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PRODUCTION OF MALLARDS ON IRRIGATED LAND IN THE SACRAMENTO VALLEY, CALIFORNIA

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The primary aim of the investigation here reported was to measure the production of mallards on the Conaway ranch, an area of irrigated farm land in the Sacramento Valley of California. Production was calculated from census figures of (1) the breeding population at the onset of nesting, and (2) the total mallard population (young and surviving adults) at the period in mid-summer when the young were beginning to fly. A secondary objective was to study the ecology of nesting in order to understand the limitations in production. The various phases of the study are recorded in the chronological order in which they were completed, with discussion of total production deferred to the end, following the postbreeding census.

Acknowledgments are gratefully made to A. Starker Leopold, Museum of Vertebrate Zoology, University of California, and to John E. Chatterin, California Division of Fish and Game, for suggestions and supervision of this investigation. Likewise I wish to express appreciation to Lee Baldock and other personnel of the Conaway ranch for their many courtesies. During the period of the field work (February 15, 1948 to February 1, 1949) the author was in the employ of the California Division of Fish and Game (Federal Aid in Wildlife Restoration Project 30-R).

DESCRIPTION OF STUDY AREA

The Conaway ranch is situated five miles southeast of Woodland, Yolo

County, California, in the center of the Sacramento Valley. The ranch consists of approximately 19,000 acres of irrigated land, typical of much of the surrounding valley. There are over 300 miles of irrigation ditch on the ranch, but due to the varied nature and needs of the crops, only 50 to 75 miles of ditch contained water at any one time during the period of the field study. Most of the ditches are bordered by roads, which facilitated observation of the ducks.

The bulk of the ranch is farmed in a three-year crop rotation of rice, fallow, and small grain. About nine per cent of the area is in permanent irrigated pasture. The acreage of pasture is being increased as rapidly as the ground can be leveled, a process which will lead to future reduction in the acreage of grain with a corresponding increase in livestock production.

The major cover types, being of varied importance to the resident mallard population, are discussed individually below. Acreages are summarized in Table 1.

(1) *Rice*: Rice in this area is normally planted in April. However, in 1948, due to late spring rains and cold weather, it was sowed in May. Actual planting is done by airplane, the seed being broadcast on the flooded fields. Since rice is flooded during the entire growing season, the only available area for nesting in the rice fields is on the check dams, which after May 15 have a cover composed mainly of watergrass (*Echino-*

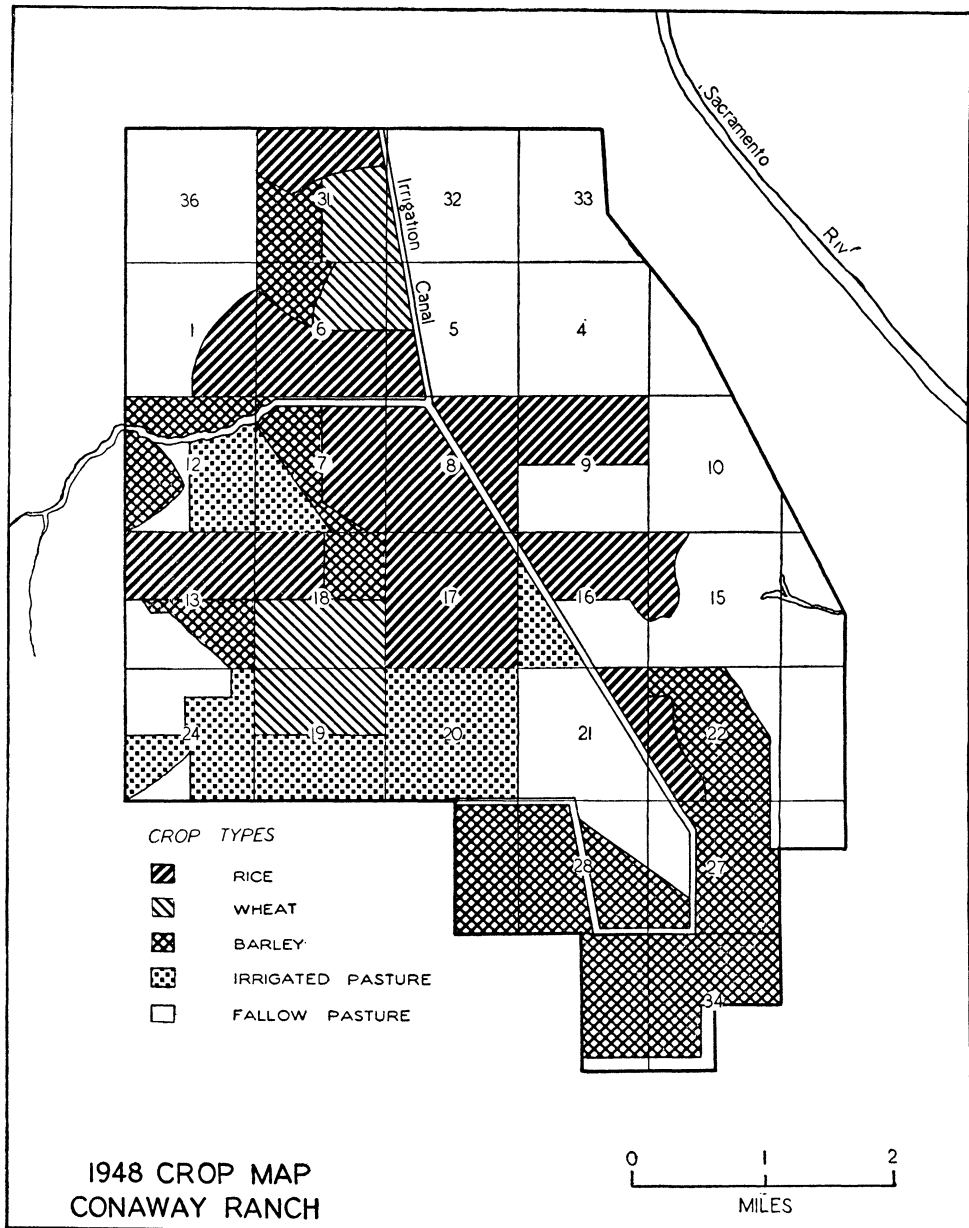


FIG. 1. Crop map of Conaway ranch in 1948.

chloa crusgalli), beardgrass (*Polypogon monspeliensis*), and mustard (*Brassica campestris*). During the early part of

the nesting season the growth on the check dams was sparse, so they were only available for late nesting. In 1948

the rice fields were drained and the crop harvested in early November. Ordinarily the harvest is completed by mid-October.

The primary importance of the rice fields to the breeding ducks is as summer cover for broods. As soon as the rice is high enough to afford protection, the hens lead their broods to the

TABLE 1.—COVER-TYPE ACREAGES ON THE CONAWAY RANCH IN 1948

Cover-type	Acres
Rice	3,400
Fallow pasture	5,500
Barley	3,210
Wheat	1,100
Irrigated pasture	1,640
Flooded land	2,770
Ditchbanks and roadsides	1,130
Tule swales	55
Total	18,805

flooded fields, where they remain until the ducklings are fledged. Later the rice serves as an important source of winter food for the entire population of mallards.

Those agricultural areas in the Sacramento Valley that are lacking in rice fields have few or no ducks during the spring and summer. Thus rice acreage is apparently the key to mallard production in this region.

(2) *Fallow pasture*: Fallow pasture, composed largely of the previous year's rice stubble, was little used by the nesting ducks. It is grazed by sheep through the winter and spring, leaving insufficient cover for nests. The only extensive use made of the fallow fields was on areas flooded by the heavy spring rains. These transient ponds were used early in the season (February and March) for loafing and feeding.

In the fall the ground is plowed in

preparation for the planting of small grains.

(3) *Wheat*: Wheat is planted in late October and early November. It grows slowly until the arrival of warm spring weather and then shoots up rapidly, attaining a height of 18 to 30 inches by the start of the duck nesting season. The wheat fields proved to be the most important nesting cover for mallards in 1948. Wheat is harvested in June and July and the fields are plowed in the late fall preparatory to the planting of rice in the spring.

(4) *Barley*: Barley culture is similar to that of wheat, the crop being planted in the early winter months and harvested in June and July. The barley was used to a minor extent by the nesting mallards.

(5) *Irrigated pasture*: Irrigated pasture supports a lush growth of ladino clover mixed with various weeds, such as dock (*Rumex* spp.), bull thistle (*Cirsium lanceolatum*), star thistle (*Centaurea solstitialis*), and jointgrass (*Paspalum distichum*). The growth in 1948 ranged from six to twelve inches when nesting started. The pasture is irrigated approximately every twenty days, depending on rainfall. Water is held on the pasture by parallel checks thirty feet apart. Sheep are grazed on the irrigated pasture in fall, winter, and spring, and cattle in the summer. Ducks used the area for nesting despite hazards of flooding and grazing.

(6) *Flooded land*: Approximately half of the Conaway ranch lies in the Yolo bypass, a two mile wide channel serving as an overflow basin for the Sacramento River in flood years. During 1948, high water in the river caused the bypass to be flooded on April 19. Water completely covered the area for two weeks,

and gradually receded through late April and May. Most of the area flooded on the ranch was fallow pasture, which caused no agricultural loss. However, about 2,770 acres of land in the bypass had been prepared for rice. The checks were washed away and no crop was planted.

The flood, occurring as it did during April and May, forced the mallards to nest almost entirely on the unflooded part of the ranch, thus considerably reducing the area of potential nesting ground and possibly cutting down somewhat on total production.

(7) *Ditchbanks and roadsides*: Spoilbanks along roads and irrigation ditches generally are covered with a dense growth of weeds and grasses, of which the most important are: wild oats (*Avena fatua*), mustard (*Brassica campestris*), bull thistle (*Cirsium lanceolatum*), star thistle (*Centaurea solstitialis*), pigweed (*Amaranthus retroflexus*), and mallow (*Malva borealis*). The ditches themselves contain a growth of tules (*Scirpus* spp.) and cattails (*Typha latifolia*). Periodically this growth becomes so dense as to necessitate dredging. On the Conaway ranch, ditch cleaning is done every two or three years, where necessary.

Spoilbanks were used for nesting by the mallards. In addition, the water area of the ditches was used for territories, for loafing, and for brood cover during the early part of the hatching season before the rice had emerged.

(8) *Tule swales*: One small tract of about 55 acres is not farmed because of the alkaline character of the soil. The center of the area is flooded during the winter and spring and contains a dense growth of tules. The edges are grown over with various alkali-tolerant plants,

such as salt grass (*Distichlis spicata*), beard grass (*Polypogon monspeliensis*), and alkali clover (*Cressa cretica*).

Some nesting took place on the edges of this area, but it was more important as a spring loafing site than as nesting ground.

PRE-NESTING PERIOD

The breeding population of mallards was censused by counting territorial pairs along the ditches, where virtually all territories were established. When the investigation began in February, 75 per cent of the mallards on the ranch were paired, and by the end of March only five per cent remained unpaired. Early pairing in this species has been described by Phillips (1923:29), Girard (1941), and others. However, while pairing was almost complete in February, there was no evidence of territorial behavior at this time. Most of the mallards were found in large concentrations on temporary ponds of standing rain water in the fallow pastures. Occasional birds found on the irrigation ditches were in groups of four to ten.

First actual territorial behavior was seen on March 19, when a drake was observed driving an intruding pair away from a section of ditch. Following this, mallards were seen less and less frequently in groups and more often in pairs spaced at intervals along the ditches. The actual length of ditch defended appeared to depend upon the width of the ditch, wider ditches seemingly furnishing more territories per unit length. In a ditch about five feet wide, the average territory was 70 yards in length. This was determined by slowly driving drakes known to be on territories along the ditch until a point was reached beyond which they

would not go but rather turned back toward the observer or escaped by flying. Extremes were 48 and 95 yards.

Observed territorial behavior, following the pattern described by Hochbaum (1944), reached a peak in the period of April 5 to 9, and then dropped off rapidly. Males apparently abandoned their territories shortly after the females began to incubate. This is concluded from the fact that the peak of the hatch occurred during the week of May 16 to 22. Allowing 26 to 28 days for an average incubation period, we find that the date of the beginning of incubation falls approximately two weeks after the period of the peak of territorial behavior. Occasional indications of territorial behavior were seen until the end of April, presumably due to late nesting.

If water were the only consideration in the selection of a territory, the mallards did not utilize all the potential sites on the ranch. With an average territory length of 70 yards, or 210 feet, there were a minimum of 1,255 possible territories. Only about a third of these potential territories actually were occupied. Either there were not enough ducks to fill the available sites or parts of the ditches were lacking in some critical requirement, such as food, or loafing sites. It was noted that in ditches which recently had been dredged, and hence supported little or no emergent vegetation, mallards rarely were seen.

The average period of territorial occupancy for eight closely observed drakes was ten days. The extremes were eight and twelve days.

In counting the breeding population of the ranch care was taken to include only those drakes that actually seemed

to be occupying territories. Ditches bordered by roads were censused every day, and ditches not bordered by roads were censused every three days throughout the entire territorial period. A weekly average was arrived at for each ditch. The total number of territorial drakes determined from these counts was 396; this was probably a conservative census. Since the sex ratio was nearly 50:50, each territorial drake was assumed to have a mate. The figure was rounded off to 400 pairs, and it is this number that is used in calculating production.

NESTING PERIOD

In searching for mallard nests, various techniques were used. Females flying into or out of a given area were watched, and the points at which they landed were noted and searched for nests. The method was only moderately successful; a large amount of time was expended to find only a few nests.

A second method was walking back and forth through the area under search attempting to flush hens off the nests. Most of the nests were found in this way. Sometimes a long cane pole was carried to cover a wider strip.

The most successful method was the dragging of a hundred-foot rope stretched between two men, which allowed approximately a hundred-foot strip to be covered at one time. It was found that practically all hens would flush when the rope passed over head. However, this method was limited by the fact that two persons were necessary; therefore it was used only for about one week during the nesting period.

The earliest laying in nests under observation was April 13. However, hatch-

ing of clutches found later indicated that some hens started even earlier. For example, a clutch of eleven eggs hatched on May 9. Allowing a minimum of 35 days for laying and incubation, this clutch was started on approximately April 3. Another brood of newly hatched ducklings was observed on April 26; the clutch must have been initiated by the middle of March. I would class the latter case as excep-

By mid-season, when these data were only half-compiled, the preference of the mallards for wheat as nesting cover became apparent. However, time spent and area covered in the different cover types was not equal, due to the varied accessibility of the types. Likewise the acreages of the various types were not equal. In order to test more equitably the distribution of nests in various cover types, a planned nest search was

TABLE 2.—DISTRIBUTION OF NESTS BY COVER TYPE ON CONAWAY RANCH IN 1948

Cover	Random Search	Planned Search*	Total Nests	Per Cent of Total Nests
Wheat	18	8	26	43
Ditchbanks and roadsides	11	2	13	22
Irrigated pasture	6	1	7	12
Fallow pasture	5	0	5	8
Rice	4	—	4	7
Tule swales	3	—	3	5
Barley	0	2	2	3
Flooded land	0	—	0	0
Total	47	13	60	100

* Five hour search in each of five types by two men dragging a hundred-foot rope.

tional, however. Most of the hens probably did not start laying before early April.

On the other hand, nests in which the clutches were not yet complete were found as late as the middle of June. These probably were second attempts, but there was no real evidence to prove this.

From the above observations it can be stated that the normal mallard nesting season in the Sacramento Valley, from the earliest laying to the latest hatching, extends from late March to the end of June.

NEST COVER

Sixty nests were located during the 1948 season, distributed among the various cover types on the ranch, as shown in Table 2.

conducted with the aid of an assistant, W. V. Wiederhoeft, between the dates of June 7 and 11. Dragging a hundred-foot rope between us, Wiederhoeft and I devoted one day each to searching for nests in wheat, barley, ditchbanks and roadsides, irrigated pasture and fallow pasture. In each type we spent about five hours and covered roughly sixty acres of ground not previously visited. Tule swales, rice, and flooded land were not considered, the former because of its small acreage, and the latter two because of insufficient cover at the time. The results of this method of sampling also are shown in Table 2 under the column "planned search".

The fact that, in spending an almost equal amount of time in each major type, over 60 per cent of the nests found were in the wheat confirmed the pre-

vious conclusion that wheat was preferred nesting cover on this area in 1948. However, observations elsewhere in the Sacramento Valley, as for example on Grey Lodge Refuge in Butte County, showed that other cover types (tules, weed fields, etc.) were preferred locally. The predilection for wheat on the Conaway ranch may have been due to a shortage of adequate nesting cover

most important source of loss, was chargeable mainly to mammalian predators. Only one case of a destroyed nest which could be attributed to crows was found and even this was doubtful. The principal nest predators were skunks, raccoons, and feral house cats. Insufficient evidence was obtained to determine which of these was the most important.

TABLE 3.—SUMMARIZED NEST RECORDS OF MALLARDS ON THE CONAWAY RANCH IN 1948

Cover	Hatched:	Destroyed by:				
		Predation	Desertion	Live-stock	Flooding	Totals
Wheat	17	7	2	—	—	26
Barley	—	—	2	—	—	2
Irrigated pasture	1	—	—	5	1	7
Fallow pasture	4	1	—	—	—	5
Rice	3	—	1	—	—	4
Tule swales	2	—	1	—	—	3
Ditchbanks and roadsides	4	7	1	—	1	13
Totals	31	15	7	5	2	60
Per cent	52	25	12	8	3	100

in other fields during the early portion of the nesting season.

NEST SUCCESS

It has been concluded by Kalmbach (1939) that the average degree of nesting success, based on twenty-two field studies of thirteen species of ducks, was 60 per cent. Mallard nesting success on the Conaway ranch in 1938 was only slightly over 50 per cent, falling below Kalmbach's figure.

In a discussion of nest fates, it should be understood that it is the termination of the clutches, either successfully or unsuccessfully, with which we are concerned. Fates of the broods after hatching are considered later.

The fates of the 60 nests found are shown in Table 3. Predation, being the

Some desertions probably were caused by too frequent interference on the part of the observer. Early in the nesting period, it was my practice to visit the nests every other day. The time between visits later was extended to a week.

Nest destruction by livestock was limited to the irrigated pasture where five nests were trampled by grazing sheep or cattle.

Two nests were flooded out—one by rising water in the ditch along which the nest was built, the other during irrigation of permanent pasture.

Distribution of nest fates by cover types is also shown in Table 3. Over half the nests located along ditchbanks and roadsides were destroyed by predators. Ditches and roads are natural travel

lanes for predators and the cover strips are so narrow that presumably it would be easy for a skunk or raccoon to find a nest located there.

The only other large loss by predation was in the wheat. The writer is inclined to believe that this was due in part to trails made by himself in the process of visiting the nests. It was almost impossible to avoid leaving these trails even after a single visit. The wheat fields were crossed at regular intervals by small drainage ditches about three feet wide. The trail left by the observer invariably started at some point along one of these drainage ditches and led to the nest. It is difficult to believe that predators, starting at random at the edge of a large wheat field, could account for almost a third of the nests without some such advantage.

It is apparent from examination of Table 3 that those birds nesting in the irrigated pasture had the least chance of success due to the grazing of stock during the nesting season.

The previous discussion has been concerned with the termination of the clutch as a whole and not with the fate of the individual eggs. The eggs fate are summarized in Table 4.

The category "Left in hatched nests" includes 6 eggs found to be infertile, 5

TABLE 4.—SUMMARIZED RECORDS OF MALLARD EGGS FOUND IN 60 NESTS, CONAWAY RANCH, 1948

	Number of Eggs	Per Cent of Total
Hatched	206	49.4
Left in hatched nests	31	7.4
Predation	104	24.9
Desertion	41	9.9
Livestock	23	5.5
Flood	12	2.9
Total	417	100.0

eggs with embryos that died early in incubation, and 20 eggs with well developed embryos that apparently were abandoned by the hens after the hatching of part of the ducklings.

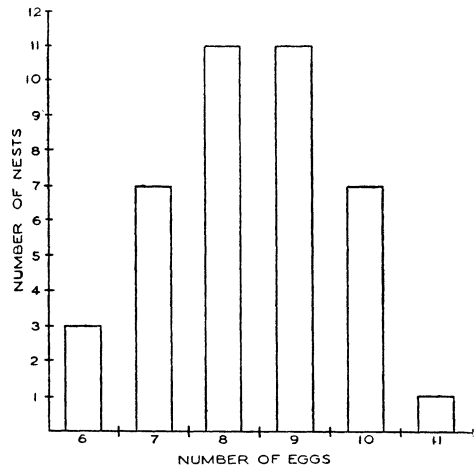


FIG. 2. Size of completed mallard clutches, based on 40 nests. The average clutch was 8.4 eggs

Of the 60 nests found, the clutches of 40 were believed to have been completed. The size distribution of the completed clutches is shown in Figure 2. The majority of the clutches had between 7 and 10 eggs; the average was 8.4.

The number of eggs in 30 of the 31 successful nests was known definitely. The average number of eggs per successful nest was 7.9. The average hatch was 6.9.

With the completion of the nesting season, it was possible to compute the period during which the peak of the hatch occurred. Known hatching dates of observed nests and estimated hatching dates of broods were combined, as shown in Figure 3. The peak of the hatch took place during the period May 16 to May 29.

A total of 106 broods were counted between June 15 and August 20. Estimated age in weeks (to the sixth week) and number of young were recorded for each brood; an average brood size was

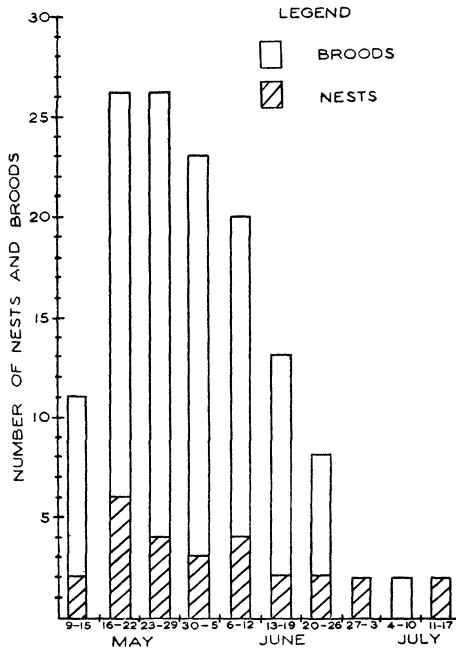


FIG. 3. Numbers of mallard clutches hatched, by weekly periods from May 9 to July 17, 1948, based both on nests studied and broods observed.

derived for each of the six age classes, as plotted in Figure 4. Whereas 6.9 young were hatched from the average successful nest, only 4.9 ducklings survived in broods up to a week of age. Thereafter mortality was progressively less and 3.6 young constituted the average brood at six weeks. It proved impossible to recognize individual broods beyond that age.

Girard (1941) found a production of approximately 4 young per hen mallard at the flapper stage. In a compilation of waterfowl populations and breeding

conditions by Williams *et al.* (1948), average brood size of fledgling mallards ranged between 4 and 7.5 in 1948. My figures obtained on the Conaway ranch indicate a somewhat lower rate of productivity, the average fledged brood being perhaps a little over 3 young.

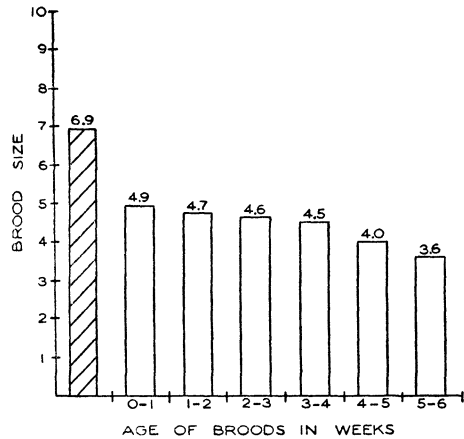


FIG. 4. Average size of mallard broods by age groups, showing gradual decrease in brood size up to the sixth week.

POST-BREEDING CENSUSES

Ground censuses were taken during the months of July and August. Two sample areas, each consisting of 160 acres of rice, were censused. These areas were the northwest quarters of Sections 9 and 17, respectively. Since virtually all the mallards on the ranch had moved to the rice fields by this time, it was felt that a census in the rice would give an approximate count for the whole ranch. The drakes were assumed to be in the rice fields undergoing the eclipse molt. It is well known that male ducks frequently leave the breeding grounds at this time and concentrate elsewhere during the flightless period. However, I had no evidence of any such movement and since some

drakes were observed I have postulated that all the breeding males still were present.

The census method involved walking the check dams in each plot, counting all mallards seen. The ducks tended to congregate on the checks and to swim back to the same check after being disturbed, thus causing little or no duplication in the count. The censuses were made on July 27, August 3, and August 10. The figures were then added, averaged, and the number of ducks per acre derived, as shown in Table 5.

The acreage of rice in 1948 was 3,400. Applying the average figure of .72 ducks per acre to this, we derive a total of 2,448 ducks on the ranch.

TABLE 5.—GROUND CENSUS OF DUCKS PER ACRE IN RICE FIELDS DURING JULY AND AUGUST, 1948

	July 27	August 3	August 10	Average
Total Ducks counted on 300 acres	253	225	212	230
Average ducks per acre	.79	.70	.66	.72

An aerial census was taken on August 12. All of the rice fields on the ranch were censused. The method employed was to divide the fields into strips of approximately one-eighth of a mile and fly along the edge of each strip at an elevation of 100 feet, counting the ducks on one strip at a time. The rice was only six to eight inches high at the time and it was found that the ducks were easily counted from this elevation. The total count obtained by this method was 2,055 ducks. It is felt that this is a more accurate figure than that obtained from the ground census, as the latter was a sample count subject to the usual

errors of sampling. Also the ground counts were taken over a longer period during which there may have been local shifts in the population, as well as some mortality among the ducklings, which could account for the variable results shown in Table 5.

CONCLUSIONS REGARDING TOTAL PRODUCTION

Accepting as accurate the pre-breeding census of 400 pairs (or 800 breeders), we can calculate the production in three ways, as shown in Table 6.

On the basis of the ground census which indicated a post-breeding population of 2,448 birds, the 400 pairs would have produced an average of 4.1 young. The somewhat more conservative total count of 2,055 birds made from the air would indicate an average production of 3.1 young per pair. Both of these figures assume no mortality among the breeding adults. Since some mortality does occur, the average number of young is in each case conservative since the totals would thereby consist of less than 800 adults and correspondingly more young.

Actual brood counts, summarized in fig. 4, showed an average brood of 3.6 young at the age of six weeks. Since all pairs certainly did not produce broods, the calculated total population of 2,240, obtained by multiplying 400 pairs by 3.6, would be high. This tends to strengthen the supposition that the aerial count is more nearly accurate than the sample ground count.

On the basis of these data, it would seem that an approximate feeding population of 800 mallards increased to a population of about 2,000 birds in late summer. On the 19,000 acre Conaway ranch this would mean that one

young duck was produced per 15 acres. Applying the same data to the 3,400 acres of rice on the ranch indicates production of one duckling per 2.8 acres of rice.

In 1948 the Sacramento Valley had approximately 185,000 acres of growing rice. Since rice acreage is presumably the key to mallard production in this area, the above figures when applied to

6.9 ducklings. Over half of the failures were due to predation.

Counts obtained on 106 broods indicated an average brood of 4.9 ducklings during the first week after hatching. Brood size gradually decreased until in the sixth week, when counting ceased. They averaged 3.6 young.

Post-breeding censuses indicated an approximate population of 2,000 young

TABLE 6.—SUMMARIZED DATA BEARING ON TOTAL PRODUCTION OF MALLARDS ON THE CONAWAY RANCH IN 1948. CALCULATED OR DERIVED FIGURES ARE ENCLOSED IN PARENTHESES.

Based on:	Breeding Population	Production per Pair	Total Young	Total Post-Breeding Population
Ground census	800	(4.1)	(1,648)	2,448
Aerial census	800	(3.1)	(1,255)	2,055
Brood counts	800	3.6	(under 1,440)	(under 2,240)

the entire valley would give an approximate total production of 65,000 young mallards raised by a calculated breeding population of 44,000.

SUMMARY

The mallard nesting season on the Conaway ranch was found to extend from the first of April through the middle of July. Breeding territories were located along irrigation ditches, an average territory comprising about 70 yards of ditch. The average period of occupancy of a territory was ten days. Peak of territorial behavior occurred during the period April 5 to 9. The breeding population was determined to be about 400 pairs by counting territorial males along the ditches.

Sixty nests were found, approximately half of them in wheat. Fifty-two per cent of the observed nests hatched successfully, the average hatch being

and adults. Each of the original pairs therefore produced about three young ducks, for a gross production on the ranch of one bird per 2.8 acres of rice.

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