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appears to be less tolerant of arid conditions than *B. speciosus*, and the dry spring and summer of 1971 may have prevented this species from reproducing in that year.

I wish to thank Dr. E. William Behrens for supplying the climatological data and the Port Aransas Police for their patience with my nocturnal expeditions.

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POPULATION DYNAMICS OF THE SAN MARCOS SALAMANDER, *EURYCEA NANA* BISHOP

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ABSTRACT

Results of a study of the population ecology and demography of a paedogenetic species of salamander, *Eurycea nana* Bishop, endemic to the San Marcos River, San Marcos, Texas, are presented. The physical, chemical and biotic aspects of the natural habitat are reported and evaluated. Information is given regarding the food habits, the reproductive conditions, the population density and range, and the existence of predators of the species.

INTRODUCTION

In the springs and underground water systems of the Edwards Plateau and Balcones Escarpment region of Texas there occur 7 described species of the lungless plethodontid salamanders of the genus *Eurycea*. The genus *Eurycea* occurs only in eastern and south-central North America, and although all species have aquatic larvae, only the 7 paedogenetic species of Texas and *Eurycea tynerensis* Moore and Hughes of northeastern Oklahoma retain their larval habits for life.

In Texas most of these species exist as small, isolated allopatric populations confined to a particular aquiferous limestone cave or spring. Six species, *Eurycea nana* Bishop (1941), *Eurycea latitans* Smith and Potter (1946), *Eurycea pterophila* Burger, Smith and Potter (1950), *Eurycea troglodytes* Baker (1957), *Eurycea tridentifera* Mitchell and Reddell (1965), and *Eurycea rathbuni* (Stejneger) Mitchell and Reddell (1965) are presently counted as endemic forms, each known only from a very restricted aquatic locale.

Eurycea nana, the San Marcos Salamander, is a paedogenetic species endemic to the headwaters of the San Marcos River in San Marcos, Hays County, Texas. Subsequent to its formal description (Bishop, 1941), little has been done to evaluate the ecology or life history of this, the smallest of the eury-

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ceas. Five principal studies have been conducted with *Eurycea nana;* they include 2 thyroxin-induced metamorphosis studies (Potter and Rabb, 1960; Andrews, 1962), a determination of oxygen consumption of the species (Norris, *et al.*, 1963), an unpublished chromosome study (Bogart, 1967) and an unpublished morphological study (Schwetman, 1967). Other published and unpublished studies which have involved *Eurycea nana* include those of Baker (1961), Wake (1966), Mitchell and Smith (1972), Hamilton (1973), Barrett (1973) and Barnhart (1975).

MATERIALS AND METHODS

Preliminary examination of the habitat of *Eurycea nana* along the northern bank of Spring Lake began in June of 1967. The 3 to 6 feet deep waters along the northern bank were explored in swim apparel and various sampling devices and methods of collecting the San Marcos Salamander were evaluated. Subsequently, an adequate and practical collecting bag and method for taking samples was devised.

The cloth bag, which proved far superior to any metallic sampler or dip nets considered, consisted of a small sack of heavy muslin with a mesh bottom. A heavy wire was inserted into the cloth binding at the mouth of the bag and bent to form a square which measured 15 cm on each side. Hinges were formed by separating the wire at opposite corners of the square and reuniting the wires by means of loops, thus providing a sampling bag which would open fully and close tightly and sample a 225-cm^2 area. This sampler was lightweight, easy to operate under water, and precluded the escape of even the smallest specimens. Amphipods of sizes less than those of the smallest *Eurycea* were trapped by the mesh.

Initial samplings with the bag indicated that approximately 3 salamanders per sample could be expected. To obtain statistically adequate numbers, it was decided that 8 randomly spaced samples should be made each day collections were taken. Collections were made weekly prior to September, 1967, and bimonthly from September through June of 1968. The 225-cm^2 samples were taken after points on a map of the collection site were chosen at random. The uniformity of the sample size, especially in terms of area, and the random gathering of such samples was essential to the subsequent calculation of the population density and total population estimates.

Each sample was taken under water by placing the sampling bag in the open position over the spot to be sampled and forcing it completely to the substratum. The hinged mouth of the device was closed as the lake bottom was reached. All vegetaion above the substratum, including approximately 15 mm of the sand and gravel bottom, was taken in the samples to assure that all salamanders in that 225-cm^2 area would be included. The salamanders and any other fauna of macroscopic size taken in the samples were immediately

preserved in 10% formalin. The wet weights (blotted dry) and dry weights (oven dried) of the sampled vegetation were determined for each sample. It was intended that the wet and dry weights of the vegetation harboring *Eurycea nana* in the sample quadrats would serve to further estimate the density of the species in that sampled locality.

Each of the 8 samples taken on a collection day were treated in the same manner as described above, and all sampled points were recorded on a map of the area. All samples were taken between 1200 and 1900 hours, the 8 samples generally requiring 3 hours to complete. Swim fins, a face mask, a snorkel, and occasionally a wet suit were employed in the one year's study.

The chemical and physical conditions of the lake's waters within and without the range of the salamander population were determined 3 times during November, 1967. For oxygen determinations, the Winkler Method (titrations performed in triplicate) and the Yellow Springs Instrument Company direct-reading oxygen meter were used. Conductivity was measured with a specific conductance meter, pH with the BTB (bromthymol blue) disc in the Hellige pH apparatus and with a Beckman pH meter, and temperatures with a Farenheit laboratory thermometer and a Yellow Springs Instrument Company thermistor thermometer. Methyl orange and phenolphthalein alkalinities were determined by dilute sulfuric acid titrations performed in duplicate.

The morphometry of the upper end of Spring Lake was determined in December, 1967, when a general outline and contour map of the area was constructed following mapping with the following: plane tables, alidades, level, compass, boat, depth meter, pole, and crew of four. Contours were drawn for 2 feet intervals.

In the laboratory, observations of gravid female *Eurycea nana* were made; specimens were maintained in 25 mm of lake water in large (200 x 70 mm) culture dishes. No attempt was made to adjust the temperature of the water to that of the natural habitat of *E. nana*; water in the dishes assumed the ambient temperature of the air-conditioned laboratory, which was generally several degrees Celcius higher than the Spring Lake waters.

Information regarding the nature of the physical habitat of *Eurycea nana,* the existence of predators of the species, the preference and abundance of food items, and the co-inhabitance of the ecosystem by other macroscopic organisms was compiled from field observations as well as from laboratory examination of samples collected and preserved. Measurements of 807 salamanders collected were taken from preserved specimens to the nearest 0.1 mm with a vernier caliper; total and snout-vent lengths greater than 15 mm. All other specimens were deemed juvenile, as no reproductive structures could be discerned in these small individuals. The larger specimens were sexed by slitting the abdominal wall from the region of the liver to the vent, thus exposing the region of the gonads. If the reproductive structures were visible, they were evaluated and recorded as to size and degree of development.

Analyses of stomach and intestinal tract contents of more than 80 preserved salamanders were made in order to ascertain the diet of *Eurycea nana* in its natural habitat.

DESCRIPTION OF THE HABITAT

The headwaters of the San Marcos River originate within the city of San Marcos, Texas, along the Balcones Fault Line which divides the city between the Blackland Prairie to the east and the eroded Edwards Plateau region to the west. Numerous springs emanate from the limestone formations to fill Spring Lake which forms the uppermost waters of the 38 mile long San Marcos River. These springs are supplied by waters from the extensive Edwards Underground Water Reservoir.

The habitat of *Eurycea nana* at the upper end of the lake is well insulated against physical or chemical changes which might result from local flooding. Likewise, drouths in the region have proven no threat to the water flow from the aquifer through the San Marcos springs; these springs have continued to flow when other springs along the Balcones Escarpment have run dry.

The many large springs which supply Spring Lake and the upper San Marcos River are responsible for the remarkable thermal stability of these waters throughout the year. In the immediate vicinity of the springs, the water temperature is always between 21.0 and 21.5° C.

On 22 and 26 November 1967, the physical and chemical conditions of 3 loci within and immediately without the collection area of *Eurycea nana* were recorded. The measurements and determinations for the one nighttime and 2 daytime determinations are given in Table 1. The loci sampled are indicated on the map presented as Figure 1. Reproducibility of pH readings was difficult to achieve; therefore, variations in pH readings between the loci recorded in Table 1 should be regarded as insignificant. The water issuing from the spring in the vicinity of loci B and C (within the population range of *E. nana*) was 28-41% saturated with oxygen and remained a constant 21.1° C (71-72° as measured with a Farenheit thermometer). In contrast, at locus A (outside the *E. nana* population range) the waters were 40-63% saturated with oxygen. These higher values may be explained in terms of the abundant oxygen-producing vegetation in this region, the stillness of the waters, the greater depth of the waters, and the absence of springs in the area. Higher oxygen content is to be expected in such a vegetated region, particularly during daylight hours. Methyl orange alkalinity determinations generally ranged from 220-232 mg/1 and specific conductance from 510-535 micromhos/cm at each of the loci.

In the immediate vicinity of the *Eurycea nana* habitat a wide variety of aquatic macrophytes, including macroscopic algae as well as aquatic angiosperms, are found. More than 49 species of aquatic macrophytes, exclusive of

LOCUS*	A			B			C		
DATE	22 XI 67	22 XI 67	26 XI 67	22 XI 67	22 XI 67	26 XI 67	22 XI 67	22 XI 67	26 XI 67
HOUR	0430	1645	1400	0500	1700	1400	0500	1700	1400
DEPTH (FEET)	10 - 15	10 - 15	15	4	4	4	4	4	4
TEMPERATURE (°F)	69°	72°	72°	71°	72°	72°	71°	72°	72°
YSI TEMPERATURE (°C)	---	21.5°	---	---	21.1°	---	---	21.1°	---
TITRATABLE OXYGEN (mg/l)	3.68 3.56 ---	4.82 5.03 ---	5.61 5.41 5.55	3.13 3.56 ---	3.19 2.94 ---	3.64 2.48 3.29	2.70 2.88 ---	2.94 2.76 ---	3.36 3.12 3.65
YSI OXYGEN (ppm)	---	4.60	---	---	3.40	---	---	2.80	---
OXYGEN SATURATION	40%	51-56%	61-63%	34-40%	33-38%	28-40%	30-32%	30-33%	35-41%
BECKMAN pH	7.18	7.20	---	7.05	7.31	7.05	7.05	7.27	---
HELLIGE BTB pH	7.20	---	---	7.00	---	---	6.90	---	---
PHENOLPHTHALEIN ALKALINITY (ppm)	0	0	0	0	0	0	0	0	0
METHYL ORANGE ALKALINITY (ppm)	292 ---	233 232	--- --- ---	239 ---	220 ---	229 231	230 ---	221 ---	--- --- ---
SPECIFIC CONDUCTANCE (micromhos/cm)	505	535	---	510	525	---	510	535	---
CURRENT	negl.	negl.	negl.	swift	swift	swift	mod.	mod.	mod.

*see Figure 1 for sampled areas.

the algae, have been reported from Spring Lake (Bruchmiller, 1973). In the shallower depths of 3 to 8 feet, *Sagittaria platyphylla* (Engelm.) J. G. Smith predominates where there is some amount of organic detritus available in the substratum. *Myriophyllum brasiliense* Cambess., *Myriophyllum heterophyllum* Michx., *Ludwigia repens* Forst., *Vallisneria americana* Michx., and the carnivorous *Utricularia gibba* L. also inhabit the waters of depths less than 8 feet. Entirely limited to the collection area is a particular species of aquatic moss, *Leptodictyum riparium* (Hedw.) Warnst., which grows attached to the concrete banks and sumberged boulders in the 37-meter-long habitat of *Eurycea nana*.

Spirogyra and a few other species of filamentous green alga are present at times in the collection area, but the dominant macroscopic algae is a large, filamentous, thick-sheathed species of *Lyngbya,* a blue green form (Cyanophycophyta, Oscillatoriales). The dense, wooly mats of this reddish-brown-colored cyanophycean alga cover most of the substratum in the *Eurycea nana*

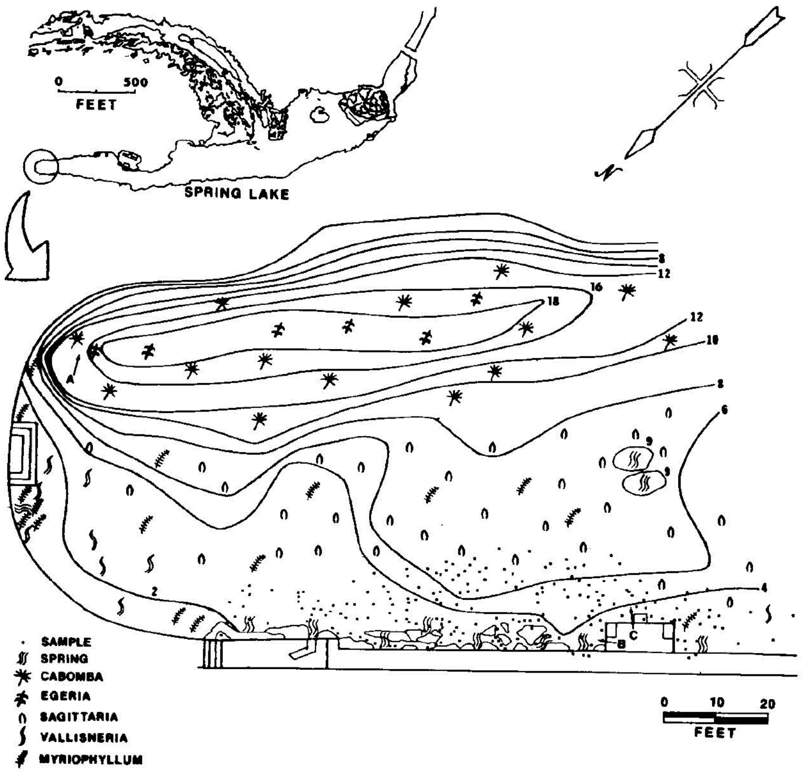

Figure 1. Contour map of the uppermost region of Spring Lake, San Marcos, Texas. Contours drawn at 2-foot intervals.

habitat. The *Lyngbya* sp. appears to be selectively adapted to conditions of shallow, spring-fed waters.

In deeper waters, *Cabomba caroliniana* Gray and *Egeria densa* Planch. become the dominant macrophytes of the mud-and-detritus-laden benthic region. On the contour map of the upper Spring Lake area presented as Figure

1, symbols representing the dominant aquatic macrophytes of the various regions have been placed.

The aquatic moss and the blue-green algal masses contain a varied biota. An abundance of tendipid larvae, many amphipods (predominantly *Hyalella azeteca* and *Gammarus* sp.), occasional hydracnids, and many small aquatic snails inhabit this vegetation. Leeches (*Placobdella* sp. and others) and planiarians were also numerous, especially in samples taken over rocky substrates. In a determination of amphipod content of aquatic moss samples in which the small crustaceans were collected in a set of graded sieves, up to 87 amphipods per g dry weight of the moss were found.

Tendipid larvae and pupae and amphipods were the usual food items revealed in the salamander stomachs and intestines. In the digestive tracts the chitinous remains of the amphipods were yellow in color, the midge fly larvae a reddish-yellow color, and the pupae were dark brown or black. On occasions other insect pupae and naiads, as well as small snails, were found in the digestive tracts. Other items, apparently taken in incidentally with the normal food of the salamanders, included grains of sand and filaments of the dark cyanophycean alga, *Lyngbya.*

Frequently occupying the same niche as *Eurycea nana* was the Fountain Darter, *Etheostoma fonticola* Jordan and Gilbert, which displays many of the same feeding and protective-concealment habits of the former. The darters were observed to feed on amphipods in laboratory aquaria and in the lake. They, like the salamanders, were found within aquatic moss growths or algal mats, as well as secreted beneath and alongside stones; they are definitely not free swimming as are the other nektonic fish in the area. As their name implies, the darters move along the substrate in rather swift waters in a darting manner; their enlarged pectoral fins enable them to overcome the current and to lodge themselves in crevices and within the mesh of vegetation. The maximum-sized individuals collected had a standard length of 25.0 mm, which is about ½ the size of the maximum total length of *Eurycea nana.*

The obvious predators of the San Marcos Salamander are shared by the Fountain Darter. Several species of sunfish constantly hover over and around the shallow, spring-fed area which is dense with aquatic moss and *Lyngbya.* Stomach content analysis of 7 of these sunfish (6 specimens of *Lepomis auritus* and one of *Chaenobryttus coronarius*) revealed insect larvae, amphipods, terrestrial isopods, filamentous algae, aquatic snails, freshwater shrimp (*Palaemonetes paludosa*), and Fountain Darters as inclusions in their diet. Although no *Eurycea nana* were found in these 7 fish, on several occasions the sunfish were observed to seize salamanders as the senior author released them back into their natural habitat. Crayfish were frequently collected in the samples; they, too, may be predators of *Eurycea nana.* Occasionally stinkpot turtles (*Sternotherus odoratus*) were sighted in the area and collected in the samples.

Bullheads (*Ictalurus melas*) and largemouth bass (*Micropterus salmoides*) also frequent the habitat of *Eurycea nana*, especially at night. They are, however highly unlikely predators of the salamanders due to the nature of their feeding habits.

DEMOGRAPHY

Size and Growth

Data compiled from measurements and examination of the reproductive structures of the 807 specimens of *Eurycea nana* enabled certain facts to be determined concerning the growth of this species.

In analysis of the sexable male salamanders, the degree of development of the testes was evaluated and recorded for each individual. From graphic representation of these data as presented in Figure 2, it can be determined that males reach sexual maturity, *i.e*, possess at least one full lobe in each testis, only after having reached a snout-vent length of 19 mm. Likewise, it is shown that those individuals that have snout-vent lengths greater than 23.5 mm are inevitably mature, having from one to more than 2 testes lobes. The figures along the ordinate axis of the graph indicate the relative sizes of the testis-lobe classes used. It was on the basis of accounts and aspects of the multiple-lobed testis of urodeles given by Humphrey (1922) that this criterion for determination of sexual maturity in *Eurycea nana* was used. In his study of *Desmognathus fuscus*, Spight (1967) correlated the age of male individuals with the number of testis lobes.

The sexable female *Eurycea nana*, or those which carried eggs of any size and number, were grouped into classes that represented degrees of sexual maturity based on the relative sizes and pigmentations of the ova. For *Eurycea nana* females, the following 4 egg size categories were ascertained, and dissected individuals were ascribed to the category best describing the most developed eggs in the ovaries: very small clear ova, small opaque-white ova, small yellow ova, and large yellow ova. Similar classes of egg development were used by Spight (1967) in describing the eggs of *Desmognathus fuscus*. *Eurycea nana* females that carried the large yellow ova were considered gravid and presumably ready to release their eggs. Data are presented graphically in Figure 3 indicating the relationship of conditions of the ova to the snout-vent lengths of the females. The absence of well-developed ova in a number of the larger females may be explained by the fact that the salamanders may have already released mature ova and only recently resumed the production of new ones in the ovaries.

The largest ova in any gravid *Eurycea nana* were 1.5-2.0 mm in diameter. Salamanders which carried eggs of this size could hardly accommodate more than 20 such eggs in the abdominal region. Although the actual egg-laying by *Eurycea nana* has never been observed and no eggs have been collected from

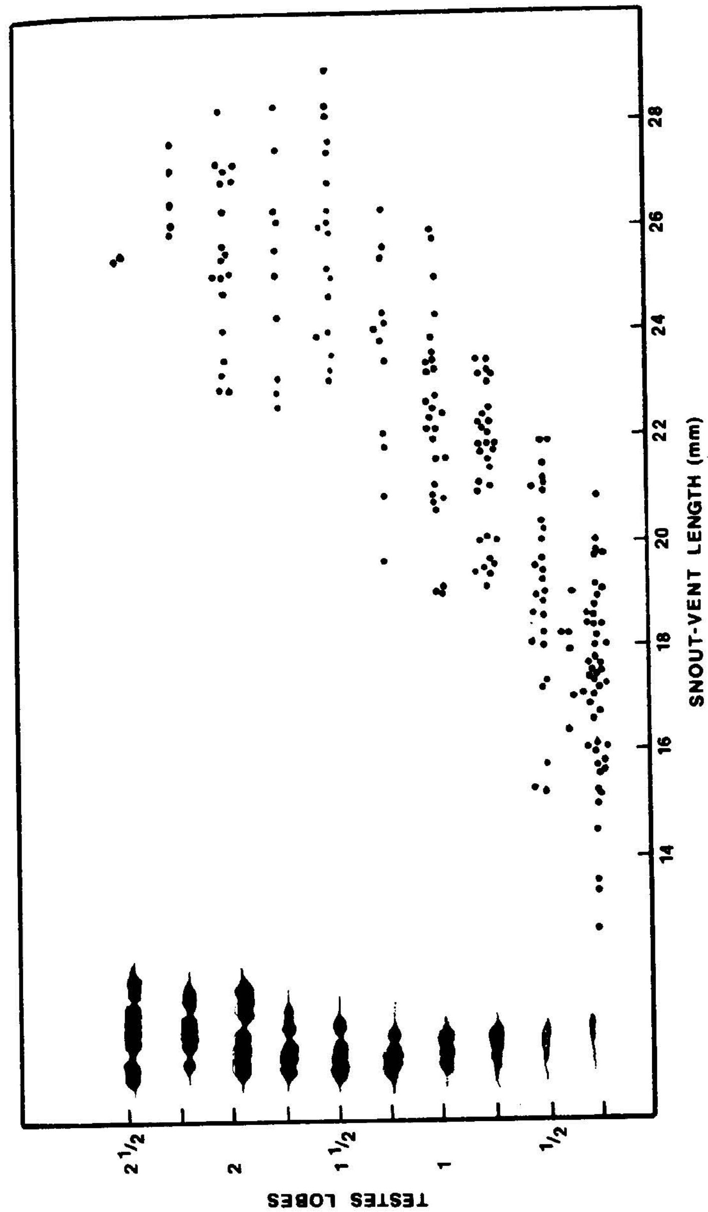

Figure 2. Correlation of snout-vent lengths with testes lobes in *Eurycea nana* males.

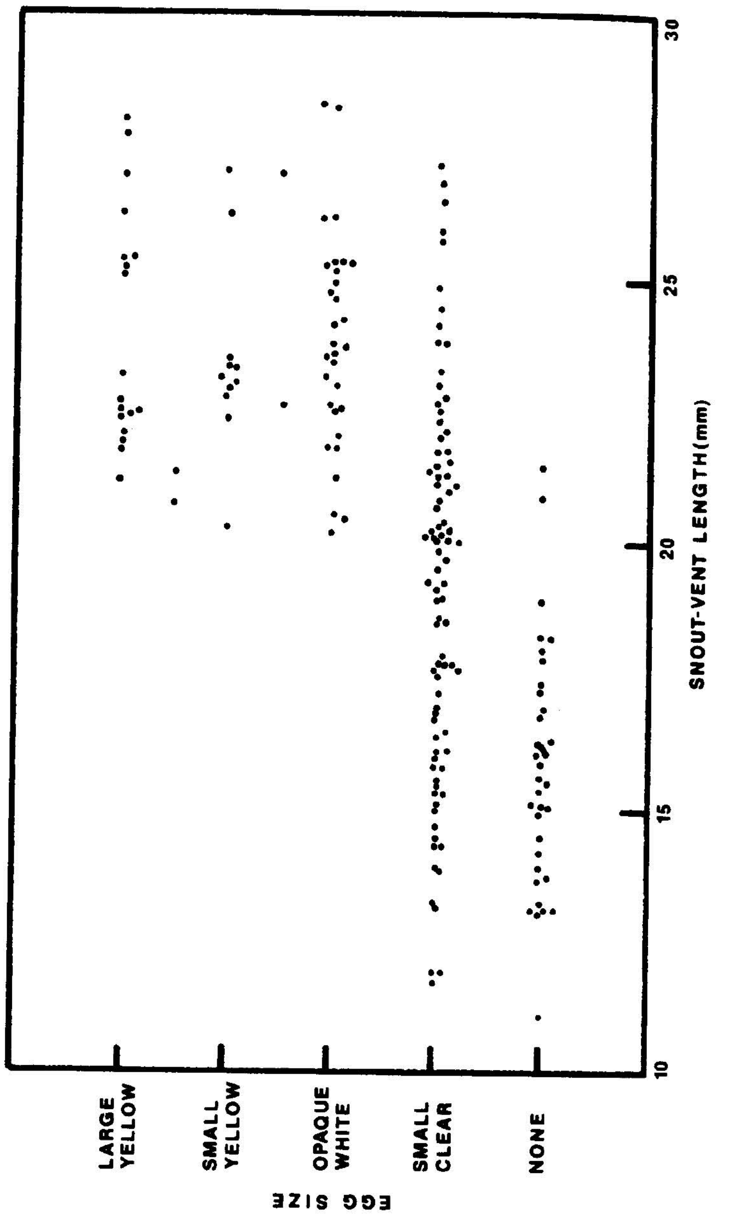

Figure 3. Correlation of snout-vent lengths with egg sizes in *Eurycea nana* females.

the habitat, courtship and egg deposition should not prove to be unlike that reported for another neotenic eurycea, *Eurycea neotenes* Bishop and Wright, from the Edwards Plateau region of Texas (Bogart, 1967).

The eggs and larvae of the troglobitic *Eurycea lucifuga* Rafinesque from Missouri were observed in nature and described by Myers (1958). The measurements of the eggs agreed well with those obtained from the same species by pituitary gland implantation (Barden and Kezer, 1944). Myers found eggs in various stages of development from early cleavage to advanced embryonic stages, attached singly to the bottom and the sides of submerged rocks in a stream issuing through a cave wall. He collected, measured, and described newly hatched larvae which were just breaking from the eggs. All measured 11 mm in total length, were sparsely pigmented dorsally with grayish chromatophores, and had immaculate ventral surfaces, gill buds, and limb buds.

A single *Eurycea nana* hatchling collected 10 May 1968, which closely resembled the descriptions of the *Eurycea lucifuga* larvae given by Myers, is illustrated in Figure 4. The *Eurycea nana* specimen, however, measured only 8.2 mm in total length. The front limbs were represented by elongate buds, and the hind limbs by very small protuberances. The venter was a pale yellow due to the presence of the yolk, and the gular region was immaculate. The gular flap was present, but no gill buds could be discerned in the preserved specimen. Light gray chromatophores covered the dorsal and caudal surfaces, and the eyes were darkly pigmented.

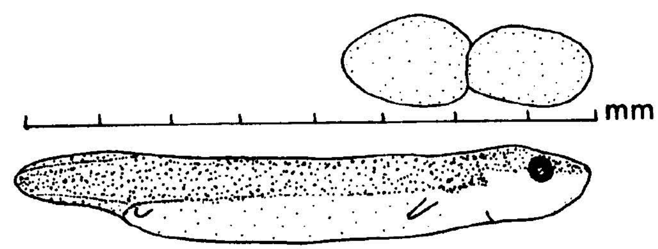

Figure 4. *Eurycea nana* hatchling collected 10 May 1968 as compared with eggs taken from a gravid female collected 29 November 1967.

A total of 7 *Eurycea nana* still possessing yolk on the venter (indicating the postembryonic stage when the intestines are not fully developed) were collected in February, May and June of 1968. They ranged in total length from 8.2 to 13.6 mm, which indicates that growth in length of the salamander must be rapid following hatching. The largest San Marcos Salamander, collected in February of 1968, had a snout-vent length of 31.2 mm and a total length of 56.4 mm.

Population Structure

The structure of the *Eurycea nana* population throughout the year is necessarily dependent on the reproductive habits of the species. In order to determine the breeding season of *Eurycea nana*, the smallest juvenile encountered in each month of collections was recorded and graphed (Fig. 5). For contrast, the largest adult from each month's collections was also plotted.

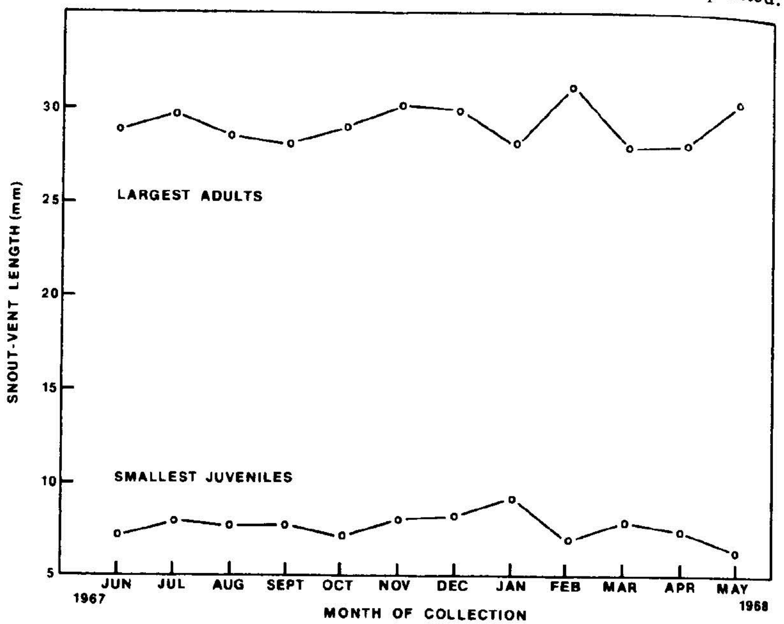

Figure 5. Comparison of the snout-vent lengths of the largest and the smallest *Eurycea nana* collected during a one-year period.

The finding of very small larvae during every month of the year serves to support the hypothesis that this population breeds in every season of the year. In further support of non-seasonal breeding by the species, Figure 6 shows that gravid females and females with ova in advanced stages of maturity occur in nearly every month of the year. Bogart also observed egg-bearing females and very small specimens of *Eurycea nana* in almost every season (Bogart, 1967).

The population structure for 3 different periods of the year is presented in Figure 7. Four categories, based on specimen maturity and reproductive condition, were established to separate the collected individuals into groups for comparison of their relative abundances in the various seasons. The June through September data were obtained from the analysis of 242 individuals, the October through January data from 362 specimens, and the February through May data from 203 specimens. The remarkable stability of the population throughout the year is obvious, further supporting the hypothesis that there is no definite breeding season.

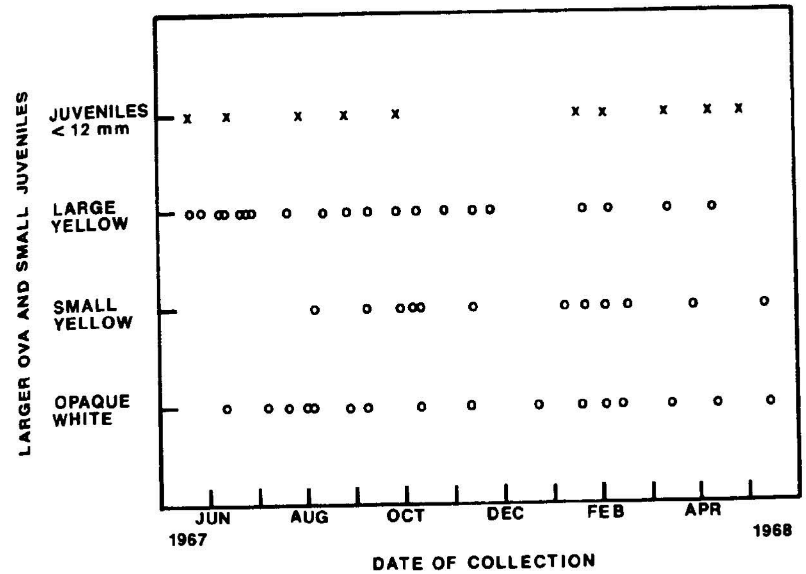

Figure 6. The occurrence of larger ova and small juveniles (less than 12 mm total length) during a one-year period.

Population Density and Range

The shallow area of Spring Lake along the northern bank is believed to constitute the range of the only stabilized population of *Eurycea nana*. This salamander has been found in other parts of Spring Lake and downstream in the upper San Marcos River by others (Brown, 1950) and by the writers, but it is the opinion of the writers that those individuals sighted represent only temporary residents of the areas in question.

In late summer and early fall, the dense, woolly mats of *Lyngbya* frequently stratify from the substratum to the surface of the water as a result of oxygen accumulation among the filaments. Entire mats are occasionally freed and float downstream. In this manner, *Eurycea nana* harbored in the mats could be distributed to virtually any part of the lake or river. Such displaced individuals could survive for limited periods of time in their new habitats, but it is highly unlikely that permanent populations would be established which could breed successfully, withstand flooding, or survive other changes in the physical and chemical conditions of the waters.

To estimate the population density within the collection area, the average number of salamanders per sample quadrat was determined, and this figure

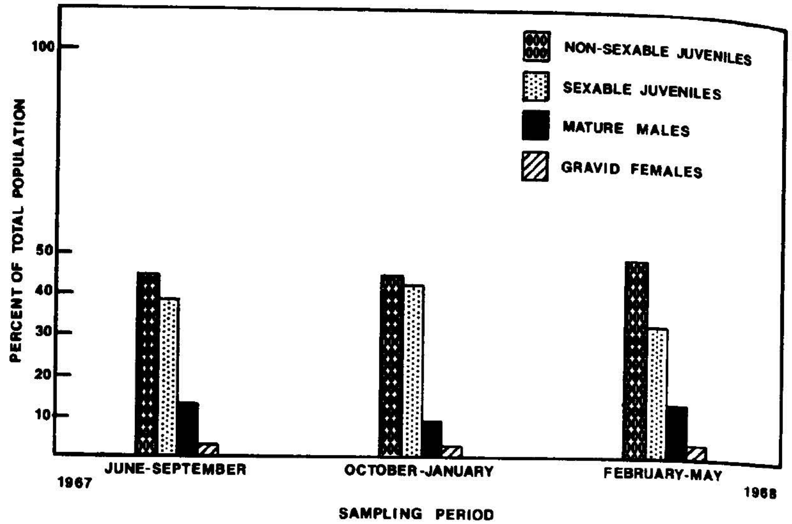

Figure 7. Population structure of *Eurycea nana* during 3 portions of a one-year period.

was converted into the number of salamanders which could be expected in the entire area sampled. Based on 216 samples, the average wet weight of the vegetation per salamander collected was 32 g and the average dry weight was 7 g. The average wet and dry weights of the vegetation per sample in 192 collections were 70 and 16 grams, respectively. From the preceding averages, the average number of salamanders per sample was determined to be 2.2 for the wet weight figure and 2.3 for the dry weight figure. Not all of the 232 samples taken were used in the computations because some of the earlier samples were not made with the sampling bag. The average number of *Eurycea nana* per sample was also figured directly from 219 samples in which 567 salamanders were captured; a figure of 2.6 was obtained which, on the basis of area, would indicate 2.6 salamanders per 225 cm^2.

The total area of the region sampled, which is deemed to encompass the entire salamander population, was determined by counting squares on a grid map of the area and was approximated to be 180 square meters. On the basis of 219 225-cm^2 samples taken, this reflects that approximately 5 square meters were actually covered in the random sampling during the 12 months.

The population density and estimate of the total population in this area was made with the use of the 2.6 salamanders per sample figure; by conversion this establishes 116 individuals per square meter. On the basis of the 180-square-meter area, a population estimate of 20,880 is obtained. It is unlikely that this figure represents an underestimate of the population size, inasmuch as barren boulders and spring issuance areas were not sampled due to the lack of vegetation. Were the 2.2 and 2.3 salamanders per sample figures (based on the wet and dry weight vegetation determinations) used in lieu of the 2.6 figure, a total population estimate of 17-18,000 would be obtained.

DISCUSSION

The uniqueness of the habitat of the *Eurycea nana* population is probably responsible for restriction of the species to that locale. The nature of the substratum, the assemblage of vegetaion, the shallow depths, and the chemical and physical stability of the waters throughout the year give this limited region of Spring Lake a character unlike that found in any other part of the San Marcos River system.

The sand and gravel, boulder-studded substratum lacks organic detritus which would create benthic conditions unfavorable for life and propagation of the salamander. No organic decomposition occurs in the area of the numerous small springs which clean the bottom of small bits of decaying plant and animal matter. The aquatic moss, *Leptodictyum riparium*, and the filamentous cyanophycean alga, *Lyngbya* sp., are found nowhere in the river as abundant as they are near these springs. The color and texture of this vegetation provides ideal cover, and harbors an abundant food supply for *Eurycea nana*. Cover is a critical factor for the species in view of the abundance of predators.

The thermal conditions, constant at all times, have likewise proven to be ideal for the existence of the species. *Eurycea nana* has shown a maximum oxygen consumption at about 25° C (as opposed to 20° and 30° C comparisons) (Norris, *et al.*, 1963). In the present study on an occasion when the temperature of an aerated aquarium inadvertently reached 30° C the salamanders went into convulsions and died. The high density and the remarkable stability of the population indicate that the 21-22° C thermal conditions are ideal for the species.

The oxygen content of the waters issuing from springs around which the San Marcos Salamander is found is rather low. The temperature-constant waters are only 30-40% saturated with oxygen. *Eurycea nana* adapts to this lower oxygen concentration by a considerable expansion of and increased blood flow through the gills. These bushy red structures are prominent on the individuals when collected, but they show marked reduction, almost to the point of apparent resorption, when specimens are kept in well-oxygenated water in the laboratory. This occurrence is in agreement with the work of Bond (1960) which demonstrated that the volume of blood in the gill filaments increases when the concentration of oxygen in the medium is reduced.

It is not surprising that *Eurycea nana* should breed throughout the year. All conditions, except that of solar radiation, remain constant throughout the seasons. Females apparently ready for oviposition of eggs represent 3-4% of the total population at any given time, and juveniles in which the testes or ovaries have not begun to develop represent 45-50% of the total at all times.

The success and stability of this salamander population is remarkable. Owing to the nature and the constancy of the habitat, *Eurycea nana* breeds the year around, maintains a uniform population structure, and has a high population density of as many as 2.6 individuals per 225-cm^2 area. It is highly unlikely that this only known population of *Eurycea nana* should ever be threatened with extinction by natural phenomena. Only man-made or -instituted changes in the habitat could endanger the population.

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