A STUDY OF FACTORS AFFECTING REPRODUCTION AND SURVIVAL OF THE RING-NECKED PHEASANT IN THE LOWER FRASER RIVER VALLEY OF BRITISH COLUMBIA

by

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This study of the ring-necked pheasant was made on the agricultural land of the Municipality of Delta in the southwestern portion of British Columbia. It was based primarily on data collected during the months of May to September in the years 1948 and 1949. Additional information obtained in the fall hunting and winter seasons of these years is also considered.

An examination of spring breeding behavior and environmental factors affecting the reproduction of the local pheasant population was made. Nest desertion comprised 54.2 and hay field mowing 36.3 per cent. of the total loss of field nests. Known predation losses were low in both years. Over 80 per cent. of the hens observed in August were accompanied by broods indicating some compensation of early nest loss had occurred through renesting.

Brood loss was greatest among chicks of from one to three weeks of age. Mowing was the major known cause of juvenile mortality.

Farm-reared pheasants were released on the area and factors influencing their survival were noted. Predation contributed greatest to the known mortality of this group.

An analysis of hunting success showed the 1949 fall harvest to be much below that of 1948. Midsummer brood loss was believed responsible for this decrease which was also revealed as a decline in the proportion of young wild cocks in the total bag for 1949. The survival of released male pheasants as indicated by hunting recovery was also low in this year dropping from 38.8 per cent. (1948) to 22.2 per cent. (1949).

In both years the fall pheasant population density and the number of cocks harvested in terms of acres per bird compared favourably with that found in other investigations.

Suggestions for further study and recommendations for management are also submitted.

--E. W. Taylor.

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A STUDY OF FACTORS AFFECTING REPRODUCTION AND SURVIVAL OF THE RING-NECKED PHEASANT IN THE LOWER FRASER RIVER VALLEY OF BRITISH COLUMBIA

This study, sponsored jointly by the University of British Columbia and the British Columbia Provincial Game Commission, was begun in the spring of 1948. Investigation was confined to the Municipality of Delta, an area of intense agricultural development in the extreme southwest corner of the Province of British Columbia. Much of the material was gathered generally throughout this region but that concerning pheasant reproduction was obtained primarily from field studies in the western half of the Municipality.

Work was first begun on May 6, 1948, and continued throughout the spring and summer until September 15 of that year. Limited observations were carried out during the following winter and field work was resumed intensively on May 1, 1949, and maintained until September 12, 1949. An analysis of hunter-success for the open seasons on pheasants was also made during both years, 1948 and 1949, and the pertinence of the results is also considered in this paper.

The objectives pursued during the investigation were: (1) A general appraisal of the pheasant habits and environment in the Delta area, (2) an examination of the reproductive cycle of pheasants in the wild state, (3) the determination of factors affecting reproduction, (4) the determination of factors influencing the survival of both wild and released farm-raised birds.

The pursuance of this investigation was made possible by the interest and co-operation of the British Columbia Provincial Game Commission and the

University of British Columbia. All research was conducted under the guidance of Dr. I. McT. Cowan, Department of Zoology of the above university, to whom I am much indebted for advice and criticism which improved and extended the quality and scope of the study. To Dr. W. A. Clemens, head of the Department of Zoology, my thanks for much assistance so generously given. Appreciation is also extended to Mr. James Hatter, of the same department, for his suggestions and aid in obtaining information on many phases of the work considered herein.

Data pertaining to the winter period of the pheasant study were augmented by population studies made by Mr. W. A. Benson. During the month of May, 1949, the assistance of Mr. L. G. Sugden added immeasurably to the collection of material on the spring pheasant numbers and activities. To the above gentlemen and the many others who, as students in Wildlife Management at the University of British Columbia, gave so generously of their time and assistance during the hunting seasons, I extend my sincere thanks.

The co-operation of many members of the British Columbia Provincial Game Department in connection with the liberation and recovery of banded pheasants is acknowledged with pleasure. Information on early pheasant broods, nesting, and numerous other data contributed by Game Warden W. H. Cameron, Ladner, B. C., were indeed most welcome.

The assistance given by the many farmers on whose land the field work was conducted added much to the success of all phases of the investigation. The co-operation of both resident and non-resident hunters in obtaining data on hunting conditions and allied subjects was much appreciated.

Advice and instruction on techniques employed in duplicating the graphs and figures contained in the text was kindly given by Mr. W. H. Cottle, a student in the Department of Zoology at the University of British

Columbia.

To my wife, for her patience, understanding, and active participation in the field work and the preparation of the manuscript, I am most grateful.

HISTORICAL

The ring-necked pheasant of British Columbia is a bird which has undergone considerable hybridization since its first introduction. The first imported stock to be successfully established was of the Chinese strain (P. torquatus) and was liberated in the vicinity of Esquimalt, B. C., in the year 1883. Further importations of the same species were made for liberations on Salt Spring Island in 1886, and Prevost Island in 1890. A small introduction of the green pheasant (P. versicolor) was made on Jedidiah Island in 1895.

The first pheasants established on the Lower Mainland were also of the Chinese variety (P. c. torquatus) and were planted on the Fraser River lowlands a few miles south of Vancouver in the year 1890. The following year, 1891, twenty-two P. c. torquatus formed the initial release for the Delta area. The first release of Mongolian stock (P. c. mongolicus) was not made on the mainland until 1908. All pheasant introductions until that time had been made largely through the interest and efforts of a small number of private individuals and a few organized sportsmen. It was not until 1909 that the propagation of pheasants for stocking purposes was taken over by the British Columbia Provincial Game Department. This organization reared many birds each year from the aforementioned Mongolian and Chinese pheasant strains and also a few from a melanistic mutant stock. However, the game-bird farm as a Provincial enterprise was abandoned in the early 1930's and was replaced by the efforts of the private pheasant

game-farmers. In recent years some of the latter have introduced into their breeding stock the Formosan (P. t. formosanus), a sub-species of the Chinese pheasant (P. ~~torquatus~~ colchicus). Hence they have indirectly added further to the complex ancestry of the pheasant in this region.

As mentioned previously, the pheasant was first brought into the Delta Municipality in 1891. In subsequent years more birds were liberated to augment the established population. In fact, annual liberations of varying numbers have been made since 1934.

DESCRIPTION OF THE AREA

The Municipality of Delta comprises an area of approximately sixty-five square miles situated in the extreme southwest corner of British Columbia (Map, page 5). It is bounded on the north by the south arm of the Fraser River, and on the south by the tidal flats of Boundary Bay and the wooded bluffs of Point Roberts. The Scott Road, running north and south along a second highland area, forms the eastern limit of the Municipality; the dyked embankments fronting the shoal waters of Roberts Bank mark the western boundary. To the northwest, and divided from the Delta proper by Canoe Pass, lies Westham Island, an area similar in nature to the adjacent mainland country.

TOPOGRAPHY

Throughout most of the Municipality the land is uniformly flat and low (Figure 1). With the exception of the upland slopes, elevation is below freshet level in the east and below freshet and high tide level in the west. The two highland regions which fringe the east and southwest borders rise abruptly to 350 feet and 200 feet respectively, and are covered with a mixed deciduous and coniferous growth.

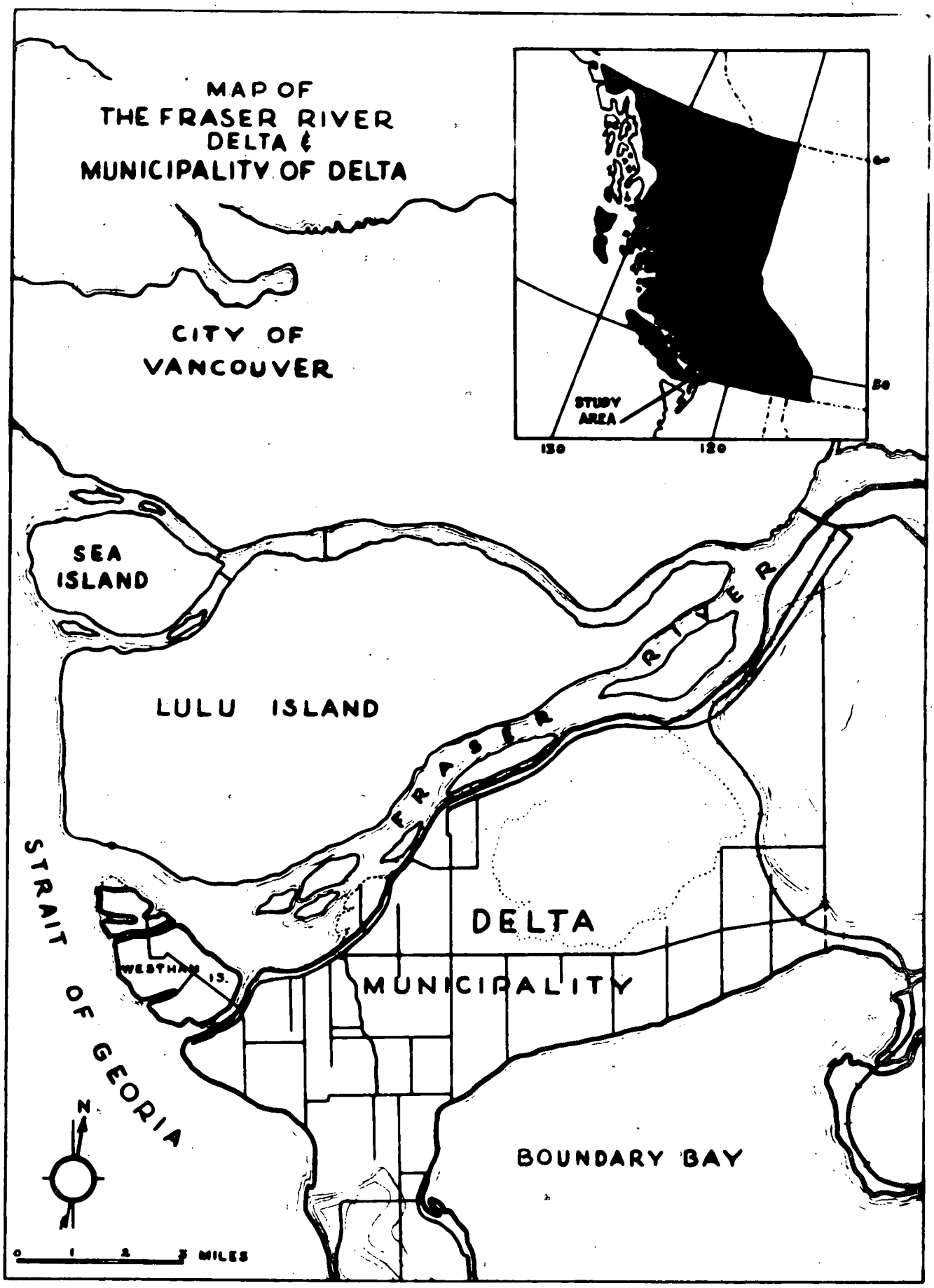

MAP OF
THE FRASER RIVER
DELTA &
MUNICIPALITY OF DELTA
CITY OF
VANCOUVER
STUDY
AREA
130
120
SEA
ISLAND
LULU ISLAND
FRASER RIVER
DELTA
MUNICIPALITY
WESTHAM IS.
STRAIT OF GEORIA
BOUNDARY BAY
N
0 1 2 3 MILES

Fig. 1 — View of the West Delta study area from the southwest highland. May, 1949.

From east to west across the entire length of the Delta runs a primary highway, the Ladner Trunk Road. Boundary Bay Road, a similar hard-surfaced traffic-way, passes north and south through the widest portion of the western municipality. Other hard-surfaced roads extend varying distances north and south from the Trunk Road. Several secondary roads of gravel-top run in a disjointed fashion parallel to the main arterial roads.

Except for a large centrally located peat bog, the land is for the most part under cultivation. Drainage ditches lie on both sides of most roads, and in many sections cut through the centers and boundaries of cultivated fields. Apart from the smaller of these ditches, most carry some water even during the summer months.

About the water-fronted perimeter of the Delta runs a protecting dyke of varying width and height. This dyke is covered in places with vegetation which ranges from mixed weeds and pasture grasses to thick hedges

of rosebush (Rosa nuttalli), blackberries (Rubus sp.), hardhack (Spirea douglasi), willow (Salix spp.), and many other smaller plants. Large trees are not generally abundant but do occur singly and in small groves. Poplar (Populus trichocarpa), alder (Alnus rubra), and occasionally spruce (Picea sitchensis), are the species most commonly found in this region.

CLIMATE

The climate of the Delta district is characteristically temperate and, on the whole, shows little extreme in any season. Data collected by the Meteorological Station at Sea Island, B. C., which is approximately seven miles northwest from the village of Ladner, may be applied to the Delta area generally. The average annual temperature as found over a period of twelve years at the Sea Island station is 48° Fahrenheit. Average monthly mean temperatures for the same period show a low of 37° F. in January, and a high of 63° F. in July. Average annual precipitation is given as 39.58 inches, the heaviest rainfall averaging 6.39 inches in December. August represents the dry period of the year with an average precipitation of 1.10 inches for the month.

SOIL

The soil type of the more intensively cultivated lowland areas of the Delta Municipality is predominantly that classified by Kelley and Spilsbury (1939) as Ladner Clay of the Ladner Series, an alluvial soil recently deposited by the Fraser River. Profile development is not apparent. A heavy, granular, grey-brown to black clay is typical throughout most of the region. Where adequate drainage has been employed, this soil compares with the most productive types of the Lower Fraser Valley. There are some indications, however, that throughout the Ladner Series there exists a lower calcium and phosphate content than is found in the soils of adjacent areas.

Within the northeast section of the Municipality lies a peat bog of approximately 4,700 acres much of which has been reclaimed for agricultural purposes. The surface of the cultivated outer fringe is reddish brown to dark brown and is generally of fibrous organic material.

The upland regions of the northeast and southwest Delta are relatively small in extent. The soil in both sections is Alderwood Sandy Loam, a type which, because of moisture relationships, is considered marginal for general farming.

LAND USE

Apart from the peat bog, an area with a ground cover of heavy moss supporting dense growths of Labrador tea (Ledum groenlandicum), blueberries (Vaccinium sp.), jack pine (Pinus contorta), and birch (Betula papyrifera), the greater part of the Delta is intensively cultivated. The distribution of land to agriculture given for the Delta Municipality in the Eighth Census of Canada, 1941, shows some of the crop types and their relative importance. Of the total area considered by the census (36,416 acres) field crops constituted 15,630 acres; market gardens, 929 acres; orchard and vineyard, 18 acres; small fruits, 139 acres; fallow land, 271 acres; pasture, 7,110 acres; other, 866 acres. Woodland comprised 761 acres; prairie or natural pasture, 3,816 acres; marsh or wasteland, 6,876 acres.

The preceding allocation has been subject to some changes since the last census, but on the whole it typifies fairly well the land use of the last few years. Through crop rotations there are annual changes of varying degree in the total acreage given to any one crop. The change in the relative abundance of major crops between 1948 and 1949 as indicated by a sample involving approximately 1,550 acres is given in Table I.

TABLE I — Changes in major crop acreages 1948 - 1949, based on a survey of approximately 1,550 acres.

Crop type	Acreage 1948	Acreage 1949	Percent. change Increase	Percent. change Decrease
Grain	331	375	13.2	
Hay	450	477	6.0	
Pasture	288	306	6.2	
Potatoes	119	123	3.3	
Peas	369	249		32.5

Red clover (Trifolium pratense), grown both for hay and for seed, is one of the major crops of this region. Other hay species, red-top (Agrostis sp.), timothy (Phleum pratense), and velvet grass (Holcus lanatus) are raised, for the most part, in mixed stands. Sugar beets (Beta sp.) comprise a crop comparatively new to this area and the seed obtained constitutes a product of considerable local importance.

Grain is also present in substantial quantity and is represented in approximate order of abundance by oats, fall rye, wheat and barley. Corn is grown in relatively small amount, primarily as fodder for dairy cattle.

Field peas have been grown extensively throughout the West Delta for the past few years and in 1948 ranked second to red clover as a summer crop. However, the failure of one of the local canning companies in the early part of 1949 resulted in the total pea acreage being reduced by about one-third. The greater part of the land left open by this crop reduction was given to the production of grain as is shown in Table I. Hay, pasture, and potatoes also increased to some extent as did corn and sugar beets to a lesser degree. Much of the acreage put into peas is at the same time seeded to red clover which thus provides an early hay crop for the following spring. This practice of seeding clover is also used to some extent with grain crops such as oats and fall rye.

Potatoes are a major agricultural product of the district and are one of the few root crops grown to any extent. Turnips and cabbage are relatively scarce, and are found more in the truck-gardens about farm residences.

Small holdings about Ladner village and in the Delta Manor subdivision produce, in addition to quantities of mixed vegetables, such small fruits as raspberries, strawberries, loganberries, and red currants.

Dairying is important throughout the entire Municipality and much of the land area is devoted to grazing and pasture fields.

FOOD AND COVER

Throughout the year food seems to be plentiful in the cultivated regions which occupy the greatest portion of the total land area. Field crops of clover, grain, peas, and mixed vegetables are abundant. Small fruits and a large variety of weed seeds are also available. In this last group wild buckwheat (Polygonum convolvulus) and lady's thumb (Polygonum persicaria), which from previous study seem highly preferred by pheasants as food, are present in considerable quantity and are widely distributed.

Cover may be divided in its distribution into three classes: That afforded by the peat bog, that of the upland slopes, and that of the vegetation of the agricultural and marshland areas. The bog with its dense hardhack fringe provides a large central refuge for pheasants during the hunting season and seems also to be well occupied by cocks during the spring. Utilization of this cover appears to be extended only to the peripheries where food is more readily attainable.

The upland area is characterized by a large wooded growth of mixed deciduous-coniferous associations principally of red alder (Alnus rubra), maple (Acer macrophyllum and A. circinatum), red cedar (Thuja plicata), Douglas fir (Pseudotsuga taxifolia), hemlock (Tsuga heterophylla), spruce

(Picea sitchensis), and willow (Salix spp.). Salal (Gaultheria shallon), Oregon grape (Berberis nervosa), huckleberry (Vaccinium parvifolium), and wild blackberry (Rubus ursinus), are the principals of the low shrub and plant vegetation. These regions of denser cover may also find favor as a pheasant refuge during hunting season but from observation it was found that few birds frequented this habitat during the spring and summer months.

Since the bulk of the pheasant population in the Delta is distributed over land devoted to agriculture, cover conditions are modified, generally, by local farming practices. Pasture land in large scattered acreages affords little or no protective cover, except where it may occasionally adjoin denser field crops or is bounded by bushy hedges (Fig. 2). Clover and hay fields are plentiful and are apparently most attractive as sites during the breeding season.

Fig. 2 — Wild hay pasture with fencerow and brushy hedge boundaries. Tilled field in foreground. May, 1949.

Hedge and fence row cover is spotty, and ranges from the denuded state typical of "clean" cultivation (Fig. 3) to heavy hedges of hardhack, rose-bush, and blackberry.

Fig. 3 — Reduced fencerow cover as a result of "clean" cultivation. May, 1949.

FAUNA

Among the faunal species of the area were several which might be considered important in their relation to the pheasant population both as possible predators and competitors. Mammals present included several species of mice of which Microtus townsendi seemed to be most abundant, weasel (Mustela e. fallenda), muskrat (Ondatra zibethica), and red fox (Vulpes fulva). Avian species were represented by marsh hawks (Circus cyaneus), short-eared marsh owls (Asio flammeus), red-tailed hawks (Buteo jomaicensis), sharp-shinned hawks (Accipiter velox), Brewer's blackbird (Euphagus cyanocephalus), red-winged blackbird (Agelaius phoeniceus), crows (Corvus brachyrhynchos), meadowlarks (Sturnella neglecta), robins (Planesticus

migratorius), killdeer plover (Oxyechus vociferus), California quail (Lophortyx californica), and Hungarian partridge (Perdix perdix).

METHODS OF STUDY

Winter observations were made on several weekends by automobile and on foot. During the spring and summer from May 1 to September 15 the observer was resident in the study area and covered the territory by bicycle and on foot.

Random selection of certain sections within the Municipality was made during 1948 in the study of nesting and cock crowing territories. These areas, where possible, were also examined during the corresponding period of 1949.

Cock crowing territories were counted and mapped over the same sections during the breeding season of both 1948 and 1949. In the latter year in addition to the plotting of cock territories, the two-minute crowing-count as described by Kimball (1949) was also employed for a time as a means of estimating cock density. Counts were made from dawn throughout the period of greatest crowing activity which usually ended about 7:30 a.m. Sex ratio counts were also taken during that time and again during the evening.

During 1949 an attempt was made to obtain a relative density of the spring pheasant population in terms of birds per acre present on the area. Seven quadrats, each one-quarter of a mile by one mile in size, were set up at random in the manner described by Einarsen (1945). The possibility of damage to growing crops which might be caused by traversing these quadrats later in the season caused the abandonment of the method early in the study. Data obtained were not considered sufficient to form a basis of density estimates and are omitted in this paper.

Hedges, fence rows, and fields were searched for "live" nests during the nesting season. After haying operations, fields were again searched for damaged nests. In recording nesting data groups of two or more eggs were considered as nests. Single eggs were classed as "dropped" and entered separately when no further nesting progress was noted on subsequent visits. "Live" nests, when found, were noted as to location, construction, number of eggs, and surrounding cover. Visits were made periodically to observe progress and the ultimate fate of the nest.

Nests uncovered by mowing activities were given a field location by determining their distance from two field boundaries. Where possible the stage of clutch development was estimated and the eggs classified as unincubated, incubating, or hatched. The crop or cover type, acreage, and the mowing dates for each field examined were also noted.

On some occasions it was possible to follow the mowers or swathers and to observe the injury and mortality suffered by hens, broods, and nests. Data on such mortality were also obtained to some extent by the evidence of carcasses still remaining in fields which had been recently cropped.

Brood data collected during the hatching period included brood size and approximate age of chicks. This information was augmented by daily brood counts throughout the summer. Age determination of broods seen in the field was estimated by comparing their development with that of juveniles of early known hatching dates resident in certain localities. Collection of these data was discontinued about September 1 as the disintegration of the family groups and the subsequent formation of flocks made accurate counts difficult to obtain.

Throughout the summer months releases of banded birds were made at various points in the Delta. Attempts were made to visit the release sites

at intervals during the first two or three weeks after each liberation to observe the adaptation of the birds to their new environment. Search was made about the release sites for banded birds that might have been injured or killed during, or shortly after, liberation.

Farmers, met in the course of field work, were queried for their views on the economic relationship of pheasants to agriculture. Sample areas of field crops (potatoes) were checked for pheasant damage to weigh the validity of the statements of some farmers concerning the depredation of this crop.

On the weekends of the first half of the hunting seasons of 1948 and 1949 road checks were maintained at four different exits from the area. Transient hunters were queried to determine their hunting success in the field and to examine the birds they had obtained. Resident hunters were canvassed and contacted by mail so that more complete information would be available for use in estimating the total hunting pressure and kill.

WINTER POPULATIONS

The data collected on the winter population of pheasants in the study area lack much of the quantitative nature of that acquired during the more intense investigations of the spring and summer period.

Sex ratios taken throughout November and December, 1948, and January, 1949, showed a population with a relatively large number of hens. This might be expected following the fall harvest of cock birds during the hunting season. It was found, however, that this disparity in sexes was generally more apparent than real.

In the open, cultivated areas, bands of hens numbering from two to fifty-five birds were seen frequently during roadside cruises while cocks were only occasionally in evidence. A search of the more heavily vege-

tated sections along some parts of the peat bog and in orchards disclosed mixed bands of both hens and cocks. In many of these groups the sex ratio was one cock to two hens. From these observations the fallacy of assuming the sex ratios obtained in the more open country as representative of the wintering birds became obvious.

Distribution of birds during this time was also difficult to assess with accuracy. The possibility of a voluntary migration of male pheasants to denser cover was obscured to some degree by the utilization of this escape habitat during the hunting season. Hens, too, were numerous in these brushy refuges but many large bands of females were also seen at this time about the nesting grounds of the previous spring. From this it might be inferred that there is no marked shifting of the female pheasant population in this area to a specific winter range.

The concentration of birds generally throughout the entire agricultural section of the Delta appeared, insofar as location was concerned, to remain fairly constant. The central and western regions which afforded better cover seemed at all seasons to have a greater population density than the more poorly covered areas of the eastern section.

The winter of 1948-49 was for the whole area one of the most severe for several years. Snow and rainfall in the latter part of November flooded many acres of fields to depths of from two to twelve inches. Several later snowfalls occurred throughout early and mid-December and accompanied by a generally lowered temperature, kept the ground surface covered with a layer of from two to five inches of lightly crusted snow. With the milder weather of late December the snow disappeared rapidly and the ground remained clear until early February when more heavy snowfalls occurred. It was not until February 26 that the last snow had disappeared from the Delta

region. However, at no time throughout the winter was there any apparent evidence of mortality due to these severe seasonal conditions. Food was abundant and the snow was never deep enough nor frozen sufficiently to render much difficulty to pheasants feeding.

SPRING POPULATIONS

By the time field work was begun on May 1, the break-up of winter bands of both cocks and hens had occurred. This dispersal, which marked the onset of the breeding season, was accompanied by an apparent increase in the number of cock birds seen compared with the number noted during the winter months. This was reflected in the sex ratio which had declined from the winter proportion of 17.6 hens per cock in December, 1948, to 4.3 hens per cock by May 31, 1949. The latter ratio was down from that of 5.4 hens per cock for the corresponding period of 1948.

Dispersal—The winter concentrations of hens did not exhibit marked tendencies to shift as a population to special nesting localities with the arrival of the spring breeding season. In most cases the disintegration of pheasant bands at this time resulted merely in their widespread and more even distribution over the local areas on which they had wintered. Nor was this dissociation of female groups complete throughout the season as groups of from two to ten hens were often seen feeding or resting together in the early morning or during the late afternoon. As stated by Baskett (1947) females probably are solitary only while incubating.

With the exception of many cock birds and some hens which frequented the marsh and bog regions, pheasant winter and breeding range in this area were practically synonymous. Male pheasants probably evidenced more clearly the change of habitat in response to physiological and environmental conditions of the season.

Cock crowing and territories--The more active manifestations of the initiation of the pheasant breeding season are revealed by the crowings of cocks as they begin territory establishment. In 1948 this phenomenon was believed to have occurred on the Delta coincident with that occurring on nearby Lulu Island. Crowing in the latter region was first heard on February 28. Indications were for an earlier breeding season in 1949 by reports of crowing heard on the Delta on January 23 of that year. However, this date is believed to be unusually early as intensive calling was not common until about March 7. The seasonal length of crowing activity was marked by persistent calling until the first week of June, after which time a noticeable decline ensued concurrent with the breaking up of cock territories. Sporadic outbursts of crowing continued with diminishing frequency until mid-July.

Two daily periods were noted in which cock crowing was most frequent. One commenced at dawn and lasted from one to two hours. The other, of similar duration but of less intensity, occurred in the late afternoon or evening. These periods seemed well defined on fine, sunny days, but were considerably modified by adverse weather conditions.

In regions of denser cover, crowing was noted to prevail for much longer periods and to be confined apparently to more specific locations than was the case in the open, farmland regions. In the latter areas cocks were usually quite conspicuous and calls were given almost exclusively from the ground in both plowed and vegetated fields with no apparent preference for any specific crowing point. On only two occasions were cocks seen to call from noticeably elevated positions; once from the top of a fencepost and once from the top of a pile of crates located in the center of a large potato field. As noted by Baskett (1947) crowings rarely originated more

than once from exactly the same location. However, there was such a consistency of calling about certain areas as to proclaim them quite definitely as cock territories.

The spring dispersion of cocks tended to radiate from areas of dense cover outwards into the more open cultivated lands which became the nesting grounds of the already established hens. From this it would appear that cock territory establishment depends largely on whether or not hens were present in the vicinity at the time of harem formation.

Crowing areas were maintained with marked persistence throughout the entire pheasant range. During the breeding season cocks were seen and heard constantly about the same location. The vigor with which these territories were maintained did not appear to be constant. It is possible that they are more actively defended during the earlier stages of mating but by the end of May, though crowing was relatively frequent, there seemed to be occasional instances of indifference by one cock to the intrusion of another.

The size of cock territories varied considerably on the Delta and appeared to be influenced by individual tolerance and the distribution of cover. Adherence to territory appeared to be greatest in the brushy, wooded areas, especially about Burns' Bog and Ladner Marsh. The actual limits of territorial areas were difficult to ascertain and the range of cocks from their usual crowing points were not easily defined. It was not uncommon to see two cocks, each accompanied by harems, feeding and crowing in apparent amity within the same ten-acre field. On other occasions the appearance of one cock in such proximity to another resulted in fighting and eventual routing from the area of one of the contestants.

Territory size seemed greatest in the more open cultivated sections

TABLE II — Cock pheasant density, May 1948 & 1949. Based on counts of crowing territories.

Plot	Plot size (in acres)	Number of cock territories		Average territory size (in acres)		Cocks per square mile	
		1948	1949	1948	1949	1948	1949
A	900	18	24	50.0	37.5	12.8	17.0
B	450	16	15	28.1	30.0	22.7	21.3
C	1030	24	25	42.9	41.2	14.9	15.5
D	1070	22	*	48.6	*	14.1	*
E	220	7	6	31.4	36.6	20.3	17.4
F	390	9	5	43.3	78.0	14.7	8.2
G	530	8	7	66.2	75.7	9.6	8.4
H	730	10	13	73.0	56.1	8.7	11.3
K	960	11	16	87.2	60.0	7.3	10.6
M	600	9	18	66.6	33.3	9.6	19.2
N	525	9	9	58.2	58.2	10.9	10.9
P	415	11	11	37.7	37.7	16.9	16.9
R	820	13	19	63.0	43.1	10.1	14.8
Total	8640	167	168	51.7	45.0	12.3	14.2

*Plot D not censused in 1949. Cock density calculated on the remaining 7,570 acres comparable for both years, 1948 and 1949.

and least in localities which provided more abundant cover. This is illustrated by examining the data in Table II from which the mean size of cock territories may be derived for the various plots. Average size on plots B and P, both containing much farm land with good interspersion and quality of cover, and plot E, with excellent wood and brush growth in a partly cultivated marsh region, were 28.1, 37.7, and 31.4 acres respectively in 1948 as compared with the mean of 51.7 acres for all plots. During 1949 mean

territory size dropped to 45.0 acres and plots B, P, and E averaged 30.0, 37.7, and 36.6 acres respectively, still well below the mean size for the open sections.

Repeated counts of crowing cocks on randomly selected tracts in the West Delta district during the spring of 1948 were made in an attempt to estimate the breeding population. All but one of these areas were censused again the following spring. From the results obtained during both years it was possible to determine the change in relative cock density from one breeding season to the next. Table II shows comparative data taken from the sample areas. It will be noted that plot D is not included in the acreage covered in 1949 and the consideration of change in cock density during corresponding periods is based on the results obtained in both years from the same 7,570 acres.

Marked variation in cock numbers from 1948 to 1949 was noticeable on half of the plots examined, the remainder showed little or no change. Alteration of habitat in three localities is believed to have caused some movement of cocks to adjacent undisturbed areas. Farm-reared adult birds released in the spring may also have contributed to the apparent increases of cock numbers in 1949 on some plots. However, change in the density of male birds per square mile from 12.3 in 1948 to 14.2 in 1949 seemed attributable to a natural increase which occurred regardless of spring released cocks. This was corroborated by the fact that the populations of crowing cocks appeared greater in other regions which were not subjected to habitat change nor supplemented by spring stocking. The improved numerical status of the male pheasant population during the 1949 breeding season may be attributed in part to a more favourable carry-over than was experienced in the preceding year. The fall hunting season for 1948 was reduced to

three weeks, one week less than is customary for the area. Reduced hunting pressure through curtailment of the length of the open season may have resulted in more cock birds surviving to increase the spring numbers.

Cock crowing census—To augment the data collected in connection with counts of crowing territories during 1949, the crowing census technique described by Kimball (1949) was also used for a short period. Although the quantitative results of the two-minute crowing counts may as yet be interpreted only as comparative indices, it was thought that they might show some correlation with trends indicated by territory counts. Accordingly, two census routes were run through portions of the Delta believed to be representative of the population and environment of the area generally. For six mornings, between May 4 and May 17, 1949, cock calls per two minutes were noted at mile intervals along the fourteen miles of road travelled. From the data gathered it was intended to determine cock density and distribution. To obtain an appreciation of the daily trend in crowing, observations were made on four mornings at four different locations throughout the period of greatest vocal activity. A summation of the results obtained by the Kimball method showed no significant correlation with those of the counts of crowing territories. This does not reflect on the merits of the crowing census when consideration is given to the fact that the study was not begun sufficiently early in the year to ensure coverage of the seasonal peak of crowing.

Many of the factors contributing to variation in the crowing census were encountered during the short period given to testing this technique. In the Delta study, cover appeared to have considerable influence on the frequency and intensity of cock calls. Crowing in the more densely covered areas of the peat bog and the marsh regions seemed to extend over a longer

daily period than in the open cultivated regions. Similarly, the frequency of individual calling appeared to be greater in the former habitat. Such responses in the crowing behavior might tend to show a greater population density for areas of continuous heavy cover than actually existed. Differences in both the time and intensity of the crowing period were also noted from day to day which resulted in some inconsistency in the numbers of calls heard at given points along the census routes.

A source of further variation was manifest in the effects of the crowing of one bird on others within audible range. Short periods of vocal inactivity were often ended by the call of some one cock which seemed to stimulate an almost immediate calling response from other male pheasants. These flurry peaks occurred throughout the greater part of the daily range of crowing activity and are shown in the graphed data (Fig. 4) from stationary two-minute counts. These minor outbursts of calling increased the possibility of wide fluctuations in calls heard at a given site on different occasions. If counts were made at the initiation of a flurry period on one day, it would indicate a higher cock density than would a count taken say the following morning which began at the point of a decline in a crowing response.

TABLE III — Comparison of data for cock density from crowing territory counts and two-minute cock crowing count census.

Station	Number of cocks: Territory count	Number of cocks: Two-minute count	Station	Number of cocks: Territory count	Number of cocks: Two-minute count
A 1	7	9	B 4	12	6
A 2	9	12	B 5	17	4
A 3	13	10	B 6	6	6
B 1	6	5	B 7	12	11
B 2	5	7	B 8	10	5
B 3	11	6			

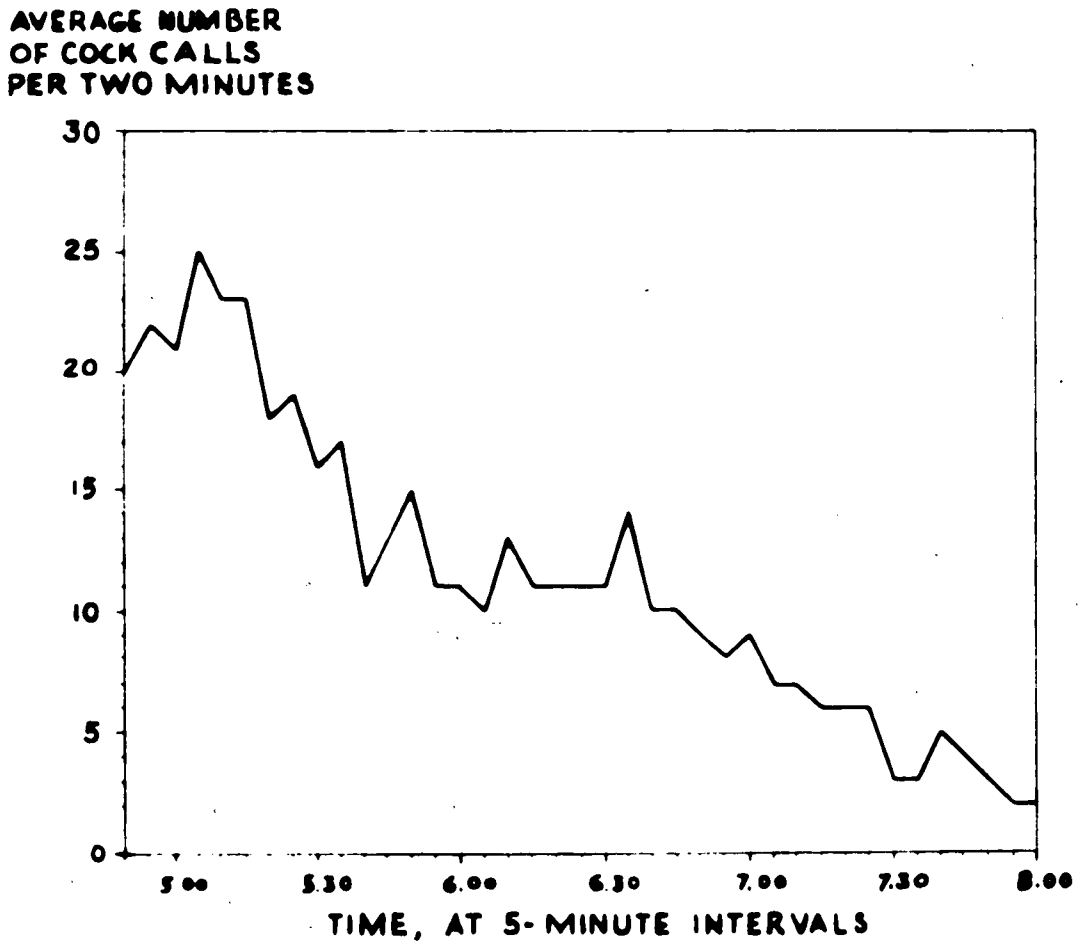


FIGURE 4. MORNING COCK-CROWING ACTIVITY, BASED ON 2-MINUTE COUNTS TAKEN MAY 10 TO 15, 1949

The average crowing frequency for each mile interval station checked during the six days of the trial was compared with the number of cock crowing territories located within a half-mile radius of each station. The half-mile radius is the range of audibility for pheasant crowing as found by McClure (1944).

Lack of correlation in the results of the two methods, readily seen in Table III, is believed due in part to the factors previously mentioned. In this study the relative advantages of the two-minute crowing count appeared to be outweighed by those of cock crowing territory counts. The consistency of cocks to maintain a certain territorial area enabled good quantitative counts and the change in cock density for both years was ascertained on all sample plots. Daily checks on territories afforded constant confirmation of cocks present, whereas the data obtained by the two-minute crowing count census varied considerably at many points from day to day.

Nesting period—As field work on the Delta area was not begun before May 1 in both study years, data on the early stages of the nesting period are limited. However, from the progress of nests found and from the appearance of broods, the establishment of early nests is estimated to have occurred about mid-April in 1948 and about the beginning of April in 1949. The latest dates for nests found established were July 17 and July 22 for the years 1948 and 1949 respectively. The period of nesting contained within the limits of the above dates is the minimum; no doubt some nests in the area were begun earlier and some later than those actually found in the field.

Egg laying—Information obtained on the egg laying of the Delta pheasants was not sufficient to enable determination of the rate at which

clutches were formed. Only three partially completed nests on which such observations could have been made were located during 1948. These nests were in an area which became inaccessible through floods and could not be visited to note clutch development. Nests found during 1949 were either being incubated at the time of discovery or had been deserted. Incomplete clutches found during mowing operations were numerous, but damage and desertion subsequent to nest exposure curtailed their usefulness as a source of information on egg-laying progress. Baskett (1947) found the rate of laying in "normal" nests to be slightly less than one egg per day and that additions to the clutch usually occurred between the periods of early morning and late afternoon feeding.

From examination of hatched nests several were noted to contain embryos which lacked but one or two days of hatching, indicating that egg laying might in some instances continue for a short time after incubation of the clutch had begun.

Clutch size—The number of eggs in "completed" nests varied for the two study years; the range being from four to sixteen in 1948 and from five to twenty-two in 1949. An average clutch size of 8.5 eggs per nest was noted for each nesting season of the years given. In nests which had acquired their full complement of eggs, a noticeable decline in the average number of eggs per clutch was apparent as the season progressed (Fig. 5). A similar trend observed for pheasants in Massachusetts (Wandell, 1942) was attributed to late nesting or to renesting attempts following destruction or desertion of initial nests. During the latter half of July many of the nests on the Delta which were exposed by removal of pea crops showed some indications of being renests. Reduction in the number of eggs per nest and the amount of pigment in the egg shells were characteristics which

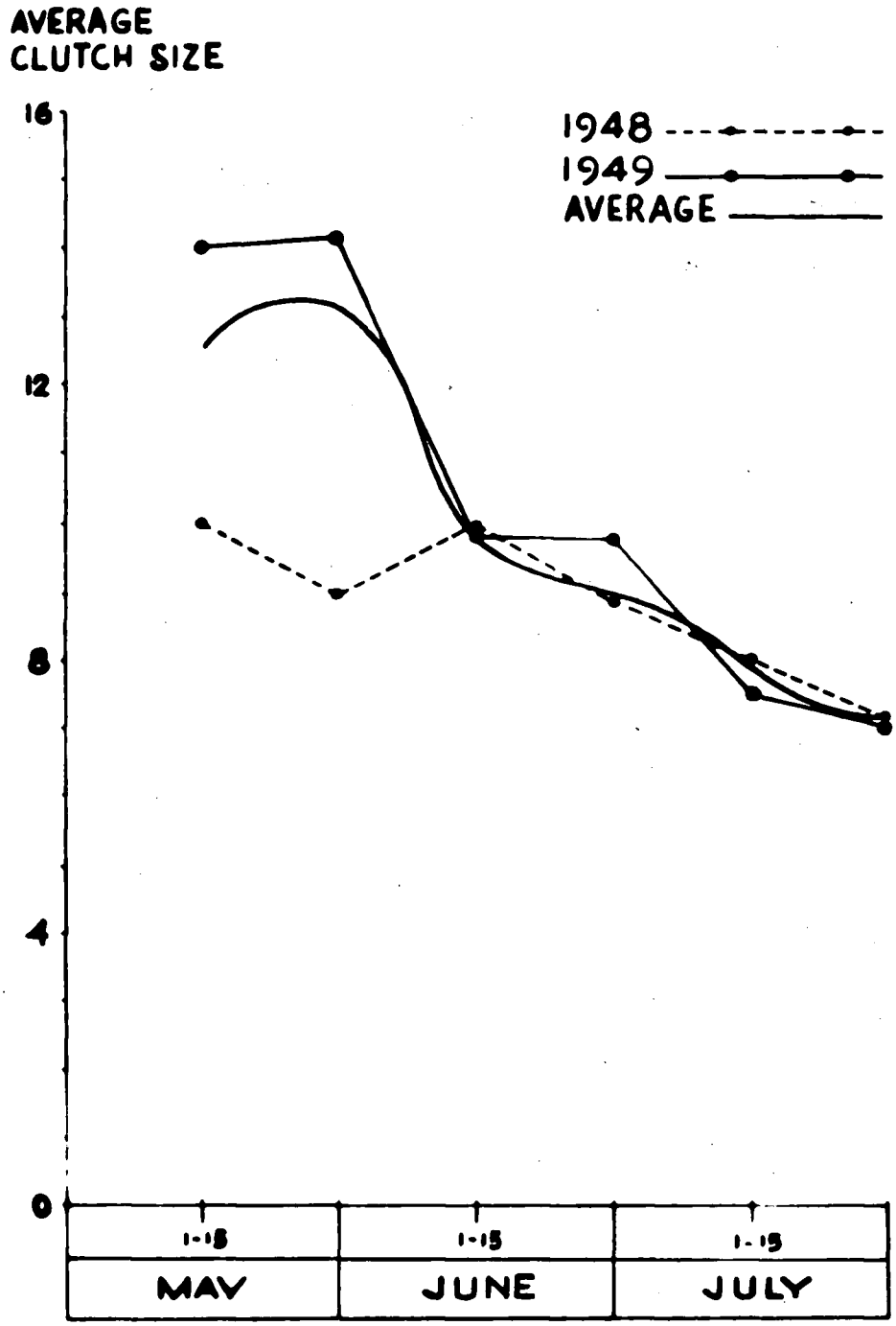


FIGURE 5. TREND OF CLUTCH SIZE THROUGHOUT THE NESTING SEASON AS SHOWN BY THE MEAN OF CLUTCHES FOUND IN EACH BI-MONTHLY PERIOD

suggested a repeat-attempt at nesting.

One hen pheasant nesting in an orchard deserted her clutch of seventeen well-incubated eggs when the grassy cover about her nest was removed by a hand scythe. Approximately sixteen days later this bird began a second nesting attempt which was ultimately successful but contained only ten eggs, several of which were relatively light in color.

Nest construction—In shape and size the nests examined in the study area conformed generally to those described in other studies. Most were circular or oval in outline and averaged 6 inches long and 5½ inches wide. Some were on the bare earth in shallow depressions of fields which lacked any heavy surface vegetation. Others were built in the weed or grass investment of fields, often between adjacent clumps of velvet grass. Nesting materials consisted of dried grasses, clover stems, grain stalks, dried leaves from pea vines, and similar items depending on the nature of the surrounding habitat. In nests that had been incubating or hatched, a light lining of breast feathers was often found. Beyond taking advantage of certain vegetative situations there was no evidence that pheasants made constructive efforts to improve the concealment of their nests. In most instances the floral growth by the time of early incubation had become so dense as to render nests invisible from distances of one or two feet.

Nesting cover and nesting density—Female pheasants during the nesting season utilized a variety of cover types some apparently more extensively and intensively than others. The rate of use for a given type may vary from year to year through the modification of season, topography, and plant growth.

In the Delta area the greater portion of the land is uniformly flat, a factor which permits relatively easy and extensive land development.

Climate, soil, and weather conditions, are favourable to the growth of a variety of crops many of which serve as cover for nesting birds. With the exception of sugar beets and red clover, however, most cultivated species are not suitable as cover until after the peak of nest initiation. Early nesting in the area seems restricted to the available non-agricultural growth afforded by fence rows, ditch banks, hedges, roadside brush, and the native vegetation on land which has been left fallow or idle for varying periods.

Many of the early nests were located on ditch banks and from Tables IV and V it may be seen that few were successful. Several were destroyed or deserted possibly because cover did not give adequate protection to the hen or the nest. Occurrence of dropped eggs found during the early stages of nest initiation and the extensive use by pheasants of ditch banks and fence rows as travel-ways suggested that the selection of such sites for nesting might have arisen more from convenience than from preference. This may explain to some extent the origin of many community or "dump" nests found in or near field edges, embankments, and similar locations (Fig. 6).

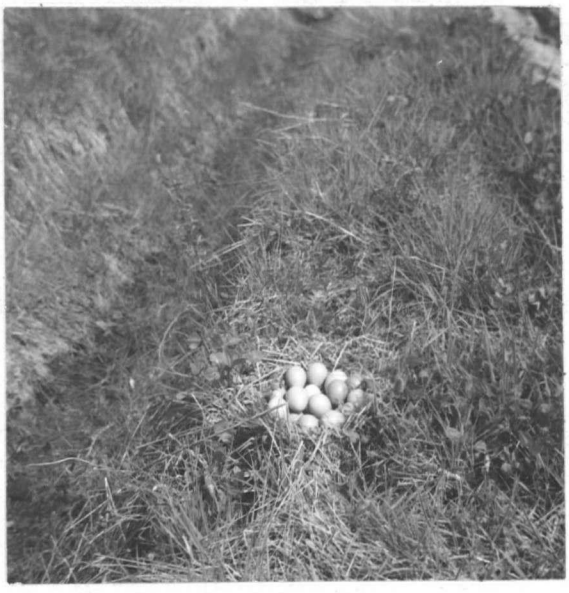


Fig. 6 — Community nest of 23 eggs on ditch bank. May, 1949.

TABLE IV -- 1948 nesting success, acreage, and nest density as shown by 247 field and non-field nests.

Cover type	No. of nests	Percent. of all nests	No. of nests successful	Percent. of nests successful	Acreage	Nest density: Acres per nest	Nest density: Nests per acre
Hay field:							
Red clover	132	53.4	49	19.8	165.5	1.25	0.79
Mixed hay	73	29.5	61	24.7	118.6	1.62	0.61
Total hay field nests	205	82.9	110	44.5	284.1	1.38	0.72
Pea fields	30	12.1	14	5.6	108.8	3.62	0.27
Pasture fields	-	-	-	-	4.5	-	-
Grain fields:							
Oats	2	0.8	2	0.8	33.5	16.75	0.05
Wheat	-	-	-	-	3.0	-	-
Barley	-	-	-	-	6.5	-	-
Total grain field nests	2	0.8	2	0.8	43.0	21.50	0.04
Total field nests	237	95.9	126	51.0	440.4	1.85	0.53
Non-field:							
Ditch banks	5	2.0	1	0.4	x		
Fence rows	3	1.2	1	0.4	x		
Gardens	2	0.9	2	0.8	x		
Total non-field nests	10	4.1	4	1.6			
Total for all nests	247	100.0	130	52.6			

xAcreage not determined.

Baskett (1947) noticed a proportional increase in hay field nests and concurrently lower proportions of fence row nests as Iowa pheasant populations increased during the years in which data were collected. The number of fence row nests found each season in the Iowa study remained approximately equal during the three year period, suggesting that a saturation point had been reached for this particular cover type. With the increased

TABLE V — 1949 nesting success, acreage, and nest density as shown by 404 field and non-field nests.

Cover type	No. of nests	Percent. of all nests	No. of nests successful	Percent. of nests successful	Acreage	Nest density: Acres per nest	Nest density: Nests per acre
Hay field:*							
Red clover	140	34.7	65	16.1	132.5	0.95	1.05
Red clover-timothy	89	22.0	39	9.7	106.0	1.23	0.84
Timothy-red clover	16	3.9	12	3.0	21.2	1.32	0.75
Timothy-velvet grass	30	7.4	8	2.0	40.0	1.37	0.75
Timothy	37	9.2	24	5.9	20.0	0.58	0.54
Red-top-timothy	53	13.1	45	11.1	86.5	1.66	0.61
Total hay field nests	365	90.3	193	47.8	406.2	1.11	0.89
Pea fields	18	4.5	6	1.5	137.4	7.63	0.13
Pasture fields	-	-	-	-	13.0	-	-
Grain fields:							
Oats	1	0.2	1	0.2	60.7	60.70	0.01
Sugar beet fields	1	0.2	1	0.2	10.0	10.00	0.10
Total field nests	385	95.2	201	49.7	627.3	1.63	0.61
Non-field:							
Ditch banks	9	2.3	-	-	x		
Fence rows	2	0.5	-	-	x		
Gardens	3	0.8	1	0.2	x		
Roadside	2	0.5	1	0.2	x		
Orchard	2	0.5	1	0.2	x		
Brush	1	0.2	-	-	x		
Total non-field nests	19	4.8	3	0.7	x		
Total for all nests	404	100.0	204	50.4			

*Hay field species are listed in order of predominance for each association.
xAcreage not determined.

population densities, breeding hens were forced into the less attractive hay field cover.

Because of the difficulty in estimating the acreage afforded by non-field cover, its contribution to the total nest production and yield in nests per acre was not readily assessed on the Delta. Hence a quantitative comparison of field and non-field cover could not be made. However, for the amount of fence rows examined very few nests were found though the available nesting cover of this type was abundant. From the number of deserted nests discovered it seemed that some hens abandoned their nests in fence rows (Fig. 7), ditch banks, and similar types, to re-establish themselves in the more concealing cover of the developing field-crop growth. The latter appeared to contain the areas most favored as sites for nesting hens.

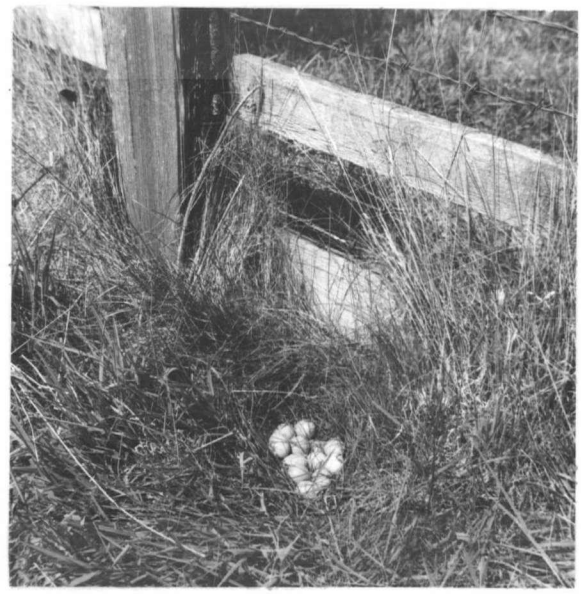


Fig. 7 — Abandoned fence row nest. May, 1949.

Hay crops—Hay crops in particular were heavily utilized. Of this group, pure stands of red clover during both 1948 and 1949 had the highest

nesting density. This preference was also extended to fields in which clover was associated with other hay species (Table VI). In one thirty-acre field of red-top hay fifteen nests were found six of which were located among a small scattered patch of volunteer red clover.

TABLE VI — Nesting density and cover change on different acreages during 1948 and 1949.

Acreage	Cover change 1948	Cover change 1949	Density Acres per nest 1948	Density Acres per nest 1949	Density change Acres per nest Plus	Density change Acres per nest Minus
45.0	Red clover	Red clover-timothy	2.14	2.64	0.50	
35.0	Red clover	Red clover	1.40	2.33	0.93	
5.3	Red clover	Red clover	5.30	1.06		4.24
10.0	Red clover	Timothy-red clover	0.50	5.00	4.50	
11.2	Timothy-red-top	Timothy-red clover	1.12	0.80		0.32
9.5	Red-top-timothy	Red-top-timothy	2.36	1.90		0.46
15.0	Red-top-timothy	Red-top-timothy	1.50	1.07		0.43
30.0	Red-top	Red-top-red clover	2.50	2.00		0.50
25.0	Peas	Red clover	3.50	0.53		2.97
4.1	Peas	Red clover	2.05	0.68		1.37
20.0	Peas	Timothy-velvet grass	16.00	1.11		14.89
17.0	Oats	Oats	0.00	0.00	-	-

The cycle for hay crops on many of the Delta farms runs generally through a three year period. New seedings of red clover usually bear the heaviest hay crop in the first year of cutting (Fig. 8). The following year may see a marked reduction in the purity of the stand by the invasion of timothy or velvet grass. By the third year red clover becomes almost subsidiary to velvet grass and the ground becomes turfy and often greatly infested with false dandelion (Hypochaeris radicata) and sheep sorrel (Rumex acetosella). Concurrent with this deterioration in the quality of clover hay, a decrease in nesting density was noted on some fields examined

Fig. 8 -- Heavy growth of early red clover, a crop ranking high as nesting cover. June, 1949.

during both years (Table VI).

Reduction in nesting density, however, was not in all cases entirely due to decline in vegetative cover. One red clover field examined in 1948 was found to have an average density of 2.0 nests per acre, but examination in 1949 revealed only 0.5 nests per acre. The cause of this decrease in nest density was believed due primarily to the presence of dairy cattle and cover depletion by grazing of the field during the period of nest establishment.

In contrast to the findings of Buss (1946) in his Wisconsin investigations old hay fields in the Delta region were generally less heavily nested than were new ones.

Peas—Of the field crop cover types, peas ranked second in use by nesting pheasants. During 1948 some pea fields were almost as heavily nested as were hay fields although the overall density in pea crops was only about one-third of that for the hay group. In 1949 the nesting in

pea fields dropped to half that noted for the crop during the previous year. This was believed due to the earlier nesting period of 1949 which resulted in many nests hatching before the first red clover mowing. The escape of these nests would be reflected in a lighter renesting density in the pea crops.

Strictly speaking, the term "preference" is not a fair description of pheasant reaction to cover types unless all types are subject to equal opportunities of selection. Because red clover offered a most attractive cover and was available at a time when nest initiation was approaching the peak, it seemed to enjoy a high nesting density. Since other hay species present at the same time did not support such large nesting concentrations it may be said that pheasants show preference for red clover as a cover type in the hay field group. However, as peas were not sown until mid-May and did not provide vegetative growth sufficient to serve as nesting cover until early June, comparable estimates of pheasant preference for this crop and others can not be made.

Grain—A similar situation existed in the grain field cover types. This group became available as nesting cover about the same time as did pea crops and both groups provided an alternate site for birds which were about to renest after having been ousted from red clover as a result of mowing activities. However, in spite of a ready availability of grain crop cover in mid-June its use was relatively low in both nesting seasons studied. This may be due to the difference in the growth form and in the pattern of sowing which is more open for grain than for either clover or peas and does not provide the dense ground cover apparently favoured by the nesting hens.

Pasture—Though the acreage of pasture land examined was comparatively small the absence of nests found seemed indicative of the low nesting pref-

erence for this particular form of cover. In addition to the usual lack of concealing vegetation, the constant presence of livestock was not conducive to nest initiation.

Sugar beets--Sugar beets, like hay crops, were also a source of cover for early nesting. However, during May the occasional cultivating by farm machinery may have disturbed and possibly destroyed any nests then established. Later in the spring when beet plant development was ensured cultivation ceased. Heavy grass and weed growth followed and the resulting cover became suitable for nesting. Nevertheless its use as such was not found to be high possibly because the bulk of nest initiation was over by the time the sugar beets afforded cover sufficiently attractive to nesting hens.

Potatoes--Potatoes also offered early nesting cover (Fig. 9) but like sugar beets were constantly being disturbed by cultivation or weeding.

Fig. 9 -- Potato field, East Delta, early June, 1949.

Spraying for potato blight and potato beetle was also practiced at intervals and with the other agricultural activities gave small chance for birds to

be undisturbed for a period long enough to rear broods.

Nest location—The location of field nests with respect to their peripheral boundaries is shown in Table VII.

TABLE VII — Nest location in relation to field peripheries.

	Distance from nests to field periphery (in feet)					
	0-30	0-60	0-90	0-120	0-150	over 150
1948						
percentage of field nests	27.0	43.6	58.8	69.2	77.0	23.0
1949						
percentage of field nests	12.4	24.0	37.1	51.0	62.7	37.3

It may be seen from the data that the proportions of nests within given distances from the nearest field margin varied considerably during the nesting periods of both study years. The distribution of 230 field nests found durint 1948 revealed the greater proportion (27 per cent.) to be contained within the first thirty feet of the perimeter and a progressive decrease in numbers as the field center was approached. This tendency did not appear to be characteristic of field nests in 1949 when only 12.4 per cent. of 380 such nests examined were found in the outer thirty feet of field edge. Concurrent with this decrease in peripheral location, the proportion of nests at distances greater than 150 feet from the outer field limits increased from 23.0 per cent. in 1948 to 37.3 per cent. during 1949. Leopold (in Baskett, 1947) noted a similar phenomenon in the nesting of Wisconsin pheasants and suggested that the apparent shift in nest locations might have arisen through crowding of nests in the peripheral areas. Baskett (1947) also noted a general increase in the relative number of nests found away from the field boundaries as nesting density became greater. In the

Delta study the average nesting density for all field nests increased from 0.53 (1948) to 0.61 (1949) nests per acre which, in conjunction with the other data, would further indicate that field nest location might have been modified by the nesting population density.

Nesting success--A total of 651 nests, both field and non-field, were examined in the course of the Delta nesting investigation. Of this number 51.3 per cent. were successfully hatched. The various cover types and the extent to which they contributed toward the nesting success of the reproductive seasons of 1948 and 1949 are shown in Tables IV and V.

The number of non-field nests as compared with the number of field nests was relatively small in each of the two years shown and the trend for clutches hatched in such cover was very low. Orchard and garden cover contained the greatest number of successful non-field nests, a fact which might be directly attributable to the comparative safety for clutches in such areas. The hazards of predation, disturbance by agricultural activities, and similar factors are possibly most prevalent among the other non-field cover types.

Field crops in both years provided approximately 95 per cent. of the total nests found, of these about one-half were successful. On the basis of acreage covered during the breeding season, the number of hatched nests increased in proportion as the season progressed. Figure 10 shows the relative number of nests hatched at the time of mowing in four major field-crop types for the bi-monthly periods from June through August in 1948 and 1949. The most obvious difference in the two seasons is noted on comparing the data for the months of June. The effect of an earlier nesting season in 1949 is revealed by an accompanying increase in the success of nests in both clover and hay crops in that year. During the latter part of July

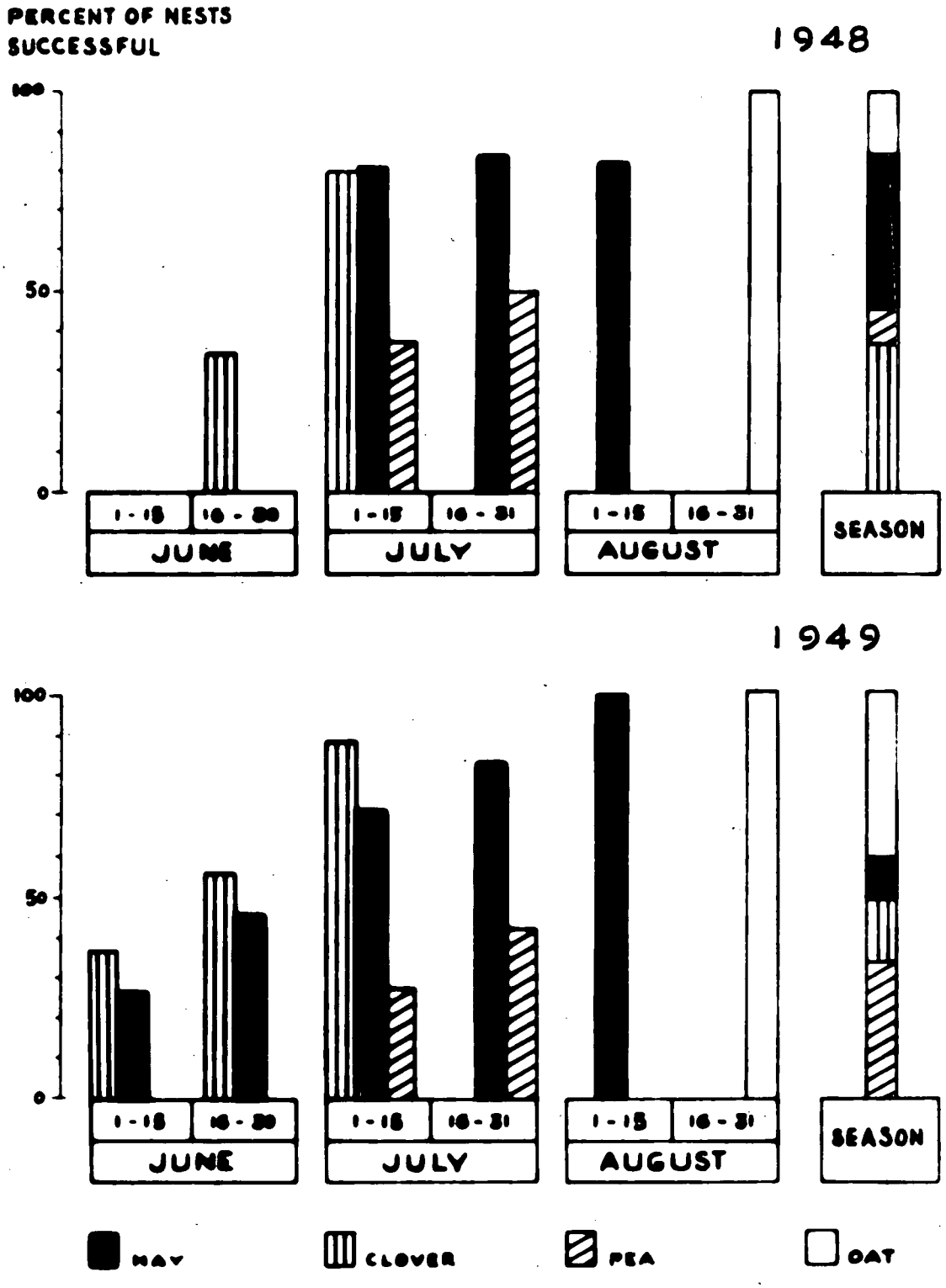


FIGURE 10. NESTING SUCCESS FOR BI-MONTHLY PERIODS AS SHOWN FOR THE MAJOR FIELD COVER TYPES EXAMINED AT TIME OF MOWING. 1948 & 1949.

and August though hay and grain fields seem to offer the greatest chance of a successful nesting outcome, it should be noted that these fields contained comparatively few nests at any time (see Tables IV and V).

Mixed hay species, not including pure red clover, provided the largest proportion of hatched nests found in any one crop type on the Delta. This favourable position might have arisen from the relatively high nesting density typical in such fields, and to the fact that, compared with some crops, mowing of mixed hay was begun generally late in the nesting season. This allowed a longer period of undisturbed nesting.

Pure growths of red clover and stands in which this species was predominant contained the greatest number of the total nests discovered during each year of the survey. From an examination of Figure 10 it may be seen that both clover and hay crops showed a substantial success of early nests in 1949 while a lower proportion of the number in these cover types hatched in 1948. As previously mentioned, this reflects in part the earlier reproductive season of 1949.

Hatching period—The appearance of the first broods in the Delta area are noted usually about the latter part of May. Hatching activity was evidenced in 1948 by the report of a brood seen on May 20, and in 1949 by one reported on May 17. Late broods were also noted by combine operators during the grain harvest in August. The post-peak limits of this phase of pheasant reproduction are based on broods observed whose hatching dates were estimated to be August 22 in 1948 and August 17 in 1949.

From the estimated ages of broods seen throughout the late spring and summer and by use of the "dropped primary" technique (Buss, 1946) in ageing juveniles found killed during mowing, the trends between the early and late dates of hatching were obtained for both years. Figure 11 enables

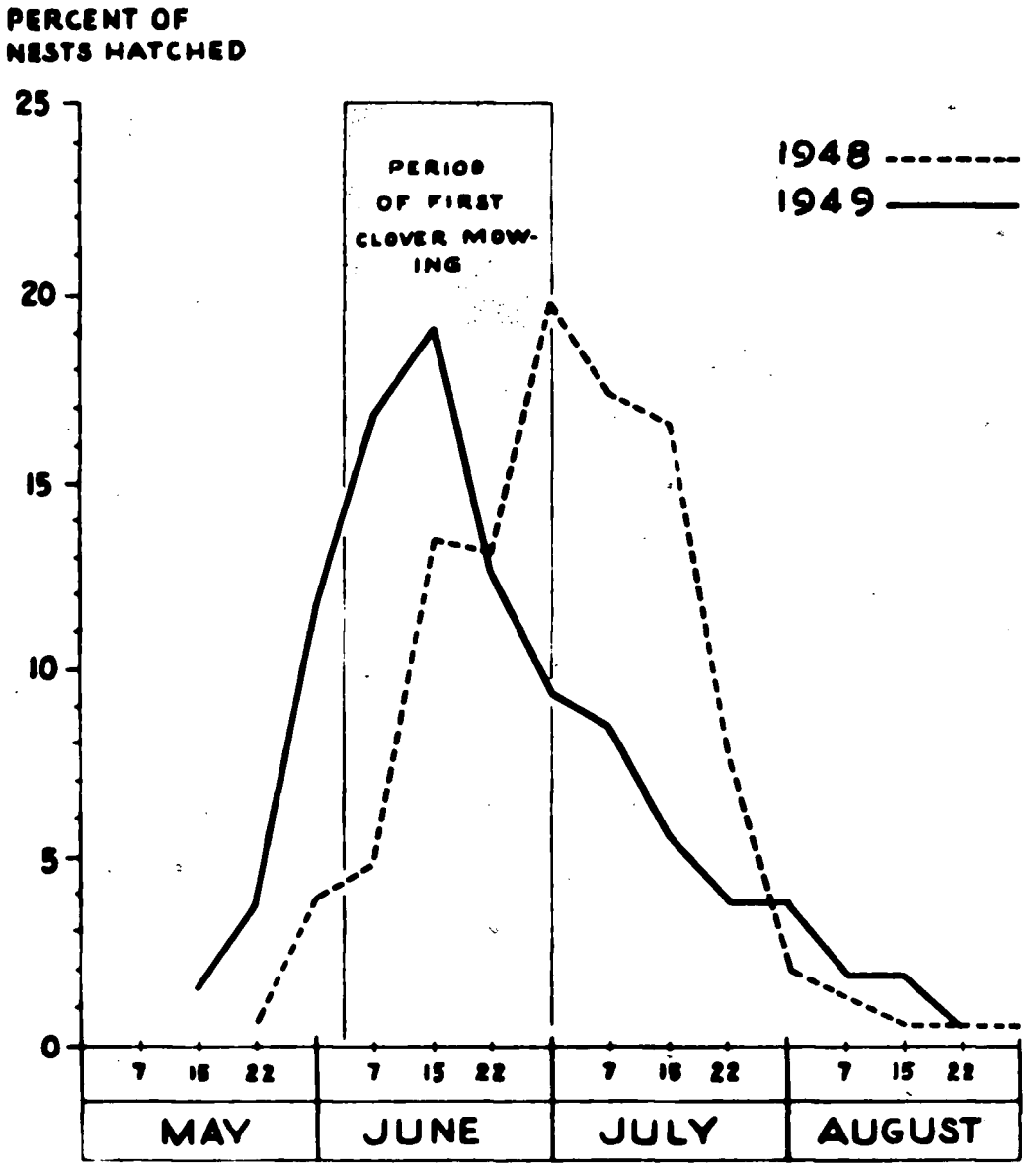


FIGURE 11. HATCHING TREND OF PHEASANT NESTS AS DERIVED FROM NESTS FOUND & ESTIMATED AGES OF BROODS SEEN DURING 1948 & 1949.

a graphic comparison of the hatching progress of the 1948 and 1949 seasons. In the latter year it may be seen that the peak of hatching activity occurred about mid-June, some two weeks earlier than in 1948. The ascending portions of both curves rise quite rapidly; that of 1949 is uninterrupted in its approach to the peak while that for 1948 reflects some disturbance in its upward course at a time corresponding closely to the period of most intense mowing. This factor was not so much felt during the 1949 season because most of the hatching had taken place before early mowing was at its height.

The decline of the hatching period also differed in each of the study years. The descent from the hatching peak appeared arrested about mid-July in 1948 possibly through renesting of hens disturbed earlier in the season. In 1949 the descent of the post-peak curve was at first quite abrupt but became more gradual throughout the months of July and August. The irregularities in this decline suggested that possible renesting activities were more widely distributed and less pronounced than they were in 1948.

LATE SPRING AND SUMMER POPULATION

As incubation progressed and the hatching season was begun, the sex ratio of Delta pheasants in both years showed a decline in the number of hens per cock seen throughout the month of June. With the appearance of hens with broods and with the disappearance of cock birds following territory disintegration, the sex ratio was again modified. The average number of hens per cock seen in July, 1948, was 5.3 and in July, 1949, 3.78; both ratios were almost identical with those for the end of May in the respective years.

Evidence of the post-nuptial moult in cocks was noted in some birds as early as the first week of July. The progress of this phenomenon was

indicated to some extent throughout that month and the first part of August by an apparent decrease in the number of cocks.

Brood period--The late spring and summer is the period in the reproductive cycle of pheasants which is characterized largely by brood rearing activities. Hens with newly hatched young tend to move from the immediate vicinity of the nest shortly after the chicks have emerged from the eggs. A hen disturbed at such a time usually undertakes actions which seem intended to draw the intruders away from the area occupied by the brood. Such protective reactions on the part of the hen apparently decrease as the young become stronger and more capable of flight.

From family groups observed most hens with broods remained within the general area of the nest for the first few weeks following hatching. The early morning and late afternoon were the periods in which they were most often seen as adherence to areas of denser, protective cover made them fairly inconspicuous during the rest of the day. The daily cruising radius of broods observed by Wandell (1942) was estimated to be not more than one-quarter of a mile. Such a distance was probably the maximum for Delta pheasant broods, considerably less seemed to be the rule.

The length of time that young birds remained with the parent hen seemed to vary considerably among the groups. Marked dispersal of broods was not generally noticeable until August. Prior to this time, and in some instances at even later dates, it was not uncommon to see hens accompanied by juveniles of approximately eight to ten weeks of age.

Hatching success--Average brood size for May and June, 1949, indicated a comparatively successful beginning for a hatching season which appeared to be slightly better than that for the corresponding period of 1948. However, the marked decrease in the number of young per brood noticeable by

early July, 1949, dropped the average below that for the same month of 1948. The decline continued through August but was not clearly evident once disintegration of broods had begun.

The relation of brood size with approximate time of hatching is based on a comparatively small number of observations for the months of July and August. However, the data obtained does show a reduction in the average number of young brought out by late-nesting hens, a point corroborated by the seasonal trend for clutch size (Fig. 5).

TABLE VIII — Pheasant average brood size, 1948 - 1949.

May			June			July			August		
	Average			Average			Average			Average	
Age in weeks	brood size 1948	1949	Age in weeks	brood size 1948	1949	Age in weeks	brood size 1948	1949	Age in weeks	brood size 1948	1949
									1	-	5.3
									2	2.5	4.2
									3	5.0	2.8
									4	4.7	4.7
						1	6.5	5.0	5	5.0	3.3
						2	6.0	6.1	6	7.0	3.2
						3	5.0	4.8	7	5.4	4.7
						4	4.3	4.3	8*	6.0	3.7
			1	7.5	10.7	5	3.3	4.2			
			2	5.0	7.0	6	3.2	5.0			
			3	2.0	5.0	7	5.0	4.0			
			4	-	4.0	8*	-	3.1			
1	-	9.4	5	-	2.0						
Monthly average	-	9.4		6.6	7.1		5.0	4.5		5.3	3.8

*Includes birds of 8 weeks and over.

Differences between the progressive brood size for the various age groups were obvious when comparisons of the data for the two years were made. From Table VIII, a gradual decline in average brood size, common to both 1948 and 1949, occurred from June through August. A similar decrease in average numbers with the increasing age of broods may be noted by

examining the size of any age group of one month and comparing it with that shown four weeks later (Table VIII). A breakdown of this regular descent of numbers appeared in the month of August particularly among the older juveniles. This may have arisen, as suggested by Errington and Hamerstrom (1937), through some banding of broods which may occur at this time.

LATE SUMMER AND FALL POPULATION

By the end of August the grain harvest had begun on the Delta; cocks became more apparent and with the onset of adult plumage on the young males the sex ratio showed a gradual decrease in the relative number of hens per cock. This trend continued until late September when approximate equality in the ratio of males to females was reached. Counts made in mid-October prior to the hunting season showed 0.99 and 0.98 hens per cock for the years 1948 and 1949 respectively.

By late August some broods had already begun to lose their identity as a family unit and by the end of September, except for late-hatched broods, many had united to form mixed bands of from ten to fifty birds.

Productivity--Like most other gallinaceous birds the pheasant as a species exhibits a comparatively high reproductive potential. Seldom, however, are conditions so favourable that this power of propagation is fully realized. The extent to which this potential may be measured is often limited by the difficulty in obtaining complete quantitative data. By early fall scarcely more than half of all young pheasants produced from the breeding season have survived the complex and unrelenting hazards which limit natural population increase.

In spite of the numerous adverse factors operating against the reproductive potential of the spring breeding population, the proportion of hens successful in producing broods increased substantially throughout the

summer months. Of all hens seen during August in both years over 80 per cent. were accompanied by young (Table IX).

TABLE IX — Percentage of hens rearing broods.

Month	Percent. of hens with broods 1948	1949
June	6.9	6.6
July	47.9	52.9
August	81.5	80.1

In the Delta area attempts to assess the yield of the breeding season in terms of birds per acre were limited during late summer and fall by the difficulty in differentiating between juvenile birds and adult hens in groups of similar appearance. Further restrictions were imposed by the inaccessibility of many census tracts which contained uncut grain or seed clover crops. As a result no data were obtained sufficient to enable a direct calculation of the population increase per unit area.

From information gathered at more favourable periods throughout the season it was possible to estimate a qualitative and to some extent quantitative determination of the productivity for both years of study. Table X shows the method and data upon which the success of the two seasons was estimated. Calculations from the data have been left as determined mathematically, but the degree of accuracy which they imply should not be construed as representing actuality. The estimate errs inasmuch as no data were obtained which would enable an approximation of the non-breeding cock numbers or of their spring and summer mortality. No account of hen loss through mowing injuries can be given because the proportion of surviving cripples is unknown. The estimates of hen losses to highway kill and

TABLE X — Productivity estimated for 1948 and 1949.

	1948	1949
Crowing cocks counted per square mile.....	12.3	14.2
Sex ratio (hens per cock) for month of May.....	5.4	4.3
Approximate breeding area (square miles).....	39.0	39.0
Estimated number of cocks in the area:		
1948 (12.3 x 39.0).....	479.7	
1949 (14.2 x 39.0).....		553.8
Estimated number of hens in the area:		
1948 (5.4 x 479.7).....	2590.4	
1949 (4.3 x 553.8).....		2481.3
Estimated potential breeding population	3070.1	3035.1
Estimated percentage of hens killed by: Mowing...	18.6	11.3
Traffic..	1.6	0.2
Predation	0.0	1.2
Estimated number of hens killed by: Mowing.....	481.8	280.3
Traffic.....	41.4	4.9
Predation....	-	29.7
Estimated number of breeding hens surviving.....	2067.2	2166.4
Percentage of hens rearing young.....	81.5	80.1
Estimated number of successful breeding hens.....	1684.7	1735.2
Average brood size (August).....	5.3	3.8
Juvenile fall increment.....	8928.9	6583.7

predation are based on data which are believed incomplete and the numerical loss shown is probably not as great as actually existed. Nevertheless, the data as treated enable a comparison of the trends in productivity during the two years and offers, within limits, a quantitative evaluation of the fall population size.

Age ratio and population turnover—The age composition of the Delta pheasant population and the method by which it was determined is shown in Table XI.

The estimate is descriptive of conditions found at the end of August and indicates in relative terms the proportion of juveniles present in the total population. No consideration has been made for spring and summer mortality of adult cocks and some error has no doubt resulted from this

omission. However, from observation, mortality of adult males throughout this period appeared to be low in both years and is not believed to have influenced unduly the final estimate.

TABLE XI — Age ratio of wild pheasant population, 1948 and 1949.

		1948	1949
Assuming the percentage of hens successfully rearing broods is.....		81.5	80.1
Average brood size (August).....		5.3	3.8
Then 100 hens of the population rear chicks numbering.....		431.9	304.4
From May—sex ratio in hens per cock.....		5.4	4.3
Then to 100 hens there are males numbering.....		18.5	23.2
Assuming no losses, total population (August):	18.5		
	100.0		
	431.9	550.4	
	23.2		
	100.0		
	304.4		427.6
Proportion of juveniles in August population.....		78.4	71.1
Assuming sex ratio of juveniles is 1:1, then:			
Total number of juvenile cocks.....		215.9	152.2
Percentage of juvenile cocks in cock population....		92.1	86.7

A complete estimation of the rate of population turnover for wild pheasants was not obtainable in the short time of the Delta study. From data collected during the hunting season it was possible to verify the age ratios in Table XI and to estimate a turnover for the population of each year. Assuming no losses between August and the opening of the hunting season the proportion of juvenile cocks removed by hunting constituted 84.8 per cent. and 74.1 per cent. of the fall crop of young males in 1948 and 1949 respectively. The rate at which the residual male birds are replaced would require more extensive methods and a greater length of study.

If the productivity estimates as derived in Table X are valid a substantial turnover in female numbers is also indicated. The calculated

1948 fall hen population of 6,531.6 birds is shown to have decreased to 2,481.3 by the spring (May) of 1949, a survival of only 37.9 per cent. as compared with a cock survival of 11.2 per cent. for the same period.

FARM-REARED RELEASED PHEASANTS

Efforts to provide more cock pheasants for the fall hunting and more hens to augment the breeding stock of the Delta pheasant population have been made annually by the British Columbia Provincial Game Commission since 1934. Birds for these purposes were pen-reared by numerous game farmers in the surrounding Lower Fraser Valley. With the exception of a small number of Formosans and some of the Mongolian strain, all releases were composed largely of the Chinese ring-necked pheasant. As indicated in Table XII the number of birds liberated during the study years 1948 and 1949 was approximately double that for 1938 and 1939 the years in which previous releases had been greatest. By this increase in numbers and by extensive banding of both cocks and hens it was hoped to obtain data which would enable an evaluation of annual artificial stocking.

TABLE XII — Pheasants liberated in Delta Municipality.

Year	No. of birds	Year	No. of birds
1934	340	1942	100
1935	280	1943	-
1936	387	1944	-
1937	892	1945	412
1938	1,229	1946	900
1939	1,363	1947	775
1940	248	1948	2,492
1941	155	1949	2,494

Most important of the problems to be considered by this investigation was the determination of the survival of farm-reared birds. Attempts were made to appraise this factor with respect to the age of birds, methods and

times of release. Whenever possible data on mortality and determination of the agents responsible were collected in the period between liberation and hunting season.

Numbers and distribution—During 1948, 2,492 farm-raised pheasants were introduced at various points throughout the Delta. Of the 2,162 which were banded, 1,238 were cocks and 914 were hens. In 1949, 1,204 cocks and 1,290 hens were banded and liberated. Releases in 1948 were made at approximately two-week intervals from June 30 to September 16. With the exception of 150 year-old birds turned out on July 13, all were twelve-week old juveniles. The first release of the 1949 season was made during late March and was composed of 394 year-old birds. The remaining introductions for that year, made in late June, August, and September, consisted of birds in age groups ranging from ten to nineteen weeks of age.

Distribution of birds was made at intervals of one mile across the entire east-to-west width of the Delta Municipality, the greater concentrations were in the central and western area. No birds were released on Westham Island. Release sites were chosen for the best combination of cover, food, freedom from possible hazards of agricultural activities, and distance from heavily travelled roads.

The marking of pheasants for purposes of later identification was limited entirely to the use of quarter-inch aluminum leg bands each with a number for the individual bird. Banding was done at the game farms on the morning of the day chosen for release. As birds were tagged they were placed in wooden crates each of which held twenty-five birds. When the number required for the day's liberation had been loaded, the birds were taken as soon as possible for distribution.

Release methods—To determine whether or not the survival of farm-

reared birds was in any way influenced by the manner in which they were released, two different methods of introduction were employed in 1949. The first known as the "day" release was used entirely throughout 1948 and as a control for the second method, the "night-gentle" release, in 1949.

"Day" releases were made usually in the late forenoon or early afternoon between 10:00 a.m. and 3:30 p.m. In liberations of this type, pheasants in groups of from fifty to seventy-five and usually of mixed sexes were freed through an opening in the center and full length of the upper surface of the crate made by removing an eight-inch panel. Emergence of the birds was usually rapid and on occasion resulted in considerable bodily contact between individuals and the planks about the opening in the crate. With this type of liberation distribution was quite widespread about the release point. Flights from the crate ranged from three or four yards up to approximately one-quarter of a mile.

"Night-gentle" liberations were conducted in 1949 in an effort to reduce the possible injury accompanying the more violent "day" method and to note the effect on distribution. Releases of this type were made at night between 10:30 p.m. and 12:30 a.m. Crates employed in this type of liberation were similar to those used in the "day" method except that exit was provided by fastening up a hinged panel at each end of the crate. Each container with its quota of birds was carried at least two hundred yards from any road and placed amid the best available cover growth. The end doors were fastened open and the crate and contents left in the field. On two or three occasions "day" release boxes had to be used. As these differed only in the location of the exit, the liberations in which they were used were essentially similar to the "night" method.

From observation it was found that the birds of the "night" release

roosted in the crates until dawn, at which time they emerged slowly and quietly in ones and twos. Approximately one hour elapsed between the departure of the first and last birds leaving the containers. No flights were made during the exodus, all birds dispersed leisurely and widely through the attendant cover.

For comparative purposes similar numbers of birds in the same proportion of sexes were "day" released one or two days before or after the "night-gentle" liberations. The same release sites were used for both methods.

PHEASANT HARVEST

The examination of a large proportion of the seasonal kill made by hunters on the Delta area provided a variety of information which would have been difficult to obtain by any other means. This appraisal, in conjunction with field data collected during the spring and summer, enabled a more comprehensive study of reproductive success, survival, and population composition with regard to age and proportions of wild and introduced birds. Further data were obtained pertinent to the two methods of release of farm-raised birds, hunting success, and hunting pressure.

The material forming the basis of this section of the study was derived from samples taken at four different stations throughout the Delta during parts of the open seasons of 1948 and 1949. Pheasant hunting periods extended from Oct. 16 to Oct. 31, 1948, and from Oct. 15 to Nov. 13, 1949. During both years cocks only were the legal game, the daily bag limit was two per hunter, and the season limit ten birds.

Checking of hunters was carried out on the weekends of Oct. 16-17 and Oct. 23-24 in 1948, and Oct. 15-16, Oct. 22-23, and Oct. 29-30, 1949. Vehicles containing hunters not resident in the area were stopped as they

passed through checking points which controlled all exits from the Delta Municipality. Occupants of these cars were queried as to their hunting success and the number of wild and banded birds taken on each day. All wild birds were classed as adults or young-of-the-year on the basis of spur development as described by Kimball (1944). In cases where age determination by this method was in doubt, a further check was made using the degree of skull ossification (Linduska, 1945) and the presence or absence of the bursa of Fabricius (Gower, 1939) as corroborating criteria. The number of hours hunted per day per hunter was obtained only for the year 1949 and as a result a comparison of hunting pressure and success on this basis could not be made for the two seasons.

As the checking stations were of no avail in obtaining data from hunters resident in the Municipality, different methods of sampling were employed to elicit information from this group. A random sample of 10 per cent. of the licensed resident hunters was taken by canvass during December, 1948, and the data collected used in estimating the local pheasant kill. Efforts made to determine the total actual hunting take for the 1949 hunting season by personal contact proved unsuccessful although a 22 per cent. sample was obtained. Pheasant bag-return cards were also used during the second year in an attempt to increase the yield of data from resident hunters. Stamped postcards, already addressed for return to the Department of Zoology, University of British Columbia, requesting an account of the days and hours hunted, the number of wild and released birds recovered, and the number of pheasants crippled and lost, were mailed in mid-December to 500 of the 646 licensed Delta hunters. It had been intended originally to distribute these cards at the time hunting licenses were being sold but some delay in printing the forms made this impossible.

The gross return of these cards was 100 in number or 20 per cent. of the total mailed. Of those returned, 15 were blank or indicated that the returner had not hunted pheasants, another 10 were incomplete in recorded information. The remaining 75 cards, or 15 per cent. of those mailed, contained data which were acceptable for use in conjunction with information gathered by the house-to-house canvass. In the tabulated summaries of the pheasant harvest some dissimilarity in the types of data taken limited the extent to which some trends could be compared during the two years. Where such apparent discrepancies occur in the Tables the source for adjustment is indicated. It should be noted that coverage of the hunting season by the checking stations was not complete; the first two weekends of the 1948 season and the first three of the 1949 period were the sources of most of the information obtained. It was felt, however, that the samples they afforded were sufficient to indicate seasonal and yearly trends.

Hunting pressure—Determination of hunting pressure in terms of guns per acre or hunters per day was not attempted during the two years because of the extensive land area involved and the necessity of daily vigilance throughout the entire open season. However, an index based on the number of hunters per weekend checked at all stations provided some comparison of conditions during the first half of both annual seasons.

TABLE XIII — Non-resident hunting pressure and success.

	Number of hunters			Hunter success (birds per hunter)			
Year	First weekend	Second weekend	Third weekend	First weekend	Second weekend	Third weekend	Total
1948	2479	410	-	0.66	0.32	-	0.61
1949	1842	550	361	0.61	0.16	0.10	0.45

From the data in Table XIII it may be seen that hunting pressure on

the opening weekend of the 1949 season was noticeably lighter than that for the same period of the previous year. This drop of approximately 25 per cent. in the number of guns afield may have resulted in part from the restoration of a split season on ducks which affected this area and a poor pre-season showing of pheasants. The decrease in hunting pressure is reflected to some extent by the license sales to hunters resident in the Delta Municipality. Of the 646 licenses sold to this group only 211 had been issued by the end of October. The pheasant season was by that time almost half completed. With the assurance of the two hunting opportunities provided by the split season on waterfowl, it is likely that the initial hunting intensity eased in 1949. Many hunters who would normally make the most of a straight season by hunting both ducks and pheasants seemed more inclined to conserve their efforts for the late season hunting.

By the second weekend of the 1949 season the relative number of guns present on the Delta had declined to approximately one-quarter of that of the initial weekend. A more detailed portrayal of this trend may be found in Table XIV which shows some comparison of conditions for resident and non-resident hunters during the first half of the 1949 season. It may be seen that both hunter numbers and effort diminished as the season progressed.

TABLE XIV — 1949 hunter success from comparable data for dates shown.

	Non-resident			Resident		
Date	No. of hunters	No. cocks killed	Hunter success	No. of hunters	No. cocks killed	Hunter success
Oct. 15	1018	672	0.66	44	47	1.06
Oct. 16	824*	466*	0.56	40	35	0.87
Oct. 22	257	40	0.15	12	5	0.41
Oct. 23	293	50	0.17	16	13	0.81
Oct. 29	128	15	0.11	10	5	0.50
Oct. 30	233	22	0.09	13	6	0.46

*Hours not known but hunters and kill known.

Hunting success—The most obvious difference in the hunting success of the two years is revealed by the difference in the total of the known seasonal kill. This harvested fraction of the population dropped from 4,577 birds in 1948 to 3,018 in 1949, a decrease of approximately 34 per cent.

In spite of what appeared to be a less bountiful pheasant crop, the number of birds bagged per non-resident hunter on the opening weekend of 1949 was only slightly lower than that for the corresponding period of 1948. On the second weekend of the latter year hunter success was half that of the first two days, whereas in 1949 it was about one-quarter. This is shown in Table XIII. A more elaborate indication of this trend is shown for local and transient hunters during 1949 in Table XIV. From this Table it may also be seen that residents had a consistently higher daily success in the number of pheasants bagged. No estimate of season success was available for the non-residents but a comparison of the success for local hunters obtained for both years showed the estimated season kill made by this group in 1949 was 30.5 per cent. less than for 1948. These data confirm the relative scarcity of birds noted for the area in 1949.

TABLE XV — 1949 hunting pressure, by dates given where number of hours and hunters known.

	Non-resident			Resident		
Date	Gun hours	No. of hunters	Gun hours per hunter	Gun hours	No. of hunters	Gun hours per hunter
Oct. 15	6594.5	1018	6.4	214	44	4.8
Oct. 16	4514.0	715	6.3	186	40	4.6
Oct. 22	1327.0	257	5.1	40	12	3.3
Oct. 23	1637.5	293	5.5	48	16	3.0
Oct. 29	601.5	128	4.7	25	10	2.5
Oct. 30	1170.0	233	5.0	57	13	4.3
Total for sample period	15844.5	2644	6.0	570	135	4.2

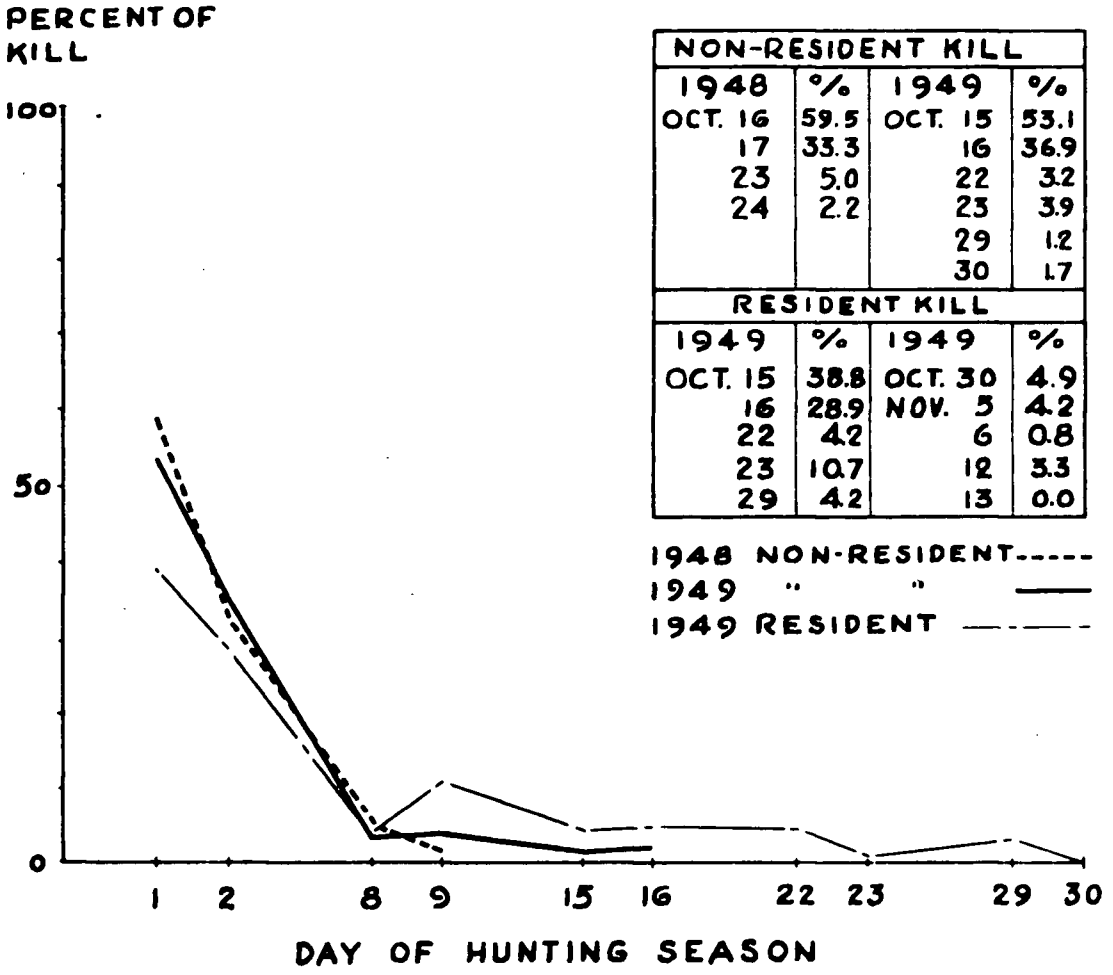
Gun hours-per-hunter (Table XV) and gun hours-per-bird killed (Table XVI) were obtained for the 1949 season only. As a measure of hunting pressure the former index shows a slight decrease as the season progressed. The local hunters as compared with the transient hunters averaged almost two hours less per day for the period shown (Table XV).

TABLE XVI — 1949 hunter success, by dates given where number of hours and birds bagged known.

	Non-resident			Resident		
Date	Gun hours	Cocks killed	Gun hours per bird	Gun hours	Cocks killed	Gun hours per bird
Oct. 15	6594.5	672	9.8	214	47	4.5
Oct. 16	4514.0	371	12.1	186	35	5.3
Oct. 22	1327.0	40	33.1	40	5	8.0
Oct. 23	1637.5	50	32.6	48	13	3.7
Oct. 29	601.5	15	40.1	25	5	5.0
Oct. 30	1170.0	22	53.1	57	6	9.5
Total for sample period	15844.5	1170	13.5	570	111	5.1

In spite of this apparent decrease in hunting activity the resident, on the average for the three weekends, obtained 0.82 birds per man in 5.1 hours in the field as compared with 0.45 birds per man for 13.5 hours of hunting by the transient hunter. It would appear, in this case, that a greater knowledge of the distribution of pheasant concentrations and more ready access to them enables the local hunter to obtain with less effort a larger kill than does the non-resident.

Distribution of the kill—The distribution of the pheasant kill as shown in Fig. 12 is given for each year on the basis of the data obtained for those periods covered by the road-check procedure. It may be seen that in neither year was information on the total pheasant harvest removed by non-resident hunters obtained for the entire season. However, a compar-



NON-RESIDENT KILL			
1948	%	1949	%
OCT. 16	59.5	OCT. 15	53.1
17	33.3	16	36.9
23	5.0	22	3.2
24	2.2	23	3.9
		29	1.2
		30	1.7

RESIDENT KILL			
1949	%	1949	%
OCT. 15	38.8	OCT. 30	4.9
16	28.9	NOV. 5	4.2
22	4.2	6	0.8
23	10.7	12	3.3
29	4.2	13	0.0

FIGURE 12. DISTRIBUTION OF KILL OF COCK PHEASANTS THROUGHOUT PART OF THE HUNTING SEASONS OF 1948 & 1949.

tively small but complete sample taken from the 1949 card returns of resident hunters showed a trend in the proportion of birds bagged on weekends which parallels that found in the non-resident data. During the checked portions of 1948 and 1949 the bag taken on the first two days of each season represented 92.8 (1948) and 90.0 (1949) per cent. of the total birds killed by transient hunters. This is, no doubt, higher than the true proportion for these initial two days. Nevertheless, an examination of the data pertaining to the distribution of kill by local hunters showed the opening weekend to claim 67.7 per cent. of the season bag of this group. Although considerably less than that found for transients the resident gunners also take a large proportion of their limit of pheasants during the first two days of hunting. Many local hunters apparently avoid shooting on the opening weekend, preferring the less crowded conditions usually found during the week days which follow. From the preceding data it may be inferred that the kill by all classes of hunter during the first two days of the open season lies between 67 and 90 per cent. of the total harvest.

The sharp decline in the number of pheasants taken on the second weekend of hunting was similar in both study years, and was concurrent with a decrease of approximately 30 per cent. in the relative number of hunters and a lessening of individual effort. Pheasants by that time were well scattered and hard to find but the smaller bags should be considered a result of reduced hunting pressure as well as of reduced pheasant numbers.

Composition of the harvest—A classification of the pheasants harvested during each of the open seasons of the two years of investigation was made on the basis of the estimated resident kill and the numbers of birds taken by transient hunters examined at the checking stations. While the total kill as computed from the data in Table XVII may be less than the

actual number of birds removed, an examination of kill distribution (Fig. 12) would indicate this difference to be relatively small.

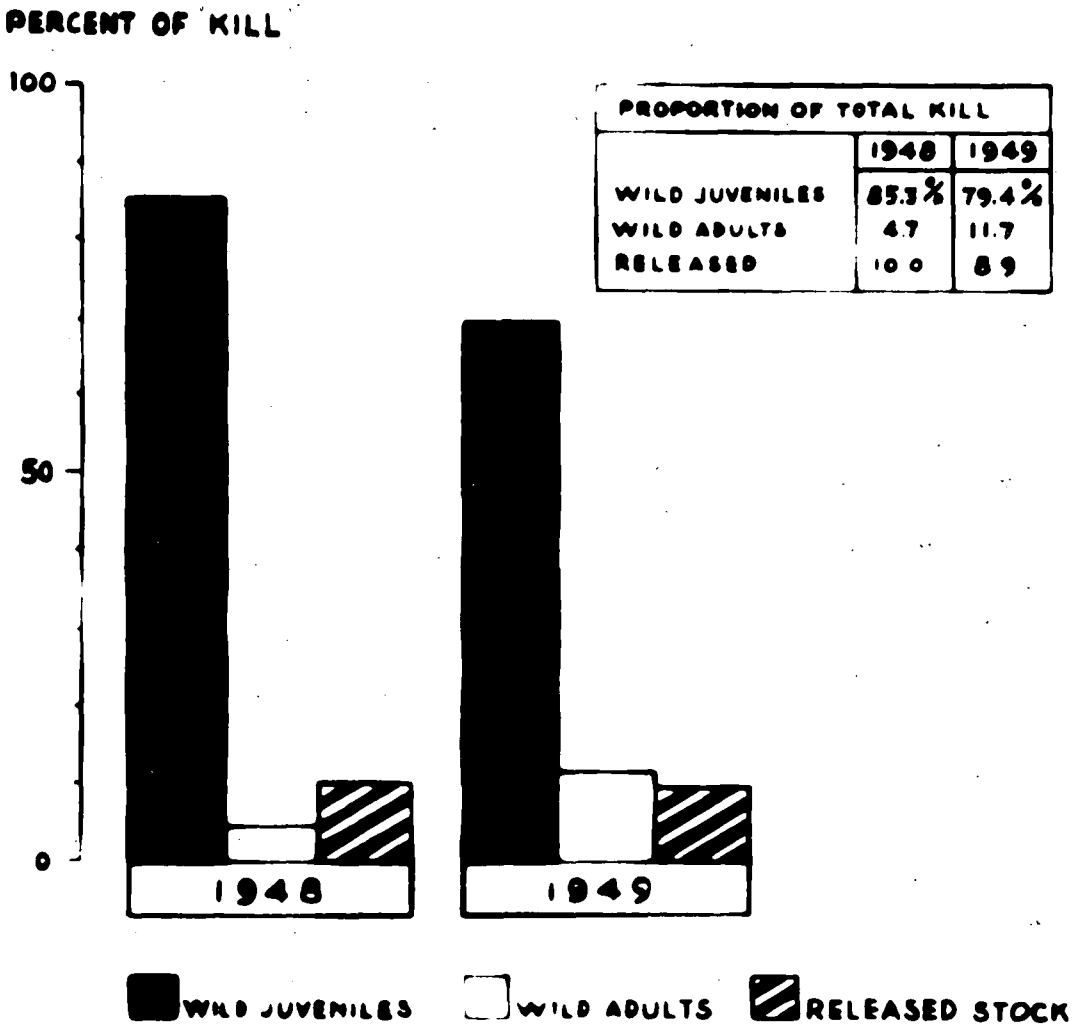
TABLE XVII — Summary of kill where wild and released bird kill are comparable.

	Estimated total kill				Combined total estimated kill			
	Resident		Non-resident					Percent. of
Year	Wild birds	Released birds	Wild birds	Released birds	Wild birds	Released birds	Total	released birds in total kill
1948	2470	286	1646	175	4116	461	4577	10.0
1949	1639	114	1109	156	2748	270	3018	8.9

Comparison of the yield from both years showed a close similarity in the relative numbers of farm-reared to wild pheasants bagged. In 1948, 10 per cent. of the kill consisted of released pheasants; in 1949, 8.9 per cent. were of this class. Figure 13 indicates the source of the shootable fall population and the proportions contributed by each group.

Wild pheasants—The identification of all unbanded birds recovered by gunning as being the products of the "wild" population was quite possibly erroneous. The extent to which farm-reared birds of previous stocking contribute to the over-all pheasant productivity is most difficult to determine. Buss (1946) found evidence of breeding among only 5 per cent. of 224 spring released hens; Ginn (1947) could not determine the complete success of 380 hens released in April but did locate 38 nests from this group. While no evidence of released hens nesting was noted in the Delta study, this does not preclude the possibility of such occurrences. The term "wild" pheasant is used here to describe those birds bearing no evidence, either in appearance or through possession of a leg-band, of game farm origin.

During 1948 and 1949 wild birds contributed most abundantly to the



PROPORTION OF TOTAL KILL		
	1948	1949
WILD JUVENILES	85.3%	79.4%
WILD ADULTS	4.7	11.7
RELEASED	10.0	8.9

FIGURE 13. COMPOSITION OF THE PHEASANT KILL FOR THE HUNTING SEASONS OF 1948 & 1949

total fall harvest. Ninety per cent. of all birds in 1948 and 91.1 per cent. of the 1949 total were of this group. A marked decline in numbers bagged by both resident and non-resident hunters was noted in the latter year. Compared with 1948, the 1949 total of wild birds taken by transient gunners decreased 33.6 per cent., by local hunters 32.6 per cent. To some extent this drop may be attributed to lighter hunting pressure but late summer brood loss appeared to be the primary factor in the reduction.

Age ratios—The ratio of young to adult pheasants killed on the various days bag-checking was enforced was obtained from that portion of the sample consisting of wild birds only. The results for the two years are shown in Table XVIII.

TABLE XVIII — Age ratios of wild pheasants as determined from bag check data.

Day of hunting	1948			1949		
	No. of juveniles	No. of adults	Percent. juvenile	No. of juveniles	No. of adults	Percent. juvenile
First	895	49	94.8	458	114	80.0*
Second	521	26	95.2	241	86	74.6*
Eighth	78	6	92.8	38	1	97.4
Ninth	38	3	92.6	35	9	79.5
Fifteenth	-	-	-	13	1	92.8
Sixteenth	-	-	-	17	4	80.9
Total	1532	84	94.8	802	215	87.2x

*Ratio erroneous due to errors in ageing.
xFirst and second day of hunting not included.

Errors incurred in ageing birds examined on the first weekend of the 1949 season invalidated the use of much of the pheasant kill data as a means of determining age ratios. As a consequence the bag check information from Oct. 15-16, the first two days of the 1949 season, was not in-

cluded in the determination of the relative number of juveniles to adults in the total harvest. The proportion of young in the 1949 season total was based on the smaller but accurately aged samples of the two succeeding weekends.

An examination of the 1948 age ratios indicated a slightly higher proportion of juveniles in the bags taken on the first two hunting days. This may reflect the greater susceptibility of young birds to gunning, in which case the age ratios as revealed by pheasant kill may be slightly biased. Application of these indices in estimating fall population age composition must consider the sex ratio of both juveniles and adults (Petrides, 1949). The proportions shown by the data in Table XVIII were representative of the male population only.

From the 1948 fall check juveniles comprised 94.8 per cent. of all cocks in the bag sample; in the following year the percentage of young dropped to 87.2. Comparison of the age ratios derived from field data (Table XI) and those revealed by the kill return show close agreement in both years. Evidence of reduced rearing success in the 1949 pheasant crop, apparent in the calculated age composition, was corroborated by a measured portion of the shootable pheasant population.

Farm-reared pheasants—The relative abundance of wild to released pheasants in the fall harvest varied but slightly during the two years. In the combined bags of 1948 and 1949 farm-reared birds represented 9.6 per cent. of the total kill. Of this amount 5.2 per cent. were taken by resident hunters and 4.4 per cent. by transients. The latter group in 1949 took 12.3 per cent. of their bag from birds released in that year as compared with the resident hunters' proportion of 6.5 per cent. from the same source. During the 1948 season the relative amount of introduced stock

obtained by each hunter type was approximately equal but a slightly greater number of banded pheasants was taken by the local gunners.

On the basis of actual and estimated band recoveries, the harvested return of cocks was 38.8 per cent. and 22.2 per cent. of the number of male birds liberated during 1948 and 1949 respectively (Table XIX). The occurrence of such a marked decrease in the kill of the released pheasants concurrent with a decline in the bag of wild birds suggests that the adverse factor or factors present on the area during the summer operated generally and not selectively on the groups.

TABLE XIX — Estimated and actual recovery of released birds, 1948-49.

	1948	1949
Total bands recovered from non-resident hunters	199	156
Estimated total bands recovered by resident hunters	286	114
Estimated total bands recovered	485	270
Less bands recovered from 1948 releases		2
Estimated total bands recovered from year's release	485	268
Number of cocks released	1248	1204
Estimated percentage of cocks harvested	38.8	22.2

A marked susceptibility of farm-reared birds to early gunning is revealed by the data in Table XX. It may be seen that the proportion of this group killed on the first two days of the open season in both years is much greater than at any succeeding period. This appears to have resulted from a relatively higher kill of birds liberated late in the summer season and is particularly evident in the 1949 data. The apparent "tameness" of farm-reared pheasants decreased gradually and seemed to persist longer in the larger release concentrations. Birds of one 1948 liberation made on August

TABLE XX — Recovery of released cock pheasants on different days during the open seasons, 1948-49, based on bag check of non-resident hunters.

Day of hunting	No. of released cocks killed 1948	1949
First	111	100
Second	51	44
Eighth	5	1
Ninth	3	6
Fifteenth	-	1
Sixteenth	-	1

12 were seen several times until October 2 still in large numbers and in the same field in which they were first released. On a number of occasions it was possible to approach within ten feet of some individuals that had been released and in the wild for over one week. This partial domestication is no doubt largely responsible for the vulnerability of farm-reared birds during the first day of hunting.

FACTORS AFFECTING REPRODUCTION

From the data presented thus far it is apparent that the factors acting upon pheasant reproduction in the Delta region of the Lower Fraser Valley are both varied and numerous. In few cases is it possible to isolate any one of these influences and attribute to it a quantitative evaluation commensurate with the ultimate success or failure of the population productivity. The two years during which data were collected on the Delta pheasants were dissimilar in many ways. The modifications imposed by environmental variations of season, agricultural practices, and other influences, restricted considerations of those factors except at a superficial level. The importance of any one of these agents may vary from year to year through interaction induced by the shifting of forces already present

or by the appearance of new elements within the biological complex.

Much of the material obtained during the study has been reduced to quantitative expressions of certain factors which enable some comparison of conditions during each of the study years. At best these numerical descriptions are estimates and somewhat incomplete yet their interpretation in conjunction with more qualitative observations may be attempted. The discussions which follow are given on this basis.

Weather—The spring (March to June) of 1948 was slightly colder than normal and, though relatively dry in March, was characterized by an unusually wet period in May coincident with the peak of nest establishment (see Fig. 14). In June conditions were somewhat improved and warm, dry weather during the early part of the month seemed favourable for the hatching season which was by then underway. The first cutting of red clover hay was also begun at that time (June 3) but was halted for almost ten days during the middle of the month by rain and dull weather. The temporary suspension of mowing activities was of doubtful benefit to the ultimate productivity of the nesting season. While the number of successful nests increased with each day of this respite the peak of mowing was delayed until it coincided closely with the peak of the hatching period. Had the weather been more favourable and allowed an earlier mowing peak the initial hatching success and survival of nesting hens might have been greater than that which apparently occurred.

In contrast to the spring of 1948 that of 1949 appeared to be phenologically earlier. A relatively warm, dry period from March to May was accompanied by a nest initiation peak which occurred about May 15, fully two weeks ahead of that in 1948. June of 1949, however, was slightly colder and wetter than usual and rain and dull weather prevailed about the

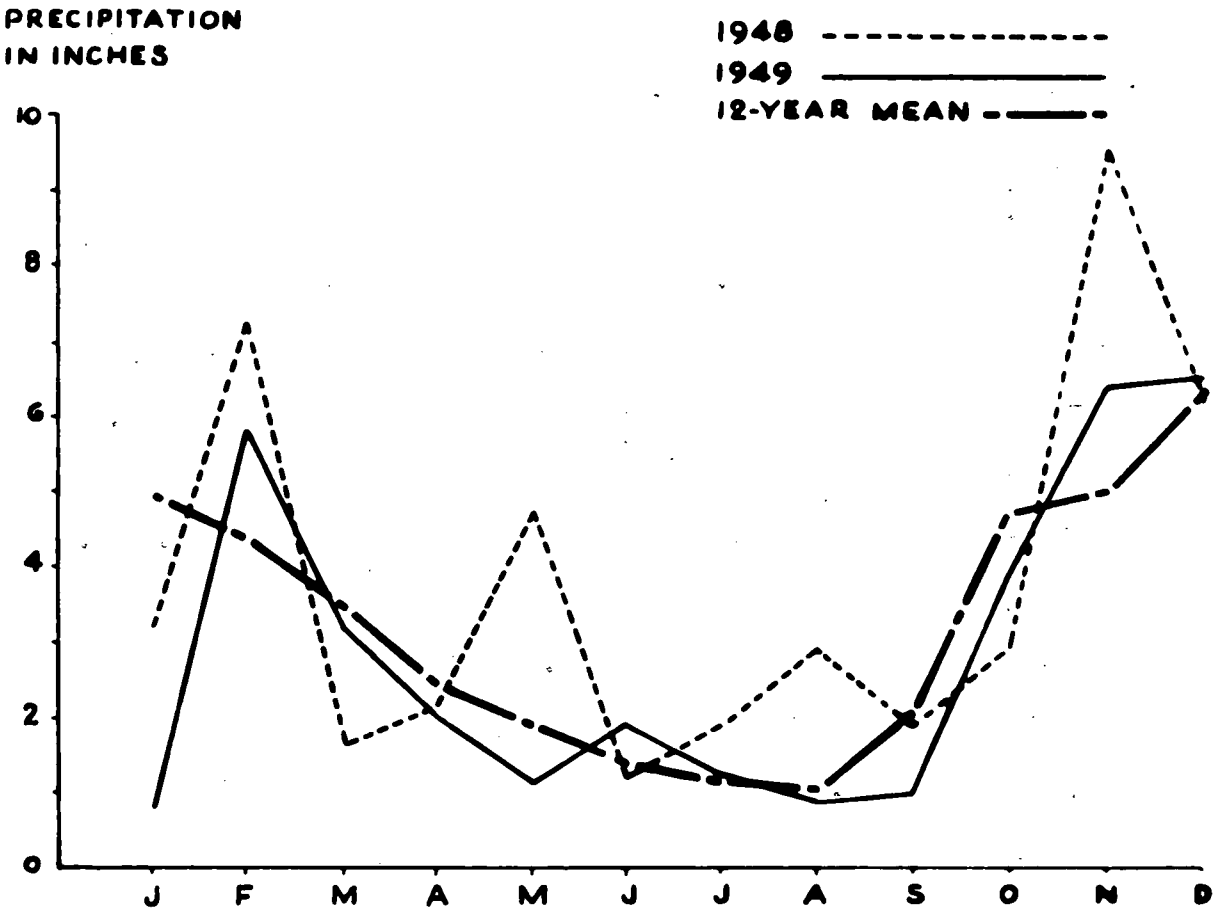


FIGURE 14. PRECIPITATION BY MONTHS, SEA ISLAND

	J	F	M	A	M	J	J	A	S	O	N	D
MEAN	37	40	43	49	54	59	63	62	58	51	42	39
1948	+1	-4	-1	-3	-1	+2	0	0	-2	-3	-1	-5
1949	-8	-6	0	-1	+1	-1	-1	-1	+1	-4	+6	-3

TABLE OF DEVIATIONS OF MONTHLY MEAN TEMPERATURE (°F FROM AVERAGE, SEA ISLAND, 1948 & 1949

time of greatest hatching activity. Mowing was begun at approximately the same time (June 3) as in the preceding year but was more sustained with the peak occurring about the third week of June. Hatching at this point was on the decline and was possibly less affected by the hazards of cutting than in 1948.

It is apparent then that weather, inasmuch as it governs the time and duration of the clover mowing, may have a decided influence on the fate of the early nests. On the other hand, adversely related peaks in nesting and farming practices may be overcome to some degree by later successful re-nesting. This apparently occurred in 1948 and is indicated by the density and success of nests in pea fields and other cover (Table IV) which were believed to be replacements arising through destruction of initial clutches.

The direct effect of weather through disturbance to both nests and hens by continued excessive rainfall may afford a further modification of the reproductive potential in some years. However, as no instances of the flooding of fields and nests due to this cause were noted even for the season of 1948 which experienced the heavier June precipitation of the two years, the implications considered above with regard to weather apply only to the nesting phase of reproduction. The influence on brood survival is considered in a later section.

Sex ratio—The actual sex ratio at any time throughout the year is difficult to obtain. Early spring and fall are the periods best suited to determining the proportions of the sexes (Fig. 15). Between the months of May and October the sex ratio shows fluctuations which follow a basic trend similar in each year reflecting the seasonal changes in the population. Reproductive activities of the hens, physiological post-reproductive changes in the males, and finally the effect of the nesting productivity

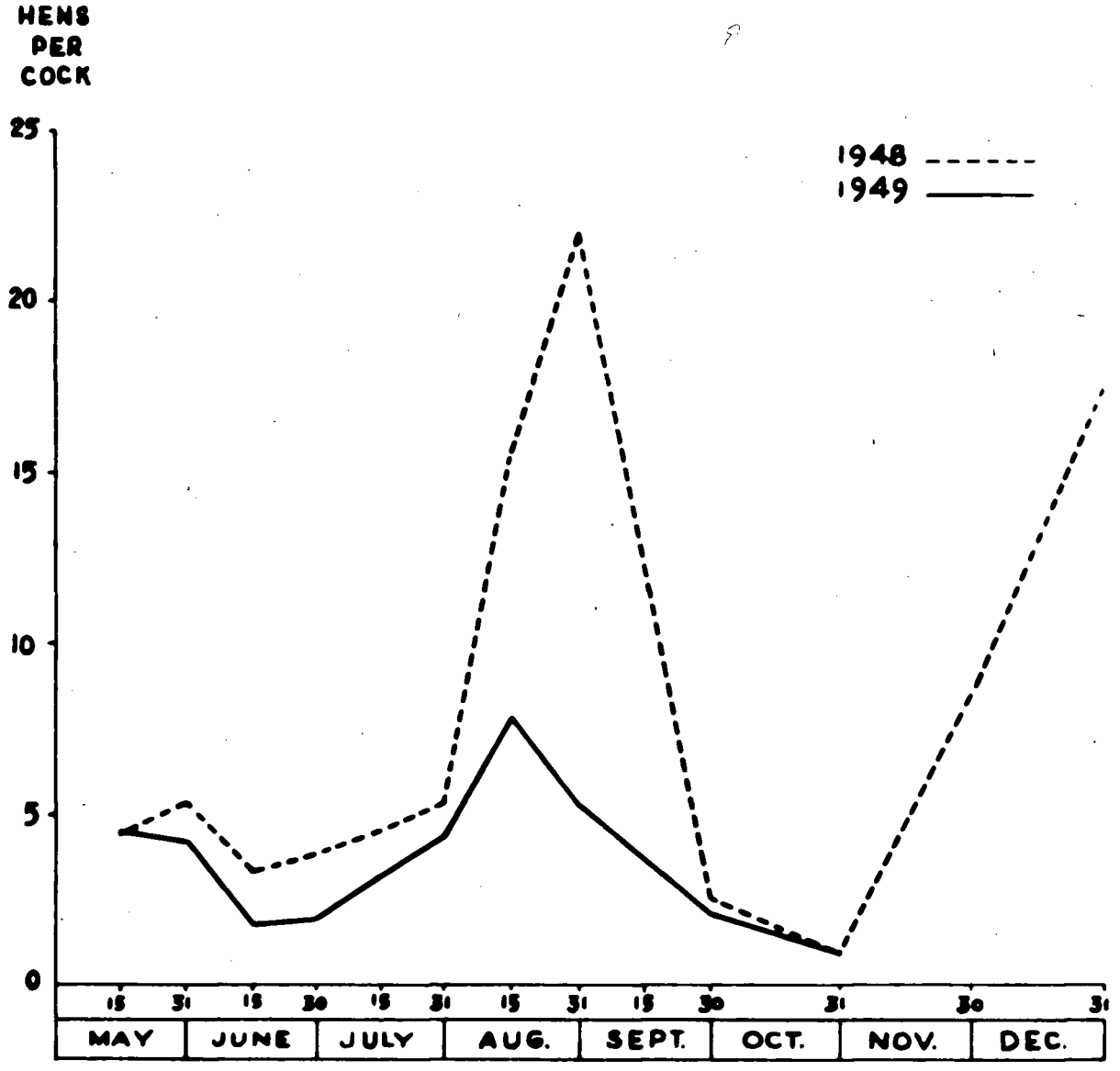


FIGURE 15. BI-MONTHLY SEX RATIOS, MAY - SEPTEMBER & MONTHLY, OCTOBER - DECEMBER FOR 1948 - 1949

all contribute in some measure to these periodic variations. The proportion of hens to cocks at the end of May was 5.4 : 1 in 1948 and 4.3 : 1 in 1949. The ratio, which was general for the area, was considered to be favourable for successful reproduction.

The fertility of clutches might be expected to vary, if at all, with the sex ratio if the disparity in sexes revealed a relatively high predominance of female birds. Instances of such unbalanced situations were noted in only a few sections of the Delta during 1948 though they were not considered sufficiently out of proportion as to be detrimental to reproduction. The highest hen-to-cock ratio maintained for any length of time in a given area was eleven-to-one and occurred during the first study year. The proportion of undeveloped eggs in successful nests in this area did not exceed 5.4 per cent. Sex ratios in 1949 were fairly uniform. Throughout the month of May of that year no area observed on the Delta showed persistently more than seven hens per cock. Investigations by Shick (1947) showed that one cock could serve as many as sixteen hens. Similarly, Twining et al. (1948) demonstrated that one cock could serve successfully fifty hens, and that one mating continued to produce fertile eggs for twenty-one days. Nests examined in all Delta areas showed a high rate of fertility and no significant difference was noted for those sections with higher female numbers.

Of ninety-six eggs found in seven deserted nests, only five were found infertile by the technique described by Twining et al. (1948) for such determination. Hatched nests showed an average minimum fertility of 94.6 per cent. for the two-year period which is believed to be representative of the degree of fertility for all nests.

These data indicated that in either year the spring breeding popu-

lation, with respect to the distribution and proportion of sexes, suffered no deficiencies in cocks sufficient to affect adversely the reproduction. Turning from a direct consideration of sex ratio as a potential effect on reproduction, this factor might also be viewed indirectly from the population data already obtained. Assuming that the productivity estimates in Table X are essentially representative of actual conditions, the maximum number of hens per cock for the 1949 spring population may be estimated as follows:

Estimated fall increment of juvenile hens	4464.5
Estimated number of successful breeding hens	1684.7
Estimated number of non-breeding hens	479.2
Estimated fall population of hens	6628.4
Assuming no loss this number will also equal the estimated (1949) spring hen population.	
Estimated total spring (1949) cock population	553.8

Calculated spring (May) sex ratio = $\frac{6628.4}{553.8}$ = 11.9 hens per cock.

When compared with the most unbalanced area of 1948 in which eleven hens per cock were found, this calculated ratio for the 1949 breeding season need not cause great variation in the relative fertility of eggs produced. However, between the fall and the following spring the reduction of cock numbers through hunting is also accompanied by substantial losses of hens through illegal kill and other winter mortality factors. This would modify the estimated sex ratio towards the lowered hen numbers actually found. It would appear then that the stocking of additional cocks in spring is of doubtful necessity in ensuring a sex ratio compatible with reproductive success.

Nesting loss—The loss of nests in relation to the total number found in the Delta area was high in each year of the investigation. It is doubtful, however, that this was truly indicative of the actual reproductive

failure of the breeding hen population, inasmuch as it is measured as a fraction of the total nesting effort and not as an unsuccessful proportion of nesting hens. That some mitigation of this loss occurred through renesting is made certain by the comparatively high percentage of hens with broods seen during the late summer.

Determination of the exact cause of failure could not be made for the majority of field nests found as most of them were not discovered until after mowing had taken place. Factors actually responsible for nest destruction were identifiable for only a small portion of the unsuccessful clutches examined.

TABLE XXI — Nesting loss factors, 1948 - 1949.

Cause of nest loss	No. of nests lost		Percent. of all nests		Percent. of total loss	
	1948	1949	1948	1949	1948	1949
Mowing	36	76	14.6	18.9	30.7	39.8
Disking	-	2	-	0.4	-	1.0
Burning	-	2	-	0.4	-	1.0
Cattle	1	1	0.4	0.2	0.9	0.5
Desertion (due to mowing and unknown causes	74	93	30.0	25.3	63.2	48.8
Predation	1	-	0.4	-	0.9	-
Compound nests	5	17	2.0	4.2	4.3	8.9
Total	117	191	47.4	49.4	100.0	100.0

The bulk of the loss shown in Table XXI was divided between "mowing" and "desertion" both of which are broad classifications and overlap to some degree. "Mowing" as a loss factor in this study includes only those nests which were in the incubating stage when exposed by cutting; "deser-

tion" comprises those nests which were found with eggs unattended and undeveloped. There were, no doubt, some nests assigned to the latter category whose vacancy could be more aptly attributed to mowing disturbance than to mere abandonment. Similarly, more specific factors such as predation and farm activities other than mowing may have been the primary cause of some of the nest desertion which for the two years averaged 54.2 per cent. of the total loss.

Fig. 16 — Destruction of nest in late incubation through hay field mowing. June, 1949.

Undoubtedly the loss in reproductive effort incurred through farming practices is in excess of that actually observed. In the two years, on the basis of a sample of 622 field nests, mowing was responsible for approximately one-third of the total nesting failure (Fig. 16). Since it was not possible to determine the factor causing the desertion of those nests completely or partly established at the time of crop removal, this estimate is believed low. If the proportion of the nests abandoned through agricultural disturbance were known, the loss to mowing might be greater than the

36.3 per cent. found for the two-year period. The apparently increased effect of this factor in 1949 is somewhat misleading. As the appraisal of mowing destruction was based on incubating nests only, the earlier nesting season of 1949 revealed a relatively greater proportion of such nests at the time of haying than were present in the corresponding period in 1948. The unknown proportion of those nests destroyed in the process of establishment may have placed the actual mowing loss in 1948 above that of 1949.

The toll of nests taken by early plowing, disking, and burning, was comparatively light and with that incurred by mowing brought the known loss of nests due to agricultural practices to 31.6 per cent. and 42.4 per cent. of the total unsuccessful nests in the years 1948 and 1949 respectively.

Predation—The destruction of nests by predators as determined in this study appeared to constitute only a small portion of the total nesting loss. It is not unlikely, however, that many of those nests found deserted were vacated through such disturbing elements. Hawks and crows were the two avian predators most abundant in the area but only the latter species were noted to show much detrimental activity towards pheasant nests. This usually occurred when clutches were exposed by agricultural practices and for this reason the actions of crows were considered more of a scavenging than predatory nature. Farm dogs and cats were also no doubt responsible for nest desertion but only one instance was observed in which loss could be definitely attributed to this group.

Foxes seemed more numerous on the Delta area during the second year of the pheasant study when fourteen of these animals were trapped, shot, or killed by vehicles as against four destroyed by trapping in 1948. No evidence of nest destruction from this source was apparent in either year.

Other sources of loss—Compound or "dump" nests also contributed to a

waste of reproductive effort. The 1948 loss through this factor was almost doubled in 1949 but was not very great in either year. The increase in numbers of compound nests in the latter year appeared to accompany a general increase in nesting density (Einarsen, 1945a).

Coincident with intraspecific communal nesting there was also some evidence of pheasant parasitism of nests of other species. One hen pheasant was flushed from the nest of a blue-winged teal (Anas discours) located among heavy thistle growth on a dyke embankment. Three pheasant eggs were found in an incubating nest of fifteen Hungarian partridge eggs. The nest was ultimately successful, the entire clutch of partridge eggs hatched as did two of the three pheasant eggs (Fig. 17). A third nest found on a ditch bank was noted to contain ten pheasant and seven California quail eggs. Some of the eggs were weathered and suggested an early initiation of the clutch possibly by the pheasant. The nest was unoccupied when found and remained that way throughout the season. These were the only

Fig. 17 -- Hungarian partridge nest containing two hatched and one unhatched pheasant eggs (upper right). June, 1949.

instances of intraspecific parasitism and as such appear to be of no significance in relation to the general nest loss.

Renesting--In spite of the fact that 52.6 per cent. and 50.4 per cent. of all nests found in 1948 and 1949 respectively were unsuccessful, over 80 per cent. of the hens seen in late summer were accompanied by broods. This apparent propensity of pheasants to re-establish their nests after destruction of initial attempts is a major factor in maintaining or increasing the pheasant population level from year to year.

Figure 18 shows the progress of clutch development at the time nests were exposed by mowing operations. The conditions represented in the diagram may deviate somewhat from those which actually existed. The assignment of data to the various bi-monthly periods shown was based on the mowing dates of the fields examined. While this information may hold for incubating nests, it is less tenable for those classified as "established" as many may have been deserted long before their discovery. Similar uncertainty exists for the successful nests, some of which may have been hatched for a considerable time before being uncovered by mowing. Considering only the trends shown for each of the two years, it may be seen that in 1948 most of the nests found in early cutting were either incomplete or in the incubation stage. Hatching which began with some intensity soon reached a peak and was accompanied by a noticeable increase in newly established nests. These nests were believed to be partly the result of renesting which followed earlier nest destruction. In 1949 many of the early nests had been hatched out by the time of the first mowing. The hatching peak was approached more slowly but was passed more quickly than in the previous season. There was no obvious secondary peak in the nesting trend of 1949, which might suggest that renesting during that year was less extensive and

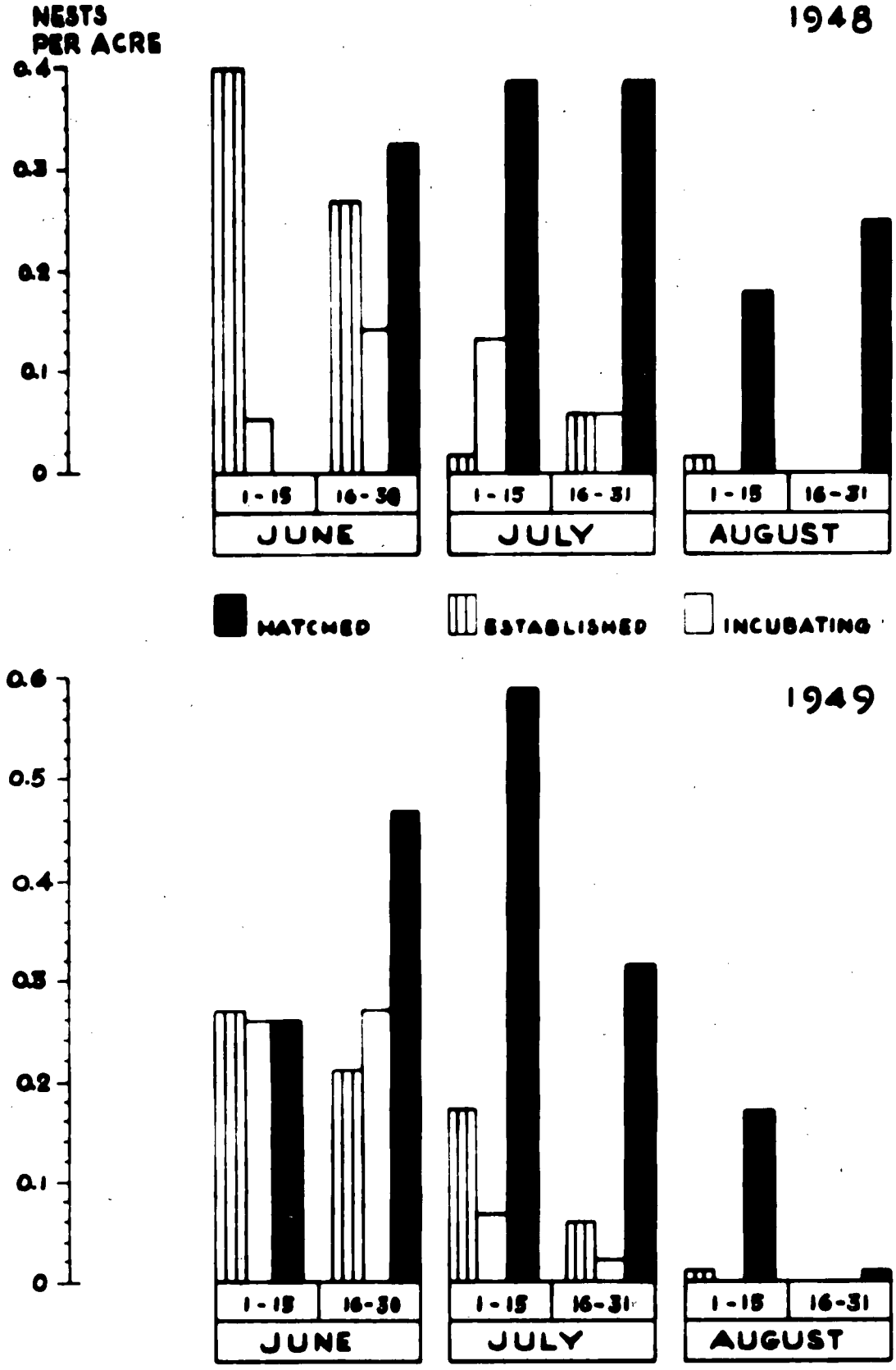


FIGURE 18. NESTING PROGRESS AS SHOWN BY NESTS REVEALED AT TIME OF MOWING. BASED ON 224 FIELD NESTS FOUND IN 1948 & 369 FOUND IN 1949.

more gradually distributed throughout the season.

Loss of nesting hens--The extent to which renesting occurs in the disrupted nesting population is dependant on the physical condition of the birds following the loss of initial nests. Hay field mowing is particularly destructive of both nests and hens. During 1948, 18.6 per cent. of the rearing or incubating females in 237 field nests were killed by mowers. The earlier hatching in 1949 reduced this loss to 11.3 per cent. The mortality of hens on 108 acres of red clover cut during June, 1948, averaged 38.3 per cent. of the monthly nesting efforts. The loss to mowing in the corresponding period of the following year was 16.7 per cent. of the females nesting on 152 acres of early clover. Such mortality may be characteristic of the destruction suffered during early clover cutting and is not implied to typify conditions found later in the other crops.

An early spring might enhance the seasonal reproductive potential through a greater movement of successful hens from the impending hazards of hay field mowing. Even so, the death and injury to hens and their accompanying chicks could through farm practices, reduce this advantage considerably.

A quantitative estimate of the number of young that might have been added to the fall increment had no mowing loss of breeding hens occurred may be attempted for both years as follows (from data in Table X):

	1948	1949
Percent. of nesting hens killed by mower.....	18.6	11.3
Estimated number of breeding hens killed by mower.....	481.8	280.3
Percentage of hens rearing broods.....	81.5	80.1
Number of hens that might have reared broods..	392.6	224.5
Average number of young per brood (August)....	5.3	3.8
Potential number of young lost to fall population through death of hens...	2080.7	853.1

On the basis of the estimated number of young derived from the residual breeding hens, the increment of young would have been increased 23.3 per

cent. and 12.9 per cent. above the calculated fall numbers in 1948 and 1949 respectively.

The above loss was derived from estimates of hen mortality only. No cognizance has been given the additional drain on productivity which may arise through injuries also inflicted by mowing. Loss from this factor is difficult to measure. Further nesting may be inhibited through physical and psychological disturbance of the bird or through an early death depending on the severity of the injury. Hens which had lost one or both feet through mower contact were seen on several occasions returning to the mown fields in search of their surviving chicks. Three crippled hens were seen escorting broods during late summer in 1949.

FACTORS AFFECTING SURVIVAL

In many ways the factors which were noted to have influenced reproduction also extended beyond that period to act upon the survival of post-breeding adults and their offspring.

Brood mortality—Factors contributing to juvenile mortality appear first as a pre-natal loss of developing embryos in hatched nests. On the basis of the number of eggs found in hatched nests Table XXII) this loss contributed a decrease of 3.3 per cent. in the productivity per nest during 1948 and slightly more (4.0 per cent.) in 1949.

TABLE XXII — Fate of eggs in successful nests.

Hatched nest data	1948	1949
Number of hatched nests	130	202
Number of eggs in hatched nests	1117	1734
Number of eggs successfully hatched	1003	1587
Number of unhatched eggs in successful nests	114	147
Unhatched eggs undeveloped	76	76
Unhatched eggs with embryos	38	71
Average clutch size of successful nests	8.59	8.58
Average number of hatched eggs in successful nests	7.71	7.85
Minimum fertility of hatched nests	93.2%	95.7%

Macroscopic examination of embryos showed no anomalies which may have been responsible for this mortality. In some instances development had progressed to within one or two days of hatching, and suggested that hens may on occasion continue to lay eggs for a few days after incubation has been started. It is possible, too, that some pre-natal deaths occurred through temperature variation as a result of inconsistencies in egg-turning and incubation by the hen. In some cases this early loss was believed caused by an extended hatching of the clutches. Two nests were found which had from two to three pipped eggs containing embryos among the shells of the hatched out portion of the clutch. Within eighteen inches of the nest were found the mowed-over carcasses of one- to two-day old chicks and the adult hen.

The loss in juveniles from the time of hatching until they are approximately three weeks of age appeared to be proportionately greater than for any other period. Hay cutting activities, which were at their height almost coincident with the peak of brood emergence, took a high toll of young birds.

Fig. 19 -- Day-old chicks killed by mowing. June, 1949.

In the harvesting of the pea crop which followed soon after haying, a further destruction of growing chicks augmented the seasonal mortality. Individual broods might be drastically reduced in numbers or entirely destroyed as a result of the mowing of both these crops (Fig. 19). Death or severe injury to the hen would be tantamount to an early decimation of orphaned chicks through increased vulnerability to exposure and predation.

For the two seasons considered in this study the average number of young leaving the nest was 7.8. By the end of three weeks this average brood had been reduced by almost two birds or 24.3 per cent. of the initial number. Once beyond this early stage, the chances of survival became greatly improved. The loss for birds of eight weeks or over was only slightly below that for those of the three to seven weeks of age group. Some deviation from this mean trend may be seen from the data in Figure 20. Here the average brood size for birds of eight weeks and over showed a considerable decrease from that of the preceding season and a lesser but noticeable decrease from the two-year mean. This decline was first noticed in early July but became most apparent about the beginning of August. No evidence in the form of dead birds could be found to account for the apparent reduction in numbers. The usual hazards of inclement weather and agricultural activities seemed much less severe during 1949 than in the previous year.

Weather—As a factor affecting brood survival weather is possibly more direct in its action than it is with respect to nesting success. The complications induced by agricultural routine which accompanied changes in early spring weather were less apparent during the brood rearing season of the summer months. Heavy rainfall about the time of hatching may cause the death of chicks through chilling and the reduction of available insect

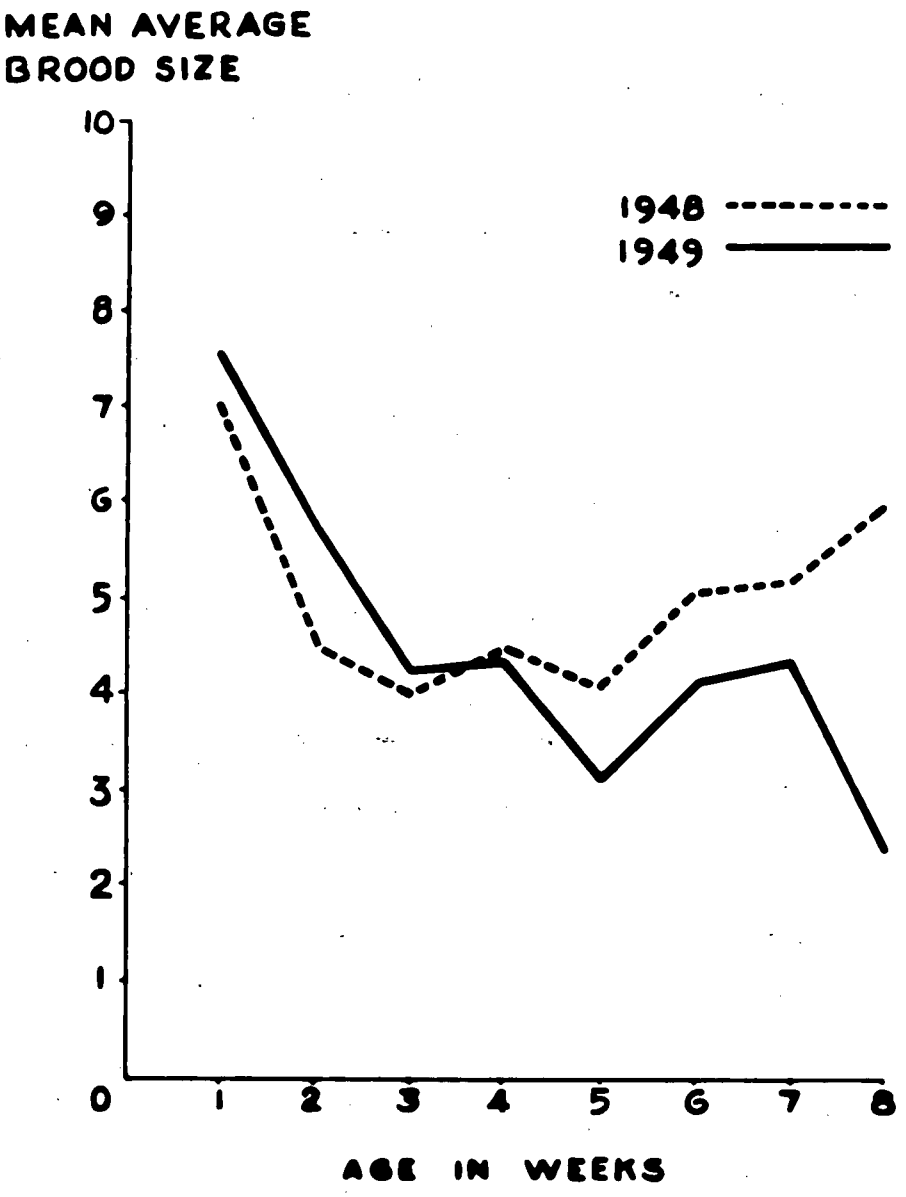


FIGURE 20. SIZE OF BROODS WITH AGE. BASED ON THE MEAN OF AVERAGE BROOD SIZE. 1948 & 1949

food (Eklund, 1942). Mortality of this nature, if it occurred at all, might have been expected during July and August of 1948. From Fig. 14 it may be seen that for these two months precipitation was from one to two inches above the twelve-year normal. By contrast both July and August of 1949 were much drier than in the previous year with little deviation from the normal trend.

Had weather been responsible for a marked reduction in young birds a substantial decrease in brood size early in the rearing season might have occurred. When weather conditions are considered with respect to the average number of young per successful hen during the time chicks might be most vulnerable (June to July), it would appear that in 1949, at least, such a premise is not tenable. The loss per average brood from June to July, 1948, was 1.6 young, whereas under the drier conditions of the same two months of 1949 the loss was 2.6 young per brood. Weather in this instance appears to be a subsidiary factor in the mortality of juveniles; the major cause is probably some other combination of decimating elements.

Predation—The effect of predation on the juvenile population as a whole was difficult to measure. Circumstantial evidence often provided the only data from which this loss might be estimated. The witnessing of predatory acts was relatively uncommon and during the Delta study the only successful instance noted was the attack of a marsh hawk on a young pheasant of four to five weeks of age. Dogs running the fields were seen to flush and chase chicks on several occasions. Cats, too, were seen daily hunting along the fence rows and field boundaries; actual attacks on broods by these animals were seen on four occasions. During 1949 the number of red foxes seen and killed on the Delta was at least fourteen, considerably more than were noted in 1948. The extent to which these animals prey on

TABLE XXIII — Causative factors in the mortality of 135 wild pheasants in 1948.

	Mortality factor														
	Mowing			Predation			Traffic			Hit fence			Unknown		
	Adult			Adult			Adult			Adult			Adult		
Month	M.	F.	Juv.	M.	F.	Juv.	M.	F.	Juv.	M.	F.	Juv.	M.	F.	Juv.
June	-	26	16	-	-	-	-	-	-	-	-	-	1	-	-
July	-	17	33	-	-	3	-	1	5	-	-	-	-	-	-
August	-	3	17	-	-	3	-	3	3	-	-	-	-	-	-
September	-	-	-	-	-	1	-	-	2	-	-	1	-	-	-
Total	-	46	66	-	-	7	-	4	10	-	-	1	1	-	-
Percent. of total mortality	82.9			5.1			10.3			0.7			0.7		

TABLE XXIV — Causative factors in the mortality of 126 wild pheasants in 1949.

	Mortality factor														
	Mowing			Predation			Traffic			Drowning			Unknown		
	Adult			Adult			Adult			Adult			Adult		
Month	M.	F.	Juv.	M.	F.	Juv.	M.	F.	Juv.	M.	F.	Juv.	M.	F.	Juv.
May	-	1	-	3	4	-	-	-	-	-	-	-	-	1	-
June	-	35	33	-	-	-	-	1	5	-	-	5	-	-	-
July	-	7	18	-	1	-	-	-	2	-	-	-	-	-	1
August	-	3	-	-	-	1	-	-	2	-	-	-	-	1	-
September	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
Total	-	46	51	3	5	1	-	1	11	-	-	5	-	2	1
Percent. of total mortality	76.9			7.3			9.5			3.9			2.4		

the local pheasant population is not known.

From Tables XXIII and XXIV predation in the Delta region was of similar intensity in both years and seemed to comprise a comparatively small portion of the total juvenile loss in wild birds. It should be noted, however, that the estimate was based on a minimum of data and is no doubt lower than actually existed. The loss to this factor was most conspicuous for farm-released juveniles in almost every month of liberation during 1948 and 1949.

Traffic—Mortality due to highway traffic ranked second as a factor operating against the survival of young birds and appeared to take greatest toll of the older juveniles. The highest number of deaths from this cause occurred mainly on the primary roads where traffic was comparatively heavy. Deficiencies of grit and gravel in the alluvial soil of the Delta area cause many pheasants to seek these materials from road sides where they may on occasion suffer injuries or death from passing vehicles.

Accidents—Miscellaneous accidents and unknown causes of death were found to some extent during each season. In 1949 five chicks were found drowned in roadside drainage ditches (Fig. 21).

A summary of the known mortality of wild birds found during the two-year period of investigation is given in Table XV.

TABLE XV — Summary of mortality, 1948 - 1949.

Cause of mortality	Number of birds lost	Percent of total mortality
Mowing	209	80.0
Traffic	26	9.9
Predation	16	6.2
Drowning	5	1.9
Hit fence	1	0.4
Unknown	4	1.6
Total	261	100.0

Fig. 21 -- Chicks drowned in drainage ditch. June, 1949.

Post-release mortality of farm-reared pheasants--Following each release of farm-reared pheasants a search for possible casualties was made about the individual points of liberation. This was begun the day after liberations were made and continued at two or three day intervals for one or two weeks.

In almost all areas which were examined closely some loss of released pheasants was evident. From the data in Table XXVI it may be seen that the known casualties were very similar in their total as a proportion of the numbers liberated each year and also in the percentage loss for each sex.

TABLE XXVI -- Farm-reared pheasant loss as a percentage of total release (based on post-release recoveries other than hunting.

Year	Loss percentage		
	Cocks	Hens	Total
1948	3.9	6.0	4.9
1949	3.6	5.0	4.5

A slightly higher mortality for hens as compared to cocks seemed typical throughout the two years of study. Known losses for individual releases during 1948 ranged from 2 per cent. to 28.3 per cent. and averaged 4.9 per cent., and from 2 per cent. to 26 per cent. with an average of 4.5 per cent. in 1949.

TABLE XXVII -- Mortality of farm-raised pheasants, 1948 - 1949, from recoveries made post-release and prior to hunting season.

Cause of loss	Percent. of year's loss 1948	1949	Percent. of total loss 1948 & 1949
Predation	83.9	26.3	53.6
Dogs	76.4	2.7	36.8
Cats	4.7	-	3.2
Hawks	2.8	3.5	3.2
Foxes	-	13.1	6.8
Unknown	-	7.0	3.6
Accidents	12.3	15.7	14.5
Cultivating	-	0.9	0.4
Mowing	6.6	-	3.6
Highway traffic	2.9	5.3	4.1
Drowning	1.9	5.2	3.6
Striking fence	0.9	4.3	2.8
Release casualties	1.9	10.6	6.4
Striking fence	0.9	0.9	0.9
Unknown	1.0	0.9	0.9
Poor condition	-	8.8	4.6
Unknown	1.9	47.4	25.5

Table XXVII lists the factors and the extent to which they were believed responsible for the death of the birds recovered between the time of release and the hunting season. Predation was revealed as the most severe of all decimating agents during both years. The relative intensity of this factor seemed greatest in 1948 and was due largely to the attacks of dogs on two groups of liberated birds. In one instance seventy out of 247 pheasants were found dead within a radius of 300 yards of the point of

release, all bore evidence of dog attacks. Losses of this nature were reduced considerably during the following year by the vigilance and efforts of Game Warden Cameron in enforcing control of farm dogs.

Cats and hawks also contributed to the destruction of released pheasants. The proportion represented by each of these animals in Table XXVII is believed to be minimum. Many dead birds were found partly eaten and though predation by hawks was often suspected they could not always be identified as the primary cause of pheasant death. In 1949 red foxes were believed responsible for most of the released birds lost to predators.

The vulnerability of farm-raised pheasants during their early adjustment to the wild environment was relatively high. In comparison with wild pheasants they were particularly susceptible to predation in all forms.

The proportion of deaths due to accidents suffered by pheasants after their release was approximately the same during both 1948 and 1949. Loss to highway traffic averaged 4.1 per cent. of the total mortality known to have occurred in the two years and was highest in 1949. Mowing was known to have claimed eight birds in 1948 but was absent as a destructive factor affecting releases of the second year. This may have resulted through attempts to avoid the mowing hazard by making no liberations during July, the month of most pea and hay field cutting. In general the heaviest losses to mowing were sustained by the wild birds during removal of early hay crops.

Casualties witnessed at the moment of release were probably fewer than the number which actually occurred. Only two fatalities were observed which resulted from striking fences, though a number of dead birds bearing lacerations and bruises which may have been caused by contact with barbed wire were found in fence rows. Ten birds recovered from the first June release of 1949 showed no sign of injury externally or internally. All were

badly feather-picked about the back and none seemed in good flesh. This condition was probably aggravated by wet weather at the time of release and death may have been due ultimately to exposure.

The mortality due to unknown causes averaged over 25 per cent. of the total loss and was particularly high during 1949. A portion of this mortality may have resulted from predation but proof of this was not conclusive.

Spraying--The marked decline in the late summer brood size of the Delta pheasants resulted in a noticeable reduction of the 1949 fall population as compared with that of 1948. No evidence was obtained which might explain or indicate the cause or causes responsible for the lowered productivity. A number of farmers throughout the Municipality were of the opinion that the widespread and increasing use of chemical sprays and dusts used in the control of plant and insect pests have had a deleterious effect on the local pheasant population. This might occur through the reduction in the food available to chicks as a result of diminished insect numbers, or through direct contamination and poisoning by certain spray or dust types.

Spray application begins as early as April and is maintained with varying intensity throughout the spring and summer until early August, depending on the nature and severity of the pest afflictions of the different seasons. Potatoes are usually the crop first treated and for almost twenty years the controlling agent used was a dust compound containing calcium arsenate. Within the last five years new mixtures employed for the eradication of potato blight and potato beetle have featured a straight 5 per cent. DDT dust in early applications followed by a 7 per cent. fixed copper dust with a starting dose of 15 pounds per acre. The number of

dustings varies from five to seven for the season and may be applied by aircraft or by mechanical tractor-drawn dusting machines.

Pea crops subject to aphis infestations are also treated with DDT compounds during the month of June.

Though no quantitative data were obtained for the intensity of spraying during the two years studied, general observations indicated that this practice was less extensive in the area during 1949. Weather conditions during that year were drier and less conducive to development of potato blight than in the previous season. Pea aphis attacks were comparatively light in 1949 and pea crop spraying was reduced markedly from that required in 1948.

Grain aphis appeared in the oat crops in late July and August in 1949 marking the first appearance of this pest in the area for a number of years. Spraying with DDT compounds was undertaken by a few farmers as a control measure but the acreage so treated was relatively small.

During August, 1949, attempts to eradicate heavy roadside growths of blackberry vines by the use of a liquid spray containing 2,4-D, and 2,4,5T were made throughout the western half of the Delta. The direct effect of this operation on the pheasants was not determined but the indirect effect through loss of protective cover might be of some consequence.

The increasing use of chemical compounds as agents in controlling plant and insect pests on the Delta requires further study before their influence on pheasant survival can be appraised. While it is possible that spraying may have contributed to the local pheasant decline the evidence of reduced activity for this practice in 1949 suggests that the loss may have been due to some other factor or factors.

Hunting pressure—The greatest known mortality of Delta pheasants is

that which constitutes the legal harvest of cock birds during the fall hunting season. Hens, in spite of complete protection by law, also suffer through error, accident, or design, some annual reduction in numbers during this period.

Information obtained through hunter bag checks enabled an estimate of survival for adult and juvenile wild birds of one sex and also for farm-reared cocks released during the study periods.

The graphed data derived from the annual sale of firearms licenses to Vancouver and New Westminster hunters is given for the years 1918 to 1948 inclusive (Fig. 22). The trend is believed applicable to the area inasmuch as a large proportion of the hunting on the Delta is done by this group. Also included in the diagram is a quantitative representation of the population status of the pheasants in the Lower Fraser Valley for those years in which the information was available. The latter data have no quantitative basis and comparison between widely separated years is not possible. This information was obtained from post-hunting season reports as presented in the annual reports of the British Columbia Game Commission for the years in question. The status of the population is depicted for the fall season only and is classified broadly as "good," "fair," or "poor" according to the general hunting success.

It will be noted that the curve representing hunting pressure (license sales) shows some corelation with world political and economic conditions. The years immediately following the termination of World Wars I and II are characterized by marked increases in hunter numbers due, no doubt, to the return of a large number of service personnel and to the increased availability of guns and ammunition. The years of world economic depression are also reflected in the trend of hunter numbers which declined from 1932 to

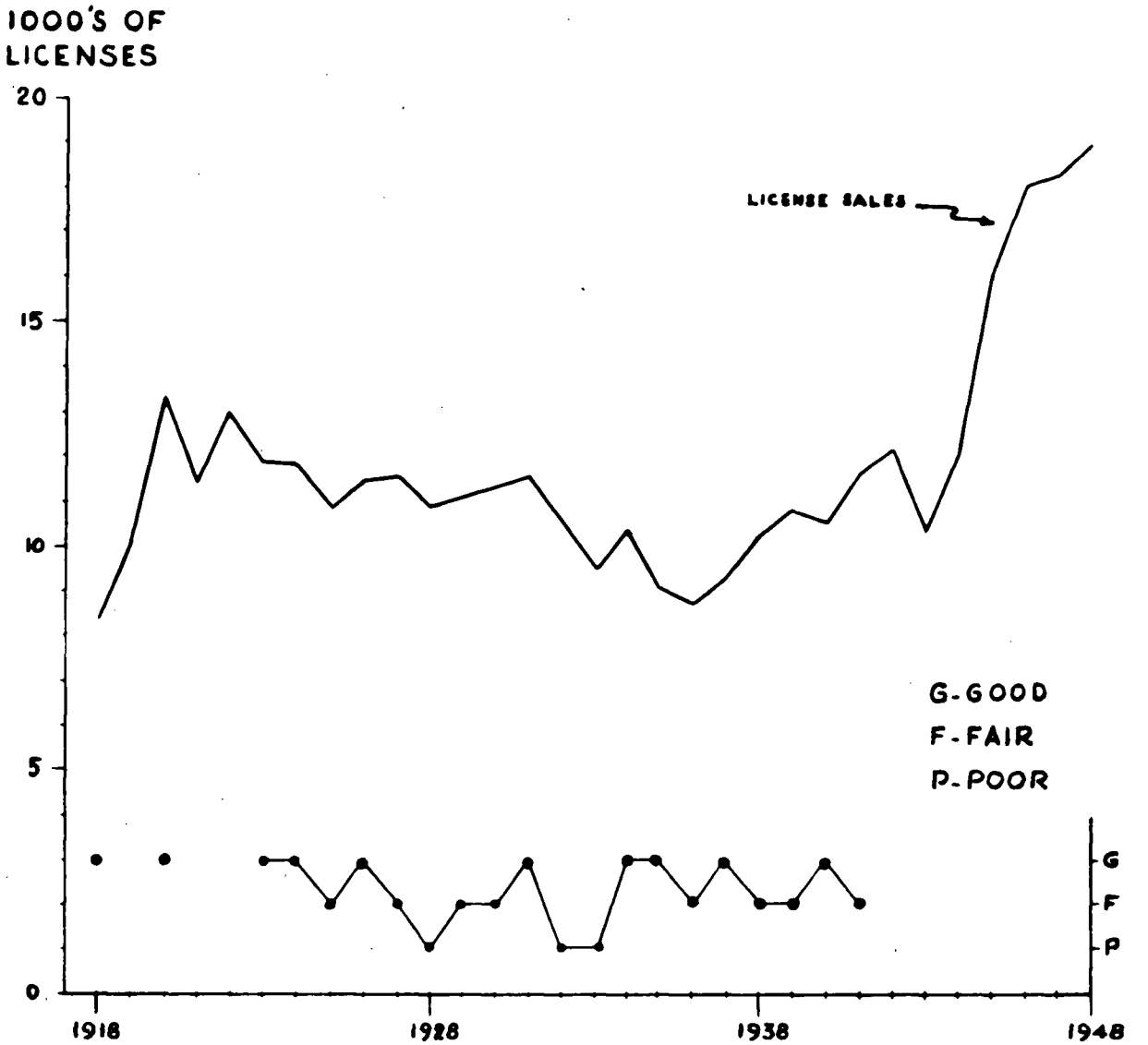


FIGURE 22. TREND IN SALE OF HUNTING LICENSES FOR NEW WESTMINSTER & VANCOUVER (COMBINED) 1918 TO 1948 WITH A QUALITATIVE ESTIMATE OF THE PHEASANT HUNTING FOR THE YEARS GIVEN.

1937. Considering the hunting pressure and the status of the pheasant population as they appear during each year (Fig. 22) it would seem that some degree of correlation exists between shootable pheasant numbers and hunting intensity. This was also noted during the 1949 season recently completed and may be explained in part at least by possible hunter reaction to pre-season indications of pheasant abundance. Such reports seem to circulate widely among the hunting fraternity and a "poor" pre-season showing of pheasants may effect some decrease in the hunter numbers.

Also apparent in the trend revealed by the annual sale of licenses is the rapid increase in hunting pressure during the last four or five years. The combined total of licensed hunters in the Vancouver and New Westminster districts showed an increase for 1948 of 58 per cent. over the number issued in 1944. If the number of pheasant hunters has also risen in proportion, it might be expected that the added pressure has contributed considerably to a decline of the pheasant population. However, data relative to pheasant and hunter abundance obtained during the two years covered by this study are not in complete accord with this assumption.

An examination of the kill of wild birds and the relative hunting pressures of the two years indicates that 83 per cent. of the 1948 and 71 per cent. of the 1949 estimated fall populations of cocks were removed in the open season. The greater harvest of 1948 might be attributed to heavier hunting density particularly during the opening weekend. Hunter success it will be noted, was only slightly higher for this period than it was for the corresponding first two days of the 1949 season (Table XIII). Comparison of the second weekends of the two years, however, showed that in 1948 a smaller number of hunters afield had twice the success in birds bagged than was evident for the same period of 1949. Since the population size

of 1949 was noticeably lower than that of 1948, it might be inferred that hunting pressure is effective until depletion of the initial fall cock population reaches a certain per-acre density. In a year when birds are abundant the kill may be high until this level is reached. Below this point, which may occur soon after the first weekend, the existing hunting pressure is relatively ineffective. This might account for the situation in 1949 when the pre-hunt number of pheasants was low. In that year the proportion of the fall pheasant crop harvested to reach this per-acre density would be lower than was the case during 1948. That it was so suggests that hunting pressure as distributed throughout both the seasons covered by the study does not appear to be a factor adverse to the survival of the male population of the Delta pheasants. More information is required, however, to confirm this premise.

From the sample of returns received from the resident hunters covering the 1949 season, the number of cocks crippled amounted to 19.8 per cent. of the reported bag total. The actual extent of this loss is not readily determined as the number of birds which are wounded and escape may be killed and recovered at some later date. If the harvest of birds can not exceed the minimum necessary for population maintenance, crippling may be most serious as a loss of game to the hunter.

Hunting survival of farm-reared birds—The survival of released birds from the first to the second year of this study appeared to be very low. Of 1,283 cocks released in 1948 only two were known to have been recovered during the open season of 1949.

Hunting recovery and survival of age groups—The proportion of cocks recovered from the various age classes of male pheasants released in 1949 is given in Table XXVIII. The data are not truly comparable throughout

TABLE XXVIII — 1949 released pheasant hunting recoveries from age groups.

Age group	No. of cocks released	No. of cocks recovered	Percent. of age group recovered	Approximate no. of days in field*
Yearling adults (spring released)	154	16	10.3	207 to 221
18 to 19 weeks	200	41	20.5	21 to 22
16 to 18 weeks	75	22	29.3	21
16 weeks	75	24	32.0	22
12 weeks	178	21	11.8	46 to 47
11 weeks	472	34	7.2	49 to 110
9 to 10 weeks	50	4	8.0	107 to 109

*Measured from date of release to opening day of hunting season.

inasmuch as the proximity of liberations to the hunting season and, in some cases, the physical condition of the birds varied to some degree. The late releases in September consisted entirely of birds of sixteen to nineteen weeks of age and the generally high return from this group is no doubt a result of the short interval between stocking and shooting.

The highest return of farm-reared cocks was noted for the sixteen week old class; 32.0 per cent. of the number liberated was recovered during the hunting season. These birds though relatively small in size appeared to be well-feathered and physically superior to those of other releases. They were supplied by a game farm which strives, through diet and care in rearing, to produce an active bird of good plumage. Similar success was apparent in the group consisting of sixteen to eighteen week old pheasants.

The harvest of the eighteen to nineteen week old stock was lower than for other groups released in the same late period. Physical condition of this class at the time of liberation did not appear to be equal to that of

sixteen to eighteen week old birds.

The comparatively poor return from the eleven week old class might be attributed, in part, to the longer exposure to decimating factors of the wild inherent in early releases. The higher proportionate return of spring-released adults liberated in March would appear to contradict this view but the general vigor and good condition of these birds may have helped them to withstand better the hazards of a long period of establishment. Many of the June released eleven week old birds were handicapped by being feather-picked and exposed to inclement wet weather at the time of liberation.

The birds of twelve weeks of age were liberated at the end of August and during the hunting season 11.8 per cent. of their numbers were taken by hunters. Their survival as indicated by the proportion harvested does not appear to be significantly favourable when compared with that for the nine to ten week old birds released at the end of June. This latter group seemed to be in better physical condition than the twelve week old juveniles, a fact which may have had more bearing on their ultimate success in the wild than did their age.

Hunting recoveries as a percentage of release months—Excluding the March release of adults made in 1949, the early (June) liberations of both years show the smallest proportionate return of birds bagged in the open season (Table XXIX). The month of July in 1948 contributed the largest fraction of birds released in any period of that year but no comparison can be made for the same period in 1949 as liberations were withheld. August plantings in both years showed a higher survival of birds than those made in June. Similarly, the September liberations were more productive in 1948 and 1949 than were those of August.

In summary, in so far as age, condition and time of release of birds

TABLE XXIX — Hunter kill of released cocks on the basis of all bands recovered during hunting season.

1948				1949			
Date of release	No. cocks released	No. cocks recovered	Percent. recovered	Date of release	No. cocks released	No. cocks recovered	Percent. recovered
				Mar. 8	17	2	1.1
				Mar. 9	70	4	5.7
				Mar. 11	16	2	1.2
				Mar. 22	51	8	15.6
				Total	154	16	10.3
June 30	53	5	9.4	June 27	100	8	8.0
				June 28	100	6	6.0
				June 30	150	9	6.0
Total	53	5	9.4	Total	350	23	6.5
July 13	19	4	21.0				
July 30	99	20	20.2				
Total	118	24	20.3				
Aug. 3	120	22	18.3	Aug. 26	100	5	5.0
Aug. 6	100	25	25.0	Aug. 27	75	10	13.2
Aug. 10	100	18	18.0	Aug. 29	100	11	11.0
Aug. 11	90	-	-	Aug. 30	75	11	14.6
Aug. 12	150	35	23.3				
Aug. 23	157	4	2.5				
Total	717	104	14.5	Total	350	37	10.5
Sept. 3	160	23	14.3	Sept. 23	175	43	24.5
Sept. 13	150	19	12.6	Sept. 24	175	44	25.1
Sept. 16	50	15	30.0				
Total	360	57	15.8	Total	350	87	24.8
Unidentified bands		9		Unidentified bands		3	
Season total	1248	199	15.9	Season total	1204	166*	13.7

*Includes 8 bands recovered by resident hunters.

is concerned, it would appear from pheasant kill data obtained in this study that relatively higher recovery of birds is made as the liberations approach the open season. The physical condition of birds on release is of prime importance at any time regardless of age. A true estimation of age-at-release as a factor in the ultimate survival of pheasants is difficult to make unless liberations of equal numbers of birds of different age groups can be made simultaneously at regular intervals throughout the season. This was not possible in the study because of the difficulty in obtaining the numbers and age classes of birds required. Time also had to be considered so that birds might be sufficiently developed to warrant shooting during the fall hunting season. This graded introduction, necessary to ensure maturity at hunting, precluded comparison of age classes because not all classes had been equally subject to the succession of hazards at the different stages of the season.

Success of release methods--Data on recoveries of pheasants released by the two different methods previously described are presented in Table XXX. Releases were comparable in numbers and sex of birds for both "day" and "night-gentle" methods. In certain areas agricultural activities did not permit liberations during all months, consequently some sites received more birds than others.

Mortality varied considerably with both the time and place of release but at six of the eight sites and in all months, losses for the "night-gentle" technique were significantly lower than were those for the "day" method. This latter type suffered some degree of loss in fourteen of the fifteen liberations, while the "gentle" method showed casualties in only ten. The range in mortality was from 2.0 to 20.0 per cent. in individual "day" introductions and averaged 8.7 per cent. for the season. For the

TABLE XXX — Comparison of post-release mortality of release types by release site in 1949.

Release site locality	Date	Day release			Night release		
		Number released	Number recovered	Percent. recovered	Number released	Number recovered	Percent. recovered
Crescent Island	June	50	2	4.0	50	0	0.0
	Aug.	50	10	20.0	50	13	26.0
Total		100	12	12.0	100	13	13.0
Parmiter Road	June	62	2	3.2	50	1	2.0
	Aug.	50	6	12.0	50	0	0.0
	Sept.	50	2	4.0	50	1	2.0
Total		162	10	6.1	150	2	1.3
Green Road	June	50	3	6.0	50	1	2.0
	Aug.	50	10	20.0	50	2	4.0
Total		100	13	13.0	100	3	3.0
Fairview Road	June	38	4	10.0	50	0	0.0
	Aug.	47	9	19.1	53	2	4.0
Total		85	13	15.2	103	2	1.9
Wellington Rd.	June	50	3	6.0	50	1	2.0
	Aug.	50	7	14.0	50	2	4.0
Total		100	10	10.0	100	3	3.0
Mason Road	June	50	2	4.0	50	3	6.0
	Sept.	50	0	0.0	50	0	0.0
Total		100	2	2.0	100	3	3.0
Grauer's farm	Aug.	50	4	8.0	50	1	2.0
Imperial Road	Aug.	50	1	2.0	50	0	0.0
Total		747	65	8.7	753	27	3.5

"night-gentle" releases this loss ranged from 2.0 to 26.0 per cent. and averaged 3.5 per cent. for the three months. Hence, the net result on the basis of early post-release recoveries proved the "night-gentle" technique to be over two and one-half times more successful in introducing farm-reared pheasants to the wild than was the ordinary "day" procedure. No experiments were conducted to determine whether the nocturnal element or the gentleness was the improving factor.

A number of "day" released birds were found dead in fence rows and on field edges within a radius of 150 yards of the release sites. None revealed any evidence of external injury. Closer examination, however, showed that many birds bore contusions and several had suffered broken ribs. These were believed to have resulted from shock and heavy uncontrolled landing after flights from the release crates.

From observation it appeared that the marked absence of violence in "gentle" liberations had some effect in reducing physical injuries which might sooner or later prove fatal to the birds. Day releases of this type might be found to be equally successful and if so, would be more expeditious than the night method.

Comparison of the survival of birds released by the "day" and "night-gentle" methods as revealed by hunting kill may be made from the data in Table XXXI. The total known recovery of "night" released pheasants by hunters in the 1949 open season was proportionately higher than for "day" released birds. Of fifteen liberations of each type, paired with respect to time, location, and numbers introduced, eight showed a greater recovery of night released stock. The kill as a proportion of the number of cock pheasants released throughout the season at eight different sites is also compared in the Table. Here it may be seen that the bag derived from

TABLE XXXI — Comparative success of release types by sites in 1949 as shown by hunter kill of cocks only.

Release site locality	Release month	Day release: Cocks released	Day release: Cocks recovered	Day release: Percent. recovered	Night release: Cocks released	Night release: Cocks recovered	Night release: Percent. recovered
Crescent Island	June	25	1	4.0	25	0	0.0
	Aug.	25	0	0.0	25	1	4.0
	Total	50	1	2.0	50	1	2.0
Parmiter Road	June	37	1	2.7	25	2	8.0
	Aug.	25	3	12.0	25	1	4.0
	Sept.	25	8	32.0	25	11	44.0
	Total	87	12	13.8	75	14	18.6
Green Road	June	25	0	0.0	25	2	8.0
	Aug.	25	1	4.0	25	0	0.0
	Total	50	1	2.0	50	2	4.0
Fairview Road	June	13	2	15.3	25	1	4.0
	Aug.	25	1	4.0	28	4	14.3
	Total	38	3	7.9	53	5	9.4
Wellington Rd.	June	25	3	12.0	25	3	12.0
	Aug.	25	3	12.0	25	6	24.0
	Total	50	6	12.0	50	9	18.0
Mason Road	June	25	2	8.0	25	1	4.0
	Sept.	25	2	8.0	25	9	36.0
	Total	50	4	8.0	50	10	20.0
Grauer's farm	Aug.	25	4	16.0	25	4	16.0
Imperial Road	Aug.	22	3	13.6	25	6	24.0
Total		372	34	9.1	378	51	13.4

"night-gentle" liberations exceeded in six locations that supplied by the "day" technique. Although differences in the percentage survival from the two methods did not in all cases show a predominance in success for the "night" releases, they did indicate consistently that this method was more productive than the "day" technique. Post-release mortality of the "night" liberations also corroborates the greater survival found for this method during the open season.

CONCLUSION

Since the introduction of the ring-necked pheasant on the Delta in 1891 no quantitative data are available which would indicate population trends for the years prior to 1948. Farmers and hunters whose acquaintance with pheasant conditions in the area is of long standing recall the days of twenty or twenty-five years ago when birds were described as being much more abundant than at present. In spite of the popular claim that a local decline in pheasant numbers has been in progress for many years it is difficult to determine its extent or reality. With the annual increase in hunting pressure the number of birds available each fall may become more widely distributed among the growing number of hunters. If the ratio of pheasants bagged per gun is the criterion used in appraising population density from year to year, a reduction in individual hunting success might suggest an apparent decline in bird numbers. A superficial interpretation of this trend based on the more obvious effect on the relative abundance of birds has fostered the theory of "over shooting" as a factor contributing to population reduction. The greater accessibility of the area afforded by increased automotive transportation is correlated by some with the poorer hunting characteristic of recent years. Others attribute the decrease to changes in farming practice involving land utilization and the increasing

use of power driven farm machinery. The establishment of red clover as a seed crop of local importance has also been suggested as a restricting influence on the development of the local pheasant population. For many years the early cutting of red clover hay as practiced since the institution of the clover seed industry has conflicted to some extent with pheasant reproduction. The increase in the number of small holdings and suburban settlement accompanied by some reduction in the size and quality of the original habitat are also blamed for some diminution of pheasant numbers. In more recent years a growing use of chemical sprays as a means of combatting insect pests and plant diseases has been added to the list of factors potentially detrimental to the resident pheasant population.

No doubt many of the popular theories concerning the trends in abundance of local birds have some factual basis. However, in spite of a possible decline the Delta pheasants have seldom failed to provide a fall crop of a size sufficient to withstand annual harvesting. In terms of acres-per-bird the pre-season density and the number of cocks killed during the relatively "poor" years of 1948 and 1949 show that production of the Delta pheasant compares favourably with that found in other areas (Table XXXII).

It should not be implied that the existence of greater pheasant numbers in the past is not real. Nor should it be inferred that the present population size is the maximum that might be attained on the area. It was apparent, however, that under the conditions which existed during this study that components of environmental resistance acting upon the pheasants as a whole were fairly constant as to type and similar in degree from one year to the next. Within limits it might be postulated that no marked increase beyond the 1948 fall density is likely to occur without some effort to modify the influence of adverse factors now in force on the area.

TABLE XXXII — Comparison of pre-season population and kill in Delta Municipality with that found in other areas (modified from Wandell, 1942).

Locality	Year	Population (pre-season) acres per bird	Acres per bird killed
Michigan (Burroughs)	1937	2.2	14.7
Michigan (English)	1933	3.8*	16.2
Iowa (Green)	1937	7.8	9.8
Pennsylvania (Randall)	1939	0.5*	7.5
Massachusetts (Wandell)	1940	22	41.1
	1941	15	35.9
Delta Municipality	1948	2.1*	5.4
	1949	2.6*	8.2

*Hens and cocks—total population.

From data already presented it may be seen that spring breeding numbers, nesting density, nesting success, and clutch size were similar in both years. Although differences in weather and the seasonal trend in hatching occurred, the reproductive success was, due to renesting, potentially the same in 1948 and 1949. The survival of broods was also comparable until the month of July at which time the similarity between the two years ends and an unexplained decrease in brood size resulted in a smaller juvenile fall population in 1949. With reproduction tending to remain relatively stable the primary contribution to increased pheasant abundance might be determined by the number of hens carried over winter to the spring breeding season. Such a carry over is believed much lower than the fall population density. The survival of young produced is the second and probably most variable element in determining the annual reproductive

success and population size. Since hunting pressure may reduce the number of birds to a certain density per unit area beyond which it appears further harvesting is ineffective, the number of birds surviving until each successive spring should be approximately the same even though annual fluctuations in brood survival should occur.

Annual introductions of farm-reared birds as a means of increasing population size are of doubtful value. On the basis of post-release recoveries which in both years amounted to over 50 per cent. of the estimated hunting return of this group, it was shown that hens had almost twice the mortality rate of cocks. Survival of the latter to the second year was extremely low. If released hens may be assumed to have a similar survival rate their effectiveness as an auxiliary reproductive unit is of doubtful significance under the present method of introduction.

RECOMMENDATIONS FOR FUTURE STUDY AND MANAGEMENT

There is still much to be learned about conditions on the Delta that is necessary for the success of any plans for improving pheasant numbers. The following recommendations, made on the basis of this study, are discussed and respectfully submitted.

1. Since a continued collection of productivity and population data are essential to future management it is suggested that spring and fall censuses be made annually on the area. Information gathered during the hunting season is also of great importance and the use of road checks for this purpose should be maintained.

2. Information on many problems affecting pheasant population size is still lacking. That which has been obtained in this study is limited to a comparison of conditions for the two years in the Delta region only. To determine whether or not observed changes in pheasant behavior are wide-

spread or peculiar only to certain sections, new study areas should be established at different localities.

3. As yet no extensive winter studies have been undertaken on the Delta. Since an apparently high loss in hen pheasants occurs between late fall and the following spring it is necessary to determine the factors most responsible so that measures may be taken to reduce this loss.

4. Mortality of nesting hens due to mowing has been shown to form a substantial loss to the annual productivity. Any practical method of eliminating or reducing hen mortality is worthy of consideration. With the almost complete use of power driven mowers flushing bars are not satisfactory. A necessarily simple and inexpensive unit that may be easily installed on the mower component might be devised. Some thought has already been given this problem and a possible solution has been conceived but as yet needs experimental proof as to its practicability.

5. With the increasing use of chemical sprays and their methods of application on the area some investigation should be made as to their possible effect on pheasant survival. This necessitates the setting up of study and control areas on which the influence of such practices might be measured.

6. The establishment of small completely protected areas of high habitat quality in which pheasants would have conditions favoring unrestricted increase might provide wild stock which could be partly removed by trapping and introduced in other areas.

7. From the work so far conducted on the stocking of farm-reared pheasants some doubt arises as to the value of such practices. The estimated proportion of cocks recovered during the open season of the year in which they were released was high compared with that found in other studies

but did not exceed 10 per cent. of the total hunting kill. The survival to the second year was practically negligible. If hens may be assumed to show similar survival their potential contribution to the population during subsequent breeding seasons is not, under the present method of stocking, economically sound. The release of immature females throughout the spring and summer subjects these birds to long periods during which they must withstand the hazards of acclimatization, predation, agricultural activities, accidental or illegal hunting kill, and possible winter mortality. All these factors must be successfully overcome before these birds may assert themselves as reproductive units. In view of these possibilities it would appear that the liberation of mature hens in the spring sufficiently early to enable nesting establishment might have more satisfactory results. In this connection it would be necessary to carry out further experimental work to determine the worth of such a practice. This could be attempted through banding and marking techniques which would enable later observation of these birds and the extent to which they were successful in rearing broods.

8. Since there is apparently some loss of hen birds through accidental or illegal kill during the hunting season, part of this loss might be redeemed by inducing some change in the released hens which would reduce the reproductive consequence of their removal and provide a basis of legitimate possession of the birds killed. If hens could be treated before a spring release in such manner that they might possibly rear a brood and then through a progressive physiological change later assume cock plumage the double effect of reproduction and legal harvest of an expended bird might be achieved.

9. The large releases of pheasants within a given area may have cer-

tain density-dependant effects which are deleterious to the resident population as a whole. Some study should be made to determine the extent to which stocking might be most successful. Overstocking might conceivably produce results more harmful than beneficial to the population.

10. It was apparent in the study that the quality of birds released, as shown by post-release and hunting recoveries, was variable. This is not intended to be a reflection on game farm management but rather the basis for inquiry as to whether or not more attention might be given to producing a type of bird which might be established more successfully in the wild. Development of stock for the especial purpose of liberation might, through suitable feeding and rearing programmes, be fruitful.

11. Work so far conducted with different release methods indicates a greater survival with the "night-gentle" technique. Similar "gentle" type liberations conducted during the day time might prove equally effective and more convenient to carry out.

12. Modification of the type of crate used in transporting and releasing pheasants also merits some consideration. The substitution of hinged-end covers affords a less hazardous exit of birds than that provided by the crates now used. Replacing the wooden top cover with canvas or heavy burlap sheeting might also reduce head injuries.

13. Habitat improvement and a determination of its effect on population size is worthy of early investigation. Some areas in the Delta region seem poor in available cover. Experimental planting of food and cover producing shrubs might improve the carrying capacity of the land. More abundant and even distribution of brushy escape cover might enable a proportionately higher survival of birds on the area than is now possible. This increase in breeding potential could raise the level of the population at-

tainable for fall harvesting.

14. Farmer-hunter relations in 1949 seemed somewhat improved over 1948, and it is essential that such progress continue if sportsmen are to be assured the maximum use of the area as a hunting ground. The closing of certain sections of nearby Lulu Island has increased the hunting pressure on the Delta Municipality. Every effort towards good deportment on the part of the hunter should be made while on farm property. The pre-season training or work-outs for hunting dogs as practiced by a few individuals is still occasionally made without authorization or consideration of the farmers' crops. Such practices are strongly condemned as they are most dangerous to the friendly relationship that must exist between farmer and hunter if public hunting on privately owned property is to continue.

SUMMARY

1. This study, sponsored jointly by the University of British Columbia and the British Columbia Provincial Game Commission, was conducted within the Municipality of Delta in the extreme western portion of the Lower Fraser Valley of British Columbia.

2. Field work was begun in early May and continued until mid-September during the years 1948 and 1949. Analysis of hunting success was also made for the first half of the open seasons of both these years.

3. The purpose of the study was: (1) A general appraisal of pheasant conditions in the Delta area, (2) an examination of the reproductive cycle of pheasants in the wild state, (3) the determination of factors affecting reproduction, (4) the determination of factors influencing the survival of both wild and released farm-reared pheasants.

4. The ring-necked pheasant (P. c. torquatus) was first introduced on the Delta in 1891. Annual liberations have been made on the area since

1934.

5. The Municipality of Delta comprises approximately sixty-five square miles of rich, flat, alluvial soil deposited by the Fraser River in the extreme southwest corner of British Columbia. The land is extensively farmed with dairying, red clover hay and seed, mixed hay, field peas, potatoes, grain, and sugar beet seed forming the major agricultural endeavours.

6. The climate of the region is characteristically temperate with little extreme in any season.

7. The spring (May) sex ratio was 5.4 and 4.3 hens per cock in the years 1948 and 1949 respectively.

8. Counts of cock crowing territories over 7,570 acres showed an estimated 12.3 and 14.2 cocks per square mile and an average territory size of 51.7 and 45.0 acres in 1948 and 1949 respectively. The Kimball method of two-minute crowing counts as an index to cock population density was not successful under the conditions of the study.

9. Nesting was believed to have begun in mid-April in 1948 with the peak occurring about May 30; the 1949 period appeared to have begun in early April reaching a peak about May 15, about two weeks earlier than for the previous year.

10. Clutch size ranged from four to twenty-two eggs per nest and averaged 8.5 for both years. A decrease in the average clutch size was apparent as the season progressed.

11. In 1948, 247 nests were found of which 52.6 per cent. were successful. Nesting success for 404 nests located in 1949 was 50.4 per cent. Field nests in both years comprised over 95 per cent. of the total found.

12. Red clover hay fields had the highest nesting density while

pasture and grain fields had the lowest of all cover types.

13. Mixed hay was the most productive of all cover types from the standpoint of nests hatched.

14. The hatching period was believed to have begun about May 20 in 1948 with the peak occurring at the end of June. The 1949 period was about two weeks earlier beginning about May 15 and reaching a peak in mid-June.

15. Average brood size for June was 6.6 and 7.1 for 1948 and 1949 respectively. August brood size in 1948 was 5.3 while in 1949 it dropped to 3.8

16. The percentage of hens seen with broods in August, 1948, was 81.5 and in 1949, 80.1.

17. The total fall increment of wild juveniles was estimated as 8928.9 in 1948 and 6583.7 in 1949.

18. The estimated age ratio of 92.1 per cent. for the proportion of juvenile cocks in the population checked closely with the 94.8 per cent. as found in the fall hunting recoveries. The estimated percentage of juveniles in 1949 was 86.7 as compared with the observed 87.2.

19. Farm-raised pheasants released on the area totalled 2,492 in 1948 and 2,494 in 1949. Approximately equal representation of sexes was made in both years. Ages ranged from nine to nineteen weeks of age.

20. "Day" and "night-gentle" releases were made in 1949 to determine which was most conducive to survival.

21. Four checking stations were in operation during the first half of both the 1948 and 1949 Delta pheasant seasons. Transient hunters only were checked. Birds were aged and examined for leg-bands. Information of a similar nature was taken by sampling the resident success through hunter interview or card returns.

22. Hunting pressure was lighter in 1949 than in 1948 and in both years was heaviest on the first weekend of the open season. In 1949 the number of hours per hunter per day for non-residents averaged 5.9 and for residents 4.2 during the first half of the season.

23. The estimated total season kill in 1949 was approximately 34 per cent. below that for 1948. Non-resident hunter success in terms of birds per gun ranged from 0.66 on the opening day to 0.09 on the sixteenth day of the season. Resident success for the same dates was 1.06 to 0.46.

24. Non-resident gunners spent an average of 9.8 hours in the field for each bird bagged on the first day of the season and 53.1 hours on the sixteenth day. Resident hunters spent only 4.5 and 9.5 hours on the average for each cock pheasant taken on the same dates.

25. Distribution of the season kill showed that approximately 50 per cent. of the birds were taken on the first day of hunting, 30 per cent. on the second, and the remainder spread over the balance of the season.

26. Of all cocks bagged in both years 91.1 per cent. were wild raised birds of which 94.8 per cent. and 87.2 per cent. were juveniles as shown for 1948 and 1949 respectively.

27. Farm-reared pheasants comprised 9.6 per cent. of the total of birds killed in the two years. Estimated recovery of cocks released was 38.8 per cent. in 1948 and 22.2 per cent. in 1949.

28. As a factor affecting reproduction weather was important through its modification of the mowing period and the resulting influence on nesting success.

29. The sex ratio during the breeding season of both years did not average more than 5.4 hens per cock and was not considered incompatible for reproductive success. Fertility of eggs was high (94.6 per cent.) during

the two year period of study.

30. Factors contributing to nesting loss were: (1) Mowing and other agricultural practices, 36.3 per cent., (2) desertion, 54.2 per cent. Predation and other sources comprised the remaining loss.

31. Renesting was an important compensatory factor in the ultimate nesting success.

32. Loss of nesting hens to mowing was estimated to be 18.6 per cent. (1948) and 11.3 per cent. (1949) of the breeding hen population.

33. Average clutch size of successful nests in both years was 8.5 from which 7.7 chicks were produced in 1948 and 7.8 in 1949.

34. The loss in juveniles from hatching until approximately three weeks of age appeared to be proportionately greater than for any other period.

35. Post-release mortality of farm-reared pheasants averaged slightly more than 4.5 per cent. for both years. Cock survival was almost twice that of hens.

36. Factors responsible for post-release mortality during the two years were: (1) Predation, 53.6 per cent.; (2) accidents, 14.5 per cent.; (3) release casualties, 6.4 per cent.; (4) unknown causes, 25.5 per cent.

37. Effects of chemical spraying of crops have not yet been determined as a factor influencing the survival of birds in this area.

38. Hunting pressure is believed to be effective until a certain per acre density of birds is reached. As a result the post-season residual population may remain much the same from year to year.

39. The estimated crippling loss for the 1949 season was approximately 19.8 per cent. of the bag total.

40. The survival of farm-reared birds as shown by hunting recoveries

was highest for late-released birds of sixteen to nineteen weeks of age.

41. The survival for "gentle" released cocks was approximately two and a half times greater than for those liberated by the "day" method.

42. A decline in pheasant population size is generally believed to have been in progress for a number of years but evidence supporting this claim is not conclusive. Fall densities and hunting recovery in terms of acres per bird indicate that the production of the Delta region in 1948 and 1949 compared favourably with that found in other studies.

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