of the same class and origin, may mean that any defects resulting at six weeks of age can be nullified by proper method of rearing. That the six weeks old field-reared (enclosure) birds survived better than the six weeks old open field-reared birds

is rather perplexing. It may be recalled that the former group came from Oregon, and the latter, from Washington. Varying conditions at the respective game farms may have had their influences on the birds. It is also possible that the enclosure method of rearing was directly responsible for having produced birds of greater survival powers.

The observations and other supporting data also indicate some significant facts. Outstanding among these was the unusual behavior of the juvenile game farm birds, particularly in the days following their release on the island. These birds, tame, unable to fly well, and apparently bewildered in their new surroundings, were not preyed upon for approximately two weeks after being liberated, and were, in some instances, saved from circumstances in which they would have eventually died. After a rather long period of adjustment the birds tended to concentrate and did not disperse about the island. Although the behavior of the birds improved somewhat during the study, undesirable characteristics were obvious, and the fact that the majority of the survivors were live-trapped in October indicated that they had retained these traits after 70 days in a natural environment. It is noteworthy, that the remnant of these birds was difficult to harvest by hunting.

In order to determine the influence of behavior on survival, it is necessary to examine the nature of mortality from predation and the causes listed in the section "Losses From Other Factors". The deaths of the juvenile game farm birds listed in this section

were results of accidents and circumstances that normally would not occur among wary birds, and which did not occur among the wild birds. The effects of predation show a similar but more pronounced trend. According to Leopold (7, p.231), the annual mortality from predation in a given species of game on a given range depends upon the following variables:

> "1. The density of the game population."
>
> "2. The density of the predator population (1 and 2 determine the game:predator abundance ratio)."
>
> "3. The predilections of the predator, that is, his natural food preferences."
>
> "4. The physical condition of the game and the escape facilities available to them."
>
> "5. The abundance of 'buffers' or alternate foods of the predator (5 in comparison with 1 determines the relative abundance of various kind of prey)."

In examining mortality from predation in this study for indications of conformity to the above principles, the concentration of predation in the area of highest pheasant density comes to attention. This high density, however, was obviously the result of the failure of the juvenile game farm birds to disperse. As the observations indicated, most of these birds inhabited a small section of the island wherein they frequented the borders of the woods and the adjacent fields. Although some of the wild birds also sought coverts more remote from the woodland borders and did not tarry for long periods in the open fields as did the game farm birds. Under such circumstances the juvenile game farm birds were probably the more vulnerable to predators. This, together with the fact that the game

farm birds were less wary and the fact that some of these birds were in poor physical condition, was undoubtedly the reason why all of the juvenile birds that were killed by predators were of game farm origin. Whether the high pheasant density resulted in an above average number of predators or aggressiveness of a few predators, however, is a subject for controversy. It certainly cannot be assumed that the influx of predators in August was a consequence of the high pheasant density. This influx was in independent factor of migration. Nevertheless, it may reasonably be assumed that migrating predators, particularly Cooper's hawks which had a predilection for pheasants, may have been detained by the abundant supply of these birds and the ease with which they could be captured.

From the practical standpoint, it would be worthwhile to predict what effects predation might have on juvenile game farm birds in a mainland pheasant habitat, on the basis of results obtained on Eliza Island. Survival would, of course, depend upon the variables of circumstance. Although in most localities the birds would be exposed to both mammalian and avian predators, as well as the human elements of mortality, rodents and other mammals, in addition to song birds would be available as alternate species of prey to both types of predators. The alterative preying of these predators on small mammals would have a tendency to equalize the amount of predation on pheasants with that on Eliza Island where only hawks and owls and their usual prey, song birds, were involved. The effectiveness of mammals in relieving predation on pheasants would,

of course, depend upon their abundance, their habits, and the predilections of the predators.

If juvenile game farm birds with characteristics similar to those on Eliza Island tended to congregate in an unlimited habitat they would be expected to attract numbers of predators, in which case the birds might nearly be annihilated before learning to elude such enemies. Because of their vulnerability, predators might selectively decimate juvenile game farm birds even if "buffers" were abundant. In most cases there would not be the delay in predation witnessed on Eliza Island. If predators were abundant in the days following release when the birds were exceptionally vulnerable, a high initial mortality from predation would be expected. Midsummer releases of young pheasants when birds of prey are in low density may offer some measure of protection, however.

The studies of Harper, et al. in California likewise indicate that juvenile game farm birds are vulnerable to predation and other decimating factors (4, pp.167-172). In these studies, the hunting returns of six to ten weeks old birds released in July were almost three times as great for transplants of wild stock as for game farm birds. The authors stated that:

> "Younger birds (six to ten weeks old) were found flocked even after several weeks in the field. This increased the possibility of a single predator killing a large number. Releasing birds in small groups throughout the area to be stocked may reduce the possibility of large numbers of birds being killed while they are concentrated near releasing points."

The results of the present study tend to agree with those of the Summer Lake investigations in Oregon (11, p.72) in that there was no significant difference in survival between pen-reared and field-reared birds released at eight weeks of age. Neither was there any significant difference in survival between the eight weeks old pen-reared birds that were incubated and hatched by three conventional methods, nor the eight and ten weeks old pen-reared birds that were incubator-hatched and electrically brooded. When compared with the wild birds, the lower survival of the above groups (60 to 75 per cent) may be attributed to physical defects and abnormal behavior which resulted in losses from "liberation shock" and an above average mortality from predation.

According to Oregon State Game Commission statistics on seasonal mortality and bag returns,[2] artificially-reared juvenile pheasants surviving at the rate of 75 per cent, as one group did in this study, would result in a two-season bag return of 12 cocks costing approximately $12.77 per bird. This is still not as good an investment as spring liberations of mature hens or in-season liberations of mature cocks according to the Commission's figures.[3]

On the basis of Oregon State Game Commission production costs of $3.13 for each adult hen liberated in the spring and $1.66 for each juvenile game farm bird released in the summer (11, p.66), the 20 survivors (1 adult hen and 19 wild-reared juveniles) resulting

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2/ See Table 1 for Oregon State Game Commission figures concerning seasonal mortality and bag returns.

3/ See Table 1 for Oregon State Game Commission figures concerning liberations of adult cocks in the fall and adult hens in the spring.

from the five hens liberated on the island in the spring of 1951 were produced at the cost of $.78 per bird; whereas, the 15 survivors of the six weeks old hen-hatched, hen-brooded, field-reared (enclosure) group were produced at a cost of $2.21 per bird. Although these figures are derived from small units of pheasants, they tend to demonstrate the better returns that may be expected from liberations of mature hens in the spring.

SUMMARY AND CONCLUSIONS

1. This study was an attempt to determine the causes of mortality and the rate of summer survival of one group of wild-reared juvenile ring-necked pheasants and eight groups of artificially-reared juvenile ring-necked pheasants on Eliza Island, Washington in 1951. Each of the nine groups differed either in age composition or in method of rearing.

2. The ecological conditions on the island are generally similar to those in some of the pheasant habitats in western Oregon and Washington and the biological information gathered here concerning pheasants is considered to be applicable to such habitats.

3. Drought conditions prevailed on Eliza Island during the summer of 1951. Less than one inch of rain fell between the first day of June and the last day of August. During this period the average maximum daily temperature was 67.1 degrees Fahrenheit.

4. The eight groups of artificially-reared juvenile pheasants used in this study consisted of: (1) units of six and eight weeks old hen-hatched, hen-brooded, field-reared (enclosure) birds; (2) one unit of six weeks old hen-hatched, hen-brooded, open field-reared birds; (3) units of six, eight, and ten weeks old incubator-hatched, electric-brooded, pen-reared birds; (4) one unit of eight weeks old incubator-hatched, steam-brooded, pen-reared birds; and (5) one unit of eight weeks old hen-hatched, hen-brooded, pen-reared birds. Each of these units contained 20 birds of mixed sexes and originated either from an Oregon or a Washington State Game Commission game

farm. The wild-reared juvenile birds were raised on the island. They were the offspring of five adult hen pheasants and two adult cock pheasants that were liberated on the island on April 10, 1951.

5. The juvenile game farm birds were liberated by the same methods generally employed by Oregon and Washington Game Commission personnel in restocking pheasant habitat. The birds were handled, transported, and immediately released on the island on July 20, 1951.

6. The study began on July 20, 1951, when the juvenile game farm birds were released, and ended on October 1, 1951. Beginning on the latter date, the pheasants were removed from the island in order to determine survival. Methods used in obtaining information about the birds consisted of being in the field daily during most of the daylight hours, employing observation techniques that would result in the sought for information.

7. In attempts to determine the numbers of wild juvenile pheasants, 24 hatched eggs were found in the nests of three adult hen pheasants. One of the adult hens was killed by a predator before it could produce a brood. An additional hen was thought to have produced a brood of chicks. Approximately 20 wild juvenile birds were estimated to have been present at the beginning of the study.

8. Observations indicated that the wild-reared birds were exceptionally wary and utilized available cover to good advantage. These birds were seldom observed in the open fields beyond the chick stage. The juvenile game farm birds, however, were unusually tame and many remained about the site of release during the first ten days

following their liberation. The majority of these birds congregated on a small portion of the island between the first of August and the end of the study. Groups of as many as 50 juvenile game farm birds were frequently observed in this area.

9. An abundance of pheasant food existed on the island during the summer months. The birds subsisted mainly on barley and Himalaya berries. Sufficient water was obtained from succulent vegetation for the pheasants did not utilize the available fresh water on the island.

10. A total of 23, or 14.4 per cent of the juvenile game farm birds died within a week after being liberated. Most of these deaths occurred within a day or two after the birds had been released. Mortality of this type was attributed to "liberation shock". Although each group suffered losses from this factor, the numbers of birds lost in the different groups varied from one to seven. The six weeks old incubator-hatched, electric-brooded, pen-reared group and the six weeks old hen-hatched, hen-brooded, open field-reared group lost the most birds from "liberation shock", seven and five respectively. The number of birds lost in the other six groups ranged from one to three.

11. Predation was insignificant until early August when large numbers of migrating avian predators made their appearance. During August and September, 23 of the juvenile pheasants were killed by Cooper's hawks. Of these kills, 17 were juvenile game farm birds and six could not be identified as to origin. After having lost seven birds from "liberation shock", the six weeks old incubator-hatched, electric-brooded, pen-reared group suffered an unusually

high loss from predation. Six of the 13 available birds in this group were killed by predators. Although more birds were available in the other eight groups of juvenile birds (from 15 to 21), the number killed by predators was low, ranging from zero to two. Whereas six of the juvenile game farm groups were known to have lost at least two birds from predation, none of the wild-reared birds were known to be victims of predators. Predation on the pheasant population was mainly confined to the area where the juvenile game farm birds were heavily concentrated.

12. Harvest returns showed that 83 per cent of the 94 juvenile game farm survivors and only 47.9 per cent of the 19 wild juvenile survivors were live trapped. This suggested that the juvenile game farm birds had retained some of their undesirable traits after 70 days in the wild.

13. The average weights of the juvenile game farm survivors were similar to the average weights of a large number of wild-reared juvenile survivors in the 1948 study on Eliza Island. Of the two cocks that survived in the six weeks old incubator-hatched, electric-brooded, pen-reared group, one weighed five ounces less than any of the other 47 cocks weighed.

14. The juvenile game farm survivors consisted of 54 hens and 40 cocks. Of the 19 wild juvenile survivors, 14 were cocks and five were hens.

15. In comparing the numbers of survivors and mortalities recovered with the numbers liberated, 22 of the juvenile game farm birds could not be accounted for. However, 12 juvenile birds that

were killed by predators could not be identified as to proper group of origin. Most of these were probably game farm birds. The other 10 or more juvenile game farm birds that could not be accounted for were most likely mortalities overlooked in the observations.

16. The findings revealed that the wild-reared birds had the highest rate of survival, 90.5 per cent. Survival ranged from 60 to 75 per cent in the six and eight weeks old hen-hatched, hen-brooded, field-reared (enclosure) groups and the 4 eight and ten weeks old pen-reared groups. The differences in survival in these six groups were not significant. Only 50 per cent of the six weeks old hen-hatched, hen-brooded, open field-reared group survived. This group was known to have lost at least five birds from "liberation shock". The lowest survival rate, 15 per cent (3 birds), occurred in the six weeks old incubator-hatched, electric-brooded, pen-reared group.

17. Because of the unknown effects of "liberation shock" which resulted in differential mortality in the various classes of juvenile game farm birds and the inexplainable high losses from predators in the six weeks old incubator-hatched, electric-brooded, pen-reared group, the results of this study cannot be regarded as conclusive.

18. The high losses from "liberation shock" and predation in the six weeks old incubator-hatched, electric-brooded, pen-reared group tended to indicate that most of these birds were in poor physical condition. A similar though less pronounced trend was

shown by the six weeks old hen-hatched, hen-brooded open field-reared group which sustained comparatively high losses from "liberation shock" and accidents. The low survival of these two groups was tentatively attributed to their age. This seemed to have been especially true of the six weeks old incubator-hatched, electric-brooded, pen-reared group, for the eight and ten weeks old birds of the same class and origin had much higher rates of survival, 70 and 65 per cent respectively. The 75 per cent survival of the six weeks old hen-hatched, hen-brooded, field-reared (enclosure) group tended to indicate that the limiting factor of age in six weeks old birds can be nullified by proper method of rearing.

19. On the basis of Oregon State Game Commission production costs ($3.13 for each adult hen liberated in the spring and $1.66 for each juvenile game farm bird liberated in the summer), the 20 survivors (1 adult hen and 19 wild-reared juveniles) resulting from the five hens liberated on the island in the spring of 1951 were produced at a cost of $.78 per bird; whereas, the highest surviving juvenile game farm group resulted in 15 survivors at a cost of $2.21 per bird. These figures indicated that the mature hens released in the spring were a much better investment than any of the groups of juvenile game farm birds that were liberated in July.

BIBLIOGRAPHY

1. Bump, Gardiner, et al. The ruffed grouse-life history, propagation, management. Buffalo, Holling press, Inc., 1947. 915p.

2. Buss, Irven O. Wisconsin pheasant populations. Madison, Wisconsin conservation department, 1946. 184p.

3. Hansen, Charles G. A ring-necked pheasant nesting and survival study on Eliza Island, Washington (unpublished manuscript). Corvallis, Oregon cooperative wildlife research unit, 1950.

4. Harper, Harold T., et al. Effects of hunting pressure and game farm stocking on pheasant populations in the Sacramento Valley, California. California fish and game 37:141-176. April, 1951.

5. Hoffman, Russel R. A pheasant nesting study with controlled predation on Eliza Island, Washington. Master's thesis. Corvallis, Oregon state college, 1949. 75 numb. leaves.

6. Jepson, Willis L. A manual of the flowering plants of California. Berkeley, University of California, 1925. 1238p.

7. Leopold, Aldo. Game management. New York, Scribner's, 1948. 481p.

8. McAtee, W. L. The ring-necked pheasant and its management in North America. Washington, D. C., American wildlife institute, 1945. 320p.

9. Salter, Linwood R. Survival and increment of an early spring release of ring-necked pheasants on Eliza Island, Washington. Master's thesis. Corvallis, Oregon state college, 1948. 74 numb. leaves.

10. Scott, Robert F. Results of a ring-necked pheasant liberation on Eliza Island, Washington. Master's thesis. Corvallis, Oregon state college, 1947. 93 numb. leaves.

11. _____ Annual report game division-Oregon state game commission. Portland, Oregon state game commission, 1951.

A P P E N D I X

List of Plants Referred to in the Text

Bracken fern	*Pteridium aquilinum pubescens* Underwood
Common horsetail	*Equisetum arvense* Linnaeus
Douglas fir	*Pseudotsuga taxifolia* Linnaeus
Cattail	*Typha latifolia* Linnaeus
Canary grass	*Phalaris arundinacea* Linnaeus
Redtop	*Agrostis alba* Linnaeus
Orchard grass	*Dactylis glomerata* Linnaeus
Annual bluegrass	*Poa annua* Linnaeus
Kentucky bluegrass	*Poa pratensis* Linnaeus
Saltgrass	*Distichlis spicata* (Linnaeus) Greene
Downy bromegrass	*Bromus tectorum* Linnaeus
Italian ryegrass	*Lolium multiflorum* Lam.
Cultivated barley	*Hordeum vulgare* Linnaeus
American bulrush	*Scirpus validus* Vahl
Three-square bulrush . . .	*Scirpus americanus* Pers.
Slough sedge	*Carex obnupta* Bailey
Wire-rush	*Juncus balticus* Willdenow
Great camass	*Camassia leichtlinii* (Baker) Watson
Willow	*Salix* sp. Linnaeus
Red alder	*Alnus rubra* Bongard
Nettle	*Urtica lyallii* Watson
Red sorrel	*Rumex acetosella* Linnaeus

List of Plants Referred to in the Text

Wild buckwheat	*Polygonum convolvulus* Linnaeus
Goosegrass	*Salicornia ambigua* Michx.
Chickweed	*Cerastium arvense* Linnaeus
Red-flowering currant . .	*Ribes sanguineum* Pursh
Ocean spray	*Holodiscus discolor* Maxim.
Thimbleberry	*Rubus parviflorus* Nuttall
Himalaya berry	*Rubus thrysanthus* Focke
Wild blackberry	*Rubus vitifolius* (Constance and Rollins)
Western serviceberry . . .	*Amelanchier alnifolia* Nuttall
Wild cherry.	*Prunus emarginata* (Doug.) Walp.
Red clover	*Trifolium pratense* Linnaeus
Alfalfa	*Medicago sativa* Linnaeus
Hairy vetch	*Vicia villosa* Linnaeus
American vetch	*Vicia americana* Muhl.
Giant vetch	*Vicia gigantea* Hook.
Beach pea	*Lathyrus maritimus* (Linnaeus) Bigelow
Marsh pea	*Lathyrus palustris* Linnaeus
Dovefoot geranium	*Geranium molle* Linnaeus
Bigleaf maple	*Acer macrophyllum* Pursh
Vine maple	*Acer circinatum* Pursh
Buffalo berry	*Shepherdia canadensis* Nuttall
Fireweed	*Epilobium angustifolium* Linnaeus

List of Plants Referred to in the Text

Salal	Gaultheria shallon Pursh
Starflower	Trientalis latifolia Hook.
Bedstraw	Galium aparine Linnaeus
Prickly lettuce	Lactuca scariola Linnaeus
Common thistle	Cirsium lanceolatum (Linnaeus) Scop.