# CALIFORNIA FISH AND GAME

"CONSERVATION OF WILDLIFE THROUGH EDUCATION"

VOLUME 43 JULY, 1957 NUMBER 3

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# CALIFORNIA FISH AND GAME

VOLUME 43 JULY, 1957 NUMBER 3

*Published Quarterly by the*

CALIFORNIA DEPARTMENT OF FISH AND GAME

SACRAMENTO

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# FOOD HABITS OF THE TEHAMA DEER HERD[1]

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## INTRODUCTION

The Tehama deer herd consists of Columbian black-tailed deer, *Odocoileus hemionus columbianus* (Richardson). These deer are migratory, summering within and in the vicinity of Lassen Volcanic National Park and wintering along the foothill slopes bounded by the watersheds of Battle Creek on the north and Deer Creek on the south (Figure 1).

In recent years an increase in herd size has been a source of concern to livestock interests, which are aware of the competition between deer and livestock for forage on the winter range. During the period from 1942 to 1949 the State of California purchased 42,897 acres of range in the wintering area, with the intent of improving the range conditions through the control of livestock grazing and by increasing the hunter harvest of deer through construction of public access roads.

The California Fish and Game Commission in February, 1950, authorized the collection of four female deer per month (not to exceed a total of 100). The purpose was to determine the food habits and to collect reproductive and other biological data pertinent to this important deer herd. In addition, supplementary stomach samples were obtained from hunter-killed deer. Collections were made by the staff of the California Department of Fish and Game Disease and Food Habits Laboratory.

The data presented here represent the results of the food habits study as determined by the stomach analyses of 96 deer collected from the winter range and 37 deer collected from the summer range. In addition, data gathered in the course of a field investigation conducted at the same time were incorporated into the study.

The important contribution of the forage production of annuals on the winter range to the diet of deer is demonstrated by the study. This phenomenon, undoubtedly, is a major factor affecting the carrying capacity of the range both for deer and livestock, not only on the Tehama winter deer range, but also on other deer winter ranges of the California annual type.

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[1] Submitted for publication December, 1956. This study was carried out by Federal Aid in Wildlife Restoration Project California W-25-R, "Food Habits Investgatons". The writers wish to express acknowledgment to Robert A. Gardner, Soil-Vegetation Survey Project, California Forest and Range Experiment Station, and to Dr. L. T. Burcham of the California Division of Forestry for their constructive suggestions regarding the original manuscript.

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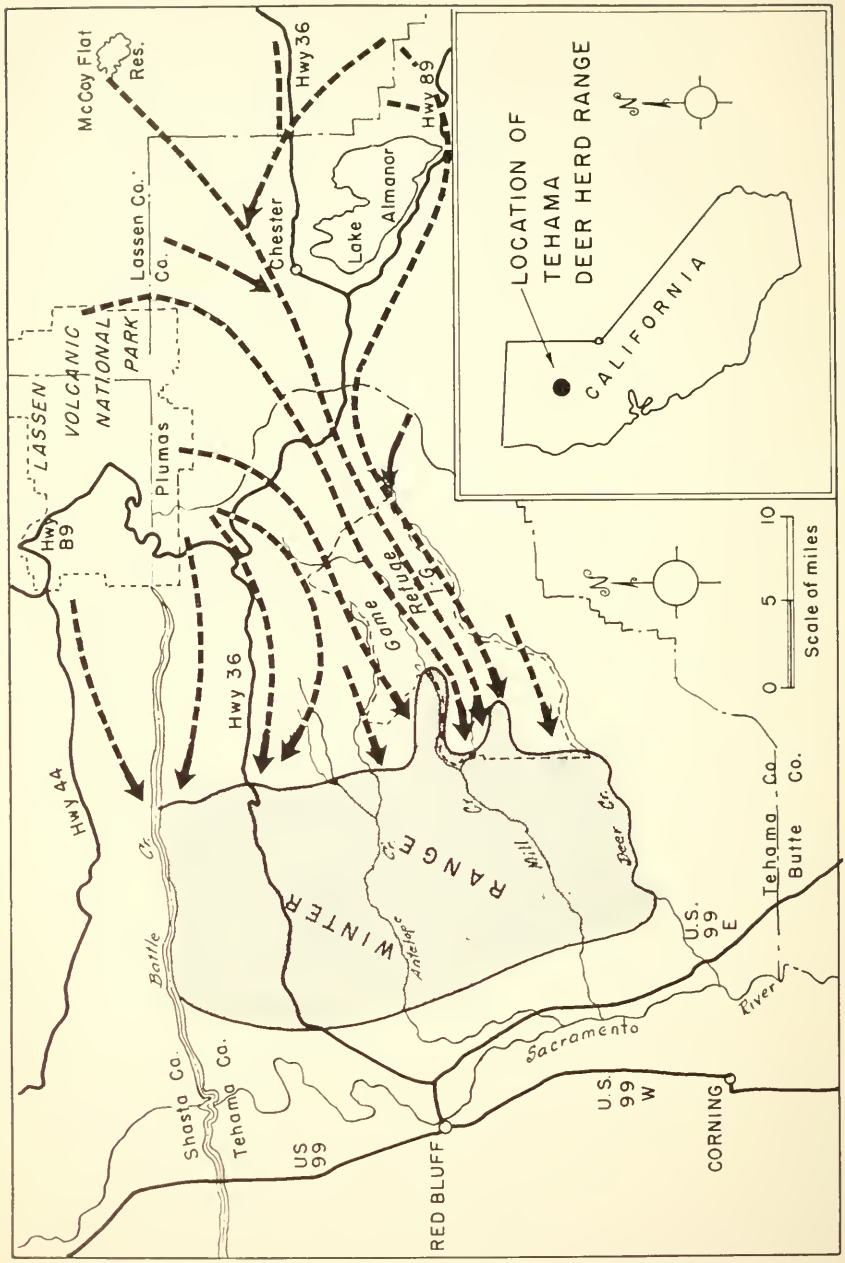


FIGURE 1. Map showing the location of the summer and winter deer ranges of the Tehama deer herd. Arrows indicate migration routes into the winter range. *Drawing by Cliffa Carson.*

## THE DEER HERD

The Tehama herd summers at elevations of 4,000 to 9,000 feet and winters from the edge of the valley floor to the 3,500 foot level. A movement of deer from the summer to the winter range usually occurs during the middle of October. This migration is well known to sportsmen, and a heavy concentration of hunting effort is directed toward the deer during the latter part of the hunting season, which in recent years has varied from the middle to the end of October. Heavy hunting pressure on the herd also occurs when the deer are on the summer range and after the deer have concentrated on their winter range. Much of the area of summer and winter ranges is relatively inaccessible to the hunters, and there are years when the deer do not move onto the lower reaches of the range until after deer season.

This herd produces an appreciable harvest of male deer, and some of the largest black-tailed deer killed in California. Despite the heavy hunting pressure and a two-buck limit in effect since 1950, there has been a noticeable increase in deer numbers in recent years. In order to obtain a greater harvest the Commission authorized a special hunt quota for taking antlerless deer from November 1 to November 6, 1955. In 1956, during the last three days of the regular season, antlerless deer could legally be taken without a quota.

Deer were not always as numerous as they have been during the past decade. A scarcity of deer in the early days prompted the Legislature to establish Refuge 1G in 1917, to give protection to the deer. This refuge persists today, despite the increase in deer numbers and the need of additional hunter harvest of deer.

## DESCRIPTION OF THE WINTER RANGE

The winter range is one of the most extensive black-tailed deer winter ranges in California. It comprises over 220,000 acres. Geologically, the area is of volcanic origin, having been influenced by a series of mud flows attributable to the volcanism of the Lassen Park region to the northeast. The watercourses have cut this once continuous volcanic breccia into steep-sided canyons, exposing prominent rim rocks and lava outcroppings. The most prominent of these are the canyons of Battle, Paynes, Antelope, Mill, and Deer creeks. In addition, sheet erosion and weathering have had the effect of leaving some slopes completely bare to bedrock, others strewn with basaltic rock, and still others with enough accumulated soil to support vegetation. Often vegetation will be found along lateral seams, where soil and moisture conditions are favorable. A strikingly striated appearance of vegetative growth, characteristic of much of the region, has resulted (Figure 3).

Work done by the California Soil-Vegetation Survey [2] indicates that the woodland-grass and grass types of the vegetative cover occur on the Toomes soils and the brush and dense hardwoods on the Stover soils. The Toomes soil series is found predominantly throughout the area and varies in depth from 8 inches to 24 inches. The deeper Stover soil series (30 inches to 40 inches in depth) supports the brush and hardwood vegetative types and occurs on colluvial stringers or benches

[2] This survey is conducted by the California Forest and Range Experiment Station and the University of California under contract with the California Division of Forestry.

FIGURE 2. The woodlond-grass cover type which characterizes the lower reaches of the Tehama winter range. Deer graze these areas in the fall months for the fallen leafage and acorns af blue oak. With the advent of early fall rains these lower foothills are the first to "green up" with the production of onnual forage and are grazed extensively by deer and livestock. *Photograph by Howard R. Leach.*

FIGURE 3. The underlying soil types are largely responsible for the striated vegetative growth illustrated here. *Photograph by Howard R. Leach.*

FIGURE 4. The deeper soils of the north-facing slopes support dense chaparral and hardwood stands. *Photograph by Howard R. Leach.*

throughout the Toomes soils, primarily on the north-facing slopes (correspondence with Robert A. Gardner, 1957). Figures 2, 3, and 4 illustrate the vegetative aspect of the winter range.

The Tehama winter deer range is, like most foothill sections of cismontane California, an annual range type in its lower reaches, with the characteristic range problems inherent in this type. The wide and irregular changes in forage production from year to year due to climatic fluctuations not only directly affect the livestock grazing of these annual ranges but also have an impact on the carrying capacity for wildlife. Deer are no exception.

## STUDY AREA

Public access to the winter range north of Antelope Creek is provided by State Highway 36 and a number of unpaved county roads. South of Antelope Creek the range is less accessible, being limited mostly to jeeps and other four-wheel drive vehicles. One such jeep road traverses the rim of Dye Creek and Mill Creek canyons from the valley floor to the lower edge of the summer range. This road provided access to the deer over the entire period, and allowed coverage of an area representative of most of the winter range. Consequently, this area was selected for study.

## VEGETATIVE DESCRIPTION OF THE STUDY AREA

Figure 5 shows a portion of a vegetative type cover map of the Tehama winter deer range delineating the study area. This map was drawn from aerial photographs by William P. Dasmann, using the techniques described by Jensen (1947). It gives the gross characteristics

of the study area relative to the interspersal of the vegetative cover types.

Essentially, the vegetative complex consists of four broad types, described as follows and shown by symbols in Figure 5.

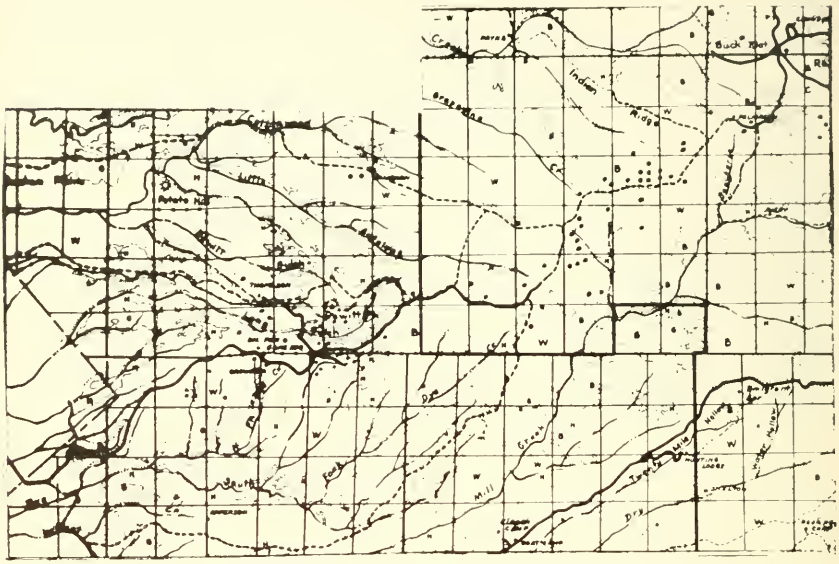


FIGURE 5. A vegetative type cover map of the study area, showing the interspersion of the vegetative types. Spots indicate where deer were collected.

The lower reaches of the foothills are, predominantly, either a grass (G) or a woodland-grass (W) type. The woodland is of blue oak with an understory of annual grasses consisting mostly of soft chess, ripgut brome, red brome (*Bromus rubens*), foxtail fescue (*Festuca megalura*), wild oat (*Avena sp.*), nitgrass (*Gastridium sp.*), and wild barley. These annual grasses are also dominant in the grass type. Some perennial grasses such as needlegrass, *Sitanion*, *Melica*, and blue grass are found but constitute little of the vegetative composition. These two vegetative types persist throughout most of the winter range.

The annual grasses and such forbs as the filarees, popcorn flower, hillside lotus, lupine, bur clover, and chickweeds germinate with the advent of early fall rains. These are supplemented over the winter and early spring months by numerous species of native and non-native broad-leafed forbs. Above the 1,000-foot elevation the woodland grass occurs for the most part on the shallow Toomes soils of the hillsides and swales and more predominantly on the south-facing slopes. Interspersed over the range are areas of chaparral or brush (B). The browse species characterizing the chaparral consist principally of buck brush, California scrub oak, western mountain mahogany, silktassel, and manzanita. Scattered in the chaparral are foothill ash, western hoptree, poison oak, California buckeye, yerba santa, chaparral honeysuckle,

redbud, and California juniper. Many of these browse plants are deciduous. There are occasional thickets of California black oak, but this oak, together with Brewer oak, is more prevalent at the upper margin of the winter range. Along the watercourses grow Fremont cottonwood, western chokecherry, creek dogwood, willow, alder, and California wild grape. The density of the chaparral varies from thick, mature stands, noticeably on the north-facing slopes, to opened-up brush fields on the more shallow soils and in areas influenced by past fire history. The hardwood stands (II) characterizing the deeper soils consist mostly of mature oaks, either growing as a dense woodland of blue oak or stringers of interior live oak along the fissures and lava outcroppings.

One hundred and one line-point forage plots were established to collect data relative to the ground cover and vegetative composition of the Tehama winter deer range. An analysis of the ground cover composition based on these plots is given in Table 1. It is considered to be representative of the entire winter range.

Table 2 gives the composition of the vegetative cover as determined by these same 101 line-point plots and is an index to the relative abundance of the principal plants making up the forage composition.

TABLE 1

Percentage Composition of Ground Cover on the Tehama Winter Deer Range

| | |
|---|---|
| Nonproductive | 54.8 |
| Annual grasses and forbs | 27.2 |
| Perennial grasses | 0.5 |
| Browses (shrubs and trees) | 17.5 |

TABLE 2

Percentage Composition of the Vegetative Cover on the Tehama Winter Deer Range

| | |
|---|---|
| Annual grasses and forbs | 59.9 |
| Perennial grasses and forbs | 11.5 |
| Total herbs | 71.4 |
| Buck brush | 6.3 |
| California scrub oak | 4.5 |
| Brewer oak | 2.9 |
| Manzanita | 1.5 |
| Western mountain-mahogany | 1.5 |
| Squaw carpet | 1.3 |
| Deer brush | 1.2 |
| Poison oak | 1.4 |
| Blue oak | 0.9 |
| Yerba santa | 0.7 |
| California black oak | 0.6 |
| Oregon grape | 0.5 |
| Western chokecherry | 0.5 |
| Silktassel | 0.5 |
| Interior live oak | 1.0 |
| Ponderosa pine | 0.4 |
| Squaw bush | 0.4 |
| Creek dogwood | 0.2 |
| Other browses | 2.3 |
| Total browse | 28.6 |

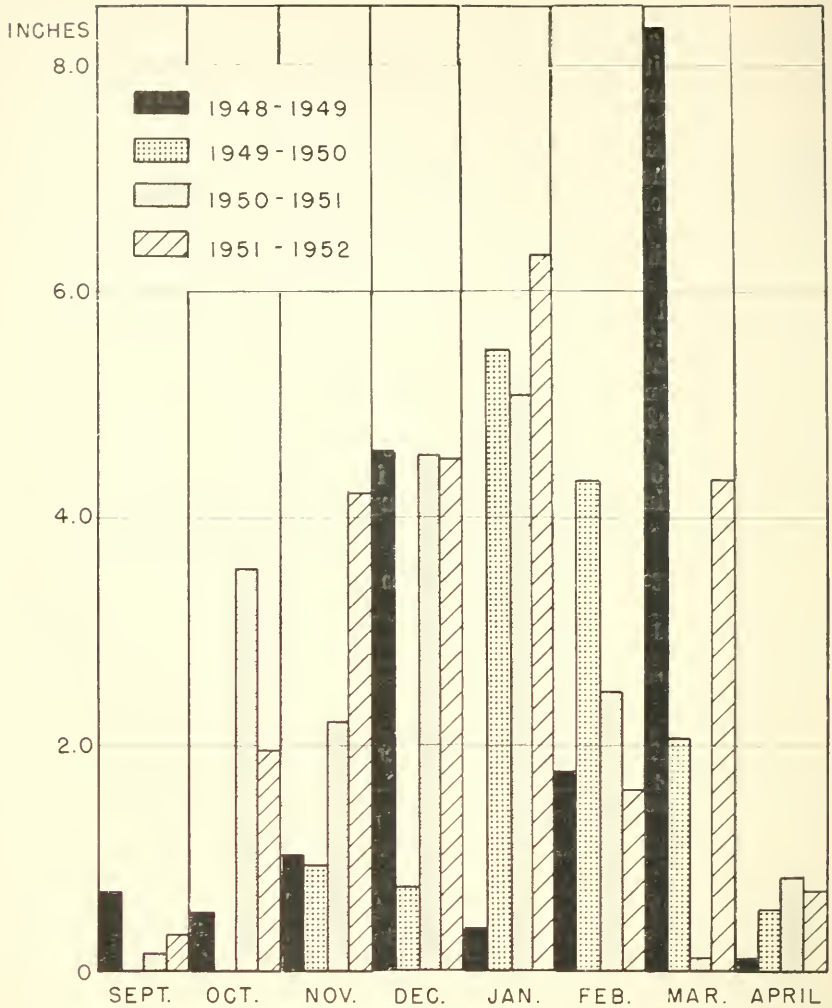


FIGURE 6. Average monthly precipitation at Red Bluff for the winter months of 1948-1952, showing wide seasonal fluctuotions in rainfall. *Drawing by Cliffa Corson.*

## CLIMATE

The climate is characteristic of much of the Central Valley foothills region of California. Generally, winter temperatures are mild and summer temperatures high. A rainy winter season is followed by a rainless summer period. Comparatively gentle rains occur normally in October and November and increase in intensity during the winter. Snow occurs occasionally at the lower elevations but melts off rapidly. At the higher elevations snow remains for varying periods. The rainy season is often accompanied by fog, which may persist for many days in succession. Seasonal precipitation both in amount and distribution is the main factor influencing forage conditions on the winter range.

In addition to precipitation, the growing period of the annual vegetation is influenced by dry, cold, northerly winds, which occur frequently and inhibit the growth of annual vegetation.

Unfortunately, weather data relative to precipitation, temperature, and snowfall are not available for the area encompassed by the winter range. The U. S. Weather Bureau maintains a permanent weather station on the edge of the summer range at Mineral, at an elevation of 4,850 feet, and another on the valley floor at Red Bluff, elevation 341 feet. The fluctuation in seasonal rainfall at Red Bluff for the winters of 1948-49, 1949-50, 1950-51, and 1951-52 is shown in Figure 6. The four winters represented illustrate the variance in seasonal precipitation which is characteristic of the area.

Considering the period of study—February, 1950, to December, 1951—it may be seen that the later winter months of 1949-50 were months of relatively high precipitation which had been preceded by an extremely dry fall period and that the winters of 1950-51 and 1951-52 were wet seasons.

## WINTER FOOD HABITS

The food items identified in the 96 deer stomach samples collected during the winter study period are summarized in Tables 3 and 4. Table 3 gives the volume in percentage and frequency of occurrence in percentage of those food items making up 0.1 percent or more of the diet for any one month of the collection. Table 4 is a supplementary list expressed in frequency of occurrence in percentage of those food items contributing less than 0.1 percent of any one monthly period.

A graphic representation of the monthly dietary changes in food habits in given in Figure 7. The following discussion of the food habits

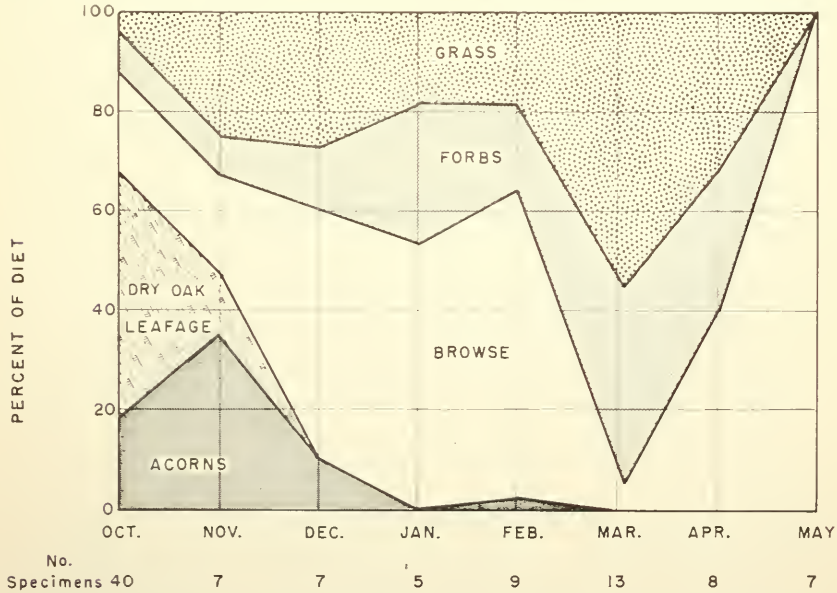


FIGURE 7. A graphic representation of the diet of deer on the Tehama winter deer range, showing the seasonal variations in food habits. *Drawing by Cliffa Corson.*

TABLE 3

Food Items Eaten by 96 Black-tailed Deer Taken From the Tehama Winter Deer Range, Expressed in Percentages *

| Scientific name | Common name | October | | November | | December | | January | | February | | March | | April | | May | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Volume | Frequency | Volume | Frequency | Volume | Frequency | Volume | Frequency | Volume | Frequency | Volume | Frequency | Volume | Frequency | Volume | Frequency | Volume | Frequency |
| | Number of specimens | 40 | | 7 | | 7 | | 5 | | 9 | | 13 | | 8 | | 7 | | 96 | |
| Browse | | | | | | | | | | | | | | | | | | | |
| *Abies concolor* | White fir | 0.3 | 5.0 | | | 0.3 | 14.2 | | | | | | | | | | | 0.1 | 0.3 |
| *Librocedrus decurrens* | Incense cedar | 0.2 | 1.0 | | | trace | 14.2 | | | | | | | | | | | trace | 0.5 |
| *Quercus douglasii* | Blue oak | 16.8 | 32.5 | 14.6 | 85.7 | 1.0 | 42.8 | trace | 40.0 | 1.0 | 22.2 | trace | 46.1 | | | 12.7 | 42.8 | 9.1 | 36.5 |
| *Quercus kelloggii* | California black oak | 27.8 | 47.5 | | | | | | | | | | | 5.6 | 12.5 | 21.0 | 71.4 | 13.6 | 26.0 |
| *Quercus garryana* | Brewer oak | 7.5 | 25.0 | | | | | | | | | | | | | | | 3.0 | 10.4 |
| *Quercus dumosa* | Scrub oak | 1.9 | 12.5 | | | 2.2 | 42.8 | 31.0 | 80.0 | 29.4 | 55.6 | | | 0.3 | 50.0 | 49.4 | 85.7 | 8.9 | 28.1 |
| *Quercus wislizenii* | Interior live oak | | | 0.3 | 14.2 | | | trace | 20.0 | trace | 11.1 | | | | | | | trace | 3.1 |
| *Quercus* spp. (acorns) | Oak | 18.7 | 82.5 | 31.9 | 85.7 | 10.7 | 42.8 | | | | | | | | | | | 11.1 | 46.9 |
| *Ribes* sp. | Gooseberry | 1.4 | 2.5 | | | | | | | | | | | | | | | 0.6 | 0.1 |
| *Cercocarpus betuloides* | Western mountain-mahogany | 2.2 | 55.0 | 4.7 | 28.5 | 2.2 | 42.8 | trace | 40.0 | trace | 33.3 | 1.1 | 46.2 | 26.5 | 87.5 | 5.1 | 100.0 | 4.2 | 54.2 |
| *Cercis occidentalis* | Redbud | 0.5 | 12.5 | | | | | | | | | | | | | trace | 14.2 | 0.2 | 6.3 |
| *Ptelea baldwinii* | Western hop-tree | trace | 5.0 | | | | | | | | | | | 2.1 | 12.5 | | | 0.1 | 3.1 |
| *Rhus diversiloba* | Poison oak | trace | 15.0 | | | | | | | | | | | | | 2.6 | 14.2 | 0.2 | 7.3 |
| *Aesculus californica* | California buckeye | | | | | | | | | | | 0.8 | 23.0 | 2.5 | 12.5 | 2.6 | 28.4 | 0.5 | 6.3 |
| *Rhamnus crocea* | Redberry | 0.4 | 30.0 | trace | 14.2 | trace | 28.5 | | | | | trace | 7.7 | | | | | 0.2 | 16.7 |
| *Ceanothus cuneatus* | Buck brush | 2.5 | 60.0 | 13.6 | 71.4 | 18.0 | 85.7 | 0.6 | 60.0 | 0.8 | 66.7 | 0.1 | 61.5 | trace | 87.5 | 2.6 | 85.7 | 3.7 | 67.7 |
| *Ceanothus integerrimus* | Deer brush | 7.3 | 40.0 | | | | | | | trace | 11.1 | | | 1.8 | 25.0 | trace | 14.2 | 3.2 | 21.0 |
| *Ceanothus prostratus* | Squaw carpet | 1.5 | 20.0 | | | 10.4 | 14.2 | | | | | | | | | | | 1.4 | 9.3 |
| *Garrya* sp. | Silktassel | 1.0 | 30.0 | | | 12.1 | 42.8 | 14.0 | 60.0 | 22.6 | 55.6 | 2.7 | 30.8 | | | | | 1.4 | 9.0 |
| *Arctostaphylos* sp. | Manzanita | trace | 15.0 | trace | 14.2 | trace | 14.2 | 0.6 | 80.0 | 1.4 | 66.7 | trace | 30.8 | 1.4 | 62.5 | 3.7 | 100.0 | 4.9 | 40.6 |
| *Fraxinus dipetala* | Foothill ash | 0.3 | 30.0 | | | | | | | | | trace | 30.8 | trace | 12.5 | trace | 42.8 | 1.7 | 27.1 |
| *Lonicera interrupta* | Chaparral honeysuckle | 0.4 | 17.5 | 0.9 | 28.5 | 4.3 | 14.2 | | | | | | | | | trace | 14.3 | 0.6 | 11.5 |
| *Quercus* sp. (galls) | Oak gall | | | | | | | | | 1.1 | 22.2 | | | | | | | 0.1 | 2.1 |
| *Eriodictyon californicum* | Yerba santa | | | | | trace | 42.8 | 8.0 | 60.0 | 6.4 | 66.7 | 0.8 | 53.8 | trace | 12.5 | trace | 14.3 | 1.1 | 21.9 |
| | Total browse | 90.7 | | 69.0 | | 61.2 | | 54.2 | | 62.7 | | 5.5 | | 40.2 | | 100.0 | | 69.9 | |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Forbs | | | | | | | | | | | | | | | | | | | |
| Fungus | Mushroom | trace | 2.5 | ------ | ------ | 3.6 | 14.2 | trace | 20.0 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0.2 | 3.1 |
| *Brodiaea capitata* | Blue dicks | trace | 2.5 | ------ | ------ | trace | 14.2 | 13.0 | 20.0 | 16.3 | 33.3 | 20.2 | 30.8 | trace | 37.5 | trace | 28.5 | 4.9 | 15.6 |
| *Eriogonum* sp. | Wild buckwheat | 2.0 | 20.0 | 0.4 | 28.6 | trace | 14.2 | trace | 20.0 | ------ | ------ | trace | 7.7 | ------ | ------ | ------ | ------ | 0.9 | 13.5 |
| *Erodium cicutarium* | Red stem filaree | 0.1 | 12.5 | 7.4 | 57.1 | 8.4 | 42.8 | 14.6 | 60.0 | trace | 44.4 | 14.1 | 31.3 | 14.4 | 87.5 | trace | 28.5 | 0.6 | 33.3 |
| *Calycadenia* sp. | Rosin weed | 1.9 | 15.0 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0.7 | 6.3 |
| *Lotus americanus* | Spanish clover | 0.5 | 7.5 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0.2 | 3.1 |
| *Medicago hispida* | Bur clover | trace | 12.5 | trace | 57.1 | trace | 28.4 | 0.2 | 60.0 | trace | 33.3 | 0.4 | 23.1 | trace | 12.5 | trace | 14.2 | 0.6 | 21.9 |
| Unidentified forbs | ------ | 3.0 | 47.5 | trace | 71.4 | trace | 14.2 | trace | 60.0 | trace | 33.3 | 4.2 | 76.9 | 11.6 | 100.0 | trace | 71.4 | 2.7 | 56.3 |
| | Total forbs | 7.5 | | 7.8 | | 12.0 | | 27.8 | | 16.3 | | 38.9 | | 26.0 | | | | 10.8 | |
| Grass | | | | | | | | | | | | | | | | | | | |
| Gramineae (dry) | Grass family | 1.4 | 32.5 | 0.9 | 57.1 | 3.9 | 57.1 | trace | 60.0 | 1.1 | 44.4 | 0.4 | 61.5 | ------ | ------ | trace | 14.2 | 2.8 | 38.5 |
| Gramineae (green) | ------ | 0.4 | 22.5 | 22.3 | 100.0 | 22.9 | 100.0 | 18.0 | 100.0 | 19.9 | 88.9 | 55.2 | 100.0 | 33.8 | 100.0 | ------ | ------ | 16.5 | 61.5 |
| | Total grass | 1.8 | | 23.2 | | 26.8 | | 18.0 | | 21.0 | | 55.6 | | 33.8 | | | | 19.3 | |

* Those food items bulking to less than 0.1 percent of the diet for any monthly period are included in Table 4.

## TABLE 4

### Supplemental List of Food Items Eaten by 96 Deer Collected on the Tehama Winter Deer Range

| Scientific name | Common name | Percentage frequency of occurrence |
|---|---|---|
| Browse | | |
| *Pinus ponderosa* | Yellow pine | 8.3 |
| *Pinus sabiniana* | Digger pine | 6.2 |
| *Juniperus californica* | California juniper | 5.2 |
| *Torreya californica* | California nutmeg | 1.0 |
| *Salix* sp. | Willow | 2.0 |
| *Arceuthobium* sp. | Pine mistletoe | 2.0 |
| *Phoradendron villosum* | Common mistletoe | 5.2 |
| *Umbellularia californica* | California laurel | 2.0 |
| *Aesculus californica* (fruit) | California buckeye | 1.0 |
| *Fremontia californica* | Flannel bush | 2.0 |
| *Chrysothamnus* sp. | Rabbitbrush | 1.0 |
| Unidentified browse | | 3.1 |
| Forbs | | |
| Lichen | | 6.2 |
| Bryophyta | | 10.4 |
| *Pellaea andromadaefolia* | Coffee fern | 5.2 |
| Polypodiaceae | Fern family | 2.0 |
| *Selaginella* sp. | Club moss | 2.0 |
| Liliaceae | Lily family | 6.2 |
| *Polygonum bolanderi* | | 9.4 |
| *Polygonum* sp. | Knotweed | 2.0 |
| *Rumex* sp. | Dock | 1.0 |
| *Amaranthus* sp. | Amaranth | 1.0 |
| *Mollugo verticillata* | Indian chickweed | 1.0 |
| *Montia perfoliata* | Miner's lettuce | 7.3 |
| *Stellaria* sp. | Chickweed | 2.0 |
| *Silene* sp. | Catch-fly | 1.0 |
| Caryophyllaceae | Pink family | 1.0 |
| *Ranunculus californicus* | California buttercup | 2.0 |
| *Athysanus pusillus* | | 8.3 |
| *Lepidium nitidum* | Common peppergrass | 15.6 |
| *Platyspermum scapgerum* | | 3.1 |
| *Thysanocarpus* sp. | Fringe pod | 2.0 |
| Cruciferae | Mustard family | 7.3 |
| *Saxifraga* sp. | Saxifrage | 2.0 |
| *Lotus* sp. | Trefoil | 6.3 |
| *Lupinus* sp. | Lupine | 2.0 |
| *Trifolium* sp. | Clover | 1.0 |
| *Limnanthes alba* | | 1.0 |
| *Euphorbia* sp. | Spurge | 3.1 |
| Leguminosae | Pea family | 1.0 |
| Malvaceae | Mallow family | 1.0 |
| *Epilobium* sp. | Willow herb | 1.0 |
| *Godetia* sp. | Godetia | 1.0 |
| *Sanicula* sp. | Snake root | 1.0 |
| *Daucus pusillus* | Rattlesnake weed | 1.0 |
| *Lomatium* sp. | Hog-fennel | 2.0 |
| *Amsinckia* sp. | Fiddleneck | 1.0 |
| *Trichostema lanceolatum* | Vinegar weed | 1.0 |
| *Galium* sp. | Bedstraw | 7.3 |
| *Ambrosia psilostachya* | Western ragweed | 1.0 |
| *Hemizonella minima* | | 1.0 |
| *Eriophyllum lanatum* | Wooly-yarrow | 1.0 |
| *Centaurea melitensis* | Napa thistle | 1.0 |
| Compositae | Sunflower family | 7.3 |

TABLE 4—Continued

Supplemental List of Food Items Eaten by 96 Deer Collected on the Tehama Winter Deer Range

| Scientific name | Common name | Percentage frequency of occurrence |
|---|---|---|
| Grass and grass-like plants | | |
| *Agropyron* sp. | Wheat grass | 2.0 |
| *Avena fatua* | Wild oat | 1.0 |
| *Bromus mollis* | Soft chess | 42.7 |
| *Bromus rigidus* | Ripgut brome | 1.0 |
| *Festuca* sp. | Fescue | 3.1 |
| *Hordeum* sp. | Wild barley | 4.1 |
| *Stipa* sp. | Needlegrass | 1.0 |
| *Poa* sp. | Blue grass | 1.0 |
| Cyperaceae | Sedge | 5.0 |
| *Juncus* sp. | Rush | 1.0 |

of the deer on the Tehama winter deer range is based chiefly on the analysis of the data presented in the above tables and Figure 6. Admittedly, the sampling is small, but it does give evidence that deer experience a seasonal dietary change influenced by the availability of forage as determined by seasonal climatic changes.

Normally the deer enter the winter range in appreciable numbers during the middle of October, the does and fawns ordinarily preceding the bucks. Once they reach the winter range they disperse over the area and remain approximately 210 days. Generally by the first week in May they have started their return to the summer range. Their exodus from the summer range is generally attributed to a response to weather conditions. It has been observed that in years of good acorn production the deer tend to move to the winter range in large numbers earlier than in years of acorn failure. Upon entering that area contiguous with the summer range, deer seek out and utilize the acorns and fallen leafage of California black oak and Brewer oak and supplement this diet with the leafage of squaw carpet, deer brush, white fir, and incense cedar. They soon move to the lower elevations and are commonly seen grazing the woodland areas, seeking the leafage and acorns of blue oak.

With the advent of the early rains in October and November there is an immediate response in the germination of the annual forage plants and the foothills "green up." These annuals normally make little growth in the months of December, January, and early February, but in late February and March they grow and mature rapidly. Deer begin to utilize the growth of green grass and forbs as soon as it makes its appearance in October and November and continue to use it until the plants reach maturity in April. The heaviest consumption of herbaceous food is apparent in March, during the period when it is most available. However, as soon as the new leafage appears on the deciduous and evergreen browse plants, an abrupt change to browse consumption is made.

Browse is the staple item of diet and it is obvious that it becomes the principal means of support in winters of adverse growing conditions (when there is little production of annual forage) or when an acorn crop failure occurs. There appears to be a seasonal preference in the utilization of browse species. Buck brush receives consistent usage by deer throughout most of the winter. It is the most abundant shrub and

one which forage utilization checks reveal to be heavily utilized. Manzanita contributes little bulk to the diet, although it is eaten in every month of the winter. Western mountain-mahogany is a semideciduous plant and apparently is most heavily utilized in the fall months and again in April and May, when the young growth becomes available. This is noticeably true of the other deciduous browses such as redbud, California buckeye, hop-tree, poison oak, and deer brush. During the months of December, January, and early February, when the herbaceous plants are normally retarded in growth, deer rely more heavily on buck brush, manzanita, scrub oak, silktassel, and yerba santa for food. Forage utilization checks show use to be heaviest on western mountain-mahogany, silktassel, and buck brush. The transition from a diet composed largely of herbs to one of browse is most pronounced in April and May, when the browse plants sprout new leafage and deer are quick to take advantage of this source of food.

It has been observed that a 20-day difference in forage growth conditions exists between the 1,000- and 3,000-foot levels. Annual forage which has reached maturity at the lower elevations in February and March is in various stages of development at the higher elevations. This altitudinal response in forage production is most noticeable in the spring months, when the deciduous trees and shrubs begin to sprout new leafage. The altitudinal distribution of deer in the winter months, and especially so during the period of spring migration, is largely in response to this phenological change in forage production as it affects both the palatability and availability of food.

## SUMMER RANGE DEER FOOD HABITS

The food habits of the Tehama deer herd on the summer range received less intensive study. The limited sampling of 37 deer stomach samples was represented by 32 deer collected monthly by the Disease and Food Habits Laboratory staff from July through September of 1950 and 1951 and five stomach samples obtained from hunter-killed deer. The general locality of the special collection was in the area southeast of Lassen Volcanic National Park and north of Lake Almanor. The collection included a sampling of deer from the Childs Meadow, Wilson Lake, Warner Creek, and Mud Creek areas in Plumas and Tehama counties.

The summer range of the Tehama deer herd, as described by Grinnell et al. (1930), reaches eastward around the northwestern base of Lassen Peak, at least to the vicinity of Manzanita Lake. In the southern portion of the area it has been found to extend down Warner Creek from Hot Springs Valley to Lake Almanor, and thence eastward to the vicinity of Westwood.

This summer range, with the exception of the higher elevations, is predominantly the transition forest climax characterized by a mixed forest of yellow pine, sugar pine, Douglas fir, white fir, and incense cedar. The understory consists principally of mountain whitethorn, snowbrush, squaw carpet, greenleaf manzanita, chinquapin, bitter cherry, western service berry, and gooseberry. Where logging and fire have removed the forest canopy, extensive brush fields of greenleaf manzanita, mountain whitethorn, and snowbrush have developed as a subclimax. Figure 8 is a photograph of typical summer range country.

FIGURE 8. An illustration of the secondary succession following fire and/or logging operations in the transition forest climax, typical summer range. Mountain whitethorn and greenleaf manzanita form the principal subclimax and are important forage species for the deer. *Photograph by Howard R. Leach.*

Table 5 is a composite summary of the food items eaten by the 37 deer collected from the summer range. Browse made up 72.1 percent of the diet. Based on the percentage volume and frequency of occurrence, the preferred browse plants consisted of mountain whitethorn, squaw carpet, greenleaf manzanita, western service berry, and snowbrush. Mountain whitethorn was the most important source of food, having constituted 33.2 percent of the diet and being found in 78.4 percent of the stomachs. This shrub is an abundant and widely distributed browse plant in the Sierran montane forest. It occurs from 4,000 to 9,000 feet and may be found growing as a forest understory or as the dominant in the subclimax montane chaparral which develops following fire and/or extensive logging operations. Forbs apparently contribute more heavily to the summer diet than does grass, since forbs formed 25.1 percent of the diet. Grass, although found in 72.9 percent of the stomachs, contributed but 2.8 percent of the food eaten. Numerous forbs were identified in the stomachs, but the bulk of this herbaceous food was unidentified.

Admittedly, determination of the food habits of deer on the summer range would require considerably more samples of deer stomachs than the 37 analyzed in Table 5. In such a study consideration would have to be made of the vegetational changes characterizing the various life zones over which the deer distribute themselves over the summer periods. The present limited sampling precludes such an analysis.

TABLE 5

Food Items Eaten by 37 Deer Collected From the Summer Range of the Tehama Deer Herd

| Scientific name | Common name | Percentage volume | Percentage frequency of occurrence |
|---|---|---|---|
| Browse | | | |
| *Ceanothus cordulatus* | Mountain whitethorn | 33.2 | 78.4 |
| *Ceanothus prostratus* | Squaw carpet | 7.3 | 45.9 |
| *Arctostaphylos patula* | Greenleaf manzanita | 6.2 | 48.6 |
| *Ceanothus velutinus* | Snowbrush | 6.1 | 18.9 |
| *Amelanchier alnifolia* | Western service berry | 3.7 | 45.9 |
| *Castanopsis sempervirens* | Chinquapin | 2.7 | 10.8 |
| *Ceanothus integerrimus* | Deer brush | 2.7 | 2.7 |
| *Alnus tenuifolia* | Mountain alder | 2.7 | 8.1 |
| *Ribes* sp. | Gooseberry | 2.4 | 10.8 |
| *Abies concolor* | White fir | 2.0 | 27.0 |
| Unidentified browse | | 1.0 | 8.1 |
| *Librocedrus decurrens* | Incense cedar | 1.0 | 51.4 |
| *Prunus emarginata* | Bitter cherry | 0.9 | 16.2 |
| *Prunus virginiana* var. *demissa* | Western choke-cherry | 0.1 | 5.4 |
| *Chrysothamnus parryi* | Rabbitbrush | 0.1 | 5.4 |
| *Pinus ponderosa* | Yellow pine | trace | 37.8 |
| *Pinus contorta* | Lodgepole pine | trace | 5.4 |
| *Salix* sp. | Willow | trace | 5.4 |
| *Populus trichocarpa* | Black cottonwood | trace | 2.7 |
| *Quercus kelloggii* | California black oak | trace | 5.4 |
| Total browse | | 72.1 | |
| Forbs | | | |
| Unidentified forbs | | 14.0 | 86.5 |
| *Ranunculus alismaefolius* | Buttercup | 5.2 | 18.9 |
| *Pedicularis semibarbata* | Lousewort | 2.6 | 2.7 |
| *Menyanthes trifoliata* | Buckbean | 1.0 | 2.7 |
| Polypodiaceae | Fern family | 0.9 | 8.1 |
| Liliaceae | Lily family | 0.7 | 8.1 |
| Lichen | Lichen | 0.5 | 59.5 |
| Fungus | Mushroom | 0.1 | 16.2 |
| *Lotus* sp. | Trefoil | 0.1 | 2.7 |
| Bryophyta | Moss | trace | 2.7 |
| *Polygonum* sp. | Knotweed | trace | 13.5 |
| *Rumex* sp. | Dock | trace | 2.7 |
| *Eriogonum* sp. | Wild buckwheat | trace | 5.4 |
| Chenopodiaceae | Pigweed family | trace | 2.7 |
| *Montia* sp. | Miner's lettuce | trace | 5.4 |
| *Potentilla* sp. | Five finger | trace | 13.5 |
| *Lupinus* sp. | Lupine | trace | 8.1 |
| *Trifolium* sp. | Clover | trace | 21.6 |
| Leguminosae | Pea family | trace | 2.7 |
| *Epilobium* sp. | Willow herb | trace | 2.7 |
| Umbellifereae | Parsley family | trace | 2.7 |
| *Phlox* sp. | Phlox | trace | 2.7 |
| *Collomia tinctoria* | | trace | 5.4 |
| *Taraxacum* sp. | Dandelion | trace | 8.1 |
| *Wyethia* sp. | Mule's ear | trace | 5.4 |
| Compositae | Sunflower family | trace | 2.7 |
| Total forbs | | 25.1 | |
| Grass and grass like plants | | | |
| Gramineae (green) | Grass family | 2.8 | 72.9 |
| Gramineae (dry) | Grass family | trace | 5.4 |
| *Bromus tectorum* | Cheat grass | trace | 2.7 |
| *Stipa* sp. | Porcupine grass | trace | 2.7 |
| *Carex* sp. | Sedge | trace | 8.1 |
| *Juncus* sp. | Rush | trace | 13.5 |
| Total grass | | 2.8 | |

## DISCUSSION

This study of the food habits of the Tehama deer herd was limited to a period from February, 1950, to December, 1951. With the possible exception of the influence of drought conditions on the forage, preceding the initial collection period in the late winter months of 1949-50, the winter range experienced a good production of annual forage during the winters of 1950-51 and 1951-52. These winters were notably wet. It is obvious that the availability of food, with respect to the herbaceous vegetation on an annual type winter range, is influenced seasonally and from year to year by variations in precipitation and temperature. These two factors determine not only the quantity of forage produced but also the quality and time of growth. The impact of good forage production on the food habits of the deer inhabiting this type of winter range is well illustrated by the data presented. It is reasonable to believe that in winters of fall drought and/or extreme cold weather the maximum carrying capacity of the range would be severely reduced and the natural reduction of deer numbers by winter die-off would result. This phenomenon of reduced carrying capacity is commonplace knowledge with livestock people, who rely heavily on the foothill ranges to graze their livestock.

A failure or severe reduction of annual forage production would force deer to subsist more heavily on the browse component of the range forage. Snow depth and/or extreme cold temperatures would not only materially affect the altitudinal distribution of deer on the winter range, but would also have an immediate effect on the availability of forage upon which they must subsist.

The data available during the study period preclude a discussion of the effect of an adverse winter on the food habits and survival of deer. Had a critical winter occurred during the course of the food habits study, the contrast in food habits data possibly would have allowed a better understanding of the dynamics of deer survival and range conditions relative to browse utilization and annual forge production on an annual type winter range.

## SUMMARY

A food habits study was made of a migratory herd of Columbian black-tailed deer known as the Tehama deer herd. This herd summers in the mountains of the Cascade Range and Sierra Nevada and winters on the foothill slopes of eastern Tehama County, California. The winter range is an annual type range. Annual grasses dominate the grassland areas and form the principle understory to the woodland and chaparral. There is wide variation both seasonally and yearly in the production of this annual forage, due to climatic fluctuations.

The stomach analyses of 96 deer collected on the winter range reveal a seasonal utilization of food plants as influenced by the changes in range forage composition. Browse (buck brush, mountain mahogany, manzanita, scrub oak, silktassel, and many deciduous browses) appear to constitute the staple item of diet throughout the winter. The leafage and acorns of the deciduous oaks contribute heavily to the early fall diet, and as the foothills "green up" with the advent of fall rains, the deer graze heavily on the annual grasses and forbs. This annual

forage production reaches its height in March, when it contributes most to the diet of the deer. Early in April the browse plants begin to leaf out with new growth and the deer appear to switch entirely to a browse diet.

The summer food habits of the Tehama deer herd are represented by 37 deer stomach analyses. The preferred browse species consist of mountain whitethorn, squaw carpet, greenleaf manzanita, western service berry, and snowbrush.

## REFERENCES

Burcham, L. T.
1956a. Historical backgrounds of range land use in California. Jour. Range Mangt., vol. 9, no. 2, p. 81-86.
1956b. Historical geography of the range livestock industry of California. Doctoral Thesis, Univ. of Calif., 416 p. (Typewritten)

Gilman, James H.
1949. Annual report on Tehama winter deer range. Calif. Dept. of Fish and Game, 44 p. (Unpublished report)

Grinnell, Joseph, Joseph Dixon, and Jean M. Linsdale
1930. Vertebrate natural history of a section of northern California through the Lassen Peak region. Univ. Calif. Publ. Zool., vol. 35, 594 p.

Hiehle, Jack L.
1951. Annual report on Tehama winter deer range for the period July 1950 to July 1951. Calif. Dept. of Fish and Game, 50 p. (Unpublished report)

Jensen, Herbert A.
1947. A system for classifying vegetation in California. Calif. Fish and Game, vol. 33, no. 4, p. 199-266.

Talbot, M. W., H. H. Biswell, and A. L. Hormay
1939. Fluctuations in the annual vegetation of California. Ecology, vol. 20, no. 3, p. 394-402.

# REPORT ON A SURVEY OF BIGHORN SHEEP IN THE SANTA ROSA MOUNTAINS, RIVERSIDE COUNTY[1]

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## INTRODUCTION

During the month of July, 1953, a survey of desert bighorn sheep (*Ovis canadensis nelsoni*) was conducted in the Santa Rosa Mountains of Riverside County by personnel of the California Department of Fish and Game and the University of California. The University personnel were employed by the Riverside County Fish and Game Commission. Primary emphasis was placed on State Game Refuge 4-D.

The main purpose of the survey was to establish the distribution and numbers of bighorn sheep. Additional data on herd composition, food habits, range condition, water, parasites, and domestic stock were gathered.

Since 1953 periodic checks have been made of the areas covered in the original survey and of several new areas by Richard Weaver, Floyd Vernoy, and Bert Craig of the California Department of Fish and Game in the course of developing and improving springs, and also by the senior author.

Acknowledgment is made to Mr. Arthur Nightingale, at whose camp we stayed during the survey in 1953, and who gave us considerable assistance in our search for information.

## METHODS

An aerial reconnaissance of the Santa Rosas was made in June, 1953, preliminary to the field work. By this method several springs, tanks, and sheep trails were located, aiding the authors in becoming acquainted with the topography and drainages.

Inasmuch as the entire Santa Rosa bighorn range could not be covered in the allotted time, it was planned first to survey the refuge and then to expand north and south until time ran out. Canyon bottoms, sidehills, and ridge tops were coursed in search of water sites, bighorn, and sign.

[1] Submitted for publication August, 1956. This study was financed by Federal Aid in Wildlife Restoration Project W-41-R, "Big Game Studies", and by funds made available by the Riverside County Fish and Game Commission.

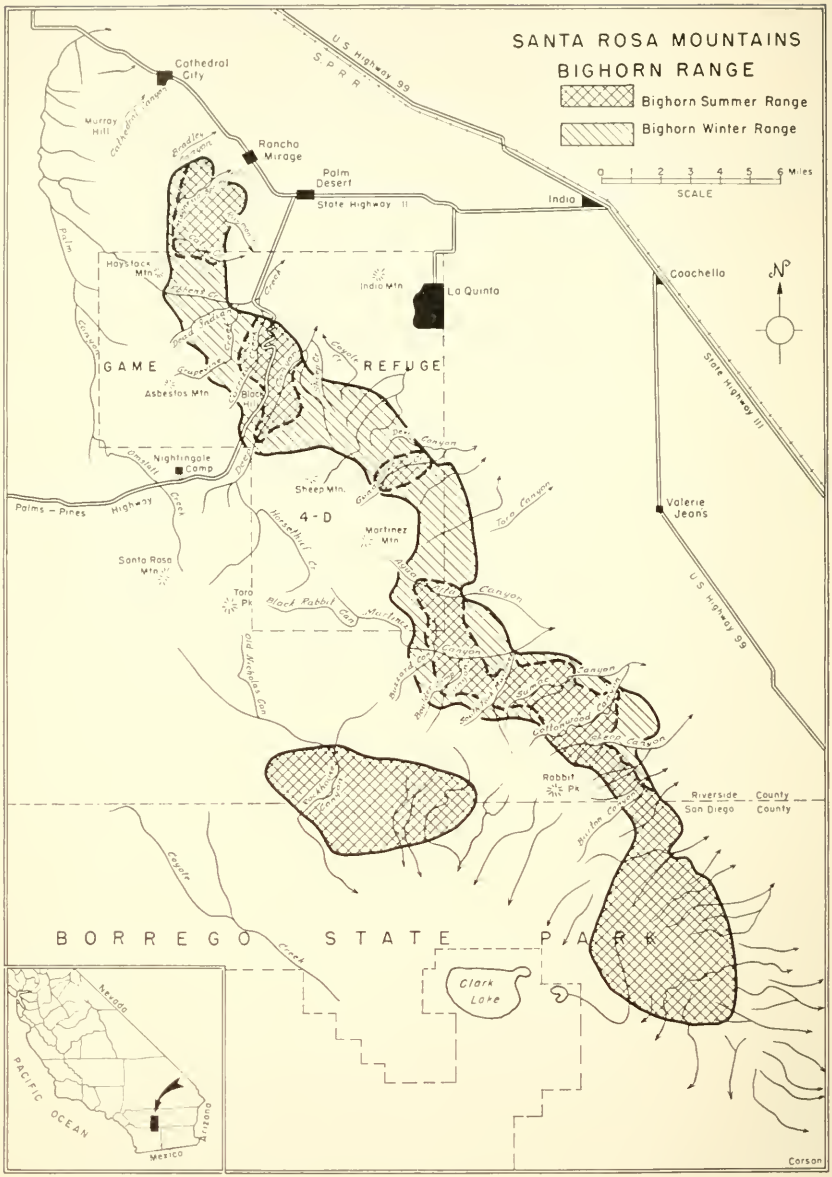


FIGURE 1. Map of the Santa Rosa Mountains area, showing bighorn range. *Drawing by Cliffa Corson.*

## DESCRIPTION OF AREA

The Santa Rosa Mountains form a southeastern extension of the San Jacinto Mountains, being separated from them by Palm Canyon. The highest summit, Toro Peak, is 8,716 feet in elevation. Secondary

summits range from 4,000 to 8,000 feet. The foothills rise from the Coachella and Borrego valley floors near sea level.

Higher slopes, above 4,000 feet, are covered with chaparral, piñon pine, and juniper. Lower slopes support a desert scrub type of vegetation composed in part of the following species: maguey (*Agave consociata*), Spanish dagger (*Yucca schidigera*), ocotillo (*Fouquieria splendens*), California juniper (*Juniperus californica*), cactus (*Opuntia* sp., *Echinocactus* sp., *Cereus* sp.), catclaw (*Acacia Greggii*), ephedra (*Ephedra* sp.), brickellbush (*Brickellia* sp.), wild buckwheat (*Eriogonum* sp.), white ratany (*Krameria Grayi*), black sage (*Salvia mellifera*), white sage (*Salvia apiana*), bee-sage (*Hyptis Emoryi*), goatnut (*Simmondsia chinensis*), rush bebbia (*Bebbia juncea*), ground cherry (*Physalis crassifolia*), Parry condalia (*Condalia Parryi*), creosote bush (*Larrea divaricata*), French tamarisk (*Tamarix gallica*), honey mesquite (*Prosopis chilensis*), screwbean mesquite (*Prosopis pubescens*), desert-willow (*Chilopsis linearis*), squawbush (*Rhus trilobata*), and galleta grass (*Hilaria rigida*).

Some species that generally grow close to water are: palm (*Washingtonia filifera*), cottonwood (*Populus Fremontii*), willow (*Salix* sp.), water-wally (*Baccharis glutinosa*), arrowweed (*Pulchea sericea*), horsetail (*Equisetum* sp.), common reed (*Phragmites communis*), cattail (*Typha latifolia*), and rush (*Juncus* sp.).

The lower slopes are steep and cut with many canyons. In many places, as in Guadalupe Canyon, Deep Canyon, the mouths of Magnesia Spring Canyon and Cat Creek, and at the junction of Ebbens, Grapevine, and Dead Indian creeks, hard rock strata have been cut, forming perpendicular cliffs and waterfalls.

FIGURE 2. Carriza Creek area, looking north across the Palms to Pines Highway. A ewe and ram can be seen near the middle. *Photograph by Fred L. Jones, September 16, 1954.*

On the east slope of the Santa Rosas a zone of undulating, low-angle, open terrain extends southward above the 1,500-2,000 foot level and below the mountain summits to about Guadalupe Creek, interrupted only by Deep Canyon (Figure 2). To the south the canyons become deeper, and the ridges attain greater stature.

## BIGHORN DISTRIBUTION

At present the bighorn occupy the lower country, generally below 4,000 feet. Figure 1 shows the winter and summer ranges to the best of our knowledge.

Water is the primary factor determining bighorn distribution. In winter, when moisture is widespread and the climate is cool, the range is more extensive. In summer the Santa Rosa sheep have not been found by us ranging farther than about one mile from available water.

The upper limit of the range is roughly determined by the chaparral line. The lower limit is indeterminate, although the sheep generally remain in the mountains or close to them. They often feed in the dry washes, and according to local residents it is not uncommon for them to come down into cultivated fields as far as two miles out from the base of the mountains during winter. We have an account of one being killed along the Southern Pacific Railroad tracks some years ago.

Old residents state that in the early days the sheep were found higher in the mountains than they are now. Although little of the higher areas appear to us to be suitable range, it is possible that the greater numbers reported prior to the die-off in the 1920's (which will be discussed later) required greater range, and so had dispersed upward. It is possible that livestock use in the higher elevations has contributed toward restricting the sheep to their present altitudinal distribution.

Owing to water localization, some areas receive heavy summer use. Magnesia Spring Canyon, Cat Creek, and Carrizo Creek were the only sources of summer water located north of the Palms to Pines Highway on the eastern slope, and were supporting all, or nearly all, of the sheep in that sector in July, 1953. No sheep were ranging in the intervening country on Ebbens, Dead Indian, and Grapevine creeks at that time. Although we covered little of the country north and east of Sheep Mountain, the same situation appeared to exist between Deep Canyon and Agua Alta Canyon, with only a few sheep occurring along Guadalupe Creek.

Sheep range continuously from Agua Alta Canyon to the southern end of the mountains. It is probable that there are sheep on the Palm Canyon side of the Santa Rosas, but we have been unable to survey that area or to obtain any information on it.

## NUMBERS AND COMPOSITION

Old residents told us of a severe die-off in the early 1920's. Many carcasses were found in the canyons and around waterholes by prospectors. The general expression of opinion is that there were more sheep in the Santa Rosas prior to this period than there are now, but that the number is greater now than at any time since the die-off.

Table 1 lists the sheep actually observed in July, 1953, with all possible duplications eliminated, and the number estimated in each area.

TABLE 1

Bighorn Observed and Estimated in Refuge 4-D, Borrego State Park, and in All of the Santa Rosa Mountains, From North to South

| Date | Locality | Ewes | Yearlings | Lambs | Rams | | | | | Unidentified | Total observed | Total estimated |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Curl | | | | Total rams | | | |
| | | | | | ¼ | ½ | ¾ | Full | | | | |
| 7/17/53 | Magnesia Spring Canyon | 13 | 1 | 6 | 1 | 4 | 10 | -- | 15 | -- | 35 | 50 |
| 7/15/53 | Cat Creek | -- | -- | -- | -- | -- | 2 | -- | 2 | -- | 2 | 10 |
| 7/15/53 | *Cat Creek | -- | -- | -- | 1 | -- | -- | -- | 1 | -- | 1 | 5 |
| 7/15/53 | *Ebbens Creek | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0 | 0 |
| 7/15/53 | *Dead Indian Creek | | -- | -- | -- | -- | -- | -- | -- | -- | 0 | 0 |
| 7/15/53 | *Grapevine Creek | | -- | | | -- | -- | -- | -- | -- | 0 | 0 |
| 7/17, 20/53 | *Carrizo Creek | 15 | 4 | 1 | 1 | 2 | 3 | | 6 | -- | 26 | 35 |
| 7/17/53 | *Deep Canyon | 1 | -- | 1 | -- | 1 | | | 1 | | 3 | 25 |
| 7/8/53 | *Guadalupe Creek | -- | | -- | -- | 1 | | 1 | 2 | -- | 2 | 6 |
| 7/2/53 | *Agua Alta Canyon | 4 | 2 | -- | -- | | 2 | -- | 2 | -- | 8 | 15 |
| 7/5, 6/53 | Martinez Canyon | 5 | 1 | 2 | -- | 2 | 1 | 3 | 6 | -- | 14 | 30 |
| 7/13/53 | Sumac Canyon | 11 | 3 | -- | 1 | 2 | 4 | 3 | 10 | | 24 | 30 |
| 7/12, 13/53 | Cottonwood Canyon | | | -- | 1 | 1 | 9 | 1 | 12 | 1 | 13 | 25 |
| 7/12/53 | Sheep Canyon | 6 | 4 | -- | 2 | -- | 1 | | 3 | -- | 13 | 25 |
| 4/55 | Sheep Canyon South to Park | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 25 |
| 5/55 | In Park to Rockhouse Canyon Area | -- | -- | | -- | -- | -- | -- | -- | -- | -- | 50 |
| 5/55 | Rockhouse Canyon Area in Park | -- | | -- | -- | -- | -- | -- | -- | -- | -- | 10 |
| 5/55 | Rockhouse Canyon Area out of Park | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 10 |
| | Subtotal in Refuge 4-D | 20 | 6 | 2 | 2 | 4 | 5 | 1 | 12 | -- | 40 | 86 |
| | Subtotal in Borrego State Park | -- | -- | -- | -- | -- | -- | | -- | -- | -- | 60 |
| | Subtotal not in Refuge or Park | 35 | 9 | 8 | 5 | 9 | 27 | 7 | 48 | 1 | 101 | 205 |
| | Totals | 55 | 15 | 10 | 7 | 13 | 32 | 8 | 60 | 1 | 141 | 351 |

* In Refuge 4-D.

Population estimates for the areas visited were made on the basis of sheep seen, the relative numbers of rams to ewes and of young to adults, and the amount of fresh sign observed. If the fresh sign appeared to be greater than the observed animals could be expected to make, a conservative addition was made. No estimate was possible for the Palm Canyon area, although we feel certain that sheep are present there, if water is available.

The estimates for the areas south of Sheep Canyon are based primarily upon spot checks made since the original survey. These figures are supported by information from local residents whose judgment proved to be sound in other areas that we covered more completely.

We believe that all of the estimates are conservative and have little doubt that the total population is larger.

The 86 sheep estimated to be in the refuge comprise 25 percent of the total estimated in the entire Santa Rosas, and the 60 in Borrego State Park, 17 percent.

From Table 1 it may be seen that the Cat Creek-Magnesia Spring Canyon area immediately to the north of Refuge 4-D, and the area south of the refuge to Borrego Park, contain the bulk of the sheep.

Unquestionably some two-year-old rams are included in the ewe classification, since identification of sexes by horns cannot be made with certainty before three years of age. Figure 3 shows a $\frac{3}{4}$-curl ram. The scrotum of a two-year-old ram must be seen for positive identification, and it is not always possible to make such an observation. Information given us indicated that the 1951 lamb crop was extremely small. Since these lambs were 2-year-olds in 1953 we believe that possible mis-sexing of two-year-old rams was of slight importance, due to a low percentage of them in the population.

FIGURE 3. A three-quarter curl ram, Santa Rosa Mountains. *Photograph by Fred L. Jones, September 16, 1954.*

The ratio of rams to ewes observed was 109:100; of lambs to ewes 18:100; and of yearlings to ewes 27:100. Exactly two-thirds of the rams had a three-quarter curl or better; that is to say, they were in the older age classes. Table 2 gives the computed number of each sex and age class in the estimated populations based on the observed ratios. The animals observed make up 40 percent of those estimated.

TABLE 2

Computed Number in Each Sex and Age Class of Estimated Populations

| Area | Young rams* | Old rams† | Ewes | Yearlings | Lambs | Totals |
|---|---|---|---|---|---|---|
| Refuge 4-D | 13 | 25 | 33 | 9 | 6 | 86 |
| Borrego State Park | 7 | 14 | 20 | 5 | 4 | 50 |
| Rest of Santa Rosas | 31 | 62 | 84 | 23 | 15 | 215 |
| Totals in Santa Rosas | 51 | 101 | 137 | 37 | 25 | 351 |

* Less than three-quarters curl.
† Three-quarters curl or better.

The observed sex ratio indicated an overabundance of rams. Since bighorn sheep are polygamous, they do not require a ram for every ewe for breeding purposes. During the mating season only a few ewes of a band are in heat at any one time, and the rams consequently give these much attention (Jones, 1950).

The optimum sex ratio in deer is often said to be about 25:100. It may be more than that in bighorn, but 50:100, or one ram for every two ewes, should be ample for breeding. It is certain that fewer rams than there are now would be able to breed all the ewes. Table 3 gives sex and age ratios found in other herds of desert bighorn.

TABLE 3

Sex and Age Ratios Observed in Desert Bighorn Herds

| Area | Year | Ram: Ewe | Lamb: Ewe | Yearling: Ewe | Number observed | Reference |
|---|---|---|---|---|---|---|
| Santa Rosa Mountains | 1953 | 109:100 | 18:100 | 27:100 | 141 | |
| Death Valley | 1938 | 89:100 | 22:100 | 11:100 | 20 | Dixon (1939) |
| Death Valley | 1955 | 57:100 | 29:100 | 8:100 | 95 | Welles (1955) |
| Arizona | 1951 | 121:100 | 65:100 | 28:100 | 154 | Russo (1956) |
| Arizona | 1952 | 137:100 | 43:100 | 11:100 | 110 | Russo (1956) |
| Arizona | 1953 | 123:100 | 50:100 | 17:100 | 156 | Russo (1956) |

Ewes normally produce single lambs, twins being rare (Jones, 1950). The observed lamb:ewe ratio of 18:100 is the lowest reported in any survey of desert bighorn for which we have data. Jack Miller, an old resident, told us that there was a large lamb crop in 1949, no lambs or very few in 1951, a large crop again in 1952, and a very small one in 1953. We have certainly confirmed this last report and our observed

yearling:ewe ratio of 27:100 in 1953 tends to confirm this statement for 1952. This yearling ratio compares favorably with those found elsewhere.

The lamb crop appears to be closely tied in with the precipitation for the year. In wet years there seem to be larger lamb crops than in dry years. A deficiency of vitamin A in the diet of ewes, resulting from a shortage of green feed during dry years, may preclude ovulation or may cause the death of lambs in the uterus or the birth of weak lambs which soon die (Miller, 1942). A shortage of water and green feed may result in inadequate quantity and quality of milk for suckling lambs, or the lack of proper feed for weaning lambs. We found two one-month old lambs dead (aged after Demming, 1952).

Competition with adults for insufficient drinking water may work to the detriment of the lambs, and prolonged searches for water up and down dry canyons (which we found them doing) may tax the lambs severely.

Other states have met the problem of reducing competition between old and young sheep by holding periodic special hunts for a limited number of mature rams. In 1954 Colorado allowed the taking of a few surplus ewes also. Table 4 summarizes information on bighorn hunting seasons compiled by Dr. Helmut K. Buechner, University of Washington. For purposes of comparison it is estimated that there are 2,000 to 2,500 bighorn in California (Jones, 1955).

TABLE 4

Summary of Special Ram Hunts Held in Other States

| State | Period | Number of hunts | Average estimated populations | Average number of permits | Average number of rams harvested |
|---|---|---|---|---|---|
| Arizona | 1953–55 | 4 | 3,025‡ | 20 | 9 |
| Colorado | 1953–55 | 3 | 5,000‡ | 196 | 61* |
| Idaho | 1946–55† | 6 | 2,500 | 44 | 16 |
| Montana | 1953–55 | 3 | 1,100 | 39 | 26 |
| Nevada | 1952–54 | 3 | 1,500 | 53 | 14 |
| New Mexico | 1954–55 | 2 | 160 | 14 | 9 |
| Wyoming | 1905–55 | 32 | 2,300 | 87 | 36 |

* In 1954, 62 rams, 14 ewes, and 3 lambs were harvested.
† Some hunts were held prior to 1946, but were not reported on.
‡ From U. S. Fish and Wildlife Service, 1956.

We collected remains of 10 carcasses and found old weathered bones of many others in 1953. Two of the carcasses were lambs born in 1953 which died in the spring at about one month of age. Another was a lamb of the previous year which died in the fall at about six months of age. None of these appeared to be predator kills, since the carcasses and bones were intact. A predator would have torn up the carcasses and eaten most of the soft bones of the younger lambs. Two other carcasses were six-month-old lambs that had died several years previously, and five were adults. With the exception of one old ram found high on a ridge, all carcasses were found near waterholes.

Remains of various additional carcasses have been found at random since the 1953 survey. Of particular interest was the location in April, 1955, of one adult ram that had been dead about six months to a year; and one lamb, three adult ewes, and two adult rams that had been dead from one to two years around Intrigue Spring in the north end of Borrego State Park. Three were along the water which runs below the spring for 150 yards and the rest were within a half mile of the spring. None of the bones was gnawed, as would be done by any predator, and there was no evidence of gunfire. Apparently these animals had died during the summer while concentrated around the water, which is the only supply in the area.

## WATER

These bighorn prefer fresh water to drink. We found foul or alkaline water to be generally unpalatable to them, although they frequently took it when slightly stagnant. When springs are sanded over the sheep will dig down with their front hooves in an attempt to reach water.

Sheep often bed down at a spring and drink at any time during the day. We observed them traveling to water most frequently early in the morning and in the evening after sunset. One night about 3 a.m. one was heard coming to a spring at which we were camped.

Even the most casual inspection of bighorn range in the Santa Rosas brings out the fact that water, or lack of it, is a prime factor limiting the numbers of animals. We therefore concentrated on locating and, wherever possible, visiting every waterhole in the area surveyed. A few additional springs have been located since the 1953 survey.

The existence of most springs depends upon rainfall. During years of subnormal precipitation, such as 1953, many otherwise reliable springs dry up. Canyons now dry may have water in other years. Cloudbursts occur periodically in all of the canyons. There may be several during one season or none for a decade. The effect on springs is unpredictable. Some may be scoured out and made available; others may be buried under several feet of sand. Consequently, spring developments must be constructed so as to have the least susceptibility to damage by cloudbursts. Summer rains are usually of such short duration, and the runoff so rapid, that springs are not benefited.

Since water is a critical factor for bighorn, and for other game as well, we strongly recommended in a preliminary report in 1953 that the program of water development in this region be accelerated. We believed that moderate sums spent on additional development could well raise the carrying capacity of the Santa Rosas many fold.

Weaver, Vernoy, and Craig have visited all of the water sites located in the original survey, in addition to several located by themselves. Each water source has been evaluated for possible improvement and wherever practical to do so development work has been accomplished.

Results of this development work have varied due both to the vagaries of the bighorn and the spring flow. As an example, Magnesia Spring was used heavily in July, 1953, though the spring was diurnal, running only at night and drying up in the daytime. In March, 1954, a tank was blasted out of a rock face below the spring. In July, 1954, the spring itself was completely dry, though the tank was full. While sheep were using it readily, they were far fewer than in the previous

summer. In December, 1954, the tank was still full. In September, 1955, it was nearly dry and no water was available for game.

A striking example of the benefit of water development in opening up sheep range was afforded on Upper Dead Indian and Grapevine creeks. In July, 1953, it was found that sheep were not using the extensive area in the upper reaches of these canyons. Since no available water was found, it was assumed that the absence of sheep was due to the lack of water. High in each of these drainages a permanent seep supplying only enough water for insects was found. In March, 1954, these seeps were developed to provide tanks of drinking water by blasting and digging out existing sandfilled basins in the bedrock. Bighorn accepted these immediately and in July, 1954, each tank was receiving considerable use. In this case previously untenable summer range was immediately transformed into suitable habitat by the development of drinking water.

## FOOD HABITS

Table 5 lists plants that we found to be eaten by bighorn. The plants listed as very important are the ones supplying the bulk of the forage. Use on forbs may well be of greater importance than our observations revealed, for cropping on them is less obvious.

TABLE 5

Plants Observed Eaten by Bighorn in the Santa Rosa Mountains

| Common name | Scientific name | Importance |
|---|---|---|
| Horsetail | *Equisetum* sp. | slight |
| Ephedra | *Ephedra* sp. | moderate |
| Cattail | *Typha latifolia* | slight |
| Grasses | Unidentified (at springs) | slight |
| Galleta grass | *Hilaria rigida* | moderate |
| Palm | *Washingtonia filifera* | slight |
| Rush | *Juncus* sp. | slight |
| Maguey | *Agave consociata* | slight |
| Stream orchis | *Epipactis gigantea* | slight |
| Willow | *Salix* sp. | slight |
| Cottonwood | *Populus Fremontii* | slight |
| Wild buckwheat | *Eriogonum* sp. | slight |
| Desert apricot | *Prunus Fremontii* | slight |
| White ratany | *Krameria canescens* | high |
| Palo verde | *Cercidium microphyllum* | slight |
| Honey mesquite | *Prosopis chilensis* | slight-moderate |
| Catclaw | *Acacia Greggii* | moderate |
| Littleleaf rushpea | *Hoffmanseggia microphylla* | slight |
| Silver bush | *Argythamnia lanceolata* | moderate |
| Bernardia | *Bernardia myricaefolia* | moderate |
| Spurge | *Euphorbia* sp. | unknown |
| Creosote bush | *Larrea divaricata* | slight |
| Goatnut | *Simmondsia chinensis* | high |
| French tamarisk | *Tamarix gallica* | slight-moderate |
| Barrel cactus | *Echinocactus cylindraceus* | slight |
| Phacelia | *Phacelia* sp. | unknown |
| Black sage | *Salvia mellifera* | slight |
| Bee sage | *Hyptis Emoryi* | high |
| Groundcherry | *Physalis crassifolia* | slight |
| Desert-willow | *Chilopsis linearis* | slight |
| Water-wally | *Baccharis glutinosa* | moderate |
| Rush bebbia | *Bebbia juncea* | moderate |
| Incienso | *Encelia farinosa* | slight |
| White bursage | *Franseria dumosa* | slight |

Table 6 lists plants occurring in the Santa Rosas which we did not observe used, but which have been found to be eaten by bighorn elsewhere.

TABLE 6

Plants Occurring in the Santa Rosa Mountains Recorded as Bighorn Food Elsewhere

| Common name | Scientific name | Locality | Reference |
|---|---|---|---|
| Fluffgrass | *Triodia pulchella* | Arizona | Russo (1956) |
| Elephant tree | *Bursera odorata* | Arizona | Russo (1956) |
| Squawbush | *Rhus trilobata* | Unknown | Seton (1929) |
| Ocotillo | *Fouquieria splendens* | Arizona | Russo (1956) |
| Cactus | *Opuntia* sp., *Mammillaria* sp | Arizona | Russo (1956) |
| Brickellbush | *Brickellia californica* | Arizona | Russo (1956) |
| Bush encelia | *Encelia frutescens* | Arizona | Russo (1956) |

In two areas there was evidence of overbrowsing on certain forage plants. Goatnut was used heavily in a half-mile radius around the upper Cat Creek spring and water-wally, rushes, and young palms were taken heavily at the spring. Some of the use on the goatnut was by rodents, but most of it was by sheep. Tamarisk was highlined, and eatclaw was browsed heavily in the wash above Magnesia Spring. Plants growing at several of the springs, such as cattail, horsetail, and various grasses and forbs, were grazed extensively on occasion. Distribution of these is limited to waterholes, where heavy use is to be expected.

## DISEASES AND PARASITES

We were told of a large scale die-off in the early 1920's. One man stated that the bighorn lost their hair while still alive. He believed that domestic sheep ranging from the valley floor had transmitted some disease to the bighorn. The loss of hair could have been due to scabies, which has been carried to bighorn by domestic sheep in other areas to their great detriment.

We observed one yearling sheep that had a violent coughing spell, and a fawn deer that was barely able to walk, but we have no idea of the causes.

Samples of 41 fresh pellet groups were collected in July, 1953, for examination for eggs and larvae of internal parasites. The examination was made by John Azevedo of the California Department of Fish and Game Disease Laboratory, Project California W-35-R. The results were as follows: No organisms were found in 36; tapeworm eggs of the species *Monezia* were found in one; nematode eggs of the species *Nematodirus* were found in two, of the species *Gongylonema* in one, and an unidentified nematode larva in another. The occurrence of eggs and larvae was much lower than Azevedo has found in other herds of bighorn in California. In June, 1955, five additional samples were sent to Dr. Erling R. Quortrup, Director of the San Diego County Livestock Department, to be examined for lungworm larvae. He found lungworm larvae in two and strongyle ova in three.

## INTERRELATIONSHIPS WITH OTHER ANIMALS

### Range Competition

Domestic stock are present in the higher elevations, generally above the bighorn range. About 20 wild horses range around Asbestos Mountain. These apparently do not range lower than the upper limit of the bighorn winter range. An undetermined number of cattle range in the brush above the bighorn range.

About 30 domestic goats live in Tahquitz and the adjoining canyons that drain into Martinez. As they are in bighorn range, have similar feeding habits, and heavily use the area, it appears that they adversely affect the bighorn. It is said that other goats that have been wild for years run on the bighorn range, though we did not see any.

A few domestic burros are present in Martinez Canyon. They use the waterholes there and in the lower portions of other incoming canyons. It is possible that their presence restricts bighorn use.

Deer are present in small numbers above the bighorn range. They adhere to the chaparral, generally above 4,000 feet. We observed three during our search for sheep, all at high elevations. We found some old deer sign and a few shed antlers as low as 2,400 feet, indicating winter range limits. Deer numbers are said to be far less than they once were. Competition with bighorn is very slight. At some of the higher springs on the north facing slopes, such as in Boulder Camp Canyon, deer and sheep are using the same springs.

Antelope ground squirrels occur throughout the sheep range and take considerable forage in some areas. Use on juniper was noted especially, and on goatnut around the upper Cat Creek Spring.

### Predation

We observed no positive indications of predation on bighorn, although some undoubtedly occurs. Mountain lions are present to the north on Mt. San Jacinto, but seldom come into the Santa Rosas. One was reported by U. S. Army surveying personnel in February, 1955, at 2,000 feet between Martinez and Toro canyons. This is in the middle of the sheep range. Jack Miller observed a large shepherd-dog-like animal, which he believed to be a wolf, chasing his goats in Tahquitz Canyon some years ago. Bobcats are common in the chaparral, but are of rare occurrence in the bighorn habitat. We saw considerable sign at the head of Deep Canyon on the Cactus Spring Trail (at 4,000 feet), while Miller has seen only one at his cabin in Martinez Canyon (at 3,000 feet) in 25 years.

Coyotes are common in the sheep habitat. We observed six during our survey and found abundant sign. Although coyotes have been known to kill adult bighorn (Russo, 1956), their depredations are generally directed at newborn lambs.

### Poaching

Poaching constitutes a drain on the bighorn population, although the extent of it is difficult to assess. Dismembered carcasses along with cartridge cases and other evidence of illegal hunting are encountered occasionally.

Continuing patrol effort throughout the bighorn range is necessary to keep poaching at a minimum.

## SUMMARY

A survey of bighorn populations in the Santa Rosa Mountains was conducted during July, 1953. Additional information was gathered through periodic visits to the area through 1955.

Bighorn range on the lower slopes, generally below the 4,000 feet contour. The estimated population for the area was set at 351.

The ratio of rams to ewes was 109:100, of lambs to ewes 18:100, and of yearlings to ewes 27:100. Two thirds of the observed rams had a three-quarter curl or better.

It is believed that availability of water is the most important limiting factor in bighorn distribution in this area, since bighorn are restricted to the immediate vicinity of springs during the long dry period.

Forage plants in the vicinity of water were found to be heavily utilized.

## REFERENCES

Deming, O. V.
1952. Tooth development of the Nelson bighorn sheep. Calif. Fish and Game, vol. 38, no. 4, p. 523-529.

Dixon, Joseph S., and E. Lowell Sumner, Jr.
1939. A survey of desert bighorn in Death Valley National Monument, summer 1938. Calif. Fish and Game, vol. 25, no. 2, p. 72-95.

Jones, Fred L.
1950. A survey of the Sierra Nevada bighorn. Sierra Club Bull., vol. 35, no. 6, p. 29-76.
1955. California bighorn inventory. Calif. Dept. of Fish and Game. (Unpublished report)

Miller, R. F., G. H. Hart, and H. H. Cole.
1942. Fertility in sheep as affected by nutrition during the breeding season and pregnancy. Univ. of Calif., Agric. Exp. Sta., Bull. 672, 31 p.

Russo, John P.
1956. The desert bighorn sheep in Arizona. Ariz. Game and Fish Dept., 153 p.

Seton, Ernest Thompson
1929. Lives of game animals. New York, Doubleday, Doran & Co., Inc., vol. 3, part 2, p. 410-780.

U. S. Fish and Wildlife Service
1956. Inventory of big-game animals of the United States, 1954. Wildl. Leaflet 376, 3 p.

Welles, Ralph
1955. Report of the 1955 summer survey of bighorn in Death Valley National Monument. Calif. Dept. of Fish and Game. (Unpublished report)

# AN IMPROVED DEVICE FOR CAPTURING DEER[1]

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## INTRODUCTION

Big game trapping and tagging programs have always exhibited a common weakness: the inability to capture the animals efficiently and economically. Field men are constantly experimenting with new devices and techniques in an effort to improve efficiency. Factors to be considered are portability, adaptability, safety, cost of materials, and simplicity of operation. The "Improved Deer Snare" has proved very adaptable to the various site factors and situations that present themselves in most trapping programs.

## CONSTRUCTION

A detailed description of the fabrication of the various parts follows. Cut the rubber used to motivate the device and to anchor the safety rope from discarded truck tubes. Cut, fold, and tie two strips approximately 6 to 10 feet long and 6 to 8 inches wide. Lash back the material with a modified sheet bend at either end, to facilitate the attachment to the anchor point and nooses. Tie a sliding loop in either end of a 25-foot length of quarter-inch green nylon rope. Procure additional rope, about 30 feet, for use as linkage between the rubber bands and the snare loops. This rope will serve as a secondary static line, for additional strength.

Cut the heads from two 20-penny nails. Score a third nail lightly near the head with the cutting portion of lineman's pliers and attach one end of the leader material very securely in the notch thus created.

TABLE 1

List of Materials Used in Making the Deer Snare *

| Item | Materials | Approximate cost |
|---|---|---|
| Trigger rubber | Discarded truck tire tubes | ---- |
| Rope | Sixty feet of 3/16-inch diameter O.D. Nylon | $1.80 |
| Nails | Three 20-penny common nails | .05 |
| Trip string | Three yards of 6-lb. test nylon fish leader | .06 |
| Bell | One No. 10 cow or sheep bell | .50 |
| | Total cost | $2.41 |

* Tools needed for setting trap are as follows: hammer, axe, machete, lineman's pliers, and tree climbers (optional).

[1] Submitted for publication June, 1956.

This will serve as the trigger. Details of construction are shown in Figures 1, 2, 3, and 4. Table 1 is a list of materials needed for construction.

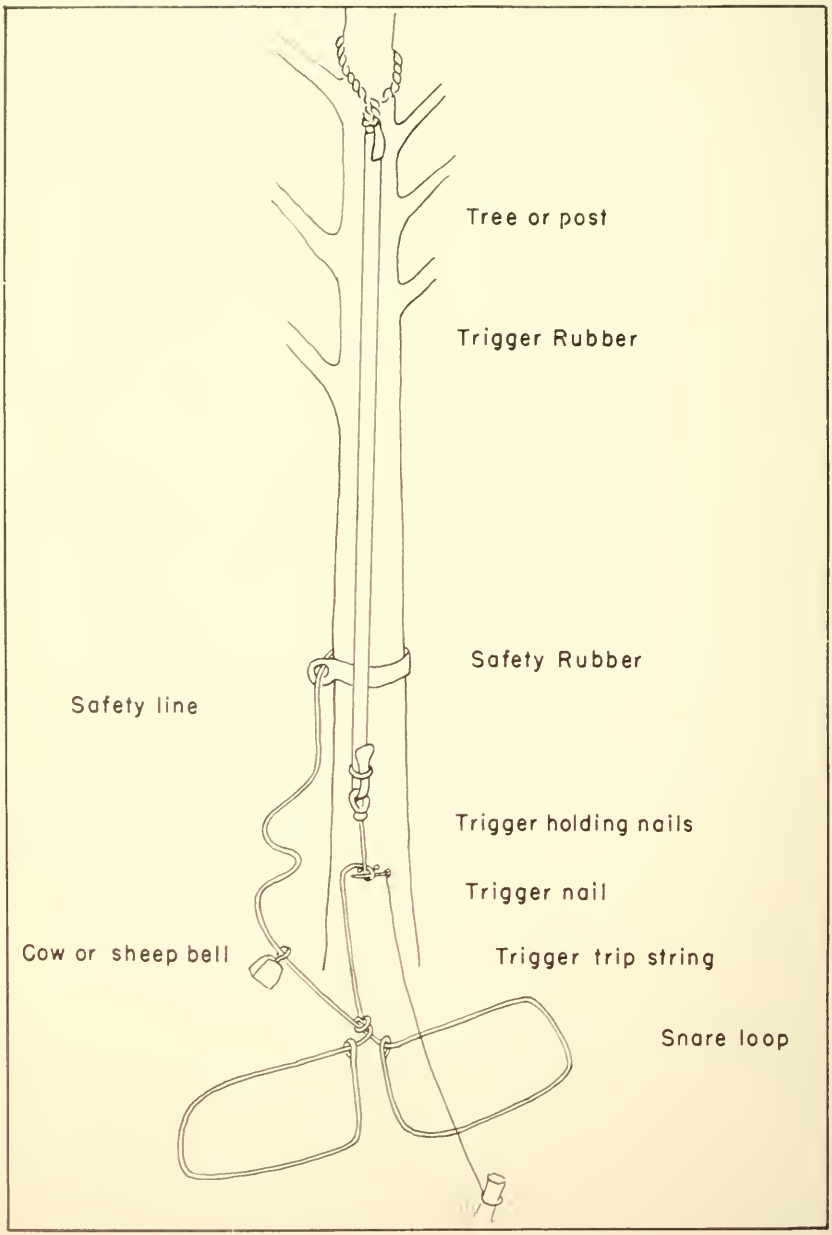


FIGURE 1. "Improved Deer Snare", showing details of construction. *Drawing by Cliffa Corson.*

## OPERATION

To make a typical setting, select a spot having a tree or post two feet or less from the trail or well-used passage. Secure one end of the actuating rubber at a height of approximately 15 feet. Drive the headless nails into the tree (or post) approximately 12 inches from the ground on the trail side. Space the nails approximately one inch apart in a horizontal plane and leave $1\frac{1}{2}$ inches protruding. Tie one end of the extra rope (static line) to the lower end of the actuating rubber, stretch the rubber to the maximum, and attach the trigger nail to the rope at the level of the two headless nails. After engaging the trigger

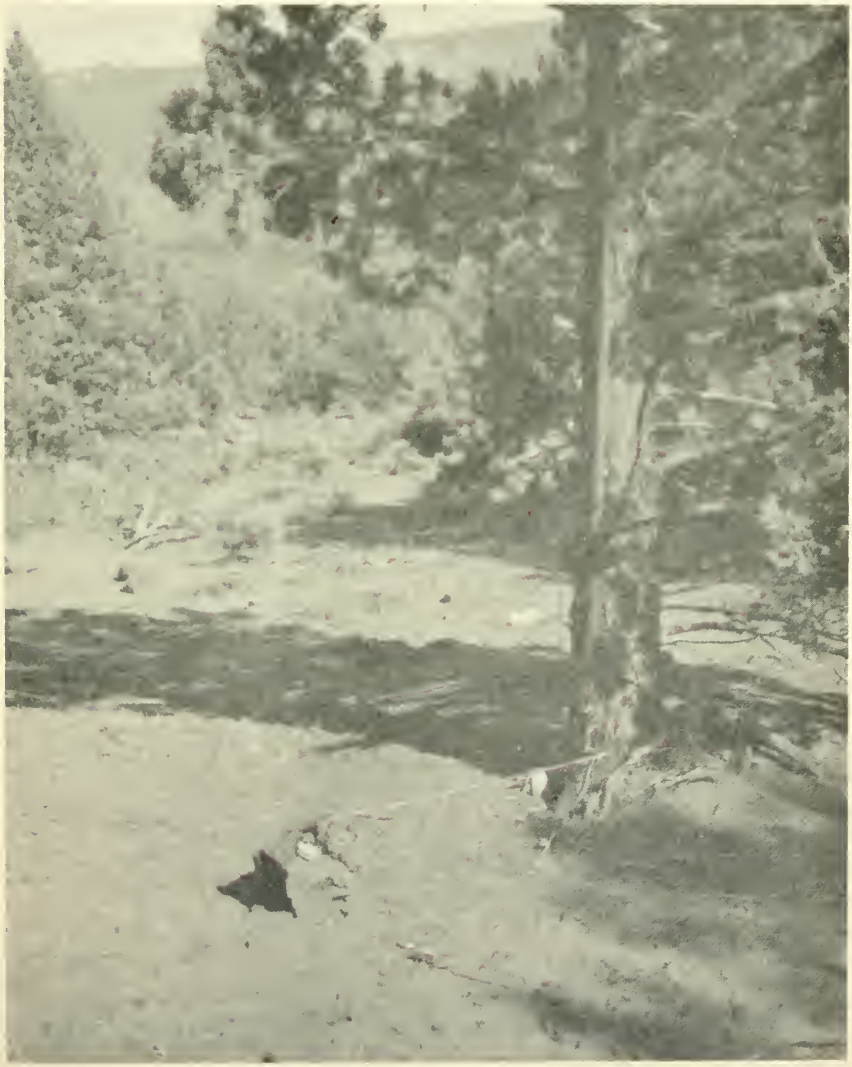

FIGURE 2. Typical snare set. *Photograph by William Auman.*

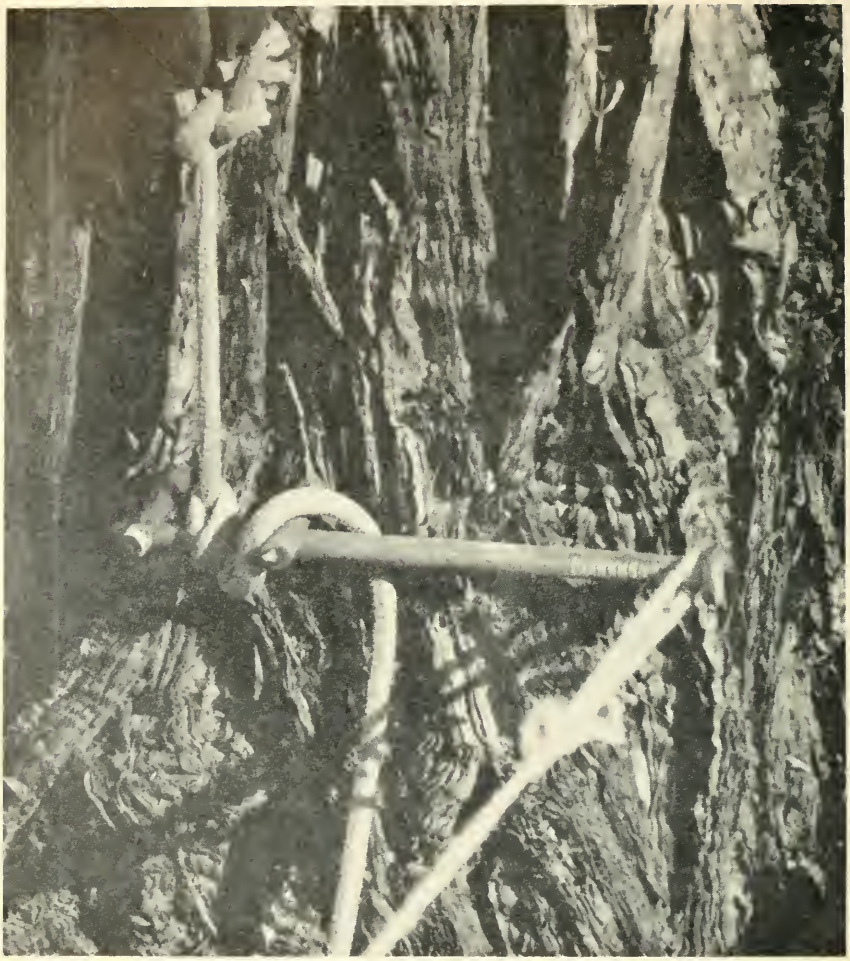

FIGURE 3 Snare trigger mechanism. *Photograph by William Auman.*

nail below these stub nails, pull the rope gently to the trail, maintaining the tension on the rubber. Attach to the exact center of the snare rope, enabling the loops of the snare to be spread fully in the trail, without any slack in the line. Pass the free end of the static line through the loop of a small bell (as used on sheep) and secure through two loops of rubber near the butt of the tree, encircling the trunk. Two or three feet of slack is allowable in this line.

Arrange the trigger nail to allow easy extraction from its position beneath the two stub nails and tie the free end of the leader material to some substantial object on the opposite side of the trail, at approximately the same height as the nails. This constitutes the trip string and should be taut at all times. Use a tree, bush, or rock if possible, since the animals hesitate to pass a stake or freshly cut limb; test the action

FIGURE 4. Variation of the typical deer snare, using a fulcrum pole in connection with a tree site setting. *Photograph by William Auman.*

of the device, reset, spread the loops to their maximum in the trail on either side of the trip string, and cover them lightly with dust.

As stated above, the "Improved Deer Snare" is highly adaptable. A small amount of imagination and ingenuity will enable the operator to make sets in nearly any situation. One variation, representing the key to success in treeless areas, is illustrated in Figure 5. The same components—rope, truck tubes, and nails—are used. The nails constituting the trigger mechanism are driven into a large stake driven into the ground near the trail. This peg should not protrude more than 14 inches and should be well hidden or camouflaged. A light, stiff pole approximately six feet long is used to supply the upward motion needed for raising the nooses around the animal's legs. The pole is butted against a stake driven firmly into the ground as the pole lies at right angles to the trail. This stake should protrude approximately two feet above the ground to provide fulcrum for both pole and rubber. The pole is held down by the rope and trigger arrangement at the end nearest the trail and prevented from moving away from the trail by the fulcrum. The rubber is attached to the pole at midpoint, stretched to the maximum over the top of the fulcrum and secured to a post placed directly in line at the proper distance behind said pivot point. Lateral motion of the pole is prevented by a slender guide stake on either side at midpoint. The static line is threaded through a bell, tied to the

trail-end of the pole, affixed to the trigger nail, and tied to the noose rope, without slack. This line is linked to the rearmost stake by the second rubber band.

The objective is to capture an animal by snaring one or two legs in a loop of rope. Considerable experimentation indicates that there

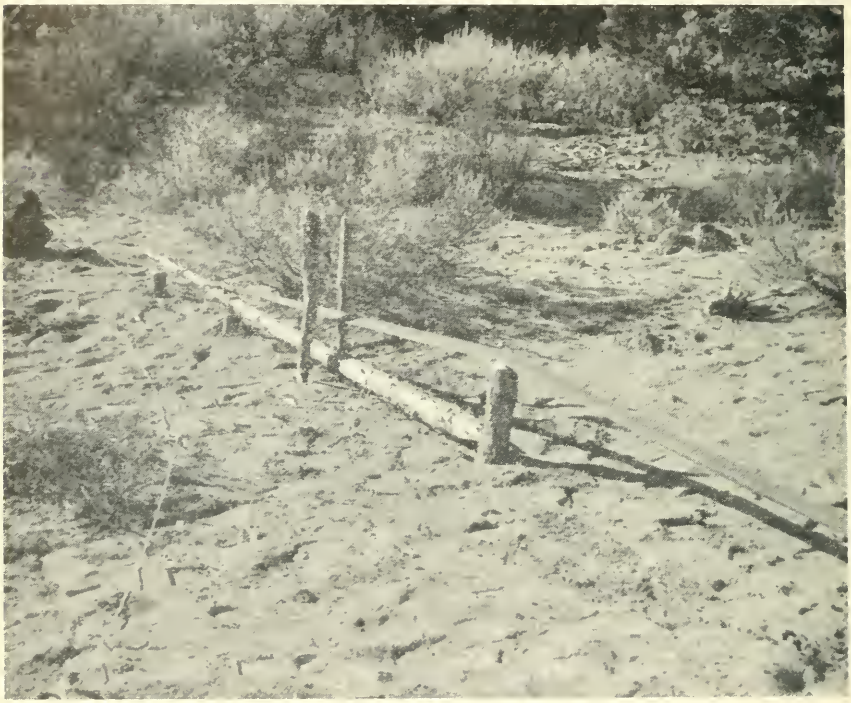

FIGURE 5. Snare set at a treeless site. *Photograph by William Auman.*

is less possibility of injuring an animal or allowing it to escape if it is held by the legs rather than the neck.

Once caught, the animal is prevented from applying full impact to the restraining ropes by the resilience of the rubber which activates the device. A bell attached to the restraining rope signals the operator, who remains in the vicinity, servicing a number of snares. If the snares are used in a belling program the snare bell should be of different tonal quality than the deer bells, in order to avoid confusion.

The snared animal, if approached cautiously, keeping the anchor point between the operator and the animal, will usually throw itself. Care should be exercised to prevent the accumulation of slack line, which the animal would use to develop momentum, resulting in shock to the animal and the device. Once the deer has thrown itself, or has been pulled to the ground, it is possible for the operator to crouch at the animal's back, placing one knee on its neck, and bind its feet. This immobilizes the deer for purposes of examination or marking.

Several sets may be made by one man in a day's time, if necessary, though a two-man team can work more efficiently. A team of operators can set out from 10 to 20 of these snares, depending upon the number of suitable locations presented within a radius which is determined by the distance the snare bell can be heard. As a deer trips the snare and becomes caught in the loops, the activity causes the bell attached to the static line to set up a clamor. The possibility of injury to the animal or escape increase in proportion to the amount of time it remains in the trap. Therefore, the operators should remain within earshot of all the operating snares.

The possibility of injury to snared animals is slight if the devices are closely attended. The authors snared a total of 62 deer during the period August 2 to September 1, 1955, (35 man days in actual operation) without injuring an animal.

The snare is particularly adapted to use on well-traveled trails leading to waterholes, salt licks, bedding grounds, and foraging areas. Baiting is sometimes helpful in attracting the deer to a certain spot, although usually this procedure is not necessary for successful operation.

# THE DEVELOPMENT OF A VINYL PLASTIC SUBCUTANEOUS TAG FOR TROUT[1]

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## INTRODUCTION

California has one of the largest catchable rainbow trout (*Salmo gairdneri*) programs in the United States. Approximately eight million such trout are planted each year by the California Department of Fish and Game at a cost exceeding one million dollars. These trout, weighing from four to six to the pound, are planted in readily accessible streams and lakes having high angling pressure. The policy followed by the Department is to plant only water from which a return in excess of 50 percent of the planted fish may be expected to reach the angler's creel.

The magnitude and costs of the catchable trout program are so great that it is important to make the best possible use of the hatchery product. A special project was begun in 1955 to develop better methods for evaluating the results of catchable stocking under various conditions, with a view to improving the program.

The great majority of planted waters have multiple access points, if not continuous roadside contact. The difficulty of censusing such waters is readily apparent, since it is virtually impossible to obtain a complete creel census or to obtain truly random samples.

Since dependence had to be placed in large part on voluntary returns, a marking program involving the removal of certain fins also could not have been expected to yield adequate results. The majority of fishermen seldom recognize the absence of fins and less frequently report such marks.

A new approach was therefore sought. The most promising one involved estimating the percentage of recapture through voluntary returns of numbered tags by anglers, supplemented by creel census.

Any tagging study involving large numbers of fish requires a tag that is easy to apply, is readily seen by the angler, and has no adverse effect on the fish.

The jaw tag (Rounsefell and Everhart, 1953, p. 279) has been widely used on catchable trout, but has revealed serious weaknesses. For example, in various studies tag loss has been demonstrated, tissue destruction has been apparent, and growth has been impaired. There was no question but that time spent in developing some other tag for catchable trout would be time well spent.

[1] Submitted for publication March, 1957. This work was performed as part of Dingell-Johnson Project California F-14-R, "Evaluation of Catchable Trout Stocking", supported by Federal Aid to Fish Restoration funds.

A series of tests with various tags was carried out at three different hatcheries and results and modifications of these tests were made simultaneously in the field. The Eipper tag, a thin arrowhead shaped metal piece to which is attached a round dangler, gave a very high tag loss in the first tests. Heincke stud tags prepared from acrylic plastic were tried in two positions on the trout. Retention in a dorsal position was good over a period of 135 days; however, an unsightly wound developed around the tag. It is possible that modifications of these or other types of tags would have yielded satisfactory results in the end, but preliminary experiments with vinyl plastic subcutaneous tags looked promising, so a major effort was made to develop this tag for use on catchable trout.

Metal subcutaneous tags have been used on livestock for several years. A special tool has been devised for inserting these tags in the ears of cattle and sheep. The first known subcutaneous tagging on fish was done by Le Cren (1954). His tagging of char involved placing metal tags in locations near the dorsal fin. Although the incision at the point of tag insertion was visible and the tag could be felt beneath the skin, it could not be seen through the pigmentation of the back. An electronic tag detector device was developed for application with the above tag (Moore and Mortimer, 1954). Bertelsen[2] of Denmark has been using plastic subcutaneous tags on plaice. Of 1,150 young plaice tattooed for detection and tagged for identification, 438 were reported returned, with only two of these showing tag loss.

The belly was chosen as the best location for the subcutaneous tag on trout. There is little if any black pigmentation here to obscure the tag and through careful tagging procedures the tag can be placed above the white guanine pigment layer (Figure 1). Inasmuch as most sportsmen turn the fish belly up in cleaning, the likelihood of their seeing the

[2] Personal communication. Dr. E. Bertelsen, Danmarks Fiskeri-og Harundersøgelser, Charlottenlund Slot, Charlottenlund, Denmark.

FIGURE 1. The location and appearance of a vinyl tag recently placed beneath the belly skin of a rainbow trout. *Photograph by Edwin P. Pister, January, 1957.*

tag in this position is greatly increased. This section of the body experiences minimum body movement and therefore irritation due to body movement is minimal. Induced mortality through blood loss or interference with vital organs may be expected to be minimal because of the fat deposits and lowered blood supply to this part of the body. It was found that this tag location permits ease of handling fish during the tagging operation.

## TAG DESCRIPTION AND PLACEMENT

The tags are prepared from soft upholsterer's yellow vinyl plastic.[3] The tag is 2½ to 3 mm. wide, 20 mm. long, and 0.018 inch thick. It is believed that a thickness between 10 and 15 thousandths would be more desirable. The tag is rounded at both ends and care is used in the manufacture to avoid any ragged ends or sharp projections.

All tags have been marked with Vinyl Stamping Black number 104N5A4 of the California Ink Company, San Francisco, California. The tags have a number plus the word "Return" on one side and on the opposite side is printed "C. F. G. Sacto." to indicate return to the California Department of Fish and Game, Sacramento. Two studies have used reward tags and these have been prepared with the words "Reward $5" on one side instead of the number. During the first year of field application several thousand tags were prepared by hand. It is now possible to obtain these tags from Howitt Plastics Company, Route 2, Box 61-B, Molalla, Oregon.

The principal tool for tagging is prepared from a Bard and Parker No. 7 scalpel handle fitted with a No. 12 blade (Figure 2A). These can be obtained from any surgical supply house. The handle is filed down to a flat blade 1 mm. thick, 4 mm. wide, and approximately 30 mm. long (Figure 2B). The handle is then bent to form a U-shape (Figure 2C). The end opposite the No. 12 blade, which is used to form the tag pocket, is finely sharpened on the outer surface. The tool is then buffed to a high polish, so as to permit a smooth and rapid operation of tag pocket formation.

Subcutaneous tagging would be quite difficult without placing the fish under anesthesia. Tricaine methanesulfonate (M.S. 222) is being used very effectively for this purpose. A concentration of ½ gram/gallon at 50 degrees F. prepares fish for the operation within 30 seconds. Four to five fish are anesthetized at a time. As the temperature increases it is necessary to reduce the number of fish exposed to this concentration for a given time or else reduce the concentration to something less than one-half gram per gallon. At this concentration fish should not be exposed to the solution for periods in excess of three minutes. At lower concentrations or lower temperatures trout may be held longer without harm. Each situation requires some experimentation and adjustment. Chlorobutanol has been tried and, although very effective in relaxing the fish for some hatchery operations, such as spawning, excessive movement occurs during an operation of this type.

[3] The plastic was obtained from three different manufacturers. In each case its exact physical properties and chemical composition could not be obtained. As these properties may influence retention, toxicity, etc., it is necessary to test these qualities for each lot of plastic used.

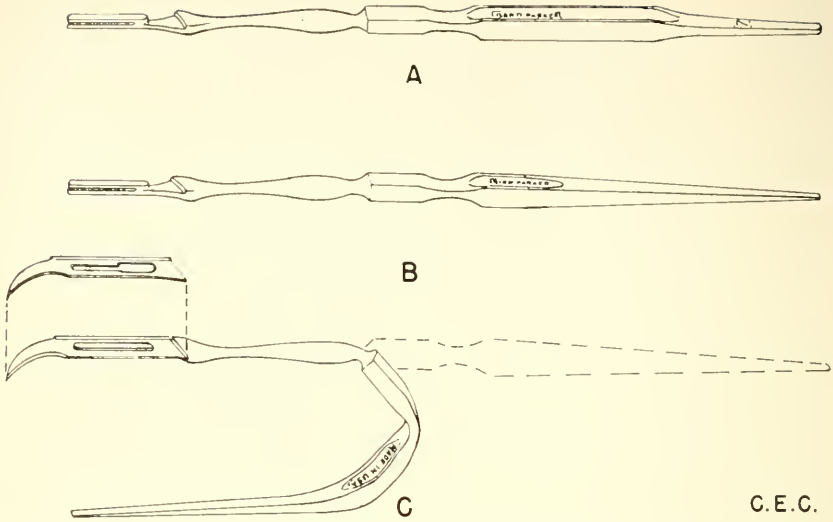


FIGURE 2. The steps in forming the subcutaneous tagging tool: A, Bard and Parker No. 7 handle for a No. 12 blade; B, The handle is filed down to a flat blade 1 mm. thick, 4 mm. wide, and approximately 30 mm. long; C, The handle bent into a U-shape with the end opposite the blade sharpened on the outer surface. *Drawings by Cliffa Carson.*

A narrow incision perpendicular to the body axis and not exceeding 4 mm. in length is made left of the sagittal line and slightly anterior of the ventral fins (Figure 3A). In making the incision it is necessary that the No. 12 blade be held nearly flat, not exceeding 30 degrees in elevation from the body axis. Possibilities of cutting the musculature are thereby greatly reduced and the resulting tapered incision seems to facilitate more rapid healing than could be obtained with a perpendicular cut.

The pocket for the tag is started by carefully inserting the opposite end of the tagging tool (Figure 3B), followed by pressing forward and gently upward simultaneously (Figure 3C). Care must be exercised to avoid bruising the tissues or cutting through the skin. If the tool is properly sharpened and buffed the white pigment is cleanly separated from the outer skin layer with moderate upward pressure. The tag is picked up with flattened forceps, immersed in isopropyl alcohol, and immediately pushed to the forward end of the pocket (Figures 3D and E). Any excess alcohol is not removed from the tag.

If the incision is made as above certainly less than one percent of the fish tagged will show any signs of bleeding. Bleeding generally indicates improper placement, poor incision, and/or poor pocket preparation. It was found that incisions made on the right-hand side of the belly generally cut blood vessels. No check was made to determine what effect tagging on the right-hand side of the body would have on mortality.

Although the above procedure may seem tedious and time consuming, it was found that within half a day of tagging all field men were capable of tagging one fish per minute. With good tools and a con-

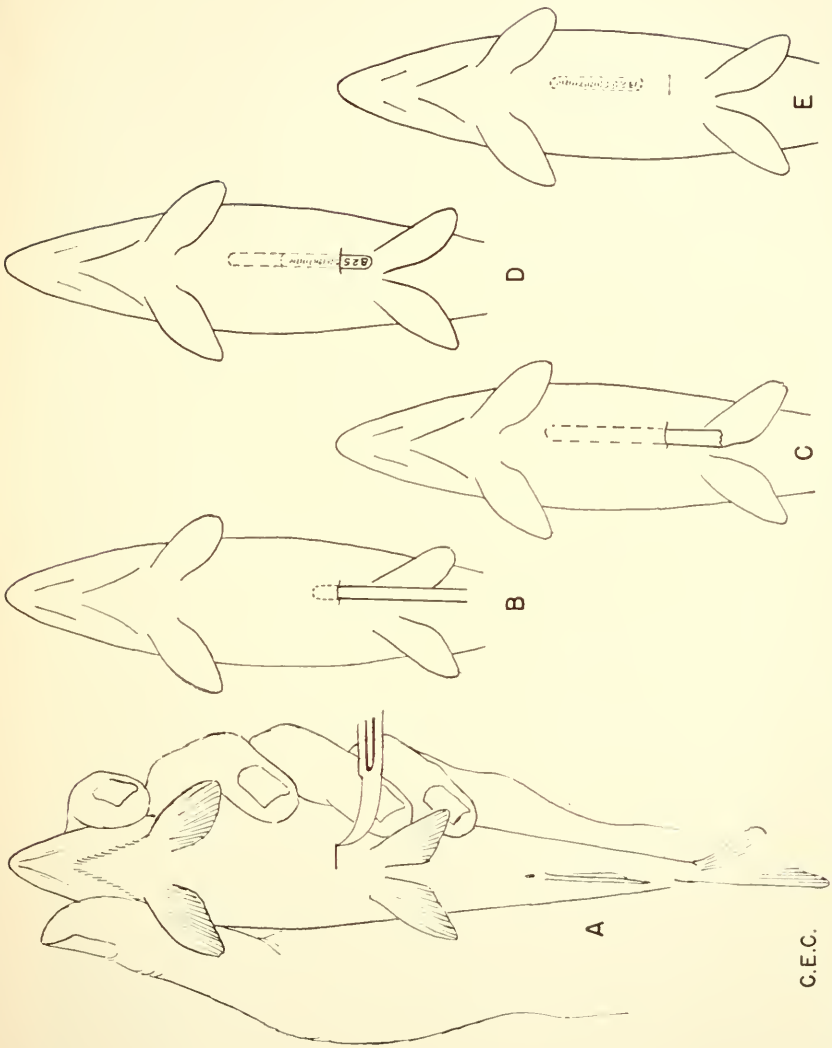


FIGURE 3. The steps in subcutaneous tagging: A, A narrow incision perpendicular to the body axis and not over 4 mm. in length is made left of the sagittal line and slightly anterior to the ventral fin; B, The opposite end of the tagging tool is then inserted into the incision and pressed gently forward and upward; C, The tag is dipped in isopropyl alcohol and pushed to the forward end of the pocket with flattened forceps (D & E). *Drawings by Cliffa Carson.*

venient working situation 100 tags per hour may be considered optimum tagging speed. Chi square analysis of tag returns from various taggers has indicated the technique is effectively learned in a short time. Significant differences in numbers of tags returned from specific lots of trout tagged by different individuals could seldom be demonstrated.

## TAG RETENTION

The initial experiments with a broad tag (5 x 15 mm.) were carried out by making tag placement in two different manners. A longitudinal placement, similar to that now used, was made. A second placement was made by locating the tag transversely across the body in the same area. In the transverse tagging half of the tag lay on one side of the incision and the other half of the tag was fitted into a pocket on the opposite side of the incision. After 135 days all transverse tags were lost. Tags in the longitudinal position showed a 24 percent tag loss with only 30 percent good retention. Most of those retained at the end of 69 days were poor (Table 1).[4]

TABLE 1

The Quality of Subcutaneous Tag Retention With Different Tag Sizes,* Placement, and Treatment of the Incisions

| Tag width and placement | Treatment of incision | Number of fish at end of study | Tag retention quality | | | | Length of study in days |
|---|---|---|---|---|---|---|---|
| | | | Good | Fair | Poor | Lost | |
| Broad (longitudinal) | Nothing | 50 | 15 | 7 | 16 | 12 | 69 |
| Broad (transverse) | Nothing | 19 | 2 | 1 | 1 | 15 | 69 |
| Broad (longitudinal) | Alcohol | 10 | 10 | | | 0 | 61 |
| Narrow (longitudinal | Alcohol and terramycin | 9 | 8 | | 1 | 0 | 61 |
| Narrow (longitudinal) | Alcohol and sulfamerazine | 10 | 10 | | | 0 | 61 |

* Broad tags (5 mm.); narrow tags (3 mm.).

Field application of the broad longitudinal tag was made in Castle Lake in 1955. Tag loss increased during the first 69 days (Table 2). With a tag loss of 57.8 percent during the 42-69 day period, it was obvious that such a tag would not be very desirable.

From the first experimental work, early tag loss was found to occur through the open incision. Tag losses occurring after the second week were related for the most part to blister formation. The blistered tissue became weakened through what appeared to be poor circulation, followed by necrosis and tag loss. It was believed at the time that blistering was caused through one or more of the following factors: (a) bacterial infection introduced with the tag and/or tagging tools; (b) toxicity of the tag itself; (c) irritation induced by the stiffness of the

[4] The terms good, fair, and poor are descriptive of the state of tissues enclosing the tag. Good retention: the skin covering the tag is normal in appearance. Healing has been complete. Fair retention: tissue repair at the incision has been complete; however, the skin covering the tag is raised in a blister. Poor retention: the incision has not healed, the tag is partly extruded, and or the skin covering the tag is necrotic. Tag loss soon follows this condition.

TABLE 2

The One-season Returns From 980 Marked and Tagged Fall-spawned Rainbow Trout Planted in Castle Lake, June 15, 1955 *

| | Number of days after planting | | | | | Totals |
|---|---|---|---|---|---|---|
| | 0-13 | 14-27 | 28-41 | 42-69 | 70-140 | |
| Tag lost | 8 (6.7) | 44 (30.3) | 62 (40.5) | 37 (57.8) | 17 (45.9) | 168 (32.4) |
| Tag retained | 112 (93.3) | 101 (69.7) | 91 (59.5) | 27 (42.2) | 20 (54.0) | 351 (67.6) |
| Totals | 120 | 145 | 153 | 64 | 37 | 519 |

* Numbers in parentheses are percentages based upon the total returns within each time series.

tag; (d) blocking of circulation through the covering tissues by the width of the tag.

The contents of the typical blister were examined from two blistered tag areas, Practically no bacteria were found. In examining the lateral and deeper tissues around the tag incision, there was no obvious tissue infection. Inflammation was local. In these studies two groups of fish, longitudinal control and transverse control, were included. Both groups underwent anesthetization, incision, and tag pocket formation. The only difference between these control groups and the tagged groups was simply that the control groups were without tags. None of the controls developed blistering or showed any signs of irritation. Complete healing was noted within two weeks.

Simultaneously with the above work on the bacterial aspects, two-year-old brood stock were tagged at one of the hatcheries. The plastic tags used were covered with a three percent aureomycin ointment. Blisters occurred in almost every instance and if bacteria were causative in blister formation aureomycin was ineffective. Tags on this group of 60 brood stock fish, although slightly larger (6 x 17 mm.), were well retained two years later in 8 out of 10 fish examined March, 1957 (Figure 4).

Tests were run to determine whether or not blister formation was the result of toxicity and/or tag irritation. To check these factors it was necessary to obtain a soft material of known low toxicity from which tags could be made. The closer the flexibility of the material could approach that of tissue the less likelihood there would be of irritation. Various silicone products meet these requirements. They have a very low order of toxicity (Rowe, Spencer, and Bass, 1948), and are substantially without effect on the human body (McGregor, 1953). As a group they maintain a very pliable state over a range of temperature far beyond the temperature range of water.

A silicone, "Silastic" S-97-11, was obtained from the Dow Corning Company for this test. Individual fish were tagged with "Silastic" and with the vinyl plastic subcutaneous tag. Observations made 19 days later showed typical blistering around both tags. Blistering, therefore, was not due to toxicity and if due to irritation this factor had been reduced as much as possible.

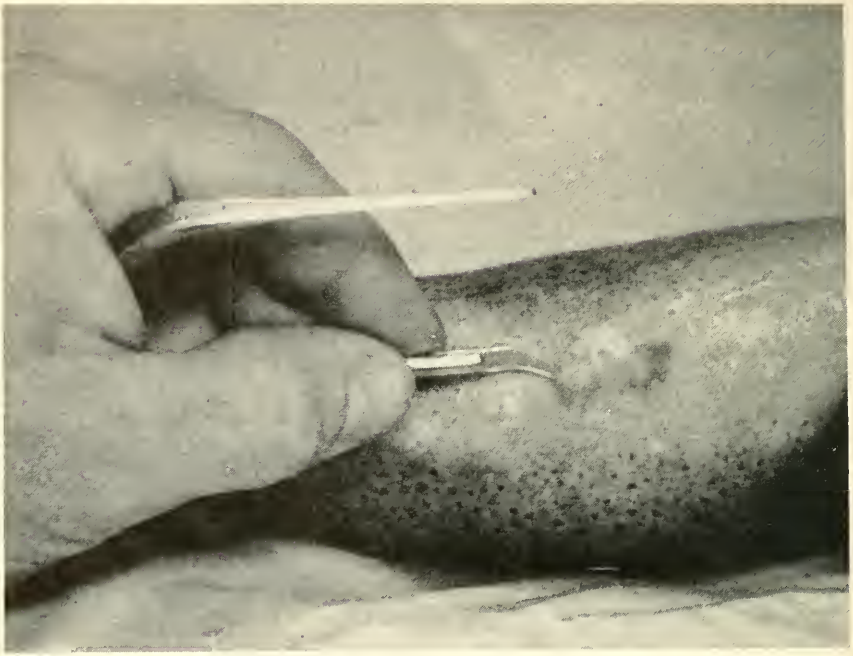

FIGURE 4. The presence of a two-year-old tag indicated by pigment deposition prior to its removal. *Photograph by George Bruley, February, 1957.*

The last aspect of experimentation concerned itself with broad (5 mm.) vs. narrow (3 mm.) tags. During field work several hundred fish were tagged using two tag sizes: 3 x 20 mm. and 5 x 15 mm. Random observations of these fish 15 days later at the hatchery, just prior to planting, indicated the narrow tag to be superior to the broad tag (Table 3). Four tags had been lost from the broad tagged group and

TABLE 3

The Quality of Subcutaneous Tag Retention as Determined From Random Observations of Tagged Fish Held for 15 Days Prior to Planting

| Tag size in mm. | Tag retention quality | | | |
|---|---|---|---|---|
| | Good | Fair | Poor | Lost |
| Narrow (3 x 20) | 10 | 3 | 0 | 0 |
| Broad (5 x 15) | 14 | 16 | 8 | 4 |

there were no observed losses in the narrow tagged group. Chi square analysis of tag returns in these two groups six months later demonstrated a significant difference between the returns of narrow and broad tags. The narrow tags returned at a significantly higher rate.

At the time the third hatchery experiment was begun, conclusions concerning bacterial infection had not been established. A series of tests was made, using both broad and narrow tags, in conjunction with specific treatment for the incision. Three types of treatment were made: isopropyl alcohol alone, alcohol and terramycin, and alcohol and sulfamerazine. In each instance the tag was dipped in alcohol and those receiving terramycin or sulfamerazine were then covered with either of these substances. Subsequent observations made on the third and seventh week and the last day of the experiment (Table 1) indicated that alcohol alone was effective in greatly improving tag retention. Tags in each instance were not accompanied by blistering and most of them could be very clearly read through the skin. There was no sign of irritation. The alcohol may hasten the healing and formation of adhesions around the tag and incision.

## MORTALITY

Values for the effects of tags on mortality have been obtained from tagged and untagged fish held in hatchery raceways. Those trout with longitudinal tags showed only one dead fish out of 56 for a period of 69 days, compared with two dead fish from the longitudinal control group (Table 4). There is no way of knowing what happened to the missing fish. Loss may have been through predation or escapment into other sections of the raceway. The transverse tag group had one death,

TABLE 4

The Comparative Mortality of Tagged and Untagged Trout for a Period of 69 Days

| Type of tagging and control | Number of fish | Missing | Known dead |
|---|---|---|---|
| Longitudinal tag | 56 | 5 | 1 |
| Longitudinal control | 56 | 3 | 2 |
| Transverse tag | 23 | 3 | 1 |
| Transverse control | 23 | 0 | 0 |
| Unmarked control | 5 | 0 | 1 |
| Fin clip control | 15 | 0 | 1 |

compared with no deaths in the transverse control group. One death was observed in the fin clipped control group.

It has been observed consistently that rainbow trout feed readily after tagging. As soon as they regain their equilibrium following anesthetization they are very active. Short-term observations of mortality have been made in the various hatcheries where the tagged fish have been held a few days prior to planting. From 1,200 fish tagged for one plant, one loss was observed during the three days prior to planting. This loss occurred during the actual tagging operation. Of the 980 tagged at Castle Lake, three losses occurred during tagging. No additional losses were noted five days later when planted.

It seems that the initial mortality from tagging is related directly to the tagging procedures and it has been observed that if temperatures of the anesthetic solution are appreciably higher than the hatchery

water, they may adversely affect the fish. It is important that the temperature of the anesthetic solution be maintained as near as possible to that of the hatchery water. At the recommended concentration of ½ gram/gallon at 50 degrees F. too long an exposure to the solution may cause death. Once gill movement ceases completely care must be used to return the fish as rapidly as possible to the hatchery water. The higher the concentration of M.S. 222, the higher the temperature, and the longer the exposure to the anesthetic, the greater danger there is of losing fish.

## GROWTH

Inasmuch as most of the returns from catchable trout are obtained in the first two or three weeks after planting, there is little opportunity to determine the effect of the tag on growth after planting. Values that have been obtained were taken from fish in the hatchery experiments. The mean growth increment is that recorded for all the fish at the conclusion of each experiment (Table 5). In the 135-day test the mean growth increment was 1.8 inches and the range was from 1.4 to 2.3

TABLE 5

The Growth of Longitudinally Tagged and Untagged Rainbow Trout From Two Hatchery Experiments

| Type of tag or control | Number of fish at end of study | Mean growth increment | Length of study in days |
|---|---|---|---|
| Broad yellow vinyl | 12* | 1.8 inches | 135 |
| No incision control | 50 | 1.8 inches | 61 |
| Incision control | 50 | 1.6 inches | 61 |
| Narrow yellow vinyl | 19 | 1.8 inches | 61 |
| Broad yellow vinyl | 15 | 1.7 inches | 61 |

* Poaching following 69 days of protected retention greatly reduced the original number of 56 trout.

inches. In the 61-day test, in which controls were run with the narrow and broad tagged groups, there was no striking difference in the mean growth rates, although fish with the broad tags had a much wider range, 0.7 to 2.6 inches.

Growth obtained from four-year-old brood stock tagged two years previously was all positive. These fish, originally 14½ to 16 inches long, showed growth increments from 2½ to 5 inches for the two-year period.

It may be concluded that in the hatchery, growth is not hampered by the tag nor by the incision. Inasmuch as these values were obtained under hatchery conditions, they may not be applied with certainty to lake or stream conditions. Conclusive testing should be done if a long-term tag return is expected.

## APPLICATION TO FIELD PROBLEMS

During the past two years the vinyl subcutaneous tag has been used on groups of trout planted in several different types of waters. The publicity given to these studies has varied from virtually none to very intense. The fact that greater numbers have been returned voluntarily than have been checked or picked up by creel checkers indicates that the tag is readily seen.

Studies on catchable trout using this tag will be published upon at a later date.

## DISCUSSION

The subcutaneous tag is demonstrating its usefulness in the catchable trout program in California. The tag is readily seen by sportsmen.

Tag loss has been shown not to be a serious consideration in the high angling intensity waters. Since 80 to 90 percent of the trout to be taken are removed within a period of two to three weeks, definitive measures of long-term tag loss cannot be obtained.

The tagging method developed is yet to be used in a long-term tagging study.

Desirable qualities which have been demonstrated for this particular type of tag are: (1) the tag does not affect growth rate of rainbow trout under hatchery conditions and may be expected not to hinder growth under lake and stream conditions; (2) the tag and the tagging procedures described are not of themselves effective in increasing mortality; (3) fish may grow without outgrowing the size of the tag; (4) the tag will not catch upon any object in the stream or lake; therefore, it is particularly valuable where tag loss may be expected through netting or contact with heavy brush.

## ACKNOWLEDGMENTS

One of the problems of inserting vinyl plastic tags was overcome through the valuable suggestion offered by E. D. Le Cren of the Freshwater Biological Association, Ambleside, Westmoreland, England. He suggested the use of a philatelist's tool for tag pocket formation. The idea was adapted to the modification of the Bard and Parker blade and handle. The interest shown by C. S. Kabel of the California Department of Fish and Game was productive through his suggestion of using the Bard and Parker surgical instrument. J. H. Wales of the California Department of Fish and Game kindly cared for one group of experimental fish and examined the blisters found on tagged fish for bacterial infection. His interest and active participation in this respect and at Castle Lake were gratefully received. Sincere appreciation is expressed to E. Bertelsen for the encouragement and presentation of unpublished data concerning vinyl plastic tag application on plaice.

The chi-square analysis on narrow vs. broad tags made by H. K. Chadwick of the California Department of Fish and Game was valuable in emphasizing a more careful examination of narrow tag application.

Without the pleasant and very cooperative assistance of California Fish and Game hatchery foremen A. J. Weaver, L. C. Hume, and R. Bliss, the experimental hatchery work would have been virtually impossible.

## SUMMARY

A subcutaneous vinyl plastic tag has been developed and is in current use in California. The tools and method of tagging are described and it has been demonstrated that the technique can be effectively learned in a relatively short time. Optimum tagging rate may be expected to be near 100 tags per hour.

Hatchery experimentation and field observations have demonstrated the following: (1) blistering may be the most serious problem related to tag retention; (2) blistering is not due to vinyl plastic toxicity, bacterial infection from the tools and or the tag, or tag irritation; (3) differences in mortality between tagged and untagged fish could not be demonstrated; (4) the growth observed with various groups of hatchery fish was not hampered by tag application; (5) the experimentation has demonstrated that of the various methods and materials used the narrow tag plus isopropyl alcohol provides the best tag retention; (6) the tag can be seen by fishermen. Greater numbers are returned voluntarily than are checked or picked up by creel checkers.

No long-term tests in lakes and streams have yet been conducted to determine how effective the tag is for such fisheries.

## REFERENCES

Le Cren, E. D.
1954. A subcutaneous tag for fish. Jour. du Conseil, vol. 20, no. 1, p. 72-82.

McGregor, R. R.
1953. Silicones in pharmacy. Pharm. Internat., vol. 7, p. 24-26, 63.

Moore, W. H., and C. H. Mortimer
1954. A portable instrument for the location of subcutaneous fish-tags. Jour. du Conseil, vol. 20, no. 1, p. 83-86.

Rounsefell, George A., and W. Harry Everhart
1953. Fishery science: Its methods and applications. New York, John Wiley & Sons, Inc., xii + 444 p.

Rowe, V. K., H. C. Spencer, and S. L. Bass
1948. Toxicological studies on certain commercial silicones and hydrolyzable silane intermediates. Jour. Indust. Hygiene and Toxicology, vol. 30, no. 6, p. 332-352.

# CLASSIFICATION, VARIATION, AND DISTRIBUTION OF THE SCULPINS, GENUS *COTTUS*, INHABITING PACIFIC SLOPE WATERS IN CALIFORNIA AND SOUTHERN OREGON, WITH A KEY TO THE SPECIES[1]

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## INTRODUCTION

The sculpins of the genus *Cottus* comprise one of the most perplexing groups of North American freshwater fishes. Variation is so marked and often so haphazard that interpretation of the species limits is frequently difficult. Moreover, many of the numerous nominal forms are based on a few poorly preserved specimens and inadequate descriptions. Perhaps for these reasons, few systematic contributions on *Cottus* have been made in recent years. That by Bailey and Dimick (1949) added substantially to our knowledge of western sculpins when they separated

[1] Submitted for publication February, 1957. Contribution from The Marine Laboratory, University of Miami, Number 176, and from the Museum of Zoology, University of Michigan.

their new species, *C. hubbsi,* from *C. rhotheus* and discussed briefly other western forms.

Sculpins form an important component of the stream fauna through much of the West. They are particularly common in colder waters and are often reported in conjunction with studies on trout and salmon.

The acquisition of new material and a review of type specimens at the United States National Museum and at Stanford University now permit a more complete discussion of the several species from the upper parts of the Klamath and Pit rivers of Oregon and California. In addition, we present a key to the species of *Cottus* now known from the Pacific drainage of California and southern Oregon and discuss their nomenclature.

The existing difficulty in identifying the numerous species has led to considerable confusion in the literature and so our primary purpose at this time is to provide an acceptable classification at the species level. The delineation of subspecies awaits more exhaustive studies, both in the field and laboratory.

Leonard P. Schultz, Ernest A. Lachner, and Robert H. Kanazawa have kindly made available material and working space at the United States National Museum. George S. Myers, Margaret Storey, and Norman J. Wilimovsky similarly aided us at the Stanford Natural History Museum. Edward C. Raney loaned specimens from Cornell University. To Reeve M. Bailey and Carl L. Hubbs appreciation is expressed for permission to use field notes. Joseph H. Wales obtained the excellent series of *C. asperrimus* from Hat Creek. We are indebted to Vladimir Walters for notes on the types of *C. aleuticus* and *C. shasta* at Stanford University.

The following museum abbreviations are employed: CU, Cornell University; UMMZ, University of Michigan Museum of Zoology; SNHM, Stanford Natural History Museum; and USNM, United States National Museum. The number of specimens and their range in standard length is given in parentheses after each museum number.

## METHODS

Counts and measurements have been taken by the methods described by Hubbs and Lagler (1947, p. 8-15) except as noted below.

*Dorsal and Anal Soft Rays.* Hubbs and Lagler (1947, p. 10) recommend that the last two elements of the dorsal and anal fins be treated as one ray. Upon dissection it is found that in many groups of fishes the last two rays stem from a single interspinal series, whereas each preceding series supports only one ray. This method of counting is well founded in such groups. In the genus *Cottus,* the dorsal and anal rays are unbranched in most species and, as described above, the last two rays are often close together and stem from a single interspinal series (Figure 1, B). Occasionally, however, this last interspinal bears three very closely approximated rays, the first well developed and the last two splint-like (Figure 1, C). In each instance the rays which arise from the last interspinal are considered one. An important variation occurs when the last ray is well developed, well separated from the preceding ray, and stems from its own interspinal (Figure 1, A). Were this a rarity or of equally probable occurrence in all populations, then

the arbitrary rule of counting the last two rays as one would introduce only a negligible and random error. Unfortunately, this is not the situation, for when this variant occurs it is likely to involve the entire sample. Moreover, it is the prevalent condition in such forms as *C. tenuis* (Figure 1, A; also Evermann and Meek, 1898, p. 83, fig. 6) and *C. cognatus* (Greeley, 1928, pl. 7), and is unusual in most other species (Figure 1, B and C), as exemplified by *C. hubbsi* (Bailey and Dimick, 1949, pl. 1). Careful dissection reveals that a very small and completely imbedded splint ray is often present in the variants; sometimes the last ray is truly single. To count the last two rays as one under these circumstances leads to apparent population differences of one ray, a large variation in this feature, when no such differences actually exist. To count every ray, no matter how small, leads to an equally biased result. In this study the last two (or three) rays are counted as one only when they stem from a single interspinal. With experience, the true situation is easily seen by noting the degree of separation of the rays: they are very close together when they stem from a common interspinal and equally far apart when they arise from separate interspinals. If there is uncertainty, an incision is made along the bases of the last several rays to expose the interspinals. In this manner unbiased counts may be made with little chance of error.

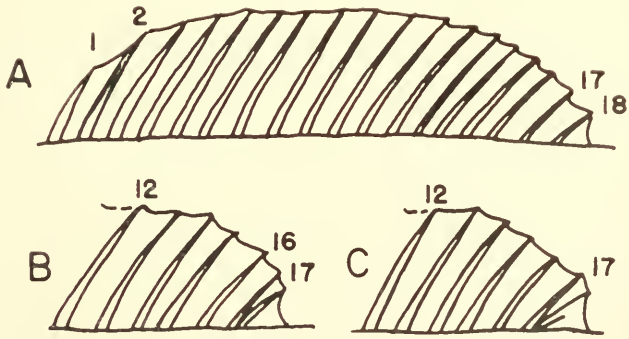


FIGURE 1. Second dorsal fin of *Cottus*, showing the variation in enumeration of rays (for clarity, segmentation is omitted). A, every element is counted; B, last two elements counted as 1; C, last three elements counted as 1.

*Pelvic Rays.* Every ray is counted no matter how rudimentary. Since a hidden spine is closely appressed to the first soft ray in all forms of *Cottus*, this element is not enumerated.

*Branching of Soft Rays.* In those species in which the pectoral and pelvic rays are branched, the branching occurs typically at or near the tips. The lower rays of the pectoral fin are never branched and the first ray of the pelvic fin often is simple. Branching is correlated with growth of the fins; thus, young individuals may have simple rays (though flattened and frayed at the tips), whereas branched rays are characteristic of the adult. Usually only a few elements are involved in the branching of dorsal and anal rays.

*Lateral-line Pores.* The first pore counted is the first one behind the union of the opercular membrane to the body. When the lateral line is

developed onto the tail, the last pore counted is the one directly over or immediately in front of the posterior edge of the hypural plate. The lateral line is termed complete when it reaches this point. When it is incomplete, every pore is counted. This count is reliable on adult fish only; in the present study no fish smaller than 40 mm. in standard length was used.

*Head-pore Arrangement.* Useful and important differences (unpublished) have been noted by the writers in their studies of this group. Although we are most concerned with the infraorbital and preoperculo-mandibular canals, in this study we present in Figure 2 a schematic

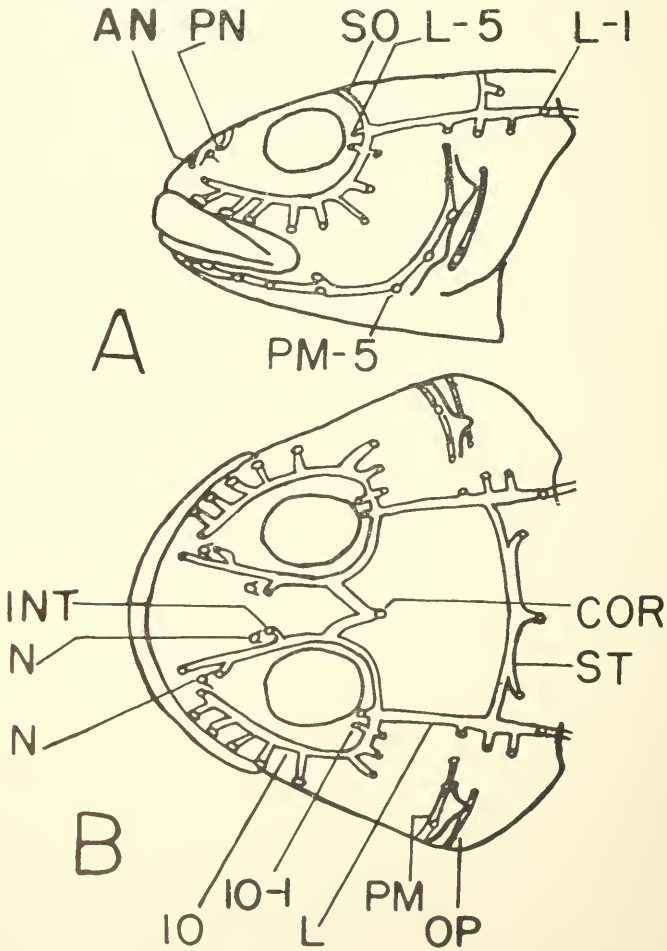


FIGURE 2. Schematic drawing of the head-pore arrangement in a hypothetical species of *Cottus*. A, lateral view. AN, anterior nasal pore; PN, posterior nasal pore; SO, supraorbital canal; L-1, L-5, lateral-canal pores 1 and 5; PM-5, pore 5 of preoperculo-mandibular canal. B, dorsal view. N, nasal openings; IO, infraorbital canal (IO-1 = pore 1); L, lateral canal; PM, preoperculo-mandibular canal; OP, opercular canal (often lacking); ST, supratemporal canal; COR, coronal pore; INT, interorbital pore.

outline of the entire cephalic canal system of a hypothetical species of sculpin. It is hoped that these features will be investigated by other workers and that this outline will serve as a basis for comparison. The terminology is after Hubbs and Cannon (1935) as modified by Illick (1956). In contrast with Illick (*op. cit.*, p. 206, fig. 1) we enumerate the pores of the lateral canal from the attachment of the gill membrane forward (the more anterior pores are absent in many species) and distinguish between the pores of the lateral and infraorbital canals. For a critical review of this topic the reader is referred to Illick (*op. cit.*) and the references cited therein.

*Infraorbital Pores.* The pore which often is present on the lateral canal at its junction with the infraorbital canal is not counted.

*Preoperculo-mandibular Pores.* Every pore below the lateral canal is counted. In most species the two preoperculo-mandibular canals do not unite on the chin and each has 11 pores, as indicated by the formula 11-11. In some species these canals are united on the chin and share a median chin pore (pore count = 10-1-10, Figure 3, A). In others the uppermost of the two post-maxillary pores, behind the corner of the mouth (Figure 3, B; also pl. 1 in Bailey and Dimick, 1949), is absent (pore count = 10-10). When both conditions exist the pore count is expressed as 9-1-9.

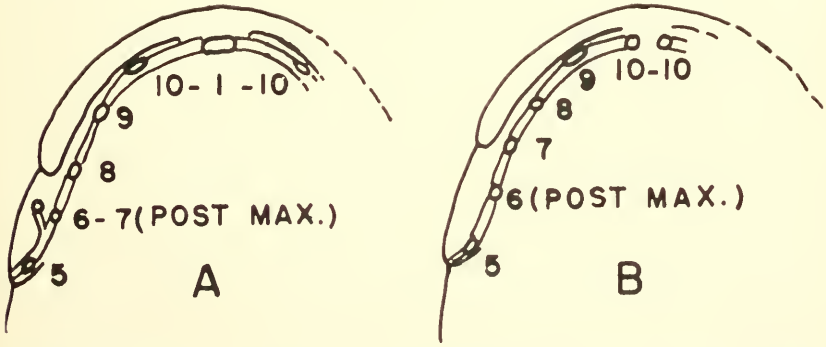


FIGURE 3. Ventral view of chin of *Cottus*. A, postmaxillary pore double, chin pore single, count = 10-1-10. B, postmaxillary pore single, chin pore double, count = 10-10. Combinations of these conditions yield counts of 9-1-9 and 11-11.

*Prickles on the Body.* The presence or absence of prickles on the body, and their distribution, has been used to characterize almost every species of *Cottus*. The considerable constancy which this feature exhibits within most populations undoubtedly led to its employment as a systematic tool. So much variation occurs between populations of most species, however, that its geographic constancy in one or two forms, such as *C. princeps*, is difficult to evaluate. A correlation with habitat has been noted. Within a given species, samples from mountain brooks are naked or have many fewer prickles, whereas lake populations exhibit the most extensive prickles. The first prickles to appear and the ones lost last are those mesial to the pectoral fin.

*Preopercular Armature.* This feature behaves much like the body prickles. In species which inhabit mountain brooks as well as lakes, the lake samples have the longer, sharper, and generally better-developed spines. The armature is totally absent in some populations of several mountain forms. Armature, like body prickles, may greatly assist in the identification of species at any one locality, but is often unreliable for relating or distinguishing allopatric forms.

In order to facilitate the identification of the species of *Cottus* in southern Oregon and California (Pacific slope), we present the following key. The data are based on studies of material from throughout the known ranges of all the species.

### KEY TO SPECIES OF COTTUS OF THE PACIFIC SLOPE OF CALIFORNIA AND SOUTHERN OREGON [2]

1. Pelvic rays 3-3; palatine teeth absent; some pectoral rays branched; lateral line incomplete ..... 2
1. Pelvic rays 4-4 (if 3-3 then lateral line complete); palatine teeth present or absent; pectoral rays branched or not; lateral line variable ..... 3
2. Two or 3 (usually) preopercular spines, the uppermost relatively long and pointed, the next lower typically recurved at tip; lateral line more complete, usually extending to or beyond base of last dorsal ray (see text for variability); ventral surface of head and abdomen nearly immaculate ..... *C. tenuis*
2. One or 2 (at most) preopercular spines, the uppermost comparatively short and blunt, the next lower not recurved at tip and usually weak; lateral line less complete, not extending beyond base of third from last dorsal ray; ventral surface of head liberally sprinkled with melanophores ..... *C. asperrimus*
3. Lateral line usually complete, with 28 or more pores (if fewer, palatine teeth present); palatine teeth variable; pectoral rays unbranched; dorsal spines 8-9 ..... 5
3. Lateral line incomplete (usually with 15-25 pores but higher in *klamathensis* below Klamath Falls); palatine teeth absent; some pectoral rays branched; dorsal spines 5-7 (rarely 8) ..... 4
4. Preoperculo-mandibular pores 10-1-10; infraorbital pores 7-7; preopercular armature much reduced or absent; dorsal soft rays usually 20-21; head pores much enlarged (larger than nasal openings) ..... *C. princeps*
4. Preoperculo-mandibular pores 10-10; infraorbital pores 8-8; upper preopercular spine well developed (2 accessory spines often present below it); dorsal soft rays usually 18-19; head pores small (smaller than nasal openings) ..... *C. klamathensis* [3]
5. Anal rays usually 17-18, pectoral rays modally 16 (often 17), dorsal rays 19-22; palatine teeth present and well developed ..... *C. asper*
5. Anal rays 12-15, pectoral rays modally 15, dorsal rays 16-18 (if more, palatine teeth absent); palatine teeth variable ..... 6
6. Pelvic fins long (when depressed, reach anus); palatine teeth absent; dorsal soft rays 17-20, total dorsal elements usually 27-29; caudal vertebrae 24-27 ..... *C. aleuticus* [4]
6. Pelvic fins short (when depressed, usually fall far short of anus); palatine teeth variable; dorsal rays 16-18 (rarely 19), total dorsal elements usually 26 or fewer; caudal vertebrae 21-24 ..... *C. gulosus* [5]

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[2] *C. beldingi* has been reported only once from the Sacramento River basin (Rutter, 1908, p. 147), based on a collection taken prior to 1900. To our knowledge, the species does not now occur in this drainage.
[3] Including *C. macrops*, see text.
[4] Including *C. protrusus*, see text.
[5] Including *C. shasta*, see text.

## SYSTEMATIC ACCOUNT

### *Cottus tenuis*

(Tables 1 and 2)

*Uranidea tenuis.* Evermann and Meek, 1898, p. 83-84, fig. 6 (original description; type locality: lower end of Upper Klamath Lake, near Klamath Falls, Oregon).

*Cottus tenuis.* Rutter, 1908, p. 145 (comparison with *C. asperrima* [sic]). Hubbs and Schultz, 1932, p. 50 (compared with *tubulatus*). Hubbs and Miller, 1948, p. 69 (relationship to *asperrimus* indicated). Bailey and Dimick, 1949, p. 15 (comparison with *C. hubbsi*).

The drawing of the type (Evermann and Meek, 1898, p. 83, fig. 6) does not accurately depict the body form since the figure represents a recently spawned and much emaciated individual. The undivided last dorsal and anal ray, the profuse branching of the upper pectoral rays, the long lateral line and the preopercular armature are correctly figured. The short spinous dorsal fin is contiguous with the soft dorsal but the two are never broadly joined. In most specimens several of the dorsal and anal soft rays are branched. The pelvic rays are branched distally in all but a few of our specimens, mostly young (see material examined), a condition noted by us in only one other species (*C. asperrimus*).

Frequency distributions of fin-ray counts and numbers of lateral-line pores are presented in Table 2.

The lateral line is never complete and generally terminates under the last few rays of the second dorsal fin. Specimens from Sprague River have a less well developed lateral line than the other populations studied (see Table 1). The head pores have seldom been used in studies on this genus although they are useful in separating many species. In *tenuis* there are 10-10 pores in the preopercule-mandibular canals (61 specimens), rarely 9-1-9 (6 specimens). The infraorbital canal has 8-8 pores in 61 specimens, with very little variation (8-9 in one and 9-9 in two).

The body prickling is quite variable. Lake specimens usually have the entire upper half of the body covered with fine prickles, while creek specimens have a patch of prickles mesial to the pectoral fin or are entirely naked. The dorsal surface of the head is never prickled. Similarly the preopercular armature is best developed in lake examples. Three sharp spines are noted in those from Upper Klamath Lake. Specimens from Sprague River retain the three spines but they are shorter and more blunt.

Vomerine teeth are present but palatine teeth are lacking in all material examined by us. Caudal vertebrae (including hypural) number 23 (3 specimens), 24 (7), or 25 (1).

#### *Comparisons and Relationships*

*C. tenuis* is most closely allied to *C. asperrimus,* which inhabits several tributaries of the Pit River of the Sacramento River system. A comparison of these forms is given under the treatment of *asperrimus.* No very close relationship is noted with any other species. *C. tenuis* and *C. asperrimus* are unique in having branched pelvic rays. *C. princeps*

differs from *tenuis* in having the dorsal fins fused, 4-4 pelvic rays, 7 dorsal spines, 20-21 dorsal soft rays, a less complete lateral line, much enlarged head pores, 7-7 infraorbital pores, 10-1-10 preoperculo-mandibular pores, and in numerous other ways. *C. klamathensis* shares with *tenuis* an absence of palatine teeth and similar head-pore counts. It differs in having more numerous dorsal spines (usually 7) 4-4 pelvic rays, a less complete lateral line (15-22 pores), and a broad union of the dorsal fins (Gilbert, 1898, fig. on p. 10). Limited material of *klamathensis* from below Klamath Falls shows a better-developed lateral line.

As discussed below, we treat *macrops* and *klamathensis* as conspecific. *C. gulosus*, an extremely variable form, has 4-4 pelvic rays, 8-9 dorsal spines, unbranched rays in all fins and a more complete lateral line (usually 32-36 pores). Evermann and Meek (1898, p. 83) ally *tenuis* and *C. marginatus*, probably on the basis of two features which they share: 3-3 pelvic rays and a lack of palatine teeth. The pelvic rays of *marginatus* are not branched, however, and it has 10-1-10 preoperculo-mandibular pores and 7-9 dorsal spines. In its general physiognomy *marginatus* appears more closely allied to *perplexus* and *klamathensis* than to *tenuis* and *asperrimus*.

There is presented in Table 1 a color comparison of *princeps*, *tenuis*, *asperrimus*, *klamathensis*, and "*macrops*", drawn by C. L. Hubbs from freshly collected specimens; that for the first three species is based on material taken in Upper Klamath Lake (Pelican Bay) on August 14, 1934 (field sta. M34-130), and the notes on *asperrimus* and "*macrops*" are based on specimens from the Fall River system near Dana, California, taken on August 17, 1934 (field sta. M34-135). Statements in parentheses under *asperrimus* are our observations where no specific reference to these items appears in Dr. Hubbs' notebook.

### Geographic Variation

Populations from Upper Klamath Lake, Agency Lake-Crooked Creek, and Sprague River—all in the Klamath basin—exhibit some degree of differentiation. We do not feel that these differences are sufficient to merit nomenclatural recognition. Specimens from Agency Lake and Crooked Creek are most similar to the Klamath Lake population but differ in having somewhat fewer dorsal soft rays and pectoral rays. The Sprague River material has a distinctly lower pectoral-ray count and somewhat fewer pores in the lateral line.

### Habits

An examination of the abundant type material of *tenuis*, collected on November 3, 1896, reveals many females with enlarged eggs and others which have obviously spawned. This evidence, coupled with Evermann and Meek's (1898, p. 84) reference to a ripe female, definitely shows that *tenuis* is a fall spawner in Klamath Lake.

### Geographic Range

*C. tenuis* is restricted to Upper Klamath Lake and its tributaries, Oregon.

TABLE 1

Life Colors of Four Species of Cottus *

| Feature | *princeps* | *tenuis* | *asperrimus* | *klamathensis* | "*macrops*" |
|---|---|---|---|---|---|
| General tone | Olive to purplish | A grayer olive to brown | Olive brown to purplish brown | More yellow-olive, with or without reddish in lighter reticulations | Yellow to olive-green to very dark slaty olive; light areas greener than ground color |
| Belly | White to gray | More metallic, silvery to brassy | (with scattered melanophores; see Rutter, 1908, fig. 3) | Duller, creamy gray to blue-gray | Dark |
| Bicolored contrast | Moderate | Strong | Variable, generally moderate to weak, strong in some, especially in young | Weak | Little |
| Lateral blotching | Coarse, rather faint | Most disrupted and intense | Reticulated, intense, with tendency for irregular light splashes | Rather faint and reticulated | Indistinct, the blotches much disrupted |
| Chin | Whitish to gray, more or less marbled with slaty | White to yellow, not marbled | (dusted with melanophores, marbled in some) | Olive to yellowish, with faint marbling or none | Somewhat marbled or uniform |
| Pelvic fins | White | White | Clear white or brassy | Yellowish or olive, with trace of bars | Brown to red, with greenish-gray cross markings |
| Anal fin | White to faintly barred | As in *princeps* | Brown to reddish, lighter than dorsal, crossed by light gray streaks | Rather strongly barred | Like pelvics |
| Dorsal fin | Light, with faint to definite dark bars | Light, with dark bars or intense dashes | Brown to reddish, crossed by light gray streaks | Reddish, with narrow olive bars | Brown to red, with greenish-gray or darker cross markings |
| Caudal fin | Light olive, with pale to dark reddish or brownish bars | Light gray, cream or yellow, with blackish bars | Like dorsal | Dark reddish or brownish, with narrow olive bars | Brown to red |

* Taken from field notes by C. L. Hubbs (see text), except for statements in parentheses.

## TABLE 2

### Frequency Distributions of Fin-ray and Lateral-line Pore Counts in Three Species of Cottus

Counts for the holotype are indicated by asterisks. See text for method of taking counts.

| Species and locality | Dorsal spines | | | | Dorsal soft rays | | | | | | | Total dorsal elements (spines + rays) | | | | | | | | | Anal rays | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 6 | 7 | 8 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 13 | 14 | 15 | 16 | 17 | 18 |
| *tenuis* | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Upper Klamath Lake | 6 | 21* | -- | -- | 3 | 19* | 5 | -- | -- | -- | -- | 1 | 4 | 20* | 2 | -- | -- | -- | -- | -- | -- | 2 | 14* | 10 | 1 | -- |
| Agency Lake | -- | 10 | 2 | -- | 10 | 2 | -- | -- | -- | -- | -- | -- | 8 | 4 | -- | -- | -- | -- | -- | -- | -- | 5 | 7 | -- | -- | -- |
| Crooked Creek | 3 | 17 | -- | -- | 10 | 8 | 2 | -- | -- | -- | -- | 1 | 10 | 8 | 1 | -- | -- | -- | -- | -- | -- | 3 | 14 | 3 | -- | -- |
| Sprague River | 3 | 5 | 1 | -- | 1 | 3 | 5 | -- | -- | -- | -- | -- | 1 | 6 | 1 | -- | -- | -- | -- | -- | 3 | 2 | 4 | -- | -- | -- |
| *asperrimus* | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Above Pit River falls | 2 | 11 | 2* | -- | 3 | 10* | 2 | -- | -- | -- | -- | 1 | 6 | 6 | 2* | -- | -- | -- | -- | -- | -- | 6 | 7* | 2 | -- | -- |
| Hat Creek (below falls) | 3 | 16 | 1 | -- | 4 | 11 | 5 | -- | -- | -- | -- | 1 | 4 | 11 | 3 | 1 | -- | -- | -- | -- | 1 | 11 | 7 | 1 | -- | -- |
| *princeps* | -- | 1 | 27* | 2 | -- | -- | 1 | 12 | 12* | 3 | 2 | -- | -- | -- | -- | 1 | 12 | 11* | 4 | 2 | -- | -- | 2 | 18 | 7* | 3 |

| Species and locality | Pelvic rays (both sides) | | | Pectoral rays (both sides) | | | | | Lateral-line pores | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 12 | 13 | 14 | 15 | 16 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| *tenuis* | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Upper Klamath Lake | -- | 52* | 2 | -- | 2 | 5 | 14* | 3 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 1 | 1 | 2 | 5 | 3 | 2* | 2 | -- |
| Agency Lake | -- | 58 | -- | -- | -- | 39 | 19 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 1 | 2 | 1 | -- | -- | -- | -- |
| Crooked Creek | -- | 39 | 1 | -- | -- | 19 | 21 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 3 | 5 | 7 | 4 | -- | 1 |
| Sprague River | 1 | 17 | -- | 1 | 8 | 8 | 1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | 1 | -- | 2 | 2 | 2 | 1 | -- | -- | -- | -- |
| *asperrimus* | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Above Pit River falls | -- | 30* | -- | -- | -- | 28* | 2 | -- | -- | -- | -- | -- | 1 | -- | 2 | 1 | 3 | 1 | 2 | 3* | 1 | -- | 1 | -- | -- | -- |
| Hat Creek (below falls) | -- | 56 | -- | -- | -- | -- | 37 | 3 | -- | -- | -- | -- | -- | 1 | 1 | 2 | 6 | 3 | 3 | 2 | 1 | -- | 1 | -- | -- | -- |
| *princeps* | -- | -- | 82* | -- | -- | 5* | 65* | 12 | 1 | 1 | -- | 1 | 1 | 2 | 6* | 3 | 3 | 3 | 1 | -- | -- | -- | -- | -- | -- | -- |

### *Cottus asperrimus*

(Tables 1 and 2)

*Cottus asperrima.* Rutter, 1908, p. 144-145, fig. 3 (original description; type locality: Fall River at Dana, California). Snyder, 1917, p. 82 (synonym of *gulosus*).

*Cottus asperrimus.* Hubbs and Schultz, 1932, p. 5 (compared to *tubulatus*). Hubbs and Miller, 1948, p. 69 (relationship with *tenuis*). Bailey and Dimick, 1949, p. 16 (removed from synonymy of *C. gulosus*).

Frequency distributions of fin-ray counts and numbers of lateral-line pores are given in Table 2. *C. asperrimus* is so similar to *tenuis* that only the differences between them need to be noted. This similarity must have been suspected by Rutter (1908, p. 145) since he presented a tabular comparison between these two species, but the characters listed by him are slight and do not hold when comparable specimens are examined. We note several diagnostic features. Typically, *asperrimus* has only one well-developed preopercular spine and a blunt knob below it, often absent, whereas *tenuis* has three preopercular spines. The lateral line is less well developed in *asperrimus*, generally extending to the base of the second to fifth ray from the last, but reaching to or beyond the last dorsal ray in *tenuis*. The latter species spawns in the fall, whereas *asperrimus* evidently spawns earlier (see Habits, below.) The life coloration (Table 1) appears to be distinctive and the pigmentation also differs, *asperrimus* showing profuse chromatophores on the venter, whereas *tenuis* is nearly immaculate. Although the pelvic, soft dorsal, and anal rays of *asperrimus* are branched, as in *tenuis*, the degree of branching seems to be weaker, particularly on the smaller topotypes (UMMZ 130650), than it is in *tenuis*. The number of preoperculomandibular pores is variable. In 19 specimens (including the holotype) the formula is 9-1-9, whereas in 41 specimens (including 2 paratopotypes, SNHM 9968) it is 10-10, as in *tenuis*. The two forms perhaps warrant only subspecific status, but our material is insufficient to decide this point with assurance.

An extensive patch of prickles is present mesial to the pectoral fin, and in most specimens the prickling extends caudad along the body above the lateral line to a point under the middle of the second dorsal fin. Few specimens exhibit such extensive prickling as the holotype (Rutter, 1908, p. 144, fig. 3). The figure of the type errs in showing unbranched pectoral rays and a peculiar head profile. Actually, the ventral contour is flat to the tip of the chin, as in other sculpins, and the dorsal profile turns abruptly downward in front of the eyes.

#### Comparisons

*C. asperrimus* differs from other sculpins in most of the characters which separate them from *C. tenuis* (see above). The 3 soft rays of the pelvic fins readily distinguish it from *klamathensis*, which occurs with *asperrimus* and has 4 pelvic rays.

The origin of *asperrimus* is considered in the zoogeographical discussion.

### Geographic Variation

Available material of this species is inadequate to determine the range of variability but does show that the number of pectoral rays in samples from above the Pit River falls is significantly greater than it is in the one sample from below these falls (15 versus 14, Table 2).

### Habits

Specimens of *asperrimus* from Hat Creek (below Pit River falls) taken on May 6, 1949, include females with large eggs, suggesting that this species, in contrast with *tenuis*, is a spring spawner.

### Geographic Range

*C. asperrimus* is probably restricted to the Pit River portion of the Sacramento River system, for a short distance above and below the falls at Fall River Mills, California.

## *Cottus princeps*

(Tables 1 and 2)

*Cottus princeps Gilbert*, 1898, p. 12-13, fig. on p. 12 (original description; type locality: Upper Klamath Lake, Oregon). Evermann and Meek, 1898, p. 83 (specimens from Pelican Bay, Upper Klamath Lake). Hubbs and Schultz, 1932, p. 4-5 (comparison with *tubulatus*). Hubbs and Miller, 1948, p. 68 (adaptation to lake life). Bailey and Dimick, 1949, p. 15-16 (compared with *hubbsi*: characters).

*Cottus evermanni* Gilbert, 1898, p. 11-12, fig. on p. 11 (original description; type locality: Lost River near Klamath Falls, Oregon). Hubbs and Schultz, 1932, p. 4-5 (comparison with *tubulatus*). Bailey and Dimick, 1949, p. 15-16 (synonymized with *princeps*, rule of first reviser).

*C. princeps* is one of the most distinctive species in the genus. There are generally 7 dorsal spines, 20-21 soft dorsal rays, 16 anal rays, 4 pelvic rays, 15-16 pectoral rays, and 15-25 lateral-line pores (Table 2). The lateral line is incomplete and ends under the posterior half of the second dorsal fin. The dorsal fins are entirely fused. A few specimens show some branched dorsal and anal rays, but this is unusual. The pelvic rays are never branched, whereas the upper pectoral rays are usually, but not always, branched.

The pelvic fins are long, reaching the anus when depressed. The body is extensively prickled. Below the lateral line the prickling usually extends caudad to a point about under the center of the second dorsal fin. Above the lateral line the entire body is prickled, except on the caudal peduncle and head.

The figures of the types of *princeps* and *evermanni* accurately depict the body form and color pattern. The anterior nasal tubes are very well developed. The head pores are much enlarged; those of the infraorbital and preopercule-mandibular canals are larger than the nasal openings. The canals are very prominent and cause cavernous openings in the bones through which they pass. All 34 specimens examined have 10-1-10 preopercule-mandibular pores. Infraorbital pores number 7-7 (12 specimens) or 6-7 (2 specimens).

The palatine teeth are absent. The preopercular armature is reduced to one blunt spine. The lower jaw usually projects slightly beyond the upper jaw. We note 24 caudal vertebrae in two specimens and Bailey and Dimick (1949, p. 16) recorded 26.

### Comparisons and Relationships

The combination of characters listed above imparts to *princeps* a distinctiveness that renders it unmistakable. *C. klamathensis* has the dorsal fins partly or completely fused, lacks palatine teeth, and has 4-4 pelvic rays. It differs trenchantly in its lower ray counts (second dorsal rays usually 18-19 instead of 20-21; anal rays 13-14 instead of 15-17), its higher number of infraorbital pores (8-8 instead of 7-7), its separate preoperculo-mandibular canals (pores number 10-10 instead of 10-1-10), its more robust body form, and in many other ways. Distinguishable features for *tenuis* and *aperrimus* have already been explained. *C. gulosus* has separate dorsal fins, 13-15 anal rays, 8-9 dorsal spines, 16-18 soft dorsal rays, and a much more complete lateral line (usually 32-36 pores).

The relationships of *princeps* are uncertain. The high number of caudal vertebrae (24-26) places it with *aleuticus* and *asper*. It shares with those species a preoperculo-mandibular pore count of 10-1-10. *C aleuticus* apparently never develops palatine teeth, while *asper* has well developed palatine tooth patches. Like *princeps*, *asper* has a long second dorsal (19-22 rays) and anal fin (15-19 rays). *C. aleuticus* similarly has a long dorsal fin but has fewer anal rays (12-15, usually 13-14). Both generally have complete lateral lines, although *aleuticus* is more variable in this respect. The color pattern of *asper* is suggestive of *princeps*. The long pelvic fins of *aleuticus* reach the anus when depressed, a feature seldom noted in other American species of *Cottus* but characteristic of *princeps* and several Asiatic species. *C. asper* is more prone to move inland than is *aleuticus*, a form common in coastal streams. If *princeps* is derived from either an *asper* or *aleuticus* type, the two have long been differentiated. Its relationships to other American species appear to be even more distant.

### Habits

All females in a series of specimens collected on November 3-5, 1896, by Meek and Alexander (USNM 124952), have the ovaries bulging with mature eggs.

### Geographic Range

*C. princeps* is known only from Upper Klamath Lake and from Lost River (near Klamath Falls), Oregon.

## MATERIAL EXAMINED

*Cottus princeps*. USNM 48227 (1, 41) holotype; USNM 48228 (1, 47), holotype of *C. evermanni*. The following are all from Upper Klamath Lake, Ore.: USNM 124952 (18, 30-68); UMMZ 130627 (14, 30-44); UMMZ 138574 (7, 47-64); SNHM 38029 (29, 45-60); and SNHM 40744 (2, 42-63).

*Cottus tenuis.* USNM 48229 (1, 74), holotype. All others are paratopotypes: USNM 48230 (38, 25-62); USNM 124958 (38, 23-70); USNM 48780 (13, 22-71); and SNHM 5705 (20, 20-44).

Additional material examined from Upper Klamath Lake, Ore.: UMMZ 130603 (2, 38-51); UMMZ 130626 (6, 32-49); UMMZ 172293 (4, 26-38); and SNHM 9333 (1, 86).

Other material: Klamath County, Ore.: UMMZ 130610 (149, 24-80) Crooked Creek; UMMZ 130581 (9, 20-56) Sprague River; UMMZ 130617 (27, 21-44) Agency Lake, mouth of Wood River; and SNHM 24185 (11, 36-48) Spring Creek, Shasta County, Calif.

*Cottus asperrimus.* USNM 58500 (1, 50), holotype; USNM 126463 (1, 48), paratopotype; SNHM 9968 (2, 41-49), paratopotypes; UMMZ 130647 (1, 39) Rush Creek, Modoc County, Calif.; UMMZ 130650 (7, 14-64) Fall River system, Shasta County, Calif.; and UMMZ 158416 (28, 41-89) reservoir on Hat Creek, about 4 miles above its junction with Pit River, Shasta County, Calif.

## NOTES ON THE CLASSIFICATION OF OTHER SPECIES

### *Cottus klamathensis*

*Cottus macrops*, described from Fall River, California (Rutter, 1908, p. 146-147, fig. 4), has generally been maintained as a valid species (Hubbs and Miller, 1948, p. 69; Bailey and Dimick, 1949, p. 15; and others), although these writers noted its similarity to *klamathensis*. Snyder (1917, p. 82) failed to observe the intimate relationship of *macrops and klamathensis* and combined both *macrops* and *asperrimus* with *gulosus*.

A careful comparison of the type material of *klamathensis* and *macrops* and of fresh collections of the two nominal forms fails to reveal differences that we judge to be of specific value. Rutter recognized the very close relationship between the two but indicated that *macrops* had a heavier build, a larger eye, the head less pointed, and the dorsal fin somewhat more posterior in position. Our material fails to confirm some of these distinctions (e.g., the larger eye), and we regard other features to be too variable or indicative of ranking below the species level. Like *klamathensis*, the body prickles in *macrops* occur on smaller individuals only (up to about 55 mm. standard length), the large adults having the skin entirely smooth. Generally, *macrops* has only one well developed preopercular spine, with the two accessory spines reduced to blunt knobs or absent. In many samples of *klamathensis* there are individuals that have all three spines developed, others that have only two, but populations from below Klamath Falls are somewhat intermediate between *klamathensis* (above the Falls) and *macrops* in this feature, having one or two developed spines. Life colors (Table 1) of the two nominal forms indicate no marked differences. The most consistent difference we have noted between the two involves the width of the mouth. In *macrops*, the snout is blunter and the mouth wider (its greatest width enters the anal base 1.2-1.6 times). In *klamathensis* (above the Falls) the snout is more pointed and the mouth narrower (its greatest width enters the anal base 1.6-2.0 times; in one collection (15 specimens) below the falls, the ratios vary from 1.3-1.8 times). The reliability of this feature is uncertain, and we feel it can be used

for subspecific separation at most. The two share a preoperculo-mandibular pore count of 10-10, lack palatine teeth, have broadly connected dorsal fins, have the vertical fins similarly marbled and with a black blotch on the posterior membranes of the first dorsal, and have similar fin-ray counts, which may be summarized as follows: dorsal spines, 6 (1), 7 (25), 8 (6); dorsal soft rays, 18 (10), 19 (21), 20 (1); anal rays, 13 (6), 14 (25), 15 (1); pelvic rays, 4-4 (26 fins); pectoral rays, 14 (9 fins), 15 (49 fins), 16 (3 fins). The lateral-line pores range from 14-22. These data are based on the following material: USNM 58499 (14, 23-57) syntypes of *macrops;* USNM 126464 (4, 22-51) syntypes of *macrops;* SNHM 24186 (4, 31-57) syntypes of *macrops;* USNM 88464 (2, 40-44) Fall River, Calif.; USNM 48266 (1, 118) type of *klamathensis;* and CU 21612 (7, 24-76) Shasta River, Calif.

We synonymize *macrops* with *klamathensis* but note that study of additional features may show them worthy of subspecific rank. Comparison of populations from above and below Klamath Falls shows that those from the lower river (excluding one sample from Shasta River) have a more complete lateral line (this was also noted by Gilbert, 1898, p. 11), and these may represent a third form worthy of naming. Gilbert believed *klamathensis* to be most nearly related to *perplexus*, a view which we share. *C. klamathensis* affords another example of fishes shared by the upper Klamath and Pit rivers (see discussion of zoogeography).

### *Cottus aleuticus*

This species is widespread in coastal streams from central California (northern San Luis Obispo County) to Alaska. As noted by Hubbs and Schultz (1932, p. 6, table 1) it belongs to those species of *Cottus* which have many (24-27) caudal vertebrae. In other features it is distinguished by having 10-1-10 preoperculo-mandibular pores, 8-9 dorsal spines, 17-20 dorsal rays (usually 18-19), 12-14 anal rays, 4 pelvic rays, 14-16 pectoral rays, long pelvic fins, no palatine teeth, and few if any prickles. Schultz and Spoor (1933) described *C. protrusus* from Unalaska Island. They noted its similarity to *aleuticus* in several features but contrasted *protrusus* only with *chamberlaini*, a very different form doubtfully distinct from *C. cognatus*. The holotype (USNM 104496) and a paratopotype (UMMZ 64234) of *protrusus* were compared with the syntypes of *aleuticus* (SNHM 2610) from Iliuliuk, Unalaska, and with other specimens from Alaska to California (variously labelled as *protrusus*, *aleuticus*, or *Uranidea microstoma*). No differences signifying other than individual variation were noted. Specimens which exhibit protruding eyes (the basis of *protrusus*) are known from widely scattered localities and appear even in the syntypic series of *aleuticus*. Whether this is a response to temperature (improbable) or one induced by disease or parasitism is not known. We regard the condition as an anomaly and, in the absence of any other difference, consider *protrusus* synonymous with *aleuticus*. *Uranidea microstoma* Lockington is preoccupied in *Cottus*, a fact long known, and was placed in the synonymy of *aleuticus* when that species was described. In the course of this study we re-examined the holotype (USNM 26922) and take this opportunity to confirm its identity with *aleuticus*.

In summarizing the distribution of this species in California, Evermann and Clark (1931, p. 57) overlooked the southernmost record given by Hubbs (1921, p. 7-8). The presence of *aleuticus* in northern San Luis Obispo County is confirmed by a recent collection (UMMZ 141194) of 74 specimens from San Carpoforo Lagoon, just south of the Monterey County line.

Shapovalov and Taft (1954, p. 26) record this species from Waddell Creek and (*in litt.*) note that their extensive collections are deposited in the California Academy of Sciences.

### *Cottus gulosus*

It is unfortunate that this variable species, known widely in the Sacramento-San Joaquin drainage and several lesser coastal streams of California, has been considered a subspecies in the *bairdi* complex by recent writers (Hubbs and Wallis, 1948, p. 141-142; Shapovalov and Dill, 1950, p. 387, as *C. b. shasta*). There is little positive evidence to support this relationship and many reasons for doubting it. We feel that this subspecific allocation has caused considerable confusion and, pending more thorough study, consider *gulosus* a valid species very closely allied to *hubbsi*. For the present, we feel that the only western forms of *Cottus* that should be aligned specifically with *bairdi* are *C. b. semiscaber* and *C. b. punctulatus* of the upper Columbia and Colorado rivers, respectively.

We agree with Synder (1905, p. 337) that *C. shasta* and *C. gulosus* are synonymous. A re-examination of the types (SNHM 4193, 3 syntypes of *shasta;* USNM 291, 2 syntypes[6] of *gulosus*) and other material, including topotypes, from the range of both forms, fails to reveal any basis for specific separation. The preoperculo-mandibular pore count is quite variable (10-1-10, 10-10, 11-11) but shows no geographic consistency. A study of fin-ray counts and numbers of lateral-line pores indicates no differences between *shasta* and *gulosus* but suggests that populations in coastal streams from Monterey Bay northward have a much less complete lateral line.

*Uranidea semiscabra centropleura* Eigenmann and Eigenmann has never been adequately discussed. Jordan and Evermann (1898, p. 1945) and Evermann and Clark (1931, p. 57) identified it with *gulosus*. Rutter (1908, p. 145) placed it in the synonymy of *asper*. Re-examination of the type (USNM 41919, 63 mm. standard length) shows conclusively that this form belongs to the *gulosus* series. The two dorsals are separate but contiguous. Fin-ray counts are as follows: 8 dorsal spines, 17 dorsal soft rays, 13 anal rays, 13 rays in each pectoral, and 4 rays in each pelvic fin. There are 35 lateral-line pores and 10-1-10 preoperculo-mandibular pores. Palatine teeth are present but not strongly developed. These features are all characteristic of *gulosus* except the few pectoral rays; should this low count be typical then subspecific recognition might be warranted for *centropleurus*.

Most of the records of *gulosus* from Washington and northern Oregon are based on *C. perplexus* Gilbert and Evermann, a species synonymized with *gulosus* by Schultz (1930, p. 14). None of these records represents *gulosus* as we define that species. Counts of the holotype of *perplexus*,

[6] Jordan and Evermann (1898, p. 1945) erred in listing USNM 290 as types.

USNM 43387 (1, 71), and of 14 of the paratopotypes, USNM 45388 (24, 18-55), are summarized as follows: dorsal spines, 7 (13 specimens)[7], 8 (2); dorsal soft rays, 18 (4), 19 (5), 20 (2)[7]; anal rays, 13 (2), 14 (4), 15 (6)[7], 16 (3); pelvic rays (both fins), 4 (30)[7]; pectoral rays, 14 (3), 15 (18), 16 (9)[7]; lateral-line pores, 20 (2); 21 (1), 22 (1), 23 (1), 24 (3), 26 (1)[7]; preoperculo-mandibular pores, 10-1-10 (8)[7], 11-11 (1). Two other specimens in the series of paratopotypes are *C. rhotheus*. In its robust body form, strongly marbled vertical fins, and the joined dorsal fins, *C. perplexus* seems more closely allied to *klamathensis* then to *gulosus*. The type material lacks palatine teeth but in 39 subtopotypes (UMMZ 93437) these teeth are present or absent.

### *Cottus asper*

Jordan and Evermann (1898, p. 1945) and Jordan, Evermann and Clark (1930, p. 383) listed *Cottopsis parvus* Girard in the synonymy of *gulosus*. Of the four series of specimens recorded by Girard in his summary account (Girard, 1858, p. 54-55), we have located one of the 12 from Petaluma (UMMZ 171133) and three of the four from Fort Reading (USNM 295; 3, 88-103). Since Girard considered only the material from Presidio in his original description (1854, p. 144-145), the specimens listed above are not types. Nevertheless, study of this material and of Girard's description leaves no doubt in our minds that *Cottopsis parvus* is identical with *Cottus asper*. Particularly diagnostic are the numerous dorsal and anal rays and the body prickles. A variational study of this widespread species is much needed. Its role as an important predator on juvenile trout and salmon is discussed by Shapovalov and Taft (1954, p. 293). Their abundant material is included in the collections of the California Academy of Sciences.

## ZOOGEOGRAPHICAL IMPLICATIONS

The mutual occurrence of *Cottus klamathensis* and the allopatric forms *C. tenuis* and *C. asperrimus* in the upper Pit and Klamath rivers poses an interesting problem in distribution and origin. A consideration of the fish faunas of the Klamath and Sacramento basins as a whole is necessary to an understanding of the hypothesis proposed below to explain the distribution of the species of *Cottus*.

Despite its geographic position between the Sacramento and Columbia drainages, the fauna of the Klamath basin surprisingly lacks the characteristic endemic genera of either of those great river systems (Miller, 1946, table 1). Even *Ptychocheilus*, ubiquitous in both the Sacramento and Columbia and with a representative species in streams between the Klamath and Columbia rivers, is absent in the Klamath system. Yet the latter basin has a comparatively rich, highly endemic fauna that is suggestive of long isolation (Hubbs and Miller, 1948, p. 68-69, and references cited). Close relationships are shown, however, between certain fishes of the Klamath Lakes and the Great Basin; for example, the peculiar suckers of the genus *Chasmistes* and the distinctive chubs assigned to the genus *Siphateles*.

[7] Holotype.

In addition to the common bond between the upper Pit and Klamath rivers exemplified by the species of *Cottus*, there is a dwarf non-parasitic lamprey (genus *Entosphenus*) known only from these two regions, and the stream representatives of *Siphateles bicolor* also show intimate relationship.

These similarities call for some kind of past connection between the Klamath system above Klamath Falls and what is now the upper segment of Pit River, including Goose Lake. It is reasonable to assume that the connection was by way of interconnecting streams through a chain of lakes (see Cope, 1883, map opposite p. 166) on the northern part of the Modoc Plateau and that the evidence for the waterway lies buried beneath the extensive Modoc lava flows (Anderson, 1941). That none of the endemic Sacramento forms reported from the upper Pit drainage (e.g., *Hesperoleucus*, *Mylopharodon*, *Ptychocheilus*, and *Hysterocarpus*) occurs in the Klamath suggests that the connection between these two basins was severed prior to the invasion of the upper Pit region (through headward erosion by Pit River) by these Sacramento types.

With this picture in mind, we may envision the origin and differentiation of two species of *Cottus* in the upper Pit as follows. After penetrating the Klamath basin prior to the formation of Klamath Falls, the ancestors of *C. klamathensis* and *C. tenuis* subsequently crossed the Modoc Plateau to reach what is now the upper Pit basin and thus attained a wide distribution in these presently disrupted waters. When the connection between the Klamath and Pit rivers was severed, the isolated stocks underwent differentiation, weaker for *C. klamathensis* than for *C. tenuis*, resulting in the evolution of the allpatric form *C. asperrimus*. With the development of the Pit River falls, the Hat Creek population of *asperrimus* below the barrier further differentiated. Although by this hypothesis we regard the Hat Creek population as a downstream derivative of *asperrimus*, an alternate idea may be considered. This is to regard *tenuis* and the Hat Creek population as peripheral remnants of a single form which has somewhat diverged and that the form occupying the old center area has diverged most into what is now called *asperrimus*. Perhaps future work will show that there are three subspecies of *tenuis*, one in the upper Klamath, one in the upper Pit, and one in Pit river below the falls. Our material, however, does not permit us to adopt this arrangement but it makes clear the intimate relationship between *asperrimus* and *tenuis*.

The clear indication of close relationship between the fishes of these two regions with those in the adjacent Great Basin finds support amongst other vertebrate groups, as in birds. The northeastern corner of California, including the upper part of Pit River (mostly above the falls), is ascribed wholly or largely to the Modoc faunal district (of the Great Basin faunal division) by Grinnell (1915, p. 12, pl. III) and by Miller (1951, p. 591, fig. 4), a district which obviously extends into the Klamath Lake region.

## SUMMARY

The characters, distribution and geographic variation of *C. tenuis*, *asperrimus*, and *princeps* are treated and nomenclatural notes are given for *klamathensis*, *aleuticus*, *gulosus*, and *asper*.

Emphasis in this paper has been directed toward working out relationships at the species level. Detailed studies need to be made in order to determine differentiation of subspecific value.

*C. asperrimus*, of Pit River, California, is regarded to be a very close relative of *tenuis*, limited to the upper Klamath drainage of Oregon and California; further studies may show them to be conspecific.

The placement of *evermanni* in the synonymy of *princeps* is confirmed and the possible relationship of this species to *aleuticus* and *asper* is discussed.

*C. macrops* is considered to be conspecific with *klamathensis*, *protrusus* is placed in the synonymy of *aleuticus*, *shasta* is regarded as identical with *gulosus*, and *parvus* is synonymized with *asper*.

It is urged that the name *bairdi* not be used for any western forms other than *punctulatus*, and *semiscaber*. The application of this name to *gulosus* has been particularly confusing and does not seem warranted in the light of our present knowledge.

*Uranidea semiscabra centropleura* is aligned with *gulosus* and may prove to be a valid subspecies.

*C. perplexus* is removed from the synonymy of *gulosus* and is considered a valid species, but its relationships with *klamathensis* need to be clarified.

The relationships of the fish fauna of the upper Klamath and Pit rivers is emphasized in a section on zoogeography, with a discussion of the origin and dispersal of the species of *Cottus* common to these two regions.

A key to the species of *Cottus* in the Sacramento and Klamath drainages is presented.

## LITERATURE CITED

Anderson, Charles A.
1941. Volcanoes of the Medicine Lake highland, California. Univ. Calif. Publ. Geol. Sci., vol. 25, p. 347-421, figs. 1-15, 1 map, pls. 4-9.

Bailey, Reeve M., and Mary Fitzgibbon Dimick
1949. *Cottus hubbsi*, a new cottid fish from the Columbia River system in Washington and Idaho. Univ. Mich., Occ. Pap. Mus. Zool., no. 513, p. 1-18, 1 pl., 1 map.

Cope, Edward Drinker
1883. On the fishes of the Recent and Pliocene lakes of the western part of the Great Basin and of the Idaho Pliocene Lake. Acad. Nat. Sci. Phila., Proc., 1883, p. 134-166, 1 map.

Evermann, Barton Warren, and Howard Walton Clark
1931. A distributional list of the species of freshwater fishes known to occur in California. Calif. Div. Fish and Game, Fish Bull. 35, p. 1-67.

Evermann, Barton Warren, and Seth Eugene Meek
1898. A report upon salmon investigations in the Columbia River basin and elsewhere on the Pacific Coast in 1896. U. S. Fish Comm., Bull., vol. 17 (1897), p. 15-84, 6 figs., 2 pls.

Gilbert, Charles H.
1898. The fishes of the Klamath basin. U. S. Fish Comm., Bull., vol. 17 (1897), p. 1-13, 6 figs.

Girard, Charles F.
1854. Observations upon a collection of fishes made on the Pacific Coast of the United States by Lieut. W. P. Trowbridge, U. S. A., for the Museum of the Smithsonian Institution. Acad. Nat. Sci. Phila., Proc., vol. 7, p. 142-156.

1858. Fishes. *In:* General report upon the zoology of the several Pacific railroad routes. U. S. Pac. R. R. Expl. and Surv., vol. 10, pt. 4, p. i-xiv, 1-400, 21 pls.

Greeley, J. R.
1928. Fishes of the Oswego watershed. *In:* A biological survey of the Oswego River system. New York Conserv. Dept., Suppl. to 17th Ann. Rept. (1927), p. 84-107, 12 col. pls.

Grinnell, Joseph
1915. A distributional list of the birds of California. Cooper Ornith. Club, Pac. Coast Avifauna, no. 11, p. 1-217, 3 pls.

Hubbs, Carl L.
1921. Notes on *Cottus asper* and *Cottus aleuticus*. Copeia, no. 90, p. 7-8.

Hubbs, Carl L., and Mott Dwight Cannon
1935. The darters of the genera *Hololepis* and *Villora*. Univ. Mich., Misc. Publ. Mus. Zool., no. 30, p. 1-93, 1 fig., 3 pls.

Hubbs, Carl L., and Karl F. Lagler
1947. Fishes of the Great Lakes region. Cranbrook Inst. Sci., Bull. 26, p. i-xi, 1-186, 251 figs., 26 col. pls., 1 map.

Hubbs, Carl L., and Robert R. Miller
1948. The Great Basin with emphasis on glacial and postglacial times. II. The zoological evidence. Univ. of Utah, Bull., vol. 38, no. 20, p. 17-166, figs. 10-29, 1 map.

Hubbs, Carl L., and Leonard P. Schultz
1932. *Cottus tubulatus*, a new sculpin from Idaho. Univ. Mich., Occ. Pap. Mus. Zool., no. 242, p. 1-9.

Hubbs, Carl L., and Orthello L. Wallis
1948. The native fish fauna of Yosemite National Park and its preservation. Yosemite Nature Notes, vol. 27, no. 12, p. 131-144, 3 figs.

Illick, Helen J.
1956. A comparative study of the cephalic lateral-line system of North American Cyprinidae. Amer. Midl. Nat., vol. 56, no. 1, p. 204-223, 39 figs.

Jordan, David Starr, and Barton Warren Evermann
1898. The fishes of North and Middle America. U. S. Nat. Mus., Bull. 47, pt. 2, p. I-XXX, 1241-2183.

Jordan, David Starr, Barton Warren Evermann, and Howard Walton Clark
1930. Check list of the fishes and fishlike vertebrates of North and Middle America north of the northern boundary of Venezuela and Colombia, U. S. Comm. Fish., Rept., 1928, pt. 2, p. I-IV, 1-670.

Miller, Alden H.
1951. An analysis of the distribution of the birds of California. Univ. Calif. Publ. Zool., vol. 50, no. 6, p. 531-644, figs. 1-5, pls. 32-40.

Miller, Robert R.
1946. The need for ichthyological surveys of the major rivers of western North America. Science, vol. 104, no. 2710, p. 517-519.

Rutter, Cloudsley
1908. The fishes of the Sacramento-San Joaquin basin, with a study of their distribution and variation. U. S. Bur. Fish., Bull., vol. 27 (1907), p. 103-152, 4 figs., pl. 6.

Schultz, Leonard P.
1930. Notes on the species of *Cottus* in western Washington. Copeia, 1930, no. 1, p. 14-15.

Schultz, Leonard P., and William A. Spoor
1933. *Cottus protrusus*, a new sculpin from Unalaska Island. Copeia, 1933, no. 3, p. 142-145.

Shapovalov, Leo, and William A. Dill
1950. A check list of the fresh-water and anadromous fishes of California. Calif. Fish and Game, vol. 36, no. 4, p. 382-391.

Shapovalov, Leo, and Alan C. Taft
1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. Calif. Dept. Fish and Game, Fish Bull. 98, p. 1-375, 32 figs.

Snyder, John Otterbein
1905. Notes on the fishes of the streams flowing into San Francisco Bay. U. S. Bur. Fish., Rept., 1904, p. 327-338.
1917. The fishes of the Lahontan system of Nevada and northeastern California. U. S. Bur. Fish., Bull., vol. 35 (1915-16), p. 31-86, 9 figs., pls. 3-5.

# NOTE

## THE REPORTED EMERGENCE OF FISHES FROM CALIFORNIA'S SUBTERRANEAN WATERS

On the basis of core samples and general stratigraphy, geologists believe that in most parts of California there is small possibility that organisms could emerge alive from underground sources, either through artesian wells or deep well pumps. If organisms were to emerge alive, they would theoretically have to come through solution channels, which means limestone formations. There is very little of this type of material in California's geological makeup.

When fishes emerge from a newly-drilled well, one fact usually overlooked is that considerable water may be pumped into the shaft during drilling operations. The water acts as a lubricant and is circulated under a pressure head up to 50 pounds. Although we have not tested fishes under pressure, we have found that sticklebacks (*Gasterosteus a. aculeatus*) in the laboratory will live for several hours in a heavy mud slurry. Rowley (1955) found that eight-inch rainbow trout (*Salmo gairdneri*) suffered no ill effects from the application of 200 pounds pressure for 48 seconds. Needless to say, any fish emerging with the drilling water or immediately thereafter must be suspected of having entered the well at the time the water was pumped in.

There are three early California records, all questionable. Saxe [1] described the artesian wells at San Jose, pointing out that fish occasionally came from the wells and that sometimes sawdust flowed out with the water. He was satisfied that the fish did not come originally from a subterranean source but that they found their way there from open streams or beds of water through underground channels. Chase (1874a) told of a 143-foot artesian well drilled five feet above high tide line on the beach at Point Hueneme. Pressure forced the water 30 feet into the air, along with thousands of two-inch "trout" (water temperature 64° F.). Smith (1884) reported a 1⅓-inch stickleback (*Gasterosteus aculeatus williamsoni*) coming from the pipe of a 191-foot artesian well at San Bernardino, California. The locations of seven California fish emergence records are shown in Figure 1.

Data on four recent fish emergences are given in Table 1. Of these, the Dowd and Cholame ranches have been studied in detail by the writer. For the latter there is ample evidence that the sticklebacks actually did come from the well. Two individuals, Mr. Howard Jack and Mrs. Palmateer Gibson, have described to me their observations of the sticklebacks swimming within the well shaft. The velocity of the artesian flow from the well would have prevented any fishes swimming up to the well. This contradicts the viewpoint of Noble (1952), who

[1] Remarks made in the report of the regular meeting of July 18, 1870, of the California Academy of Sciences, reported in the Proceedings, California Academy of Sciences, vol. 4, p. 130.

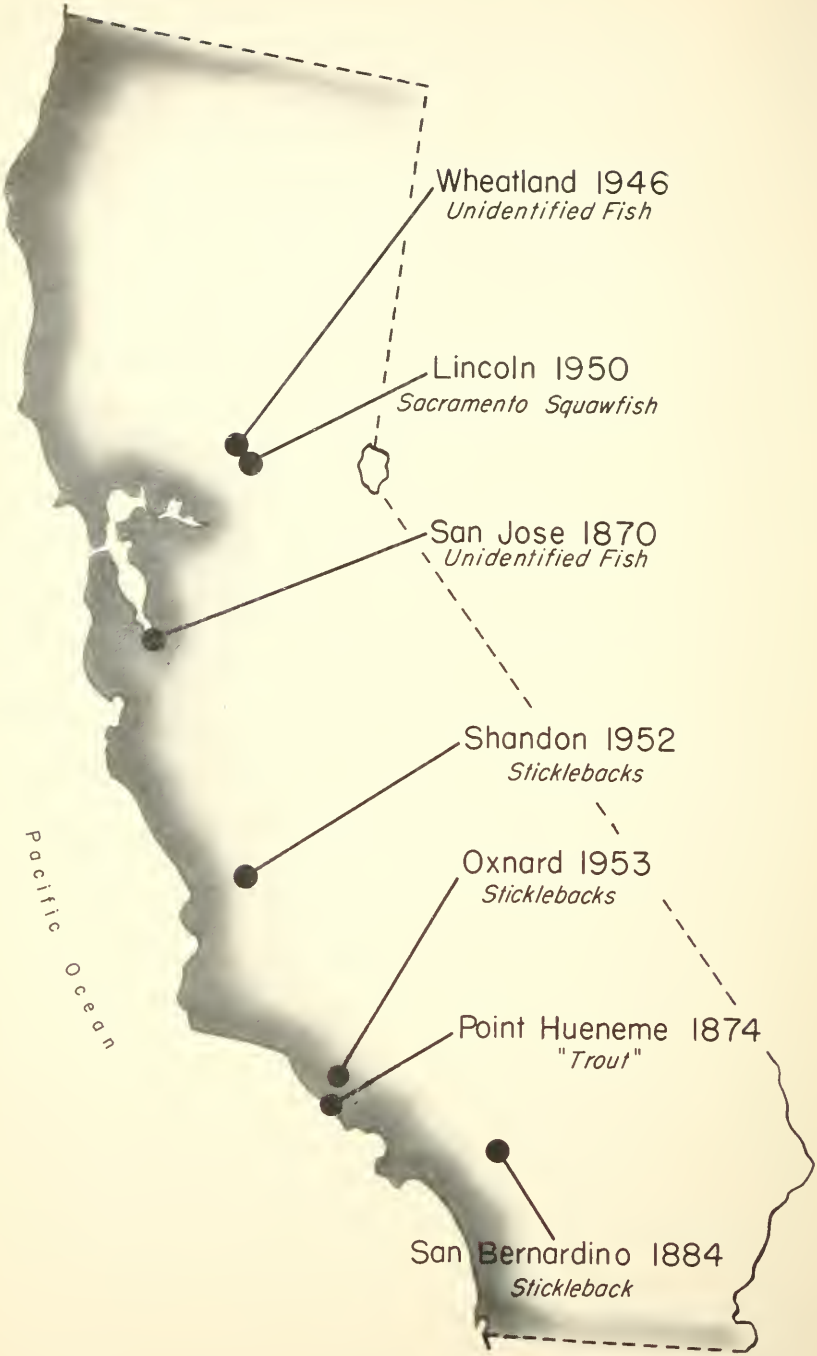


FIGURE 1. Locations of several subterranean fish emergence records in California.

TABLE 1

Recent Californian Subterranean Fish Emergences

| Ranch name | James Clack | Delbert Dowd | Cholame Rancho | Daryl Arnold |
|---|---|---|---|---|
| Location | 3½ miles northwest of Wheatland | 3 miles northwest of Lincoln | North of Shandon | Near Oxnard |
| Geological formation | Ione; Eocene clay, sand, shale | | Quaternary alluvium conglomerate | Quaternary alluvium heavy adobe |
| Kind of fish | "1½ inches, long and silvery" | 5 Sacramento squawfish, *Ptychocheilus grandis* | About 50 sticklebacks | 5 sticklebacks |
| | | | *Gasterosteus aculeatus microcephelus* | |
| Date of emergence | Spring, 1946 | October 10, 1950 | February 5, 1952 | January 6, 1953 |
| Location of specimens | Unknown | California Academy of Sciences 20,501 | California Academy of Sciences 20,693 | Unknown |
| Depth of well | 465 feet | 543 feet | 600 feet | 1,300 feet |
| Diameter of shaft | 14 inches | Unknown | Unknown | 16 inches |
| Gallons of water used in drilling | Unknown | 500 | 36,000 | Unknown |
| Source of drilling water | Unknown | Main ranch well | Roadside pools and main well | Old well and adjacent new well. |
| Rate of effluent flow or pump size | 10-inch pump | 8-inch pump | 1,200 gallon per minute artesian | 1,150 gallons per minute |
| Nearest permanent water | 3 miles | Coon Creek 2 miles north | Several miles | Calleguas Creek 3 miles south |
| Source of data | Correspondence | Several interviews | Many interviews | Correspondence |

believed that the fish had swum to the well by means of surface puddles. However, we cannot be certain that some of the sticklebacks were not inadvertently placed in the well with the drilling water from the roadside ditches.

It is hoped that careful observations of future emergences of fishes from deep wells will provide sufficient data to provide answers to some of the questions raised herein.

## REFERENCES

Chase, A. W.
1874a. Note on subterranean fishes in California. Amer. Jour. Sci., ser. 3, vol. 7, p. 74.
1874b. Note on subterranean fishes in California. Forest and Stream, vol. 2, p. 70.
Noble, Glenn A.
1952. The case of the artesian sticklebacks. Calif. Fish and Game, vol. 38, no. 3, p. 439.
Rowley, William E., Jr.
1955. Hydrostatic pressure tests on rainbow trout. Calif. Fish and Game, vol. 41, no. 3, p. 243-244.
Smith, Rosa
1884. Note on the occurrence of *Gasterosteus williamsoni* Girard, in an artesian well at San Bernardino, Calif. U. S. Nat. Mus., Proc., (1883), vol. 6, p. 217.

*Earl S. Herald, Steinhart Aquarium, California Academy of Sciences, San Francisco 18, California, January, 1957.*

# REVIEWS

### *Tomorrow's Birthright*

By Barrow Lyons; Funk & Wagnalls Company, New York, 1955; viii + 424 p. $5.

In Tomorrow's Birthright, a history of the political battles which have been fought over our natural resources, the reader will find a wealth of reliable information. Anyone who desires to bring himself up to date on the whole problem of conservation of natural resources will do well to put this book on his desk and keep it there until he has digested every chapter. Here is no dry compilation of statistics but a carefully written, interesting book which discusses our past, present, and future conservation problems. It is "a political and economic interpretation of our natural resources".

The author, Barrow Lyons, divides his book into three parts. Part I gives a complete discussion of our problems relating to soil, forest, and water resources. Part II—The Politics of Power—debates the methods most suitable for a permanent control of our land and water resources. Part III—Resources for Survival—draws a bead on our future prospects for survival and includes discussions of oil, atomic power, solar energy, and basic metals.

At no point does Mr. Lyons lose sight of his theme: the political problems connected with planning our economic future. He believes that our experience has shown that whenever the American people are fully and correctly informed and have been alerted to the dangers involved, they can be relied upon to make the proper choice among courses of action. He proposes, in his book, to place the necessary information before the voters. This book differs from previous books on conservation in that it presents this full account of the interaction of politics and our natural resources.

For every voter, and every member of Congress or a state legislature, Tomorrow's Birthright will lay the groundwork for intelligent understanding of this very important problem. It is clearly written and the type is excellent. Every conservationist should be pleased to add this book to his library.

"It is not suggested here that we have become so weak we may not survive. That could happen. But plenty of good land remains, plenty of forest that can be used and made to yield lumber for thousands of years, plenty of grassland upon which cattle may graze. And much of what is lost can be regained. But it has become necessary for all of the people operating individually or through the government to promote a great effort in conservation and wise use; and there are other measures which must be adopted if we are to stop the destruction of our natural resources soon enough to rescue them so that they will provide for the future."—*Willis A. Evans, California Department of Fish and Game.*

### *Cowry Shells of World Seas*

By Joyce Allan; Georgian House, Melbourne, Australia, 1956; x + 170 p., with 15 plates and text figures. 63 shillings, Australian.

Although cowries are found in most tropical and subtropical seas of the world and have always been highly prized for their superb beauty, there have been few complete treatises such as this available to the modern conchologist or amateur shell collector. The present volume, which undoubtedly represents many months of intensive work on the part of the author, includes an introductory chapter containing a considerable amount of general information on the life history, habits, and classification of cowries. This section is followed in turn by chapters detailing the various genera and species of true cowries and allied cowry groups. For each species the naming authority and date are given, as well as descriptive information on shell color, size, and characters. The known geographical range is stated and occasionally synonyms and other pertinent data.

Six of the 15 plates illustrating the species discussed are in color and add much to the attractiveness of the book.

The author briefly discusses a common undesirable practice known among taxonomists as "splitting". She then unfortunately (or unwisely) proceeds to use a system of classification that is sadly lacking in logic. Using this system of classification (based only upon shell characters) one would have to give a different generic name to opposite sexes of one of the near relatives of the cowries found in Californian waters. The same awkward situation is unquestionably true in other localities. Only when cowry devotees look beneath the shells, and perform critical studies on the animals that live within, will this problem be resolved.

The index is arranged alphabetically so it is not difficult to locate a page reference for any species of cowry regardless of the genus to which it is assigned. All in all this volume is a worth-while addition to the library of any shell collector, whether amateur or professional.—*John E. Fitch, California Department of Fish and Game.*

### Duck Shooting Along the Atlantic Tidewater

Edited by Eugene V. Connett; William Morrow and Co., New York, 1947; xii+308 p., illustrated with photographs and drawings, and color plates by Dr. Edgar Burke and Lynn Bogue Hunt. $15.

This comprehensive work is the product of 16 prominent sportsmen who wrote more or less independently. Each chapter has to do with a particular section of the Atlantic seaboard from New Brunswick to Florida and the Louisiana marshes.

The purpose of the book may best be described by quoting from the preface: "Several years ago Dr. Edgar Burke asked me if I would join him in writing a book on Duck Shooting, saying before many more years elapsed few of the men who actually witnessed those memorable old days of market gunning, and the years of superb shooting which followed them would be with us. He felt that the time had come to gather as much authentic information of those bygone days as possible and make a permanent record of them for future generations of duck shooters."

This book is written expressly for the layman, contains a minimum of scientific terms, and is easy to read. It is printed in the large 8- by 11-inch size, which make the illustrations more appealing to the eye. The 12 reproductions in full color of the paintings by Lynn Bogue Hunt and Dr. Burke are superb. It also includes 137 black-and-white plates, falling in two categories: (1) photographs on waterfowl contributed by the Fish and Wildlife Service and (2) photographs on the shooting sport, hunter stances, decoys, blinds, etc. The photographs by the Fish and Wildlife Service are excellent in showing waterfowl in their native habitat, but are just added to the book for interest and do not follow along with the continuity of the story.

The first chapter, "Future of Waterfowl", by Fredrick C. Lincoln, and the last chapter, "Waterfowl", by Ludlow Griscom, add greatly to this edition because both of them stress conservation and give even the average reader an inkling there is more to waterfowl than just shooting them. The point is brought out time and time again that there are other influences on waterfowl populations, such as: disease, breeding and nesting habits, migration, etc.

Probably the most colorful and descriptive chapter is the one by Dr. Burke on "Making and Painting Decoys". Dr. Burke believes that today's factory made output is inadequate in quantity and in quality. If the quality is acceptable, the price is usually prohibitive. His suggestion is to make one's own decoys. A very good lesson in decoy making follows.

This book should be of interest to the general public.—*Jack R. Slosson, California Department of Fish and Game.*

### Audubon Western Bird Guide

By Richard H. Pough. Doubleday & Company, Inc., New York, 1957; xxxvi+316 p., 32 color plates by Don Eckelberry, line drawings by Terry M. Shortt. $4.95.

The area covered in this volume approximates some 2½ million square miles in western North America, including the bordering oceans. It includes the area west of a line drawn from the Bering Strait and the Arctic Ocean south to the Mexican border, encompassing portions of the Dakotas, Nebraska, Kansas, Oklahoma, and Texas. Although 614 kinds of birds are known to occur within this area, only 203 are exclusively western and it is these 203 to which the bulk of attention is given. The other 411 species, migrants and water birds, were described in two previous works by the author and only their names and ranges are included here.

The birds are listed in the standard order adopted by the Check-list Committee of the American Ornithologists Union.

For the 203 species discussed, the descriptions are adequate and a tremendous amount of up-to-date information on habits and habitat, voice, nest, range, etc., has been presented. These birds are exactingly depicted in the very fine color illustrations and black-and-white text figures.

Of general interest are the bibliography, which has been arranged by states and other large geographical regions, and the illustrated glossary of bird topography. The index appears to be complete and is easy to find.

This volume, as well as the two preceding companion volumes: Audubon Bird Guide and Audubon Water Bird Guide, was sponsored by the National Audubon Society.—*John E. Fitch, California Department of Fish and Game.*

*The Book of Flowering Trees and Shrubs*

By Stanley B. Whitehead: Frederick Warne & Co., Ltd., New York, 1956: 244 p., 63 color plates by Joan Lupton. $3.50.

Gardeners in California and elsewhere have access to descriptive literature regarding a wide variety of flowering shrubs and trees. However, there always remains a big question, what does the flower look like in color? The Book of Flowering Trees and Shrubs answers this important question. A total of 248 varieties of these flowering plants is correctly depicted, along with an illuminating discussion of the plant soil and exposure requirements. Informative chapters on selection of shrubs to suit the garden, planting and propagation, and the care of flowering shrubs are included.

Western gardening is developing rapidly, and if we are fortunate enough to be able to draw upon the vast experience of gardeners in other parts of the world, we should take full advantage. This book, I believe, will serve as a source of inspiration to professional and amateur gardeners alike for years to come.—*Parke H. Young, California Department of Fish and Game.*

*The Ornithologists' Guide*

Edited by Major-General H. P. W. Hobson: Philosophical Library, Inc., New York, 1956: xx + 275 p., 34 figs. $10.

This publication is a compilation of 67 short articles, each written by one of 46 authors and edited by Major-General H. P. W. Hobson. Many of the authors are professional ornithologists or amateurs affiliated with ornithological organizations in England or her possessions.

The introduction by the editor states that "this handbook has been compiled to encourage the study of birds by pointing out where there are worth-while opportunities for study and showing how these may be turned to advantage."

Special emphasis is placed on theory and practice of bird study to aid international bird watchers. Many good suggestions are given on note taking, study techniques, selection of birding equipment, breeding studies, bird study with the aid of photography, banding techniques, color marking, nest occupation recording devices, bird study with use of tape recorders, etc.

This book, covering such a broad field and touching on so many aspects of bird study, is necessarily general in its overall presentation. The articles are well written and concise, but because of their brevity do not give much technical information useful to the scientific worker.

One section will be of much interest to those planning a trip abroad, or in need of information from a specific section of a foreign continent, for it lists many references, ornithological societies by area, locations of extensive collections, and some of the leading ornithologists on the various continents.

The only regret of the reviewer is that the book has a noticeable lack of information and references on bird watching on the North American Continent, which would have been of some aid to foreign ornithologists traveling or studying on this continent.

Technicians in this country may disagree with some of the statements on theories and techniques, but on the whole "The Ornithologists' Guide" is a book recommended to the amateur ornithologist.—*Robert D. Mallette, California Department of Fish and Game.*

*Fishes: A Guide to Familiar American Species*

By Herbert S. Zim and Hurst H. Shoemaker; Simon and Schuster, New York, 1956; 160 p., 278 color drawings. Limp bound $1, de luxe cloth $1.95.

Only four inches wide and six inches high, this little book is another addition to the familiar Golden Nature Guide series. Between the covers (be sure to buy the de luxe cloth edition—you'll want this booklet on hand for a long time) in realistic color and often amid native surroundings are 278 species representing most of the families of American bony fishes. Notes on sharks and rays, lampreys and hagfishes, and animals mistaken for fishes are also presented. There is, refreshingly enough, no added emphasis on game fishes. Some of the remaining short, but direct and informative, sections include Parts of Fishes, Adaptations, Scales and Tails, Origin and Development of Fishes, and Amateur Activities for Fish Study. The subject is neatly wrapped up in the last few pages by a very adequate index, an index to scientific names, a list of the larger public aquaria and biological stations, and a bibliography of seven nontechnical books about fishes for further reading.

This guide answers the need for an inexpensive, general guide to fishes, both marine and freshwater, written in popular style. Much of the information on the habits of fishes is submerged in dry, scientific documents. One has to pluck the interesting tidbits from among chi-squares, holotypes, and angler-hours; few readers have the time or patience. Such labors even tax the fidelity of some fishery scientists.

The numerous books on angling assist but little, since they are concerned mainly with knots and gadgets and commonly insert, at best, only scattered, inaccurate notes on fish life history. Semipopular works such as "The Life Story of the Fish" by Brian Curtis and "A Study of Fish" by Chapman Pincher, while more than worthwhile for those who can afford them, lack the full-color drawings found in this guide.

Skin divers and aquarists will furnish the main audience for this guide. Sales should continue strong, since both these groups are growing and numerically are probably equal to or greater than the several million bird watchers in the country, and bird guides do sell. Relatively few anglers will be interested. Science teachers and students and members and employees of conservation organizations both public and private will provide another large outlet.—*Almo J. Cordone, California Department of Fish and Game.*

*Animal Agents and Vectors of Human Disease*

By Ernest Carroll Faust; Lea and Febiger, Philadelphia, 1955; 660 p., 216 text figures, and 9 plates, including one in color. $9.75.

It is quite evident that the distinguished Doctor Faust is a professor of parasitology, in that his book devotes 428 pages to the endoparasites and 63 pages to the ectoparasites. There are eight sections, with titles as follows: General Information and Orientation; Protozoan Agents of Disease; Roundworms (Nematodes); Tapeworms and Flukes; Other Helminths Parasitizing Man; Arthropods as Agents and Vectors; Other Invertebrate and Vertebrate Agents of Disease; and Technical Aids. The book contains many useful tables, including ones on the natural history of the more important endoparasites; pathology and clinical manifestations produced by animal agents of disease; diagnostic examination procedures; chemotherapeutic procedures; differential characteristics of protozoan parasites; arthropods as vectors of human pathogens; and snakes harmful to man. The excellent illustrations and plates that have appeared in the author's other publications are liberally used thoughout.

To this reviewer it appears that Doctor Faust has summarized the most important contributions of his authoritative books on clinical parasitology and human helminthology, and combined them in this book with a small addendum of miscellany. In the condensation he has sacrificed some of the morphological characteristics of the endoparasites, and as a result the facility of identification is somewhat impaired. Some of the uncommon helminths have been omitted.

The entomological section is not exhaustive, but is rather adequately covered in a narrative sense.

The miscellany includes a chapter on the urticating marine invertebrates, and a chapter on veniferous reptiles. A short chapter of three pages deals with the role of fishes in the discomfitures of mankind. Specifically, there are discussions of food poisoning through spoilage of fish, poisoning through the ingestion of toxins present

in the reproductive organs or blood of certain piscine species, and mechanical and poisonous injury from forcible contact with ectodermal spines. Finally, there is a chapter on certain mammals harmful to man. Mentioned in passing are the mechanical injuries that might be inflicted by dogs, cats, bulls, elephants, etc.; however, descriptions are given of the duck-billed platypus and its venom apparatus, and the vampire bat's proclivity for human blood, with resultant anemia in the victim.

The last section of the book involves descriptive material on laboratory diagnosis, culture technics, seriological procedures for diagnosis, and the preservation of arthropods, mollusks, and vertebrates.

The limitations of the book may be illustrated by the following, taken from the identification of specimens. "The time has long since passed when it is sufficient to identify an arthropod as a tick, mite, fly, or mosquito." As an alternative, the author suggests addressing a letter to the Curator of Arthropods, U. S. National Museum, Washington, D. C., for instructions on how to ship the specimen, and then proceeding to follow instructions received. In the preface the author stated that the contents would be useful and stimulating to the zoologist, laboratory diagnostician, and public health worker, and others.

The viral, richettsial, and bacterial diseases are considered in 22 pages, with some rather important omissions. The vampire bat is mentioned as a possible transmitter of rabies, but the insectivorous bat, dog, fox, skunk, and others are ignored. The book discusses many invertebrates and vertebrates, but other than a brief mention of birds in connection with the encephalitides, the members of the class Aves are ignored, along with their role as vectors of disease, e.g., ornithosis. In the preface it was written that the book would be useful to the epidemiologist, yet the entire field of the zoonoses is minimized or absent.

The undergraduate student and some cliniticians will find the book handy for reference, particularly in using the excellent tables contained therein. *Merton N. Rosen, California Department of Fish and Game.*

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