Variation in the Pacific Mud Turtle

By L. M. SEELIGER

A SUPERFICIAL examination of Pacific mud turtles, *Clemmys marmorata* (Baird and Girard), from various localities readily reveals difences in external characters. The purpose of this study was to ascertain whether these differences are geographic or merely individual. Correlation of external characters with age or sex must be understood before further analysis is attempted. Most of the specimens examined in the course of the present study are in the Museum of Vertebrate Zoology of the University of California; others were from the California Academy of Sciences, Stanford University, the San Diego Society of Natural History, the private collection of L. M. Klauber, and the College of Puget Sound. Acknowledgment is made to those in charge of these collections who made the material available. In all, 158 specimens were studied; of these 138 were from California, 9 from Oregon, 6 from Lower California, 4 from Washington, and 1 from Idaho.

Measurements were made to the nearest millimeter by means of 200 mm. calipers. The length of the carapace and of the plastron was taken as the distance between the mid-anterior and mid-posterior margins of each. The external characters of specimens were compared with those given by Van Denburgh (1922: 974–976), whose description was found to be the most recent and complete. Particular attention was paid to characters that differed from his description and to those indicated as variable.

AGE VARIATION

The condition of the surface of the plates of the carapace is correlated with the age of the specimen, assuming that the animals of similar sizes are of about the same age. The results of this comparison are shown in Figure 1. All the individuals in which the entire surfaces of the plates are granu-

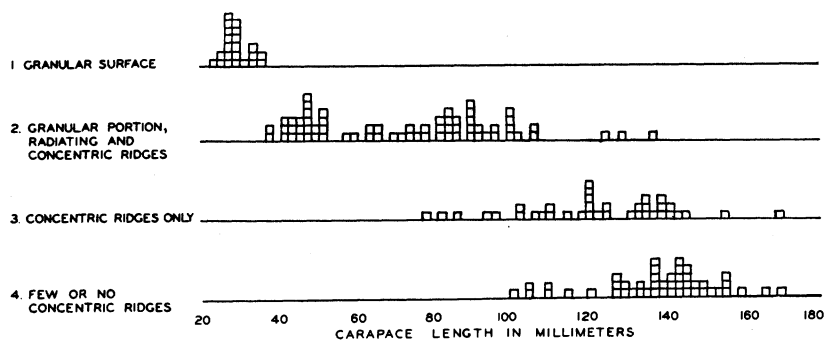

Fig. 1. Condition of the carapace surface correlated with size.

lar (stage 1) are small. These can be considered as hatchlings since the umbilical scar is still present and the shell is completely granular and soft. Stage 2 of the carapace surface (see Fig. 1) is present in larger specimens, nearly all of which have a carapace length of 40 to 100 mm.; it can be noted that the range in sizes in this group is much greater than in those of the first

stage. The relative size of the granular portion is progressively reduced with development. The radial and concentric ridges in each carapace plate vary with the size of the specimens. In the smallest individuals (carapace length 46 to 49 mm.) about two-thirds of each individual plate is granular, in those specimens about 55 mm. long the granular portion occupies about one-half of the plate, and in the larger specimens it occupies about one-fourth or less. The radial ridges are much more numerous and prominent in the smaller individuals; as the individual becomes larger, these ridges gradually become indistinct and fewer and give way to the concentric ridges.

Although there is overlapping in stages 3 (concentric ridges only) and 4 (few or no concentric ridges), it will be noted that most of the individuals in stage 4 are large whereas there is a considerable number of smaller individuals in stage 3. Some specimens with a comparatively smooth carapace have irregular holes which are probably due to wear or injury. This would suggest that these are older individuals than those not thus scarred.

In the smallest individuals, those with a granular carapace surface, the outline of the carapace is practically round whereas in the adults it is more oblong. The general appearance of both the carapace and plastral plates can be associated with this difference in shape. The individual plates of the young specimens are broader in comparison to their length, and the nuchal plate, narrow in the adults, is comparatively broad in the small specimens. The following table includes 10 typical specimens of each type of carapace surface. From it can be seen the relation of the carapace length to width in the several age groups.

	Type of carapace surface	Average length in mm.	Average width in mm.	Average width / Average length
1.	Granular	30.1	28.6	.950
2.	Granular portion and radiating and concentric ridges in each plate	67.9	56.5	.832
3.	Concentric ridges only	125.7	101.8	.810
4.	Few or no concentric ridges	145.9	114.0	.781

The tails of the smallest specimens are found to be comparatively longer and more slender than those of the adults. In only the smallest individuals (carapace length 24 to 38 mm.) is the tail relatively long. In these individuals the ratio of the tail length to the carapace length is .75 to 1.0. This relationship can be seen by examining Figure 2 which compares the ratio of the relative carapace length (carapace length: tail length) with actual carapace length. It is also shown that the tails of nearly all the adults are no shorter than those of the middle-sized groups.

In the following comparisons a specimen is considered small if the carapace length is less than 50 mm. The median dorsal ridge is present in all of the small specimens and is prominent in most of the very small individuals. A slight ridge is found in most of the adults and in a few adults it is distinct. Nearly all the adults have a definite hump at the posterior part of the carapace directly over the tail. The supracaudal plates bend upward, and there is a notch between them. None of the small specimens has this type of supracaudals but instead they are flat. The posterior part of the plastron is only weakly notched in nearly all the small specimens whereas in most of the adults it is distinctly and deeply notched.

Small and large specimens differ in coloration. As a general rule the coloration of the small individuals was found to be more consistent than that of the adults. The plastron of all small specimens with one exception (a specimen 48 mm. long) is gray or grayish brown in the center and yellow on the outside. The plastron of most of the adults is an almost solid yellow with traces of brown on the plate junctions; the brown coloring is much more prominent in some of the adults and is usually in the form of irregular brown splotches. The carapace of all the small specimens is uniform brown; more than half of these small specimens have an outer yellow margin. In some of the specimens a few black spots are evident. A few of the small specimens examined (43 to 48 mm. in length) do not have this type of coloration, but these are not the smallest individuals. The color of the carapace of most of the adults is olive or horn, with various dark markings, usually radiating marks or irregular black spots. The adults definitely have more black in the carapace than do the young.

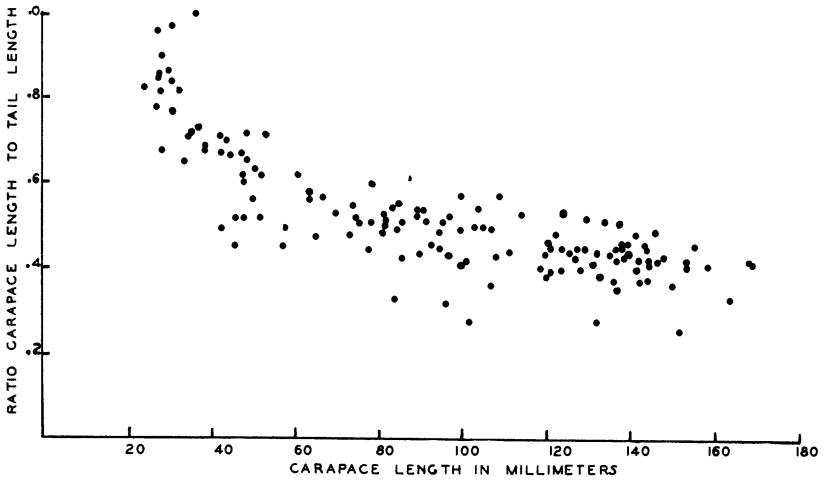

Fig. 2. Relation of tail length to size.

Smaller specimens tend to have more dark color on the top of the head than the adults. It is to be noted that this condition was found only in the smallest specimens (about 30 mm. long) whereas only a few of the somewhat larger ones (about 40 to 50 mm.) have this type of head coloration.

The coloration of the adults varies considerably; the heads of most of them are either reticulated with dark markings on a lighter yellowish olive, or are marked with light spots on a dark background or with dark spots on a light background. Longitudinal yellow stripes in a dark background or sometimes dark stripes in a yellow background are found on the chin or throat of nearly all the small specimens. The chin of most of the adults is yellow with brown spots. The under side of the limbs of most of the small specimens is yellow and a brownish or grayish color, the yellow occurring as more or less longitudinal stripes. The under surface of the limbs of the adults is yellow with brown spots. The upper surface of the limbs of both the adults and young is usually dark brown or grayish.

Sexual Differences

Male and female *Clemmys marmorata* have certain external differences. These secondary sexual characteristics are not readily distinguishable in the youngest specimens, but can be recognized in most adults. In the doubtful cases sex was determined by an examination of the internal organs.

The most evident external sexual difference was found to be the general shape of the plastron. The plastron of the male is concave, the deepest part being appproximately at the division between the abdominal and femoral plates; the plastron of the female is flat with no concavity. In about two-thirds of the sexually mature males (22 of 37 specimens examined) this concavity is deep or prominent; in the others it is present, but the degree of concavity is small. Five of the 43 females examined have a slightly concave plastron, but the general shape of the plastron is somewhat different from that of the male. Although the concavity is at about the same place as that of the males, the posterior part of the plastron has a somewhat rounded shape due to the downward slope of its extreme posterior portion.

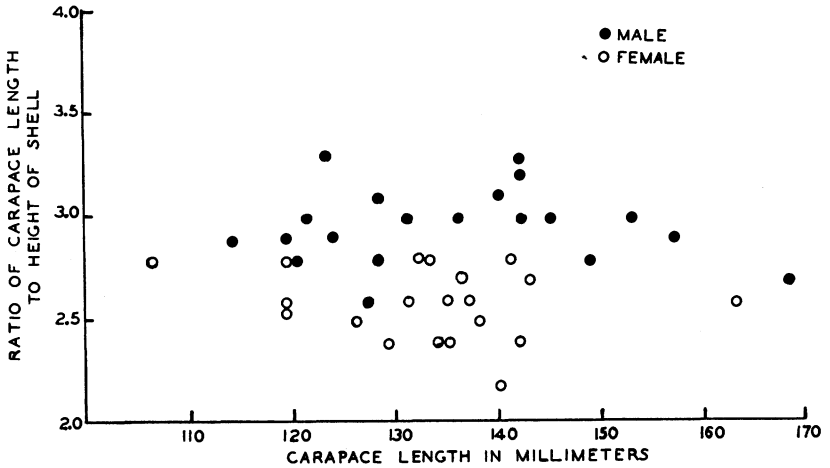

Fig. 3. Comparison of relative heights of the shells of males and females.

The anal opening of 59 per cent of the males (37 of 63 specimens) is beyond the posterior margin of the carapace; in the others this opening is only at the margin. In none of the females is the anal opening beyond the margin of the carapace. It is at the margin in 55 per cent of the females (23 of 42 specimens); in the others it is more anterior. Specimens under 50 mm. long were not considered in the above comparisons. In the male individuals with the anus beyond the carapace edge, the base of the tail is noticeably thicker than that of the females. In those in which the anus is not beyond the carapace edge the base of the tail is about like that of the females. Thus males that do not have the enlarged basal portion of the tail have the gradual tapering tail of females, whereas in males with the anus beyond the posterior carapace edge the portion of the tail beyond the anus tapers much more abruptly. Comparisons made between 57 males and 62 females reveal no correlation between sex and size, nor is there any difference between the relative tail length of males and females.

Examination of 20 adult males and 20 adult females selected at random shows that the relative height of the shells of the males tends to be less than that of the females. The average ratio of all the males was 2.97 whereas that of the females was 2.59. Some of the males, however, do have shells as high as some of the females and thus comparative height of the specimen is not a clear external criterion of sex (see Fig. 3).

No sexual differences were found in the coloration of the carapace, the plastron, or of the limbs and tail. Indications of sexual differences in the head and neck coloration were found, but these differences were not evident in all the specimens. Males tend to have a very few or no brown spots on the yellow chin or throat whereas the females have many more brown spots. The line of demarcation between the yellow coloration on the under side of the neck and the brown sides tends to be sharper in the males than in the females. The top of the head of the male usually is brown with few black spots whereas that of the female has more spots.

The following data on head and neck coloration were obtained from the adult specimens from California in the Museum of Vertebrate Zoology; the specimens considered did not show any indications of the juvenal coloration and all had a carapace length of over 50 mm. Sixty-two per cent of all the males have few or no spots on the under side of the neck, and 71 per cent of all the females have many spots. This difference may be said to be more pronounced in the specimens from the northern part of the state since 88 per cent of these males show few or no spots on the under side of the neck. The number of females with many brown spots is about the same in the northern and southern part of the state. Fifty-three per cent of the specimens with a definite line of demarcation between the yellow ventral coloration of the neck and the brown sides are males; 31 per cent of the individuals with the difference between the ventral and lateral colorations of the neck noticeable but without a definite line of demarcation are males; only 25 per cent of the individuals with no definite division at all are males. Seventy-seven per cent of the specimens having few dark spots on the top of the head are males; about the same number of males and females have a moderate number of spots; only 23 per cent of the specimens with many dark spots are males. Storer (1930: 436) found essentially the same sexual characteristics in *Clemmys marmorata* but no mention was made of color.

Individual Variation

The plates of the shell that show most individual variation are the comparatively small axillary plates, anterior to the bridge and between the carapace and plastron. In most mud turtles these are triangular, but sometimes they may be almost rectangular. These plates were found to be comparatively large, moderate, very small, or absent. No geographic correlation in the distribution of the different types of plates was found.

Several abnormalities in the carapace or plastral plates were found. Specimen No. 43581, Calif. Acad. Sci., from Siskiyou County, had very small abdominal plates that did not extend to the mid-plastral junction. There are six instead of five vertebral plates in No. 14605, from Trinity County. Specimen No. 17577, from Shasta County, had seven instead of the usual four costal plates on one side of the carapace; each of these had a distinct granular

portion. A prominent wide depressed area in the center of the plastron, extending to several of the plate junctions found in specimen No. 5099 from Mendocino County. Specimen No. 11904, San Diego Soc. Nat. Hist., had an extra abdominal plate and also a small vertebral plate.

The supracaudal plates, directly over the base of the tail, exhibit individual variation. It has already been noted that these plates are flat in young individuals. In some of the adults they curve abruptly upward and form a low hump; in others there is a less developed hump, and in a few these plates are as flat as in young specimens. No sexual or geographic correlation among the various types of supracaudals was found. Most adults have only a slight median ridge along the back, but in some it is entirely absent and in others it is prominent.

There is considerable individual variation in the coloration of mature individuals. The variations in the pattern of the carapace are striking. Dark radating lines on an olive or brown background is the predominant type of coloration, but many specimens have few markings of any kind and others have dark spots or both lines and spots. A few other color patterns, such as a dark and light reticulated pattern, or olive lines on a darker background are to be found. Individual variation in the coloration of the plastron is less marked than that of the carapace. About two-thirds of the adults have a solid yellow plastron with only a little brown on the plate junctions; in others the brown coloration is more extensive. Some individuals exhibit an irregular brown spot on each plate.

Some tendency toward sexual correlation in the coloration of the top of the head is discernible among the individual variations. Males tend to have fewer dark markings than females. In many specimens the number of spots on the top of the head produces a reticulated appearance; the majority of these are females. The coloration of the top of the head varies more than that of any other part of the animal. The ground color varies through light brown, dark brown, grayish brown, reddish brown, gray, and olive. In the majority of individuals the spots or reticulations are black or extremely dark brown, but they may be yellow, brown, olive, tan, or grayish olive. The individual variations in the coloration of the chin or throat and sides of the neck are less evident than those of the top of the head. Males tend to have fewer brown spots on the throat than females, and the line of demarcation between the browner sides of the neck and the yellow chin tends to be sharper in the males. In some specimens the sides of the neck are striped instead of spotted.

Geographic Variation

All the specimens from Oregon were from the southern or southwestern part of that state except for one from the northwestern section. The specimen from Idaho was from the southern part of the state; the Washington specimens were from the west-central section. The specimens from Lower California were taken within approximately 300 miles of the California border.

There is definite geographic variation in the form of the inguinal plate. The condition of this plate can easily be noted in the smallest specimens. There is a marked difference between the comparatively large and the small inguinals. The great majority (89 per cent) of California specimens north

of the San Francisco Bay have large inguinal plates. The exceptions are not from the extreme northern part of the state. In none of the northern specimens is the inguinal plate entirely absent. All the specimens but one from Oregon, Washington, and Idaho have comparatively large triangular inguinals. Specimens in the central inland portion of California have all

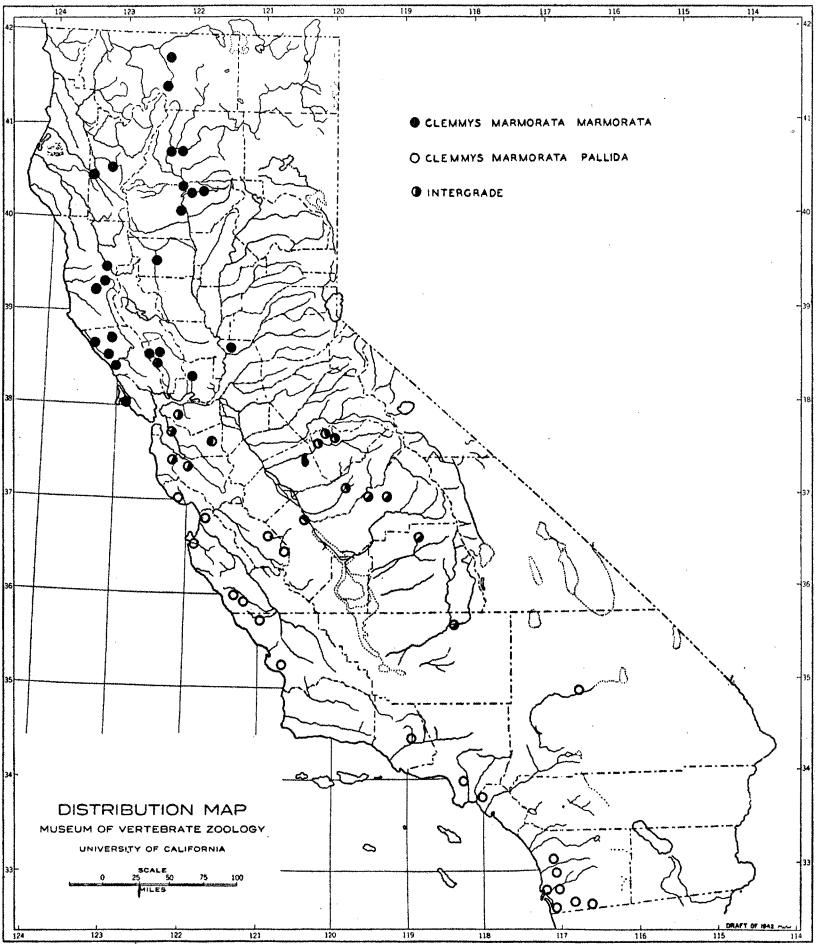

Fig. 4. California localities from which specimens have been examined.

types of inguinals. All individuals from the southern part of the state have extremely small inguinals or none at all. Specimens from near the coast south of the San Francisco Bay region have plates similar to those of the extreme southern portion of the state and are included with the southern group in the following comparisons. Sixty per cent of the southern specimens have no inguinals, in 34 per cent the inguinals are small, and in only 6 per cent are there comparatively large inguinals. Four of the six Lower California specimens have large inguinals, but they are either rectangular or round instead of triangular. One specimen has only a single large inguinal.

There is a tendency toward geographic variation in the coloration of the sides of the neck. Specimens from the northern part of California have the side of the neck brown or gray with darker spots or lines, whereas in specimens from the southern part of the state this area is yellow with brown markings. In 81 per cent of the individuals (see Fig. 5) from northern Calfiornia

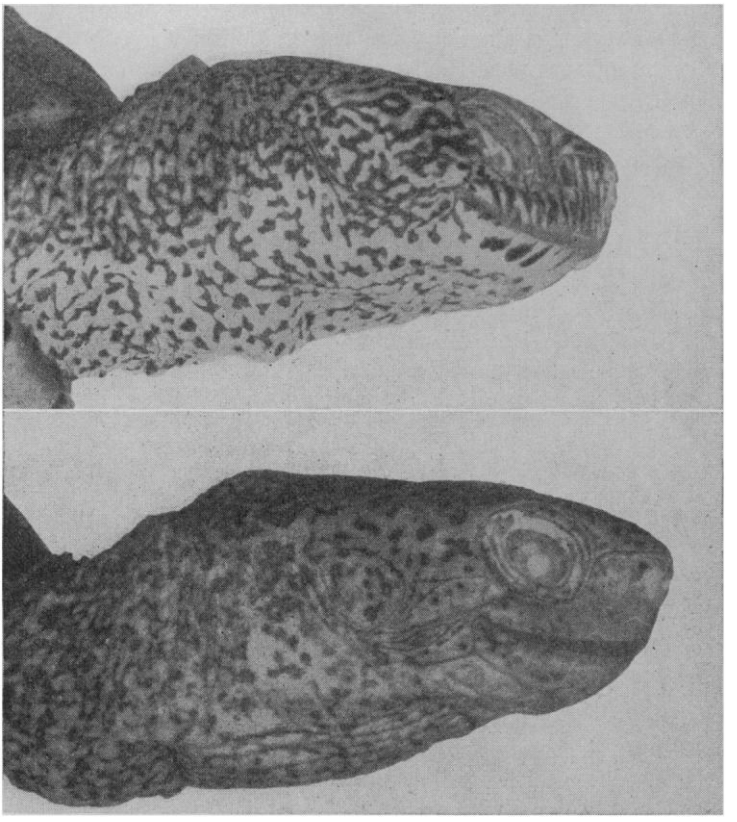

Fig. 5. Coloration of head and neck. Upper, *Clemmys marmorata marmorata* (Mus. Vert. Zool. 14602). Lower, *Clemmys marmorata pallida* (Mus. Vert. Zool. 6716).

the sides of the neck are dark. Five of the seven individuals with the light coloration are from localities near the central section of the state. Most of the specimens from the states north of California are young or poorly preserved; one specimen has the dark coloration of specimens from northern California. The specimens in the central region of intergradation have both types of coloration and neither is predominant. Seventy-seven per cent of the adult specimens from the southern part of the state have the light coloration. The few specimens from Lower California have the dark coloration which is predominant in individuals from northern California.

On the basis of the geographic differences found in this study, *Clemmys marmorata* can be divided into the following subspecies:

Clemmys marmorata marmorata (Baird and Girard)

TYPE LOCALITY.—Puget Sound.

DIAGNOSIS.—*Clemmys marmorata marmorata* can be distinguished from the southern subspecies (see beyond) by the presence of a pair of triangular inguinal plates, which usually (89 per cent) are relatively large. The sides of the neck usually are brownish or grayish with darker spots contrasting with the light color of the under side.

RANGE.—Pacific coast region from British Columbia south to San Francisco Bay; intergrades with the southern subspecies south of the Bay and in the San Joaquin Valley region.

LOCALITIES FROM WHICH SPECIMENS HAVE BEEN EXAMINED.—*Washington.*—Fort Steilacoom, Pierce Co. *Oregon.*—Keno and Klamath Falls, Klamath Co.; Willamette Valley, Clackamas Co.; Rainie Falls, Josephine Co.; Tiller, Douglas Co. *Idaho.*—Above Shoshone, Jerome Co. *California.*—Montague and Gazelle, Siskiyou Co.; Hayfork and Mad River, Trinity Co.; Ydalpom and Pit River, below mouth McCloud River, Shasta Co.; Payne's Creek and Dale's, Tehama Co.; 14 mi. N. Ukiah, Lake Leonard, and Mount Sanhedrin, Mendocino Co.; Winslow, Glenn Co.; Skaggs Springs, Duncan Mills, and Cazadero, Sonoma Co.; Calistoga, Angwin, and Conn Creek, Napa Co.; Rio Linda, Sacramento Co.; Vacaville, Solano Co.; Inverness, Marin Co.

Clemmys marmorata ***pallida,*** subsp. nov.

The name *Emys nigra* cannot be applied to this form since the type was taken on Poso Creek, Kern County, which is in the area of intergradation; *nigra* is here referred to *C. m. marmorata.* The intergrades from the San Joaquin Valley as a group fall closer to *C. m. marmorata.*

TYPE.—Adult female, No. 6716 Mus. Vert. Zool.; collected by J. E. Law on Lower Coyote Creek, near Alamitos, Orange County, California, summer of 1916 or 1917; carapace length, 134, width, 108 mm.; plastral length, 118, width, 74; axillary plates triangular; no inguinals; carapace coloration light brown with darker brown spots and radiating lines; plastron yellow with brown spots; head and neck yellow with brown spots.

DIAGNOSIS.—Inguinal plates absent (60 per cent) or small (34 per cent). The sides and ventral surface of the neck usually have a light uniform background color with dark spots.

RANGE.—Mohave River and the coastal region of southern California northward from the Mexican boundary, west of the San Joaquin Valley, to the vicinity of Monterey Bay; intergrades in the San Joaquin Valley and in the San Francisco Bay region with *Clemmys marmorata marmorata.*

LOCALITIES FROM WHICH SPECIMENS HAVE BEEN EXAMINED.—*California.*—Waddell Creek and Santa Cruz Mountains, Santa Cruz Co.; Carmel, Castroville, Mission San Antonio, and Sana, Monterey Co.; Panoche and New Idria, San Benito Co.; Nacimiento Creek and San Luis Obispo, San Luis Obispo Co.; Fillmore, Ventura Co.; Los Angeles River, Los Angeles Co.; Lower Coyote Creek, near Alamitos, Orange Co.; El Cajon, Chula Vista, San Diego, Adobe Falls, Lyons Valley, Potrero, Escondido, and Poway Corners, San Diego Co.; Yermo and Victorville, San Bernardino Co.

LOCALITIES FROM WHICH INTERGRADES HAVE BEEN EXAMINED.—*California.*—Livermore and Alameda, Alameda Co.; Lafayette, Contra Costa Co.; Palo Alto, Santa Clara Co.; Coulterville, Pleasant Valley, and Dudley, Mariposa Co.; Fresno River, Madera Co.; Friant, Trimmer Springs, Dunlap, and Mendota, Fresno Co.; north Fork Kaweah River, Sequoia National Park, Tulare Co.; Isabella, Kern Co.

Since the few specimens from Lower California are not similar to either the southern or northern forms herein defined, no attempt will be made to assign them to either subspecies.

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Influence of Availability on the Feeding Habits of the Common Garter Snake [1]

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THE common garter snake, *Thamnophis s. sirtalis* (Linnaeus), is generally known as a terrestrial animal. Our particular interest in predators on fishes has, however, led us to study this reptile in relation to the aquatic habitat. We were stimulated in this by the several specimens encountered around fish rearing establishments. At such stations, large numbers of young fish, mostly trout from advanced fry to fingerling stages, are confined in portions of natural streams or in adjacent, associated waters. Repeated observations showed that this garter snake rivals the watersnake (*Natrix s. sipedon*) as a successful fish predator under these circumstances (Lagler and Salyer, 1946). This led us in turn to the study of the garter snake in relation to fish populations in natural waters.

Our materials from Michigan have been accumulating since 1930 and at present represent eighteen fish cultural establishments and thirty-one locations on the immediate shores or banks of natural lakes, ponds, and streams away from hatcheries or rearing stations. In all, 238 specimens collected during daylight hours were examined; of these 87 contained no food. A random sample, 109 of the 151 individuals with food, averaged 644 mm. (25.4 inches) in length and ranged from 9.25 to 34.25 inches. Methods used for food analysis are the precise qualitative and quantitative ones described earlier by us (Salyer and Lagler, 1940).

[1] Contribution from the Department of Zoology of the University of Michigan and from the Institute for Fisheries Research of the Michigan Department of Conservation.