# The Natural History of Necturus: I. Habitats and Habits

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## Habitats

The mudpuppies are entirely aquatic; in habits they are more fish than amphibian. Their legs are weak, and they are nearly helpless on land.

Barnes (1826) has stated that Necturus occasionally emerges from the water, and climbs the bank or shore. J. Augustine Smith (1828)* considered Necturus as truly amphibious, it having been seen many times on the shores of lakes, though water is its proper element. In 1827 Harlan published a picture of the mudpuppy. In 1831 Cuvier used the same picture (it appears to be the same plate!) but drew in around the animal an imaginary landscape that makes it appear the animal is out on land. Some earlier-day workers (Smith, 1832; DeKay, 1842; Holbrook, 1842; Kneeland, 1868; Fulleborn, 1894), perhaps misled by Barnes' statement or by Cuvier's figure, have said that Necturus occasionally come on land. As late as 1888, the *Riverside Natural History* (edited by J. S. Kingsley) gives a figure showing Necturus out on land. Potter (1938) reported that Necturus comes ashore only occasionally. But normally the mudpuppies do not come on land (Pearse 1921, Evermann and Clark 1920, Willey 1929, and others), although they may once in a while get stranded, as may happen to any aquatic animal (Bishop 1926).

Their wide distribution may be due to an ability to tolerate all sorts of environments (Bishop 1926). They are found in greatest abundance in the clear waters of the northern and eastern United States. They are found in the Great Lakes and tributaries, in the Mississippi and other major rivers, as well as in small ponds and streams. They are found in the clear open waters of lakes and streams where there is no plant growth, as well as in weed-choked bays, canals, creeks, and irrigation ditches; in water that is clear or turbid, deep or shallow, rapid or slow-flowing or standing; cold or lukewarm; on gravel, mud or muck bottoms; in canals, reservoirs, backwaters, bayous, lakes, streams.

Different species of Necturus may prefer different habitats (Viosca 1937). *Necturus punctatus* is sometimes found in the

*The complete bibliography will be printed following the last paper of this series.

litter of backwash areas, out of the main current (Brimley, 1924). *Necturus maculosus lewisi* is associated with *N. punctatus*, but seems to ascend the streams to higher levels. Both *N. punctatus* and *N. m. lewisi* seem *not* to be found in rocky streams. Eaton (1953) said that *N. m. lewisi* occurs in rivers of North Carolina where bottom is muddy or sandy, and water is moving; and *N. punctatus* prefers small shady creeks where muddy bottoms carry accumulations of dead leaves. *Necturus m. beyeri* seems to prefer spring-fed streams with sandy bottoms where the temperature is near 70°F., which is warmer than *Necturus m. maculosus* prefers (Viosca 1937). Set- and trot-line operations indicate that *N. m. louisianensis* inhabits either shallow or deep standing water where there is good cover—such areas of good cover as roots of trees, submerged logs, rock pits, cavities in limbs may shelter a number of individuals (Cagle 1954). Viosca believes all species of Necturus favor clear streams, which, however, may be muddied temporarily by floods or high water.

In any event, a major factor governing choice of habitat appears to be the presence of suitable hiding places. Available food-supply becomes important only when the stream provides suitable hiding and nesting places (Bishop 1927). In all areas, an essential of the habitat seems to be relative freedom of the water from the water mold, *Saprolegnia*. Eggs, larvae, adults—all stages—are attacked by the water mold and fall victim to it (Morse 1901, Sayle 1916, Bishop 1926). Mold grows wherever there is an abrasion of the skin (Pearse 1921). The lack of resistance to *Saprolegnia* by Necturus is all the more amazing when one considers their constant exposure to it, and their remarkable ability to recover from severe mutilation (Eycleshymer 1906), if kept free from mold. Their tenacity of life ("vital principle") has been noted by Kneeland (1858) and Maximilian (1865). For the treatment of *Saprolegnia*-infested salamanders, Mellen (1927) recommends brushing the affected area with kerosene, followed by a clear-water rinse to remove the oil, the salamander then to be placed in a mud bath for a few weeks. I do not know how effective this treatment is for Necturus.

Local conditions may cause wholesale destruction of mudpuppies, as reported by Milner (1874). Evermann & Clark (1920), on finding considerable numbers dead along the shore, concluded that there is a brief period of unusual mortality among them, in the spring of the year.

Within their known range Necturus may be "not common" (Brimley 1920, Raleigh, N.C.). Extensive seining may not reveal many specimens even in areas where they are known to occur (Langlois, 1927, Au Sable River, Michigan). Or they may be "common" (Garnier, 1888, in Don River and Lake St. Clair; Hurter, 1893, Mississippi and Merrimac rivers; and many others). The classic examples of abundance are given by Milner (1874):

> The so-called "water lizard", *Menobranchus lateralis* Say is very numerous in some of the streams and portions of the lake shore. Mr. George Clarke, of Ecorse, Michigan, had a minnow-seine fitted to the bag of a sweep-seine, and at one haul took two thousand of the "Water lizards". Estimating the extent that the net passed over, he calculated the average number of lizards to each square rod to be four.
>
> A fisherman at Evanston, Ill., a few years ago, had nine hundred hooks set in the lake, and in one day took from these five hundred lizards, . . .

## Habits

Most of our knowledge of the habits of the mudpuppies is based on observations made in clear water. Here they hide during most of the day, concealed under any convenient shelter. Flat rocks, boards, logs, are perhaps preferred, but cracks between rocks, excavations in the banks of streams or dense weed beds may be used, as may also such exceptional items as cans, canvas, even an old hat! (Eycleshymer 1906; Evermann & Clark 1920). There are reports of mudpuppies which tried to hide in water-intake pipes, later issuing from the water-mains in town (Kneeland 1857; Riley 1872; Marshall 1892; Harrington 1903; Evermann & Clark 1920; Bishop 1923; Warfel 1936; Toner and St. Remy 1941).

The animals avoid sunlight (Kneeland 1858a). If not already hidden, they conceal themselves at the approach of a boat, so are not usually seen. They may be locally abundant but so well hidden as to escape detection. If a cautious approach is made, the hidden animals may be seen because they often hide all but the head and bushy red gills. When disturbed, the gills turn dark red, and are pulled down tight against the sides of the body. If their concealment is gently removed, the Necturus move slowly away, seeking a new hiding place; but if greatly disturbed, the animals will move rapidly away by walking or by swimming.

In walking, the diagonally opposite legs move in unison (Figure 1), and in rapid walking the tail swings from side to side thus aiding in the movement of the hind legs. These are moved with considerable rotary or circular motion at the shoulder and hip, giving the impression of a crank being turned. In swimming, the broad tail is lashed vigorously from side to side, the legs being held along the sides of the body.* Variations from this normal mode of locomotion have been reported. Kneeland (1858) said there did not appear to be any regular association of anterior and posterior extremities; that front legs and back

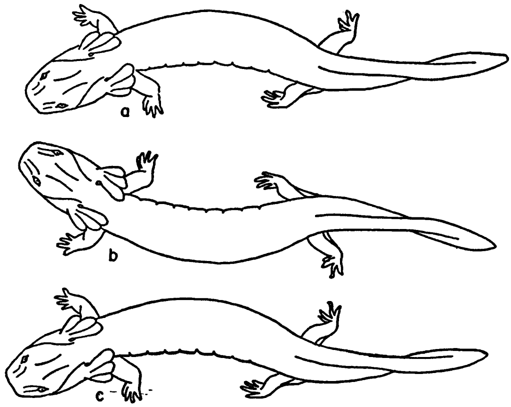


FIG. 1. Three successive postures taken by Necturus in walking: *a, b,* and *c*. For explanation, see Text.

legs are not moved alternately, but quite independently. Kneeland (1857) also reported that during swimming the specimens he observed kept their limbs stretched out at right angles as if to steady themselves.

In un-clear or weedy water, Necturus may be active throughout the day. Information on habits in such water has been gained by the times when Necturus bites at hooks, or can be dip-netted; this is at any time of day or night. Necturus is generally considered to be a nocturnal animal (Kneeland 1858; Allyn & Shockley 1939; and many others). They forage at night; then they are easily captured by dip-net or spear (Pearse 1921; Lagler & Goellner 1941) in the beam of a jack-light.

*Evans (1946) described two methods of locomotion in terrestrial salamanders. In slow movement, the legs are used, and the body is lifted from the ground. In rapid movement the salamanders "swim" over the ground with little assistance from the legs, though the legs make "walking" movements.

How much or how far the mudpuppies move about in search for food is not known. Cagle (1954) in trot-line operations collecting *N. louisianensis* noted an absence of random movement or wandering in this species.

The mudpuppies remain active at all seasons of the year in some localities; in other localities they may "disappear" seasonally. Maximilian (1865) said they bury themselves in the mud and silt in the winter, which may be true for some. But in most cases they do not hibernate (Kneeland 1857; Evermann & Clark 1920; Over 1923); at least, many remain active throughout the winter. They may be found in very cold water (Newman 1926), seemingly insensitive to the cold. Kneeland (1857) reported that his animals were frozen under an inch of ice every night for three months with no harm done, nor was there any decrease in activity. Reports of Necturus being caught by ice-fishermen are too numerous to catalogue. Evermann & Clark (1920) got 15 specimens from some boys who stunned the Necturus by hitting on the ice above them with a club.

Estivation seems a more likely occurrence than hibernation. Pearse (1921) quotes Alexander Nielsen to the effect that the mudpuppies bury themselves in the mud in the shallows of lakes to keep cool during the summer. Viosca (1937) supposes that most southern forms estivate. He suggests that the robust-bodied *N. m. maculosus* and *N. maculosus beyeri* hide under flat rocks, etc.; and that the other species, being better adapted in body form for burrowing, hide under leaves, or crawl into crawfish tunnels, or tunnels left by rotting of roots or by the activities of *Amphiuma.* Adult Necturus retreat to colder, deeper waters during summer, but larvae remain in the shallower, warmer water (Bogart 1952). Noble refers to a migration of adults to warmer water. Further, Necturus are seldom caught by fishermen in the warmer months (Maxmilian 1865; Allyn & Shockley 1939; Cagle 1954; and many others), in spite of greater fishing activity at that season. Allyn & Shockley (1939) reported that specimens taken in Indiana in the fall were gaunt and lean, while those caught in the spring were plump and meaty. They may fast during the summer. At any rate, these observations may help explain why fewer mudpuppies are caught on hook and line in the summer.

In aquaria the habits may be altered somewhat. The animals continue to avoid the light if possible. They lie quietly during the day, concealed by the best cover they can find. If there is no cover, they will seek the most shaded area. They become active at night, and may be vigorous enough in their actions to escape from tanks in which the water level is 1 foot below the rim. They may also be restless during the day, especially if the water in the tank is warmer than that to which they are accustomed.

Feeding captive Necturus may sometimes be troublesome. Brown (1928) could not get his animals to eat in captivity. Bennett (1937) fed his specimens on small earthworms (under four inches) and "small white worms," as well as on small pieces of beef and liver. Small larvae of *Amblystoma* and *Necturus* were quickly eaten. Meat dropped to animals in small cubic foot tanks was not eaten and had to be waved in front of the animal's nose with forceps; in large aquaria, meat was eaten over-night. Bennett reported that his Necturus, no matter how hungry, would not eat the eggs of white fish or perch. Some Necturus in tanks eagerly eat small fish. Conveniently, specimens can subsist for long periods without food.

Space requirements are easily met. Bennett (1937) kept a specimen in a 12-inch goldfish bowl for two years. I have kept specimens in wide-mouth gallon jugs for 6 months; and three of my specimens shared with apparent contentment 4 inches of water in a can 10 inches in diameter. Running water is not required for the maintenance of Necturus in tanks, though Mellen (1927) believed that it is required.

Within limits, freshness or pollution of the water seems unimportant to the Necturus as long as the temperature is favorable. Temperatures lower than 15.5°C. (Bennett 1937) or 18°C. (Sayle 1916) are most favorable for keeping Necturus. I have kept several specimens in gallon jugs (half-filled with water) in refrigerators where the temperature ranged from 5.5°C. to 13.3°C. At these temperatures the water does not have to be changed oftener than each two weeks.

Sudden changes in temperature may disturb some mudpuppies and not affect others, so long as the temperature does not exceed 30°C. (Sayle 1916). In water warmer than 30°C. the Necturus become hyperactive; their gills fan rapidly, and the animals struggle violently until, exhausted, they float belly-up in the water (Sayle 1916; Reese 1906). Death occurs at temperatures between 35° and 40°C. (Cole 1922). Davenport & Castle (1895) listed the death point for a "salamander" (genus not named) as 44°C.; the critical temperature for Necturus is well below this. Animals may be transferred suddenly from water at 0°C. to 18°C., or from 32°C. to 4°C. without apparent ill-effects (Reese 1906). As would be expected, animals changed from cold to warm water usually become more active. Animals changed to colder water usually show a temporary increase in activity, then become sluggish. The pattern is not consistent in all cases; that is to say, some become active, some become quiet when a temperature change is made.

Necturus is very sensitive to light; they are negatively phototropic. Specimens can be herded from one end to the other in a tank by the use of a flashlight (Bishop 1926). Even in light of 1 candle-meter intensity, the animals seek the dark. The whole body is light sensitive. Blinded animals respond as well as normal individuals to light stimulus (Pearse 1910); even decapitated larvae are negatively phototropic when light is directed on the tail (Eycleshymer 1908, 1914).

All parts of the Necturus body are sensitive to light (Reese 1906). The head is the most sensitive, the tail next; the whole belly side is light sensitive, but reaction to the light is slower. Reese observed no reaction to pure red light, yet light from a "red" bulb which had some yellow and green rays produced a fairly strong reaction. Head and tail were about equally sensitive to the "red" bulb. Blue light produced a decided reaction; head and tail were about equally sensitive. When light came from above, the head was more sensitive; when light came from below, the tail was more sensitive.

Light directed on the tail causes Necturus to move forward; light directed on the head usually causes the animal to move backward (Pearse 1910; Sayle 1916; Cole 1922). Reaction time varies with the part of the body exposed, the head area being most sensitive, the back area least sensitive (Table 1). Pearse (1910) in eyeless forms found the tail more sensitive than the head, probably due to injuries produced by the removal of eyes.

Table 1

Reaction times in seconds of various regions of the body to light, 144 C.M.

| Individual Number | Head | Pectoral Girdle | Back | Pelvic Girdle | Tail |
|---|---|---|---|---|---|
| 1 | 19 | 90 | 162 | 159 | 153 |
| 2 | 22 | 130 | 203 | 180 | 120 |
| 3 | 15 | 180 | 240 | 120 | 120 |
| Average | 18.6 | 133.3 | 201.6 | 153 | 131 |

(From Mary Honora Sayle, 1916, P. 99. A 144 candle-meter Nernst lamp was used; light passed through a ⅜ inch hole and directed on the part of the body named. Temperature was 21.11 - 23.89°C.)

Cole (1922) measured the time required for Necturus to crawl backward out of a beam of light 10 cm. in diameter and of 4,200 candle-meters intensity, directed upon the head; his data are shown in Figure 2. The same animals were blinded; 48 hours after their eyes were removed, the animals were tested again. The responses obtained were almost identical with the responses of the normal animals. Cole concluded, therefore, that the skin is more important than the eyes as a receptor for light. His data also show that reaction time is much slower at colder temperatures.

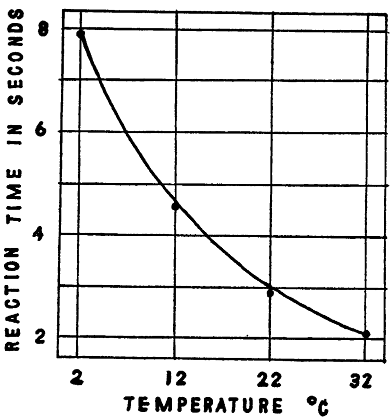


Fig. 2. Relation between temperature and reaction-time. Each data-point is the average of 60 trials (ten for each of 6 animals). Intensity of light, 4200 candle-meters. (Data from Cole, *Jour. Genl. Physiol.,* 1922).

Reactions to touch have been tested by Sayle (1916). The nostrils, head, gills, pectoral girdle, back, pelvic girdle, and tail are all sensitive to the touch of a wooden stick (size of a pencil) or glass rod. Animals are more sensitive to sharp instruments than to blunt. In the usual response, the animal moves forward, sometimes only an inch or two, although stimulation of nostrils and the mouth region may produce a backward jerk. The feet may be drawn in close to the body, and the tail may be strongly flexed; gills will usually be drawn close to the body. Nostrils, gills and tail are the areas most sensitive to touch; the dorsal region between the hind legs is least sensitive. When the hind legs are stimulated, they are drawn under the body, and the front legs start to walk.

The Necturus seem insensitive to a soft or "caressing" stimulus—or maybe they are deceived by it (as are many higher animals). A soft brush rubbed against the skin produces no response. In tanks, small fish (Kneeland 1858) or turtles (Bennett 1937), nibbling daintily, may remove all the fronds of the gills, without the Necturus showing the least annoyance or discomfort. Several *Palaemonetes* feasted upon the tail of one of my specimens, gently eroding the skin and muscle until the terminal three caudal vertebrae were entirely exposed. At no time did the Necturus "lose his head" over this disturbance; nor did I ever see him snap at the little shrimp.

Bennett (1937) put two specimens of *Triturus pyrogaster* (Japanese Newt) in an aquarium with Necturus. The newts bit at the spots on Necturus but seemed to cause no discomfort. Dawson (1920) clipped small pieces from the tail of non-anaesthetized Necturus without causing any apparent discomfort.

A general cutaneous, chemical sense is present. Definite response is made to many acids, alkalies, etc., when these are placed by pipette on or near the Necturus skin. Sayle (1916) tested the reactions to HCl, $H_2SO_4$, $NH_3$ and acetic acid; to KOH, ammonium hydrate, MgCl and $MgSO_4$; to alcohol*, clove oil, and turpentine. A definite response was noted to all these agents except turpentine. Responsiveness is roughly proportional to the degree of electrolytic dissociation, as well as to the concentration of the agent (Sayle 1916). Gills are the most sensitive area, with nostrils, head and tail sensitive in the order named.

Sometimes the mudpuppies rub their gills with their forefeet, passing them over the gills from above downward and forward, as if to cleanse them (Kneeland 1858). This action may be the result of a heavy infestation with *Sphyranura osleri*, an ectoparasite, which the Necturus on occasion try to rub off (Wright & Macallum 1887).

Bennett (1937) reported apparent dormancy, as follows: "Among the mudpuppies many peculiarities, perhaps the most mystifying, was that observed one evening when a specimen was found in a state of dormancy. The forelegs were raised, elbows high, the toes pointing forward, parallel to the black bands masking the eyes. To all appearances it seemed dead, except, as mentioned above, for the peculiar position of the forelegs. Normally the individual was very nervous, and could not be touched, but on this occasion it was gently pushed about with

*Necturus, like some humans, is deceived by dilute alcohol (10% or more dilute). They are less sensitive to alcohol than to acids and/or alkalies. An easy way to anaesthetize Necturus is to add alcohol a little at a time to the container in which they are kept, until they "pass out," presumably in a rosy glow.

a pencil. Finally it was turned upside down, and indeed the creature was thought to be dead, when suddenly it sprang to life and splashed about the aquarium apparently quite alarmed at being disturbed. This state of dormancy has since been frequently observed by the writer. It has been noticed with different specimens under various conditions."

## Men of Science in Texas, 1820-1880: II

*S. W. Geiser*

In the last issue of *Field & Laboratory* (26, 86-139) appeared the first 331 sketches (Abadie to Gilbert) of collectors, explorers, and observers, in a series that will extend through several issues. My fears of omissions were justified: I find that a sketch of Samuel Botsford Buckley (1809-84), a graduate of Wesleyan University in Connecticut, and twice State Geologist of Texas (1866-7 and 1874-5) was unaccountably omitted. This omission is the more notable since for twenty years I have been holding in abeyance the publication of a sketch of Buckley (on whom I have very extensive materials) waiting for a portrait of this naturalist to come into my possession. The series continues:

GILCHRIST, Dr. Edward, U.S.N. (1811-69) Dr. Gilchrist sent to the Boston Society of Natural History in 1869, two specimens of *Lycopodium lepidodendron* from Texas. At that time, Dr. Gilchrist was Inspector of Hospitals, U.S.N., stationed at the Naval Hospital at Chelsea, Massachusetts. He was born in Medford, Massachusetts, later moved to New Hampshire. He entered the naval service 26 January 1832 after attending the Dartmouth Medical School during the year 1828/9. Where he secured his M.D. degree I do not know. He served for fifteen years as surgeon on board naval vessels: on the U.S.S. *Peacock* off the coast of Brazil (1832/3); on the *Vincennes* of the Wilkes Exploring Expedition to the South Seas (1837-40); on the *Savannah, Levant* and *Portsmouth* (1843-48), and for shorter periods on a number of other vessels. From the complete service-record of Dr. Gilchrist, furnished me by the U.S. Navy Department, it is difficult to ascertain when he had an opportunity to make a collection of plants from the coast of Texas. Most of his cruises took him to others parts of the world. He was required to make but few reports, and this adds further to the difficulty of tracing his movements. . . . *Biographical materials*: Massachusetts Historical Society, *Proceedings* (II), 14, 1900, 81; Boston *Post,* November 8, November 9, 1869.

GIRARD, Dr. Joseph Basil, U.S.A. (*d. post* 1902) While assigned to the army post at Fort Davis, Dr. Girard sent (1880) a large package of plants collected near the fort to the Gray Herbarium at Cambridge.