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THE RESOURCES AGENCY
Department of Fish and Game

SACRAMENTO VALLEY MUSKRAT SURVEY 1978*

by

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ABSTRACT

Sacramento Valley muskrat populations were studied by two methods. Live trapping and tagging data was collected during the Spring and Summer of 1978 and the Spring of 1979. Data was also collected from muskrats taken during the 1978-79 trapping season. Data collected from a total of 898 muskrats revealed trends in population densities, sex and age ratios, reproductive and survival rates, habitat relationships, and seasonal population fluctions. A method for censusing muskrat population dynamics is also discussed.

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INTRODUCTION

Since its introduction into the Sacramento Valley in the 1920s, the muskrat (Ondatra zibethicus) has become widespread throughout the Sacramento and San Joaquin River drainages. With this expansion in range it has become so numerous as to be regaurded as one of the most valuable fur sources in California. From 40,000 to over 100,000 have been taken annually over the last 25 years in California by liscensed fur trappers. This has provided a minimum income to trappers of from $24,000, when prices were low in 1967-68, to over $246,000 during the 1976-77 season.

The muskrat, being an extremely adaptable animal, is found almost anywhere in the Sacramento Valley where suitable water and food exist. The numerous irrigation and drainage canals created by extensive agricultural development, especially in irrigated rice culture and pasture, probably comprise the most important habitat for the muskrat in California today (Seymour 1954).

The few studies which have been done on Sacramento Valley muskrats have dealt with distribution and range extensions (Storer 1938, Twining and Hensley 1943, Seymour 1954) or muskrat caused damage (Belluomini 1978). The purpose of this study is to supply base-line data concerning Sacramento Valley muskrat population dynamics.

STUDY AREA

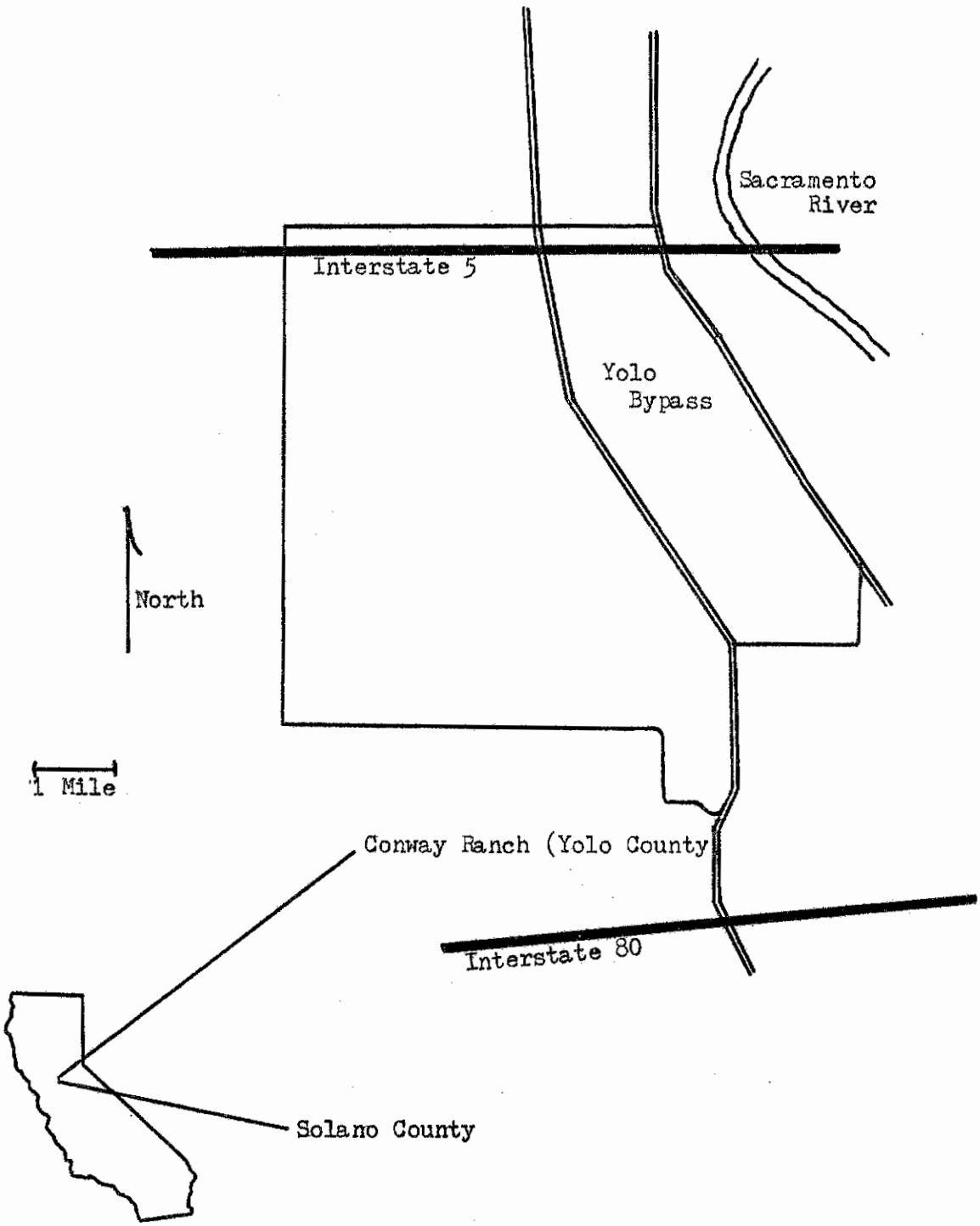
This study was conducted primarily on the Conway Ranch, a large (19,500 acre) farming operation located approximatly six miles east of Woodland in Yolo County (Figure 1). This area produces a variety of crops including sugar-beets, rice, corn, wheat, and safflower. The extensive use of man made irrigation canals, supplying water to these crops, has provided muskrat populations in this area with miles of suitable waterways. A natural slough also flowed through this area, and the muskrat populations it contained were also studied.

The agricultural canals found in the study area varied considerably in terms of size and water flow characteristics. Two types of canals were found on the Conway Ranch, those being drainage and supply canals. Supply canals typically contain water only when the adjacent crops are being irrigated, or during winter when precipitation provides moisture. The drainage canals, in contrast, usually contain some water year round, and levels are more stable than in supply canals. Flooded rice fields are conspicuous from May through August, and supply muskrat habitat on a seasonal basis.

In addition to the water fluctuations imposed by agricultural demands, some areas of the ranch are managed for waterfowl hunting during the Fall and Winter. Water is maintained in these areas which would normally be drained during this time of year.

The east side of the Conway Ranch is contained in the Yolo Bypass. This area serves as an overflow basin for the Sacramento River, and may be completely submerged during years of high precipitation.

Figure 1. The study area.



The "natural" vegetation of the area is restricted, by agricultural practices, to canals, watercourses and their boundaries. The dominant plants associated with these areas are cat-tails (Typha spp.) and bulrushes (Scirpus spp.). A very dense growth of water purslane (Ludwigia sp.) and knotweed (Polygonum sp.) was evident in some areas. The banks and levees adjacent to all canals were covered with a variety of vegetation including mustard, (Brassica sp.), fennell (Foeniculum sp.), and a variety of grasses (Phalaris, Avena, Bromus, Polypogon, Hordeum, Cyndon).

Three specific areas of manageable size were selected for part of this study, they are described in more detail below.

Pelican Cut

The "Pelican Cut" is a large drainage canal which contains substantial amounts of water when irrigation is takeing place, and during times of rainwater run-off. During parts of winter and early spring this ditch may be almost dry, with only a narrow channel of water running down its course in many sections. By the end of April, when extensive irrigation starts, the water level in this canal rose approximatly three feet. This made many more areas suitable for muskrat habitation. The total length sampled was 0.8 miles long, and was set off from other sections by culverts and road crossings.

A narrow strip of cat-tail and bulrush growth occured along both banks of this canal. The growth of the previously mentioned grass species was extremely dense on both banks. Crops associated with this area during this study included sugarbeets, corn, and wheat.

Willow Slough

This waterway is a natural slough which also serves as a drain for agriculture. It, however, differs considerably from the man made irrigation canals which are so prevalent in this area. The bulrush and cat-tail growth is extremely dense along this waterway, creating extensive "marshy" areas up to thirty feet wide along its borders. Unlike the agricultural canals, Willow Slough is bordered by areas of riparian vegetation. This dense growth consisted mainly of California blackberry (Rubus ursinus), willows (Salix spp.), cottonwoods (Populus fremontii), wild rose (Rosa sp.), valley oak (Quercus lobata), and various grasses and forbs.

The section of slough studied was one half mile in length and varied from thirty to sixty feet in width. At its west end it was "blocked off" by a road crossing and culvert. Its east end was marked by the end of navigable waters where cat-tail and bulrush growth completely choked off the waterway.

Otis Road Drain

The "Otis Road Drain" is very similar to the Pelican Cut in that it also is a drainage canal, and its banks are lined by the same type of vegetation. This canal, however , is more typical of the drains in this area, being not more than ten feet wide at its widest. It averages closer to three or four feet in width during times of "normal" water flow. Occasionally flows would increase and raise the level of this canad several feet. During the majority of the time this ditch was only drainimg the adjacent rice and beet fields which produced a minimum of flow.

The length of this canal sampled was a one mile section running north and south and set off by culverts and road crossings at each end. The crops associated with this area included rice and sugarbeets.

Additional data was collected from an area in Solano County south of Davis (Figure 1). This area was of considerably different habitat than found on the Conway Ranch. It was composed almost entirely of marshes and natural watercourses. Vegetation here was dominated by bulrush and cat-tail growth, with bulrush being the dominant form.

METHODS

Two methods were used to study muskrats during this survey. Live trapping and tagging was combined with the collection of data during the muskrat trapping season to investigate muskrat population dynamics.

Live trapping was done on the three previously described areas of the Conway Ranch during the Spring and Summer of 1978, and during the Spring of 1979. Limited trapping was done on some additional areas during the Summer of 1978. Cage type traps, patterened after commercially available live traps, were constructed from one by two inch welded wire fabric. Traps were placed on "floats" constructed of wood and styrofoam which allowed them to be easily positioned in canals, and remain unaffected by fluctuating water conditions. As many as sixty traps were used, and trap densities of 20 to 120 per mile of canal were tried.

Trapped muskrats were weighed, sexed, measured (tail length an heigth), marked, and released. Two methods were used to mark muskrats during this study, ear tagging and tail banding. Number one ear tags were attached to the right ear of captured muskrats. The one difficulty associated with the use of these small tags is the problem of detecting there presence on recaptured muskrats. Tail banding was tried in an attempt to elimate this problem. Aliminum butt-end leg bands, commonly used for bird banding, were clamped onto the base of adult muskrat tails. On the largest adults there is a noticable restriction at the base of the tail where the size 18 band (inside diameter 0.56 inch) fit securely.

By plotting the distribution of captures for each tagged muskrat, home ranges for individuals could be determined. As the summer progressed, the number of "kits" captured in each area would indicate the reproductive success of the adults established there.

During the 1978-79 trapping season all muskrats taken by the trapper working on the Conway Ranch were examined. Trapped muskrats were toe clipped at the sight of capture for later identification in the laboratory. During the latter part of the season, the location of and type of trap used was noted for each individual taken.

Muskrats were taken in several different types of traps. "Floats" accounted for the greatest number of captures, being the commonest type of "set". Floats used were wood structures on which two, or sometimes one, leg-hold trap was placed. "Doubles", two muskrats on a single float, were not uncommon. "Basket traps", simple wire cages set in under water runways, also accounted for many captures. Multiple captures in these were common, with as many as seven individuals being taken in one trap. Conventional leg-hold and conibear sets were

also used to a small degree, and several muskrats were collected by shooting.

Total trap nights on the Conway Ranch, for all trap types combined, equals approximately 5700. It must be realized that each type of trap used has different chances of success. Most floats, for example, are capable of 200% success and basket traps are higher yet. Considering each trap type seperately, floats represented approximately 4000 trap nights, basket traps 950, conibear traps 492, and single leg-hold bank and log sets 250.

Trapping pressure on specific areas of the Conway Ranch is related to accessability. During the trapping season, the majority of the roads in the area are impassable. The large number of traps being used limited the amount of time that could be spent checking each set. Trapping pressure was therefore concentrated along canals where access was not a problem. In reference to the three areas extensively live trapped, only the "Pelican Cut" was trapped during the 1978-79 trapping season. The other two study areas were not trapped.

Trapped muskrats were weighed, sexed and aged by examination of external genitalia (Baumgartner and Bellrose 1943), and additional measurements were taken (overall length, hind foot length, tail length and tail height). After skinning, the carcass was examined internally. Testis length or appearance of the uterus was noted as an age determining factor (Errington 1939). The presence of placental scars and embryos in uteri was recorded. Zygomatic breadth was recorded as another means by which age could be determined (Alexander 1951), as was the appearance of the first upper molar (Olsen 1959). Pelts were arranged in an ordered fashion so that when dry, they were examined for age differentiating characteristics (Applegate and Predmore 1947, Shanks 1948).

RESULTS

A total of 898 muskrats were captured and examined during this study. 657 of these were taken on the Conway Ranch during the 1978-79 trapping season. Data was collected on 113 individuals taken in live traps during the Spring and Summer of 1978 and the Spring of 1979. Three of these were recaptured during the 1978-79 trapping season. An additional 131 muskrats taken in Solano County during the latter part of the 1978-79 season provided valuable reproductive data.

A single trapper working the Conway Ranch accounted for all 661 muskrats taken there. All but four of these, which were victims of racoon (Procyon lotor), Norway rat (Rattus norvegicus), or roof rat (Rattus rattus) depredation, were examined..

Possibly the most beneficial information recorded during the trapping season was obtained by noting the presence, appearance, and number of placental scars and embryos in the uteri of female muskrats. A total of 56 adult female muskrats were taken on the Conway Ranch. Of these, 35 had "readable" uteri in which placental scars were countable. Only one adult female lacked any evidence conceiving young in the form of placental scars.

Of the 242 juvenile females (born 1978), 43 or 17.8% appeared, from the presence of placental scars, to have conceived young during their first year. All uteri of juveniles with scars were readable. Frequency distributions of the number

of placental scars observed in the uteri of adults and juveniles taken on the Conway Ranch are summarized (Figure 2).

The placental scar data collected from Solano County muskrats was not differentiated between adults and juveniles, as these "rats", being caught in late February or early March were difficult to age accurately. The mean number of 1978 placental scars for these and Conway Ranch muskrats are summarized (Table 1).

An indication of litter size is given by the number of fresh placental scars and embryos observed in muskrats taken during the latter part of the trapping season. This data, taken from muskrats trapped on both areas (Yolo and Solano Counties), is summarized (Table 2).

Indications of early Spring or late Winter breeding were noted by the capture of small muskrats during the trapping season, presence of embryos in female uteri, evidence of lactating females, and presence of fresh placental scars. The smallest individuals taken during the trapping season were trapped on the 12th of February. These "kits" were 250 amd 260 grams in weight and were taken in the same cage trap with an adult male and lactating female.. Numerous other muskrats approximately 500 grams in weight were taken throughout the trapping season. This compares with adults ranging in weight from 800 to almost 1500 grams.

On January 23rd the first small (less than 5 millimeters overall length) embryos were found in muskrat uteri. On February 5th the first female with fresh placental scars was noted. By examining the percentages of females containing uteri with placental scars in a given time period (Table 3), the start of the breeding season is indicated.

All muskrats taken on the Conway Ranch, with the exception of four, were aged and sexed. A representation of the population structure is reflected by the number and percentages of the sexes taken in each age class (Table 4). During the latter part of the trapping on the Conway Ranch, the type of trap each individual was captured in was recorded. A summary of ages and sexes taken in each trap type is noted (Table 5).

Results from live trapping (Table 6) are most indicative of densities and sex ratios of adults. The recovery of tagged muskrats during the trapping season was extremely limited. Out of the 66 tagged muskrats that survived the constant sampling during the Spring and Summer of 1978, only 3 were taken during the 1978-79 trapping season. An additional 5 were recaptured during the live trapping which occured in the Spring of 1979. A summary of the recaptures for each individual area studied is given (Table 7).

DISCUSSION

The results of this study gives indications of many different aspects of muskrat population dynamics. Data collected during the 1978-79 trapping season, combined with results of live trapping during the Spring and Summer of 1978 and Spring of 1979 give good indications of population densities, sex and age ratios, reproductive and survival rates, habitat relationships, and seasonal populations fluctuations. A discussion of the various aspects of population dynamics studied, as well as comparisons with findings in other areas, are presented below.

Figure 2. Frequency distributions of placental scar counts taken from Conway Ranch muskrats.

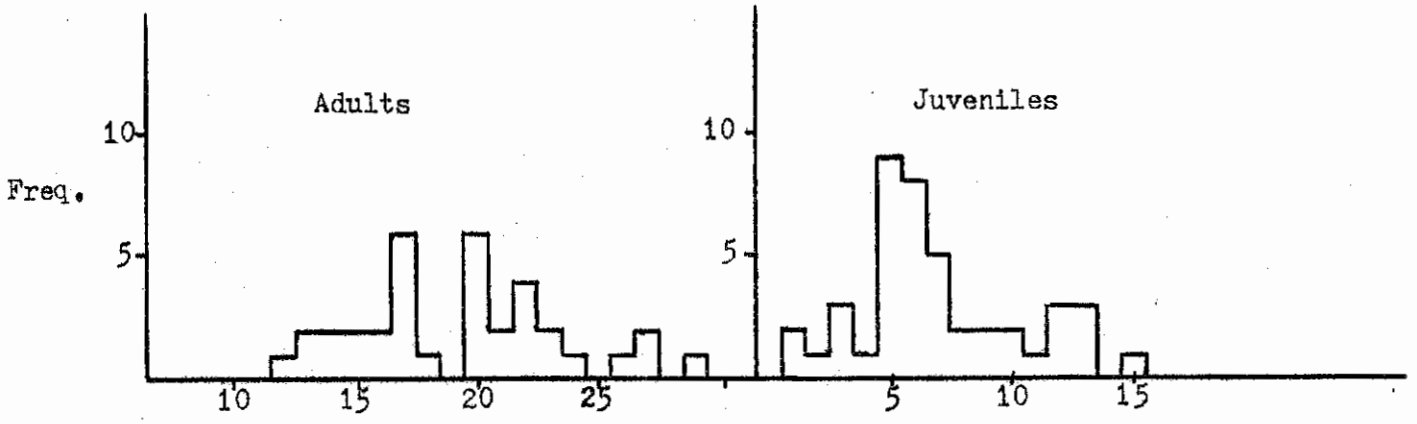


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Table 1. Number of 1978 placental scars found in the uteri of females examined during the 1978-89 trapping season (mean and standard deviation).

	Adults	Juveniles	Combined
Conway Ranch	19.3 ± 4.3	7.3 ± 3.4	12.5 ± 7.3
Solano County	——	——	13.9 ± 7.6

* * *

Table 2. Number of fresh placental scars and embryos found in the uteri of muskrats taken during the 1978-79 trapping season (mean and standard deviation).

	Scars	Embryos
Conway Ranch	5.4 ± 1.2	5.4 ± 1.0
Solano County	5.7 ± 1.4	6.1 ± 1.6
Total	5.5 ± 1.3	5.9 ± 1.3

Table 3. Occurence of fresh placental scars in muskrats taken during the 1978-79 trapping season (Conway Ranch and Solano County data combined).

	Total Females Examined	# with Fresh Scars	% with Fresh Scars
Feb. 5-Feb. 13	65	11	16.9
Feb. 14-Feb. 22	32	3	9.4
Feb. 23-Mar. 3	31	8	25.8

* * *

Table 4. Age and sex structure of the muskrats trapped on the Conway Ranch during the 1978-79 trapping season.

Adults 158(24.0%)		Juveniles 449(76.0%)	
male	female	male	female
102(64.6%)	56(35.4%)	257(51.5%)	242(48.5%)

* * *

Table 5. Age and sex structure of muskrats taken on the Conway Ranch, divided into type of trap used.

	Total		Adult		Juvenile	
	adults	juvenile	male	female	male	female
Floats	72(27.0%)	195(73.0%)	46(63.9%)	26(36.1%)	95(48.7%)	100(51.3%)
Baskets	21(22.3%)	73(77.7%)	12(57.1%)	9(42.9%)	37(50.7%)	36(49.3%)
Leghold	3(12.0%)	22(88.0%)	2(66.7%)	1(33.3%)	12(54.5%)	10(45.5%)
Conibear	0	1(100%)	0	0	0	1(100%)
Shot	1(16.7%)	5(83.3%)	0	1(100%)	3(60.0%)	2(40.0%)

Table 6. Summary of live trapping captures on the Conway Ranch during the spring and summer of 1978, and the spring of 1979.

	Pelican Cut	Willow Slough	Otis Road Drain	total
Linear miles	0.8	0.5	1.0	2.3
1978				
# individuals	24	32	15	71
Adults	11	11	9	31
male	6	6	5	17
female	5	5	4	14
Juveniles	13	21	6	40
male	3	9	3	15
female	10	11	3	24
Mortalities	8	12	3	23
% mortality	33.3	37.5	20.0	32.4
Estimated # breeding pairs	4	5	5	14
per mile	5	10	5	6.1
1979				
# individuals	7	13	5	25
Adults	6	13	5	24
male	4	7	4	15
female	2	6	1	9
Juveniles	1	0	0	1
male	1	0	0	1
female	0	0	0	0
Mortalities	1	2	0	3
% mortality	14.3	15.4	0	12.5
Estimated # breeding pairs	2	6	4	12
per mile	2.5	12	4	5.2

Table 7. Number of tagged muskrats recaptured during the 1978-79 trapping season, and during the 1979 live trapping.

	# tagged muskrats	1978-79 trapping season	1979 live trapping	total recaptures	percent recaptures
Pelican Cut	16	2	0	2	12.5
Willow Slough	20	0	2	2	10.0
Otis Road Drain	12	1	1	2	16.2
Additional areas	18	0	2	2	11.1
Total areas	66	3	5	8	12.1

Reproductive Rates

The overall reproductive rates of most mammals is a factor of several variables. Length of breeding season, litter size, number of litters per year, and age of first breeding are all important factors which were investigated during this study.

The length of the breeding season in muskrats has been found to be quite variable. Errington's extensive studies (1963) have found a general pattern of activity centering around a several month period of reproduction peaking in June. In contrast Svihla and Svihla (1931) observed embryos in young muskrats occuring in every month of the year in Louisiana, with peak activity centered around the Winter months.

The breeding activity of Sacramento Valley muskrats appears to occur on almost a year-round basis, with peak activity in the Summer months, and a cessation of activity in mid Winter. Numerous litters, as revealed by the presence of fresh placental scars, were being born as early as mid February (Table 3). The earliest embryos were found on the 23rd of January when a single female was found to contain four small embryos. On the following day, three additional muskrats were found to contain embryos of similar size. The termination of breeding activity was not well documented during this study. It was noted, however, that none of the 147 female muskrats examined between December 22nd, when trapping started, and January 23rd contained embryos or showed fresh placental scars.

An indication of late Winter breeding was seen in the capure of two small kits on February 12th. Their age, as indicated by Dorney and Rusch's size and age data (1953), is approximately 25 to 28 days old. This would put their birth at approximately mid December and conception in mid November. The numerous small, less than 500 gram, muskrats taken during the trapping season indicates substantial amounts of September and October breeding, providing Dorney and Rusch's growth data from Wisconsin is meaningful in relation to California muskrats.

The number of young per litter, as was found in the case of breeding season length, has been seen to vary in relation to geographical area. Various studies, as summarized by Errington (1963) show mean litter sizes ranging from three to eight. A litter size of between five and six was found to be the mean size as indicated by placental scar and embryo counts (Table 2). Any difference in the mean litter size found in the two different areas, or between embryo and scar counts was not found to be significant (paired t tests, 95% confidence interval).

The muskrats' overall reproductive capacity is reflected in the total number of placental scars laid down during the 1978 breeding season. This figure is a factor of litter size and the number of litters a given individual produces in one year. Figure two gives some indication of the overall reproductive capacity of Sacramento Valley muskrats. The mean number of young produced by an adult on the Conway Ranch is given in table one. This figure (19.3) probably reflects three or four litters. Although the muskrats taken in Solano County were not divided as to age class, the mean number of scars compares favorably with that found on the Conway Ranch (Table 1).

Some criticism has been expressed questioning the accuracy of placental scars as accurate indicators of reproduction (Davis and Emlen 1948). The agreement seen between the number of fresh placental scars and the number of embryos per uterus (Table 2) suggests that scar counts are accurate indicators of reproduction in

muskrats. Similarly, Errington (1963) found that placental scar counts were comparable to both embryo counts and data collected from litters examined in nests.

The occurrence of reproductively active "young of the year" undoubtedly adds to the overall reproductive potential of muskrat populations. In Errington's extensive work in Iowa (1963) he found breeding to occur in only 1.5% of young females examined in their calendar year of birth. He did, however, note years of relatively high degrees of precocial breeding, with as many as 6% of the "juvenile" females examined showing placental scars. Errington felt this fluctuation is part of the "ten year cycle" thought to occur in muskrat populations. Similarly, Mathiak (1966) found the occurrence of precocial breeding to vary from complete abscence in some years to one year in which 23% of the young of the year females had produced young as evidenced by the presence of placental scars.

During this study 17.8% of the females examined in their first year contained placental scars. This would seem to be a relatively high occurrence of precocial breeding, and would contribute substantialy to the overall reproductive capacity of Sacramento Valley muskrat populations. In addition, some juveniles produced two litters as evidenced by frequency distributions of scar counts (Figure 2).

Population Structure

The age and sex ratios of the muskrats inhabiting the Conway Ranch are indicated by the data collected during the 1978-79 trapping season (Table 4). This data indicates a population made up of 24% adults and 76% juveniles. The population sex structure differs between age classes, with males making up 64.5% of the adults and the juveniles being made up of approximately equal numbers of males (51.5%) and females (48.5%).

In considering age ratios, it must be pointed out that many individuals refered to here as juveniles are actually adults in that they are, or have been, reproductively active. The aging of muskrats was complicated by the extended breeding season with litters being produced as early as February, and as late as November. The age determining characteristics of "juveniles" born in February of 1978 would tend to overlap with those of adults born late in the fall of 1977. However, by applying several different age criteria, as summarized by Schofield (1955), error was minimized.

Sex and age ratios, as determined by trapping data, may be somewhat biased. Differential trappability has been shown in reference to age, sex, and reproductive condition of varius small mammal species (Smith et al 1975). By considering the various sex and age ratios of the muskrats captured in the several different types of traps used (Table 5), it can be determined if trap selectivity was a factor in collecting the data for this study.

It would seem that the basket traps, being set in runways, would be least selective in that they would take any muskrat moving along a given runway. The floats, in contrast, rely on the muskrats' habit of "hauling out" on objects in the water.

The percentages of male and female muskrats in the adult classes (Table 4) seems inconsistant with that found in the juvenile classes with males making up 64.6% of the adult classes and 51.5% of the juvenile classes. The percentage of adult males and females captured in the basket traps (57.9% male, 42.9% female) does

not differ significantly from an expected 50:50 ratio (Chi-square test, 95% confidence interval). The percentages of males and females captured on floats (63.9% male, 36.1% female) is of significant difference. The floats then, show a degree of selectiveness for males in the adult class. Since the floats were the most common type of set used, the unbalanced adult sex ratio seen in the over all catch is probably a result of trap selectivity. Similar testing for selectiveness for adults or juveniles does not show any significant difference in capture ratios between basket traps and floats. It must be kept in mind that many "juveniles" are actually mature individuals by the time this trapping was done, and wouldn't be expected to differ significantly from adults in terms of trap selectivity.

Survival Rates

The turnover rate of Sacramento Valley muskrats, as indicated by comparisons of reproductive capacity in terms of placental scar counts (Figure 2, Table 1 and 2) and the age ratios of Winter populations (Table 4), is quite high. If 100% survival was achieved by the young produced during the 1978 breeding season, the population would be expected to be made up of approximately 92% juveniles. This compares with a population made up of 76% juveniles as indicated by trapping data (Table 4). This 92% figure assumes that all adult females produced a mean number of young as indicated by placental scar counts (Table 1), and 17.8% of the young females produced conceived litters averageing 7.3 young (Table 1).

Survival is also indicated by the number of recaptures of tagged individuals taken during the 1978-79 trapping season, and during the following Spring live trapping (Table 7). Willow Slough, showed the highest turnover rate with only two of the twenty individuals tagged being recovered during the Spring 1979 live trapping. The Pelican Cut and Otis Road drain showed lower turnover rates as indicated by recapture data (Table 7). It is interesting to note that Willow Slough, which was not trapped during the 1978-79 trapping season, showed the lowest percentage of total recaptures.

No indication of tag shedding was noted during this study. Throughout the extended sampling during the Spring and Summer of 1978 no tagged muskrats were seen to lose tags. Tail banding was not successful in that no tail band stayed on for more than two weeks.

Population Densities

Muskrat densities as determined by Spring and Summer live trapping varied from between 2.5 and 12 adult pairs per mile. The number of breeding pairs occupying a given habitat (Table 6) was estimated by examining capture data, and taking into account the muskrats' territorial and monogamous behavior (Errington 1963). Since adult males were captured with relative ease in comparison to females (see sex ratio discussion) the presence of an adult male often was taken to indicate a breeding pair. During 1978 when live trapping was continued through the Summer months, this relationship was evident as most of the females were eventually captured.

Trap mortality, which occurred to a great degree during the 1978 live trapping and to a lesser extent during 1979, had a definite affect on the reselts. Muskrats

that were eliminated were replaced by individuals that moved into the vacant area. This accounts for the fact that some estimated adult populations (Table 6) are smaller than the total number of adults captured in a given area.

Willow Slough had by far the greatest population density of any area studied (Table 6). This is probably a factor of the highly suitable habitat, in the form of wide margins of marsh-like vegetation. The other two areas studied had limited amounts of this type of vegetation.

The population densities found in Willow Slough and the Otis Road drain were essentially similar during the two periods of sampling (1978 and 1979). Densities in the Pelican Cut were considerably lower during the 1979 sampling (Table 6). The number of muskrats taken from this canal during the 1978-79 trapping season seemed to be down from previous years. This change may have been due to the extensive stress put on the populations here by the constant 1978 live trapping. More time was spent trapping here than in the other two areas. Muskrats were so susceptible to "trap addiction" that one adult female in the Pelican Cut was captured a total of 29 times. Under such stress it appeared that this female did not produce a single litter, as no kits were captured in her territory. The extent to which stress limits the female muskrats ability to reproduce has been suggested by Dozier (1947) who, in reference to the raising of muskrats in captivity, stated "handling and disturbing female muskrats during the breeding period and after copulation was found to be detrimental to conception and reproduction".

Although an attempt was made to determine densities of juvenile muskrats in these areas, these individuals were not readily captured in the type of trap system used. Although the traps were baited with carrots, their effectiveness relyed on the muskrats' habit of climbing on objects floating on or protruding above the water. Juvenile muskrats apparently do no practice this behavior, as the only small (less than 300 grams) kits taken were captured in live traps set in bank runways. This type of set was not applicable to most areas.

Movements

The movements of muskrats, as revealed by this study, are extremely limited. Recaptures of individuals during the 1978-79 trapping season, and the 1979 live trapping, in most cases, occured in the same areas as their initial capture and tagging during the 1979 live trapping. One muskrat was taken just across a road from their capture location in the Otis Road drain. Furthest movements were seen in two "rats" recaptured in Willow Slough. These indiviuals were originally tagged in another section of Willow Slough during some limited sampling in the Summer of 1978. The water level in ths section of Willow Slough was extremely low during the early spring of 1979. This may have accounted for these individuals movement.

CENSUSING TECHNIQUES

During this study an attempt was made to try and determine a valid technique for accuratly censusing muskrat populations. As population size had been determined for several areas, it was hoped that a valid indicator could be found that would accuratly estimate these populations. The most valid indicator of muskrat numbers is undoubtably reflected in the presence of muskrat "sign" within the area being considered. Assigning some useable value to this indicator is where the

difficulty lies in describing a census technique.

The presence of muskrat sign in the form of feedbeds, accumulations of vegetation remaining at muskrat feeding stations, is a good indicator of muskrat activity. Attemps to correlate feedbed abundance with population densities were not successful in that feedbed abundance seemed to be related to type of area, not necessarily muskrat abundance. The marshy areas along Willow Slough contained numerous feedbeds, while the area censused in the Pelican Cut, where muskrats were abundant, contained few feedbeds, although "cuttings" were loosely distributed along the canal.

Possibly the best means by which muskrat populations can be censused, as noted by Errington (1963), would be by plotting the foci of muskrat activity at the start of the breeding season when territories are established. This would be at the time of lowest populations, and it may be possible to accuratly estimate the number of "breeding pairs" along a given section of canal.

Some work was done attempting to apply this technique during the Spring of 1979. This technique seemed to be quite applicable, although it seemed that often one territory seemed to be continuous with the adjacent one. The accuracy of this method demands that the censuser knows what to look for in terms of muskrat "sign".

SUMMARY

This survey documents many aspects of muskrat population dynamics which may be peculiar to Sacramento Valley populations. It must be kept in mind that this survey was of reasonably short duration, and may not show some aspects of muskrat population dynamics which might become apparent in a long term study. The phemonenon of the ten year cycle, for example, which Errington (1963) showed to be an influential factor concerning muskrat populations, was not considered in this study.

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