

Arthur Stepka
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DEPARTMENT OF COMMERCE
BUREAU OF FISHERIES
HUGH M. SMITH, Commissioner

FROGS: THEIR NATURAL HISTORY AND UTILIZATION

By A. H. WRIGHT
Cornell University

APPENDIX VI TO THE REPORT OF THE U. S. COMMISSIONER
OF FISHERIES FOR 1919



Bureau of Fisheries Document No. 888

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BULLFROG (*RANA CATESBEIANA*). DESIRABLE SPECIES; ADULT, NATURAL SIZE.

FROGS: THEIR NATURAL HISTORY AND UTILIZATION.

By A. H. WRIGHT, *Cornell University.*

INTRODUCTION.

From time to time since Seth Green's day efforts have been made by our best fish-culturists to raise frogs; but in all this period no definite successful mode of procedure has been evolved. Some of these workers became^a "skeptical" and from "personal study and experience" were made "unbelievers." Others wrote about frog culture in an effort to supply information when they had nothing to give. Still others gave what little they had of value and commented:^b "We are just as glad as you are that this bullfrog story is finished." Finally, the most serious group^c announced complete success in "their preliminary experiments," and their efforts were sincerely appreciated by both the public and the culturists; but these experiments were abandoned.

Several writers have taken advantage of the public's intense desire for knowledge on this subject and have perpetrated all sorts of hoaxes and fakes on the credulity of their readers. Periodically some newspapers write of mythical "frog farms" for space fillers. Magazines occasionally accept similar articles, which should never have seen the light, and at present one must needs be on guard against the half-digested, hastily issued, worthless literature which would lead the uninitiated to believe the problem is entirely solved and that frog culture is wholly feasible. Too frequently the public seems to be fed on prettily written, fanciful speculation, and, as a consequence, frog culture receives much undeserved ridicule.

Notwithstanding all this deception and lack of definite procedure and in spite of the fact that little of importance has appeared to encourage it, the public continues to be vitally interested in the possibilities of frog culture. Many a reader of "The Virginian," after the dissertation on the "frawg business," has asked if there is really anything in it. The experiments which were started several years ago at the Pennsylvania State fish hatcheries aroused astonishing and widespread public comment. The commissioner of fisheries of Pennsylvania said:^d

The interest was confined not to Pennsylvania alone but extended to nearly all parts of the United States. Newspapers, trade papers, and magazines commented on

^a Mather, Fred: *Modern fish culture in fresh and salt water*, pp. 301, 302. New York, 1900.

^b Dyche, L. L.: *Ponds, pond fish, and pond-fish culture*, p. 158. State Department of Fish and Game. Kansas. Topeka, 1914.

^c Report, Department of Fisheries of Pennsylvania from December, 1904, to Nov. 30, 1905, p. 51. Harrisburg, 1906.

^d *Loc. cit.* pp. 51, 52.

our work in this direction at considerable lengths, and all approvingly. Letters from private citizens were received from nearly every State in the country asking for further information. These were followed by communications from fish commissions and fish-culturists in the same vein.

In former years, at the sessions of the fishery and fish-cultural societies, frog culture was a frequent topic of inquiry, though not of extended discussion. To-day the U. S. Bureau of Fisheries receives countless inquiries and requests for literature, for information, and for possible sources of breeding stock, and this report is written to supply the information which must precede all careful experimental work on frog culture.

The difficulties encountered in many of the preceding efforts have arisen from lack of knowledge of the natural history of our native species of frogs. Such knowledge is an absolutely necessary premise to intelligent, successful endeavor. Often the best of the previous experimenters were not sure whether they had bullfrog or leopard-frog spawn, and thought that possibly the bullfrog bred twice a year when it breeds but once a year, or considered that bullfrog tadpoles transformed the same year they were hatched or in the following spring, neither of which conditions obtains. A careful critical study of most of the previous efforts reveals uncertainties of this sort, one of the most marked of which is the lack of positively identified stock with which to begin. Here, as in every other farming enterprise, it is necessary to have the seed or stock true to name. Fortified with this precaution and equipped with some of the cardinal points in the life history of the species to be raised, the prospective frog culturist stands a far better chance of success than in a blind "hit-or-miss" endeavor.

COMMERCIAL FROG HUNTING.

SOURCE OF SUPPLY.

The market is yet solely reliant upon the natural supply of frogs. Of this industry, previous to 1900, F. M. Chamberlain, of the U. S. Bureau of Fisheries, remarked as follows:^a

The business of taking frogs for market has greatly increased in recent years. It is now carried on in all sections of the United States and is of economic importance in about 15 States, while in nearly all the remaining States and Territories frogs are taken for local or home consumption [in quantities] of which it is impossible to get a statistical account. The States supplying the largest quantities for the markets are California, Missouri, New York, Arkansas, Maryland, Virginia, Ohio, and Indiana. More frogs are taken in New York than in any other State, but on account of their comparatively small size their value is less than in Missouri and California. The Canadian Province of Ontario also yields a rather large supply of market frogs. As ascertained by inquiries of the U. S. Fish Commission, the annual catch in the United States is but little less than 1,000,000, with a gross value to the hunters of about \$50,000. The yearly cost of frogs and frog legs to the consumers is not less than \$150,000.

The localities in which especially important frog hunting is done are the marshes of the western end of Lake Erie and Lewis and Grand Reservoirs, in Ohio; the marshes of the Sacramento and San Joaquin Rivers, Calif.; the valley of the Kankakee River, Ind.; Oneida Lake, Seneca River, and other waters of northern New York; and the St. Francis River and the sunken lands of the Mississippi River, in Arkansas and Missouri.

* * * The prices received for frogs vary greatly and depend on the condition of the market, the size of the frogs, and the locality. Dressed legs yield the hunters from 12½ to 50 cents a pound, and live frogs from 5 cents to \$4 a dozen. In the Kankakee Valley, Ind., for example, the prices received by the hunters are 75 cents a

^a A manual of fish-culture based on the methods of the U. S. Commission of Fish and Fisheries. Revised edition, pp. 252, 253. U. S. Commission of Fish and Fisheries, Washington, 1900.

dozen for large frogs, 10 cents a dozen for medium-sized frogs, and 5 cents a dozen for small frogs, while in San Francisco the market price is \$3 to \$4 a dozen.

To the above list of States yielding a considerable supply of frogs in 1900 there should be added Illinois and Minnesota. Of the latter C. H. Townsend writes:^a

The most valuable product of these fisheries is the frog, the value of the catch in 1899 constituting nearly one-fourth of the entire fishery yield of the State. The species taken is the "meadow frog," which is quite small, the average weight being between 1 and 2 ounces each. * * * Professional frog catchers are said to make from \$5 to \$10 per day during the best of the season. Most of the catch is shipped direct to Chicago.

The frog industry in this State was started about 1895, and has grown in importance. In 1899 over \$5,000 worth were taken in the vicinity of Minneapolis alone. Litchfield was the next greatest frog-producing center in the State that year. In 1900 this industry had shifted from the latter place to Smith Lake, where one dealer purchased over \$5,000 worth during the year.

By the year 1900, then, the following 10 States contributed a large proportion of the market frogs of the country: California, Missouri, New York, Arkansas, Minnesota, Illinois, Maryland, Virginia, Ohio, and Indiana.

In 1908, 250,000 pounds of frogs' legs, with a value of \$42,000, were reported for the whole of the United States.^b The 13 States which furnished this total were:

States.	Quantity.	Value.	States.	Quantity.	Value.
	<i>Pounds.</i>			<i>Pounds.</i>	
Missouri.....	67,000	\$11,000	Tennessee.....	5,000	\$1,000
Minnesota.....	66,000	7,900	Ohio.....	4,000	600
Louisiana.....	38,000	4,500	Virginia.....	3,000	700
Arkansas.....	27,000	4,000	Iowa.....	2,500	300
Illinois.....	25,000	6,800	Delaware.....	1,900	700
Wisconsin.....	14,000	2,600	Maryland.....	1,000	500
North Carolina.....	5,400	900			

At least 8 of these 13 States are along the Mississippi River, and 6 of them fall wholly within that district. The Mississippi River division contributed 193,000 pounds; the Gulf of Mexico division, 38,000 pounds; the Great Lakes division, 17,000 pounds; and the Atlantic coast division, 11,000 pounds. Thus it is apparent that the Mississippi River States are becoming more important in commercial frog hunting. Before 1900 Missouri and Arkansas were the principal States in this region furnishing frog legs. By 1900 Minnesota and Illinois were added to the list, and by 1908 Louisiana, Wisconsin, Tennessee, and Iowa began to contribute appreciable quotas.

In the previous summation New York does not appear, but in 1915 and 1916 in the Oneida lake region the following is noted:^c

[One firm conducted] a gross business of about \$15,000 per year in frogs alone. One customer bought between June 1, 1915, and March 1, 1916, \$1,687.50 worth of frogs' legs. When sold per hundred, live weight, large and small, the price ranges from 30 cents to \$1.50 or averages \$1.05. The legs sell per pound, large and small, from 10 to 50 cents, and average 35 cents per pound. An expert can dress between 1,500 and 1,600 frogs per hour, but an average rate is about 1,000 per hour.

^a Townsend, C. H.: Statistics of the fisheries of the Mississippi River and tributaries. Appendix to Report of the Commissioner, U. S. Commission of Fish and Fisheries for 1901, p. 726. Washington, 1902.

^b Fisheries of the United States, 1908, pp. 26, 28, 33, et seq. Washington, 1911.

^c Adams, Chas. C., and Hankinson, T. L.: Notes on Oneida Lake fish and fisheries. Transactions, American Fisheries Society, Vol. XLV, No. 3, June, 1916, p. 163. New York.

METHODS OF CAPTURE.

There are various methods of capturing frogs. The boy's favorite device is the fish pole, with the line baited with red cloth, worms, grasshoppers, or other insects; and this method is yet frequently employed by the market hunter. A more common method, however, is clubbing. Many of us as boys used to choose a good strong club about walking-stick length. With this instrument we skirted the edges of the swamps, lakes, or marshy creeks in the spring or early summer, traversed the clover or hay fields of the uplands in July about cutting time, or hunted in the wet lowlands a little later. Some of the men and boys occasionally put nails in the end of the club, but this more cruel method avails little. The frogs which were killed were put into a bag or strung on a cord by loops tied about their loins. They were dressed immediately after the trip.

[In Minnesota]^a frogs are also taken by sticks and gunny sacks. In using sticks the frogs are usually killed and then sold in a dressed condition for food. Gunny sacks in a wet condition are used in their capture by being thrown over the frogs. Frogs are kept alive for market in gunny sacks placed in running water and covered with hay or straw to keep out the frost.

Some expert froggers are very adept at catching them alive by hand. A frog catcher will hold one hand over or in front of the prey to attract its attention and capture the game by a sudden movement of the other hand.

Several methods are based on the migration of the frogs in the fall or spring. In the central New York region in late September, through October, and even in November, frogs are frequently encountered working their way down the hills toward the swamps around or at either end of some of our Finger Lakes. Many reach the swamp in the fall, and many winter in the ravines and enter the swamps in the spring. In many cases State roads or other similar and partial barriers skirt our lakes—that is, steam railroads, electric railways, etc.—and the frog catchers make use of these. A calcium-carbide can or a barrel placed at the swamp end of a culvert may yield numerous frogs which are traveling down the ravines, and the swamps or ditches dug at the base of the hills and at the swamp's border may give good returns.

[In Minnesota]^a frogs are caught in various ways, but chiefly in pits dug between sloughs and the adjoining high grass. The season for their capture in this manner is usually in the fall, when they are returning to the water. These pits are about 3 feet long, 2 feet wide, and 2 feet deep.

There are many other variations of this pit, posthole, ditch, or excavation method. In Oneida Lake an outgrowth of the pit and can methods is the use of screens.

[This form of capture]^b is used in the fall when the frogs migrate from the fields and swamps toward the lake for hibernation. This migration is not regular, it takes place mostly at night, particularly during warm rains, after a light frost. Taking advantage of this migrating behavior, cheesecloth screens, about 18 inches high, supported by sticks, are placed along the shore to intercept the migrating frogs. At intervals of two or three rods nail kegs, carbide cans, or posthole-like excavations entrap the frogs which, failing to surmount the screen, wander along it and fall into the traps. The frog catcher has only to collect the frogs from those traps. Late in the season one may find various sized frogs, mice, and other small mammals drowned and frozen in these small wells.

^a Townsend, C. H.: Loc. cit., p. 726.

^b Adams, C. C., and Hankinson, T. L.: Loc. cit., pp. 161, 162.



FIG. 1.—GREEN FROG (*RANA CLAMITANS*). DESIRABLE SPECIES; NATURAL SIZE.



FIG. 2.—"WESTERN BULLFROG" (*RANA AURORA*). DESIRABLE SPECIES; NATURAL SIZE.

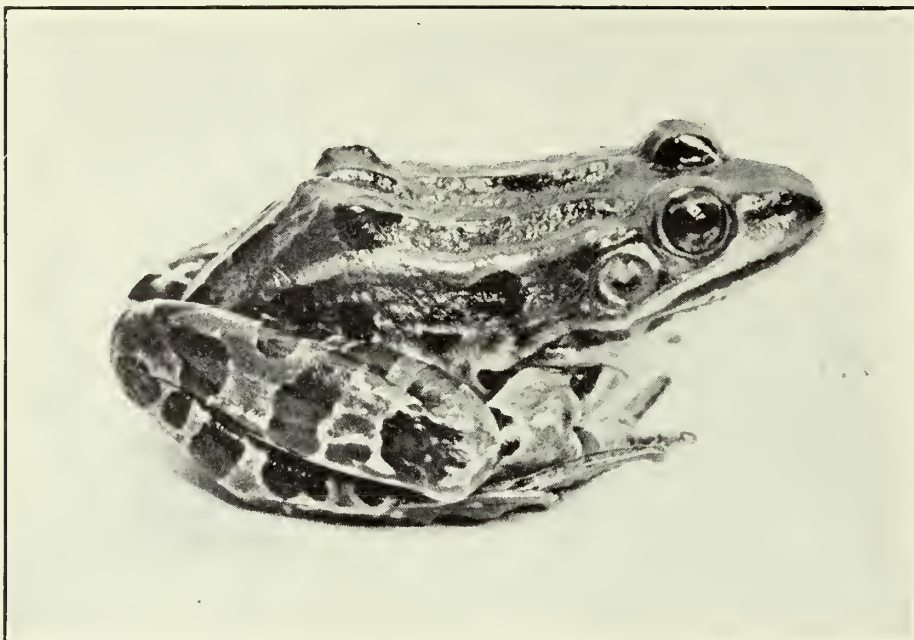


FIG. 1.—LEOPARD FROG (*RANA PAPIENS*). DESIRABLE SPECIES;
NATURAL SIZE.



FIG. 2.—PICKEREL FROG (*RANA PALUSTRIS*). DESIRABLE
SPECIES; NATURAL SIZE.

The screens have to be placed far enough back from the lake shore to avoid water rising too near the surface and thus destroy the traps. On the swampy ground the holes are similarly obliterated by the water. To overcome this difficulty, Mr. A. W. Thierre, of Lower South Bay, has devised a trap of woven wire screen; with a one-half-inch mesh. If this trap was placed at an opening in the screen, which is not the case, it would allow the undersized frogs to escape and to reach the lake and find proper winter quarters, while the screens tend to destroy both the smaller kinds of frogs and immature individuals of the larger species. This wire trap has an inclined surface up which the frogs crawl, and from which they fall into the trap cavity, and from which they seldom escape. Thierre also uses a large minnow box to store his frogs until delivery to the dealers.

By means of the screens and traps a single night's catch may amount to about 500 pounds, from about a half mile of screen in a good locality. As much as \$70 has been paid for a single catch.

In many regions, as in central New York and elsewhere, the professionals come to know where the frogs hibernate and often dig them out of the mud in large numbers. In the Erie Canal, after the water is withdrawn, many frogs are taken from the mud or even from beneath the ice of some of the pools.

A favorite method of capture at night is to use a bull's-eye or any form of bright light. The frogs are dazed and in most cases can be caught by hand or approached near enough for their easy dispatch. Sometimes in the deeper waters and swamps two men are needed for this form of capture, one to row the boat and the other to locate and shoot the prey. The lantern may be on the prow of the boat, carried in the hand, or worn on the head, as with alligator hunters. The rifle and spear and gig are used mainly in Illinois, Arkansas, Missouri, and Tennessee. The spear may be one of several sorts, three-pronged or single, or merely a nail or a straightened fishhook in the end of a pole.

COMMERCIAL FROGS.

DESIRABLE SPECIES (PLS. I, II, AND III).

The six eastern edible species fall into two groups of three each:

Those with more or less uniform dorsal coloration on the back, and with an eardrum larger than the eye in the male, namely, the green frog (*Rana clamitans*), the bullfrog (*R. catesbeiana*), and the southern bullfrog (*R. grylio*).

Those which are blotched or spotted on the back and with the ear of the male not larger than the eye, namely, the leopard frog (*Rana pipiens*), the southern leopard frog (*R. sphenoccephala*), and the pickerel frog (*R. palustris*).

In the western States three species enter into commercial catches. They are the yellow-legged frog (*Rana boylei*); the western frog (*R. pretiosa*); and the "western bullfrog" (*R. aurora*).

The above nine forms are all true frogs (*Rana*) which have teeth on the upper jaw, no adhesive, enlarged disks on the ends of the fingers and toes, and no large parotoid gland back of each eye. Most of them are smooth of skin, and all reach an adult length of at least 3 inches, not counting the hind legs.

EASTERN SPECIES.

✓ GREEN FROG.—The green frog (Pl. II, fig. 1) is larger than a leopard frog and has two ridges down its back. The forward upper parts are bright green; the posterior region, brown or olive. The under

parts are white, with some marbling; in the male the throat is yellow. This species reaches $3\frac{1}{2}$ to 4 inches or more in length and extends in range from the Gulf of Mexico to Hudson Bay, occurring in practically all of eastern North America.

BULLFROG.—The bullfrog (Pl. I) is much larger than the green frog, and the two are often confused. The bullfrog has no ridges down either side of its back. On its upper parts it may vary from yellowish green to a dark brown, while its under parts are yellowish white, with some mottlings. In size it may reach 8 inches, and its range is from eastern North America to the Rockies.

THE SOUTHERN BULLFROG.—The southern bullfrog is quite similar to the common bullfrog and varies from brownish olive to bone brown or blackish brown above, with some prominent, scattered black spots. The under parts often have a network of black or brown and yellow, one of the most striking ventral colorations of any North American frog. This species has a more pointed snout than the bullfrog, possesses a narrower head (measured at the eardrums), and has all the hind toes except the fourth proportionally longer than the same toes of the bullfrog. Of this form, the author has taken no specimens over 5 or 6 inches in length, while the extreme for the bullfrog may be much more. The known range of the southern bullfrog is in the extreme southeastern United States.

LEOPARD FROG.—The leopard frog or meadow frog (Pl. III, fig. 1), the most widespread and most common form of North America, has all the under parts white or whitish. On either side of the back is a prominent fold, which is narrower and higher than in the pickerel frog. Between these two main folds sometimes there are other smaller folds. The spots between the two folds are irregular in outline and in position, are not necessarily opposite, and occupy less space than the background color, which varies from bronze to green. The spots below the lateral fold are less regularly placed and never so large as in the pickerel frog. The leopard frog reaches a length of $3\frac{1}{2}$ to 4 inches and is found from the Sierra Nevada Mountains eastward and from the extreme north to Mexico.

THE SOUTHERN LEOPARD FROG.—The southern leopard frog is very similar to the common leopard frog and varies from it in a very few characters. It usually has a distinct white spot in the middle of the eardrum, unlike the leopard frog, in which it is generally absent. Then, the head of the southern form is contained 2.5 times, or less than 3 times, in the length of the head and body combined, while the common form has it 3 to 3.5 times. Furthermore, in the southern species the snout is acuminate or pointed and is contained about 1.5 times in the head, while in the other form the snout is less pointed and is contained 2 or more times in the head. This species may reach the size of a common meadow frog and occurs in the southern States.

PICKEREL FROG.—The pickerel frog (Pl. III, fig. 2), in life has the under parts of the legs and belly orange yellow. On either side of the back is a broad, low fold of skin. Between these folds there are two regular, more or less opposite, rows of dark, squarish spots, which occupy far more of the back than the light-brown, ground color. Below each back fold the spots are larger and more regular than in the leopard frog. The pickerel frog reaches a length of 3 to $3\frac{1}{2}$ inches and is found from the central plains to the Atlantic seaboard and from the Gulf of Mexico to Hudson Bay.



FIG. 1.—SPADEFoot (SCAPHIOPUS HOLBROOKII). POSSIBLE SPECIES;
NATURAL SIZE.

(After Overton. Mus. Brooklyn Inst. Arts and Sci. Sci. Bull., Vol. 2, No. 3.)



FIG. 2.—COMMON TOAD (BUFO AMERICANUS).
POSSIBLE SPECIES; NATURAL SIZE.



FIG. 3.—WOOD FROG (RANA SYLVATICA).
POSSIBLE SPECIES; NATURAL SIZE.

WESTERN SPECIES.^a

The western species are somewhat confusing. At present Camp (1917) recognizes three species, while Cope (1889) held there were four.^b The three species are *Rana boylei*, the yellow-legged frog; *Rana pretiosa*, the western frog; and *Rana aurora* (both *aurora* and *draytoni*), the so-called "western bullfrog."

YELLOW-LEGGED FROG.—The yellow-legged frog has the ear or tympanic region not darker than the rest of the head, possesses no red in its coloration, and has the fold along the upper lip colored like the rest of the body. These creatures are $2\frac{1}{2}$ to $3\frac{1}{2}$ inches in length and occur in California. They have been less used for food because of their skin secretions.

WESTERN FROG.—In the western frog the hind leg, when brought forward along the body, has the inner angle of the bent heel reaching to the eye or nostril, but never beyond. The back and top of the head has prominent, inky-black spots. This species attains a length of 3 to 4 inches and extends from Nevada and northern California throughout Oregon and Washington to Alberta and east into Montana, Wyoming, and Utah.

"WESTERN BULLFROG."—The "western bullfrog" (Pl. II, fig. 2), unlike the western frog (*R. pretiosa*), has no inky spots on the back and top of the head, and the heel reaches to or beyond the nostril. These creatures may have their skin very smooth (*aurora*) or roughened (*draytoni*), have the lateral folds of the back indistinct (*aurora*) or prominent (*draytoni*), possess unspotted or dotted backs (*aurora*) or have regularly placed, light, centered spots (*draytoni*), be medium, 3 inches long (*aurora*), or large, 4 inches (*draytoni*). The "western bullfrog" extends from Puget Sound to Lower California.

These last two forms, the western frog and the "western bullfrog," usually have the tympanic region darker than the rest of the head, red often present in the coloration, and the fold along the upper lip usually white or lighter than the rest of the head.

POSSIBLE MARKETABLE SPECIES (PL. IV).

There are several species of true frogs which are smaller, such as the wood frog and its relative, the northern wood frog; the mink frog (*Rana septentrionalis*) of extreme northeastern United States and Canada; the carpenter frog (*R. virgatipes*) of New Jersey and the Carolinas; or the local and rare gopher frog (*R. aesopus*) of Florida. It will, doubtless, never become feasible to use these species in frog culture.

The *wood frog* (Pl. IV, fig. 3) is either light or reddish brown above, with a darker brown streak or mask on either side of the head. Underneath it is a glistening white. The *northern wood frog* is like the wood frog; but the length of the hind leg to the heel does not exceed the combined length of the head and body, while in the

^a The author is indebted to Charles Lewis Camp's "Notes on the systematic status of the toads and frogs of California" (University of California Publications in Zoology, vol. 17, No. 9, pp. 115-125, Feb. 3, 1917, University of California Press, Berkeley) for most of what follows on the western forms. The author also has specimens from the Pacific coast collected by Profs. J. C. Bradley, W. A. Hilton, A. C. Chandler, and the writer.

^b Cope, E. D.: The Batrachia of North America. U. S. National Museum Bulletin No. 34, 432-447. Washington, 1889.

wood frog it does. The *mink frog*, like the bullfrog, has no fold of skin on either side of the back, one joint of the fourth toe is free of web, and the male has the eardrum larger than the eye. This form is small, the body being from 2 to 3 inches in length. The mink frog is light olive with irregular spottings on the posterior back and sides, with the hind legs spotted or banded. The *carpenter frog* has no lateral folds, two joints of the fourth toe are free, and the animal is brownish, with four yellowish or golden-brown, longitudinal stripes on the back. The under parts are yellowish white, with alternating dark and light stripes on the hind legs. The *gopher frog*, unlike the pickerel and leopard frogs, has a hind leg to heel length shorter than the total length of the head and body and has its spotted dorsal skin also quite warty.

The *spadefoots* (Pl. IV, fig. 1),^a with vertical pupils and sharp spades on their hind feet, are almost large enough to be of value in the market, but are uncertain in habits. The *toads* (Pl. IV, fig. 2), with parotoid glands just back of the eye and with warty skins, may some day serve as food, though a greater prejudice will have to be overcome than in the case of the frogs.

UNDESIRABLE SPECIES.

The tree frogs, with no parotoid gland back of the eye and with disks on the fingers and toes, comprise most of this class. The males of these creatures can always be told from true-frog males, because the area under the chin is always colored darker or differently from the rest of the under parts, while true frogs rarely have such a coloration. Rarely a male green frog or other species may have a yellow or another color under the chin, but it is not sharply indicated, as in the tree frogs, and does not appear discolored.

Common among these tree frogs are some with small disks and a length of 1 inch or less; namely the *cricket frog* (*Acris gryllus*) with a triangle between its eyes, webbed feet, and prominent, alternating, dark and light longitudinal bands on the back of the thighs; and the *swamp cricket frog* (*Pseudacris*) with webs small or absent and with a more or less smooth skin.

The tree frogs proper, with large disks, are several in number, of which the peeper, the tree toad, the Carolina tree frog, the Florida tree frog, the Pacific tree frog, and the southern tree frog are most common. None reach much beyond 2 or, at the most, 2½ inches in length. The brownish and smooth *peeper* (*Hyla crucifer*) (Pl. XXII, fig. 16), is recognized by an X-shaped mark on its back. The *tree toad* (*H. versicolor*) (Pl. XI, fig. 3) of the eastern United States is grayish brown or green; is rough of skin; and has a light spot below the eye and a network of dark and yellow on the posterior part of the thighs, while its relative of the southwest (*H. arenicolor*) has no network on the thighs. The tree toad of the piney woods (*H. femoralis*) has the posterior surface of the thighs, with round yellowish or white spots, but not a reticulation or network. The *Carolina tree frog* (*H. cinerea*) is grass-green above, with a straw-colored stripe along the side of the head and body, while *H. evittata* of Maryland and Virginia has no such stripe. The green of Anderson's tree

^a See footnote, p. 22.

toad (*H. andersonii*) is bounded beneath by a white line and this by a purplish brown or purple color. The *Florida tree frog* (*H. gratiosa*) of Florida and Georgia, the largest ($2\frac{1}{2}$ inches long) of all our tree frogs, has many roundish spots on its dorsal surfaces and very large disks. The *Pacific tree frog* (*Hyla regilla*) and the *southern tree frog* (*H. squirella*) have the thighs with no particular color pattern, are not pure green on the back, like the Carolina tree frog, and have the body not so slim as in this form. One occurs on the Pacific coast and the other in our southern States.

Our *narrow-mouthed toads*, unlike the true frogs, have no teeth in the upper jaw, are never 2 inches in length, have the eardrum hidden, and possess a peculiar fold of skin on the top of the head.

CULTURE OF FROGS.

BREEDING HABITS.

Those frogs which appear in the early spring usually begin croaking at once and proceed to pair and ovulate with little or no intervals between appearance and egg laying, while those which appear last wait for longer periods between emergence and croaking and between croaking and ovulation. It has been much in vogue to say of many species that they breed "in early spring," but many of our forms of which this has been said do not breed until summer. The males in many cases resort to the breeding grounds before the females, and the females may wait until their eggs are ripe before they enter the water. Or, as is the case with some toads, the two may meet on the trip to the water and become mated before the destination is reached. The croaking or mating male seizes the first female within reach and maintains his embrace until the eggs are laid. Sometimes in gregarious species six or eight males strive for one female, and often the female is killed. Fertilization comes exactly at the extrusion of the eggs or slightly after it.

At first no envelopes about the eggs are apparent and the egg mass may feel soft and sticky. After a few minutes this substance absorbs water, and each egg then is revealed to be a spherical body closely surrounded by a membrane and by one or two jellylike envelopes. (See fig. 1.) Some eggs have only the inner envelope present. This gelatinous substance comes from the oviduct and forms, when swollen, the egg capsules, tubes, bands, films, or masses to which we are so accustomed. The egg masses (Pls. XIII to XIX) are spherical in the wood frog, the pickerel frog, and in some of the other true frogs; plinthlike in the leopard frog and southern leopard frog; a spiral in the various toads; a surface film in the green frog, bullfrog, and tree toad; and a submerged film or mass in the swamp cricket frog. In the peeper and cricket frog the eggs are separate. The wood, pickerel, and leopard frogs lay their whole complement in a short time; the film form of the green frog, bullfrog, and tree frog takes longer, the first two maintaining the same position and the latter moving about during the process. With the toads and spadefoots some time is consumed in laying their spirals or bands. In the peeper several hours may transpire before the eggs are all laid.

DEVELOPMENT AND TRANSFORMATION.

The eggs hatch in from 3 or 4 to 25 days, depending on the temperature conditions. At hatching, the larvæ have a distinct neck, with a prominent head and body. The tail is very small or absent. On the ventral side of the head is an invagination or depression which is to be the mouth. Behind this comes the ventral adhesive disk or disks, which help the little creature to attach itself to the egg mass or to hang itself upon some plants. In front of the mouth are two deep, dark pits which later become the nostrils. On either side of the head appear swellings which become the external gills. The eyes do not yet appear.

As development goes on the external gills appear as branched organs, two or three on a side; the eye shows as a ring beneath the skin; and the tail grows and presents a middle muscular portion where the muscle segments clearly show. This middle part supports a thin, waferlike tail fin the parts of which are called, respectively, the lower and upper crests. The nasal pit shifts in position and becomes the nostril, and the vent opens. The mouth appears, and dependence on the yolk of the belly ceases. Soon the external gills begin to disappear, a lateral flap or fold of skin connects the head with the body, and the neck region disappears. Beneath this fold internal gills develop. On the left side, the lateral flap does not close completely, but leaves an opening, the spiracle. The water passes into the mouth over the internal gills and out this hole on the left side. On the mouth a membranous, fringed lip, with upper and lower portion, comes into being. At the portal are horny jaws or mandibles. On the upper and lower portions are rows of horny teeth. The eye is no longer a covered pigmented ring, but is now at the surface. The intestine has become much elongated and coiled. The buds of the hind limbs begin to appear. The fore limbs start to develop beneath the skin. When the hind limbs have reached considerable size the left arm comes out through the spiracle and the right arm breaks through the skin.

The process of transformation is now on. The tail crests decrease in size, and the creature begins to live on its tail; that is, absorbs it. The gills vanish, and the lungs begin to serve as the sole respiratory organs, if the skin be not considered. The eye assumes eyelids. The tadpole mouth fringe, with its horny jaws and horny teeth, is discarded, and a true frog mouth begins to appear. The long intestine becomes wonderfully shortened, and the small frog, with a vestige of a tail, is ready to leave the water. This process is termed transformation or metamorphosis.

SELECTION OF STOCK.

Most of the inquiries which the Bureau receives center about possible literature concerning frog culture or about the supply of breeding-frog stock, frogs either unmated or mated, eggs, or tadpoles. At the present time no supply bureau or hatchery can offer certified eggs or tadpoles of a particular species, and rarely can mated pairs be supplied. Some of the dealers in zoological supplies and some hatcheries can furnish frogs and might at certain seasons offer to furnish mated pairs. But such, which are paired in captivity, would



FIG. 1.—HABITAT OF THE LEOPARD FROG; A LARGE CAT-TAIL AND SEDGY SWAMP.



FIG. 2.—HABITAT OF THE PICKEREL FROG; THE BACKWATER OF AN UPLAND STREAM.



FIG. 1.—HABITAT OF THE GREEN FROG; A PERMANENT POND (FOREGROUND) NEAR A STREAM (BACKGROUND).



FIG. 2.—HABITAT OF THE BULLFROG; A MILL POND FILLED WITH STUMPS, FALLEN TREES, ETC.

usually be undesirable; they might lay in transit, break the embrace en route, or never lay at all, as is generally the rule. A more extended discussion of the five or six groups of stock follows: (1) Individual frogs; (2) mated pairs; (3) eggs; (4) tadpoles; and (5) transition stages.

INDIVIDUAL FROGS.

In many ways it might appear that the easiest and most certain method of securing stock would be to begin with the individual frogs. To be sure, they are to be found throughout the active period of the year—that is, from the early thaws of spring to the hard frosts of fall—but one must know their breeding season or he may carry them almost a year before the first eggs are secured. If the material come from a supply bureau, there is no certainty as to the period of previous captivity, the amount of freedom the frogs had in such quarters, etc. Frequently it has been found that with the leopard frog, green frog, and bullfrog the males were first captured and the females taken later, sometimes two or three weeks afterwards. To hold the males in captivity or in close quarters tends to reduce their breeding potentiality. Or, if females be captured just before breeding and be brought into the hatchery to await the subsequent capture of impulsive breeding males, the chances are that in rare cases the female may lay without the male, or that, by the time a pair or pairs are mated in the laboratory or hatchery, one or the other member may be weakened, and the pair may continue in the embrace several weeks until the death of one or both individuals. In most cases such a mated pair proves unfruitful. Over and over again has the writer taken gravid females and mated them with captive males or with males subsequently taken, and in almost every instance no eggs were laid or, if so, they were frequently infertile.

If, however, the experimenter has a good pond or water inclosure, with more or less natural conditions, he might stock it with individual frogs and not encounter the above difficulties so inherent in confining frogs in close quarters. If the prospective culturist wishes to start with the individual frogs, he must choose or determine what species he prefers or what his region offers. At present the four principal eastern species for the frog market are the leopard frog, the pickerel frog, the green frog, and the bullfrog.

If the leopard frog be chosen, the person who purposes to breed this species can usually secure enough frogs from the swampy marshlands (Pl. V, fig. 1), or backwaters and overflow ponds of streams in his own neighborhood. The leopard or spring frog appears from its hibernation in the muddy bottoms of our marshes and ponds when the streams have just freed themselves of ice and the lowlands are overflowing. When the temperature of the water reaches 41 to 50°, they may confidently be expected to appear in numbers.^a From the middle of March to the middle of April is the period in which to expect them to appear for breeding. In early spring, whenever a low guttural croaking is heard in swampy stretches, it is that of the leopard frog. The croak is wholly unlike the shrill notes of the peeper and swamp cricket frog or the short

^a The dates of first appearance, spawning, etc., of the commercial species were determined for the latitude of Ithaca, N. Y., but might well apply for northeastern United States if not for all of northern United States.

rattlelike note of the wood frog, all three of which are frogs too small to be considered commercially.

In the shallow water, along the edges of swamps, or on the banks of dead streams or backwaters one can find many leopard frogs. In the early spring—in fact, at all times during the breeding period—they can best be taken at night with an electric flashlight or acetylene lamp, lantern, or jack of any kind. Later in the spring the frogs are more easily captured during the day. To be sure that the captor has individuals of both sexes, he must be able to distinguish them. The male of a leopard frog has the thumb of the fore foot much enlarged on the inner edge and has a vocal sac between each ear and shoulder. These vocal sacs can be demonstrated by seizing the frog around the waist just in front of the hind limbs and alternately squeezing and relaxing the pressure. In this way a male will inflate the sacs. The ripe females are very gravid and swollen and have no vocal sacs and no enlarged thumbs. It seems advisable to have an equal, or preferably greater, number of males than females to insure all the females being mated. It seems to be the condition at the sexual congresses of this species that the males exceed the females in number. Of course there is some evidence that a male may mate the second time in a season, but this is not fully established. Frequently the author has put his captives in close quarters to obtain quick matings and then placed the pairs in the pond or inclosure meant for the breeding purposes. To keep them mated more than two or three days at the most in the laboratory or hatchery may result in a long embrace, and this defeats the purpose of the operation. If the culturist plans to begin with adult breeders, he can secure individuals of this species without great difficulty, because it is so gregarious at the time of the breeding assemblies; he will have a little more difficulty in locating the smaller gregarious breeder, the pickerel frog, and doubtless even a lesser measure of success in the case of the more solitary green frogs and bullfrogs.

It is yet a doubtful question whether the pickerel frog will become as important a commercial form as the leopard frog, green frog, or bullfrog. It is slightly smaller than the leopard frog, and the acrid secretion of its skin may militate against its availability. Whoever wishes to experiment with it will not find it in exactly the same habitat as the leopard frog. The leopard frog is essentially a frog (in its greatest abundance) of the cat-tail swamps, sedgy marshes (Pl. V, fig. 1), and grassy overflows (Pl. VII, fig. 1), while the pickerel frog is more often found in sphagnum bogs, marl ponds, cold streams, in the shallows of mill ponds, or in the quiet waters of bayous (Pl. V, fig. 2), away from the currents of our clear streams. It usually appears from hibernation about the same time as the toad and later than the leopard frog. When the air temperatures approach 48 to 58°, pickerel frogs begin to appear and become numerous at 58 to 67°. They hibernate in the water, and when it reaches 45 to 53° they come out of their winter sleep. In point of time this outcoming occurs between March 19 and April 25. The croak of the male is low and grating, and usually to the tyro this will be a poor guide for their capture. The male is usually smaller, darker in color, and with the thumbs enlarged, as in the males of the leopard frog.



FIG. 1.—HABITAT OF THE LEOPARD FROG AND TOAD; AN OVERFLOW AREA OF A STREAM. DRIES UP IN MIDSUMMER.



FIG. 2.—HABITAT OF THE TOAD AND PEEPER; A SHALLOW MEADOW POND WHICH DRIES UP IN MIDSUMMER.



FIG. 1.—HABITAT OF THE WOOD-FROG; A WOODLAND POND.



FIG. 2.—HABITAT OF THE MINK FROG; A BEAVER POND FILLED WITH WATER LILIES, DORSET, ONTARIO.

The green frog is one of the solitary species. In habitat it is not as restricted as the bullfrog. Both occur in swamps, and in our deeper, larger ponds and reservoirs. In the smaller ponds and pools only the green frog is present. In fact, along watercourses there is hardly a small pond (Pl. VI, fig. 1) which can not claim a green frog. In the swamps only does the leopard frog exceed it in abundance. The latter often inhabits the less permanent situations; the green frog usually chooses more permanent, deeper bodies of water. The green frog starts to appear when the air reaches 54 to 61° and quite commonly at 61 to 69°. It also, like the leopard frog, pickerel frog, and bullfrog, hibernates in the water and awakens when the temperature of the water reaches 46 to 58°. It most assuredly is not "the first species heard in the spring." In fact, it does not begin to croak until a month after its first appearance. Then its low-pitched, short "bass-viol" note is very distinctive. The male of the green frog also has enlarged thumbs, and, in addition, has a yellow throat and a tympanum larger than the eye, while the female has a tympanum only equal in size to the eye. This species, being solitary, would be hard to secure alive in sufficient quantities for breeding purposes unless more effort were expended on its capture than it was actually worth. Wherever they are common, as in big mill ponds and small lakes, one might take enough to determine if the green frog be the species most desired. They are best taken at night.

Finally, in the East, the bullfrog appears to be the most desirable because of its size. One commonly associates the bullfrog with marshy bayous, buttonbush swamps, mill ponds (Pl. VI., fig. 2), or lakes. They are not, however, as restricted in habitat as some texts might lead the reader to infer. The author has found them along both upland and lowland streams, in clear brooks which fed cold, marly, sphagnum ponds, and along watercourses laden with such marshy vegetation as lizard's-tail, marsh cress, arrowhead, pickerel weed, and swamp loosestrife. Rarely they have appeared in small numbers in temporary or very small ponds, a more logical home for the green frog. Such distribution can ordinarily be explained by the loss or draining of a former mill pond or reservoir habitat near by, and such records are more accidental than normal. These frogs seem to prefer mill ponds, hydraulic lakes, reservoirs, and kindred bodies of water. The author's best collecting grounds were a clear, glacial lake in a New England kettle hole, with a slight suggestion of the sphagnous flora about it; a pond in a clear trout brook; a large reservoir for a hydraulic laboratory; a disused mill pond; and a wooded lake whose shifting water level had made a fringe of overhanging dead trees, floating logs, and submerged roots and limbs. In every case the shores were more or less wooded, but more important are two factors: Shallows where the species can transform; and brush, stumps whose roots are at the edge of the pond or overturned and driftwood along the banks.

When the bullfrog comes out, at least seven of the species which appear in the spring are entirely or almost finished with their spawning. The bullfrog is such a wary form that in some years its presence is not suspected until June, when croaking begins. When the air

reaches 68 to 75° (certainly 76 to 79°), the appearance of the bullfrogs may be expected, provided the temperature of the water bottoms is 57 to 64° or averages 64 to 69°. They are the last frogs to appear and come out from May 11 to June 4. They begin to croak about two or three weeks after emergence from hibernation.

When croaking begins, the males often take certain perches in which they keep a proprietary interest. About one pond the author once located seven such places, each with its possessor, only once finding two in one place. The characteristics of the stands can best be described by presenting the following list of positions occupied by certain frogs in one pond: The first was on a board in water filled with brush; another was perched on a log among brush beneath a float of a boathouse; the third was on the bank among some limbs extending into the water; the fourth was by an overturned stump whose roots were partly out of the water and partly submerged; the fifth was among some driftwood along the shore; the sixth was a stationary float; and the last was at the base of a tree fallen into the pond. At these stands one could have had good success in capturing the frogs at night. This habit of maintaining perches obtains more particularly when the species is not especially numerous in a pond or lake. When, however, the numbers of males about a lake are numerous enough to make their night croaking seem a real chorus, and when they are abundant among the fallen logs and brush of the swampy borders of lakes, it is not likely that any one individual holds a favorite site to the exclusion of the others. In such places one can easily take, in an hour or so, 30 or 40 adults with the aid of either flash light or acetylene light.

If one wishes to secure them by day he may adopt the device of the familiar red flannel on a hook or ordinary fish bait. At the breeding season one occasionally finds them in grassy situations. Here they lie on the surface of the water. One has only to wade among them to capture them by hand. At first they may become frightened, but soon they reappear. Whenever bullfrogs are hard to find or scarce in certain bad seasons let the collector search out a former mill pond whose dam is gone, and in the temporary small ponds remaining he can frequently find the frogs in their circumscribed quarters.

The males have the first finger enlarged (Pl. XII, fig. 4) and enlarged tympana. They begin croaking 15 to 30 days before actual spawning takes place. In some ponds the males are very much in evidence. In one lake, when the bullfrogs were laying freely, as many as 10 males were found within a space of 8 feet. Here among the dead branches of overhanging elderberry bushes (Pl. XIII, fig. 1) they were hidden because of the dense mat made by the shrubs. At this time in midday the author had no difficulty in capturing, by hand, in half an hour, some 25 males, while only three or four females were observed. This was in the middle of June. Later in the season the females appear more in evidence. Doubtless these easy captures of a supposedly shy form were naturally due to the fact that it was their breeding season. The author is, however, coming to believe that this species is as easy of capture as any other large frog. Even after a bullfrog has left the water's surface one may capture it while it is swimming beneath the water, for it is very slow as compared with some of the other



FIG. 1.—HABITAT OF COUCH'S AND HAMMOND'S SPADEFOOTS AND OF TWO TOADS (*BUFO WOODHOUSII* AND *BUFO COMPACTILIS*), SIERRA BLANCA, TEX.



FIG. 2.—HABITAT OF THE SOUTHERN BULLFROG; OVERFLOWED AREA AND TANGLED SWAMP OF A CLEAR SOUTHERN STREAM, THEODORE, ALA.



FIG. 1.—HABITAT OF THE CRICKET FROG; A SHALLOW GRASSY AND SEDGY MEADOW POOL, DINWIDDIE, VA.

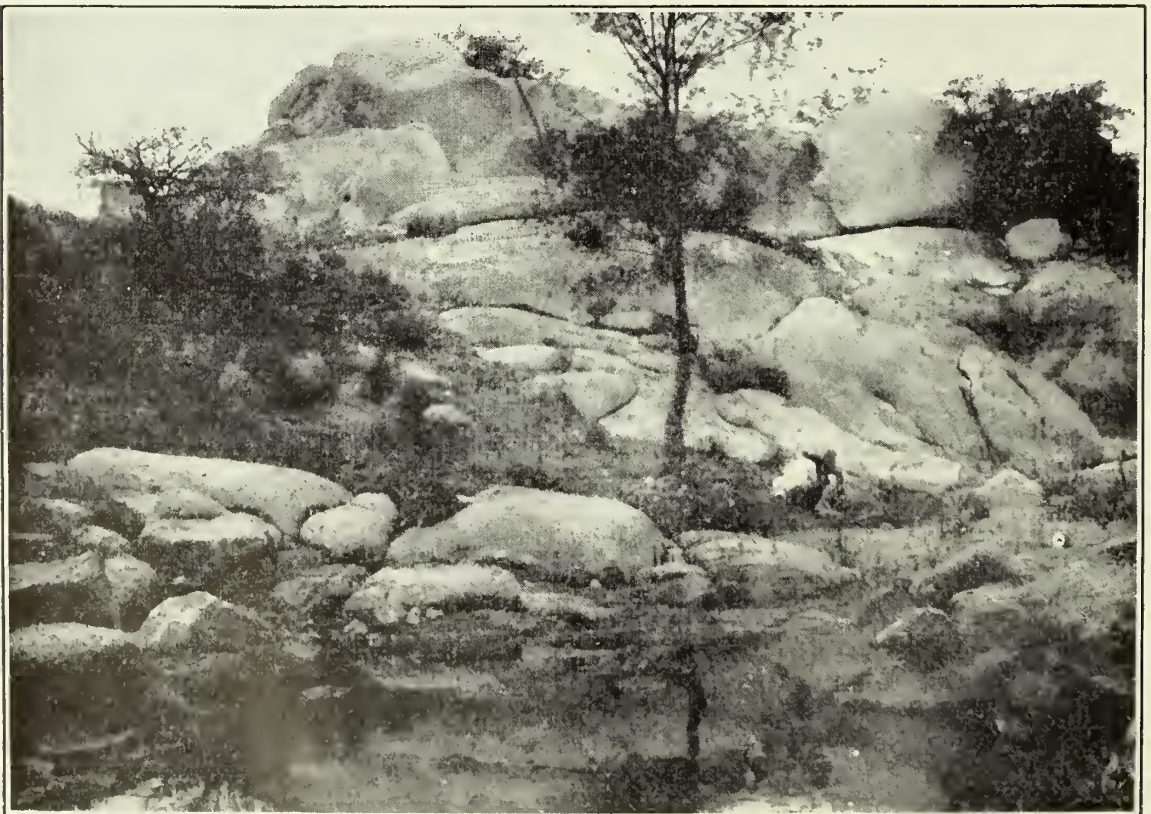


FIG. 2.—HABITAT OF THE DESERT TREE TOAD (*HYLA ARENICOLOR*) AND OF A TOAD (*BUFO PUNCTATUS*); A ROCKY CREEK IN A DESERT MOUNTAIN PASS, DRAGON, TEXAS PASS, ARIZ.

forms. If one wish to stock his inclosure or ponds with adults, let him do it by the first of July, or preferably by June 1.

The southern bullfrog is one of the common forms of the deep-wooded swamps and of the water-lily-filled watercourses of such areas and is often called the swamp bullfrog. Equally frequent is it in the vast, open, swampy stretches or "prairies" of the Everglade, Okefinokee, and other famous southern swamps. The bright green and yellow of the under parts make it very conspicuous when in hand. Often these creatures will not dive until within an oar's length, but in the main this species is a shy form. Occasionally the author has taken them when visiting trap lanterns in aquatic situations.

The southern leopard frog is similar to the common leopard frog in habitat, mating, and general habits.

MATED PAIRS (PLS. XI AND XII).

Some articles on frog culture advocate stocking the suitable waters with a sufficient number of mated pairs of mature frogs. To the writer the main consideration in using individual breeders or mated pairs is that it positively proves to the beginner the identity of the species with which he is stocking his waters. Heretofore the most creditable published attempts with eggs or tadpoles taken afield leaves one with the impression that the experimenter was not absolutely sure whether he had good or worthless species. If mated pairs be the starting point, avoid pairs mated in captivity by some one other than yourself, for you do not know their period of captivity. If mated by the person concerned within one or two days after being taken in the field, return them to the out-of-door environment at once. The only sure source of fertile pairs is the field-mated pairs. The writer finds that in at least nine different species of frogs the pairs captured afield usually remain mated, no matter how long the journey to the laboratory or hatchery or pond, however roughly handled, or however hot the glass jar (not advisable) became from sun exposure. If they broke apart on the trip, they soon resumed mating and seldom released their hold when transferred from aquarium to aquarium or from pond to pond.

When mated pairs are secured in the field, one can reasonably expect them to lay the following night or the next day unless the temperature of the water drops suddenly. Rarely a pair may wait several days before ovulation. The prospective frog breeder can identify his material by the mode of embrace. All of the four principal commercial eastern frogs belong to the true-frog (*Rana*) group, in which the male holds the female behind the forearm with his hands appressed to the breast of the female (Pl. XI, figs. 1 and 2). This is the so-called pectoral embrace, and any mated pair with pectoral embrace found after April 25 is almost positively one of the four principal marketable eastern species. Before April 25 the wood frog pairs might be taken; but if the characters of this species already described are remembered, no mistake will be made.

DESIRABLE SPECIES.—Of the four principal marketable eastern species, the mating of the leopard frog is easily the most familiar. This species is not restricted to night courtship, although most of it occurs at this time, and more mated pairs can be secured at night with

a light than in the daytime. One can frequently observe the mating behavior of this species during the day, if he can discover a spot where the species has already begun ovulation. The author has taken most of his mated pairs under such conditions. Before they are mated the males may be heard croaking at the surface. Occasionally when wading through an area in which eggs are numerous, one hears croaks which at first puzzle him; they come from the mated and mating frogs beneath the water and often reveal the position of the game on the bottom. At such times, one finds several males and gravid females about and under sticks. More rarely, the pairs appear at the surface. The period of mating begins April 1 or before, but the bulk of it does not come until the middle of April; it continues for about three weeks, extending to the first or middle of May.

Like the leopard frog, the pickerel frog is gregarious at the breeding time and often gathers in small, restricted areas for egg laying. This facilitates its capture. The beginning of mating usually comes the last week in April, the earliest record being April 5, the average April 23. This species mates by day or night. The author has seen very vigorous matings at all times of day. Often, within a small area 6 feet square or less, one can find 12 to 15 pickerel frogs mating or pairs in egg-laying positions. The mating places are often, but not always, in shallows. Along one shore, within a short stretch, the author has counted 20 or more frogs actively mating, to say nothing of those in the water. In one instance, in a space 3 feet square, were 21 unmated males, 5 mated pairs, and 8 fresh egg masses (representing 16 more frogs). Usually with most of the frogs, mated pairs, captured in the field, laid the night of the same day of their capture, but the rule did not always hold true with the pickerel frog; in fact, it seemed the exception. To find pairs of pickerel frogs which had mated in the laboratory waiting two or three days before ovulation was not surprising, but frequently pairs from the field waited from two to five days before laying. In two instances in different years (one, in an early season, the other in a late season) the eggs were laid after remaining in the embrace a week. In 1912 a pair continued in the embrace two weeks before ovulation. This delayed deposition makes the pickerel frog less desirable than the leopard frog.

The green frog is a solitary species. This habit makes it difficult to capture mated pairs in the field. One might better begin with the eggs or tadpoles or adult breeders. The mating is more active at night than by day. It does not begin before the latter part of May. With captive individuals it has been noted as early as May 22. The interval between first croaking and actual mating may be considerable. In his night collecting the author not infrequently located places where a male might be found croaking several nights in succession. Egg masses have subsequently been recorded in such spots so often that it has been found a good plan to keep such localities in mind when searching for eggs by day or night. About such masses the original or other males are afterwards frequently found for varying periods. In fact, many have been captured in this way.

The bullfrog is as shy as the green frog, and only about places where they are abundant could one ever hope to capture an appreciable number of pairs.



FIG. 1.—GREEN FROGS. EARDRUM NORMAL IN FEMALE, ENLARGED IN MALE.

(After Wright, Carnegie Publ. No. 197.)



FIG. 2.—LEOPARD FROGS. PECTORAL EMBRACE.

(After Wright, Carnegie Publ. No. 197.)



FIG. 3.—TREE TOADS. AXILLARY EMBRACE.
(After Wright, Carnegie Publ. No. 197.)



FIG. 4.—COUCH'S SPADEFOOTS. INGUINAL EMBRACE.



FIG. 1.—WOOD FROG. CONCAVE WEB OF FEMALE.



FIG. 2.—WOOD FROG. CONVEX WEB OF MALE.

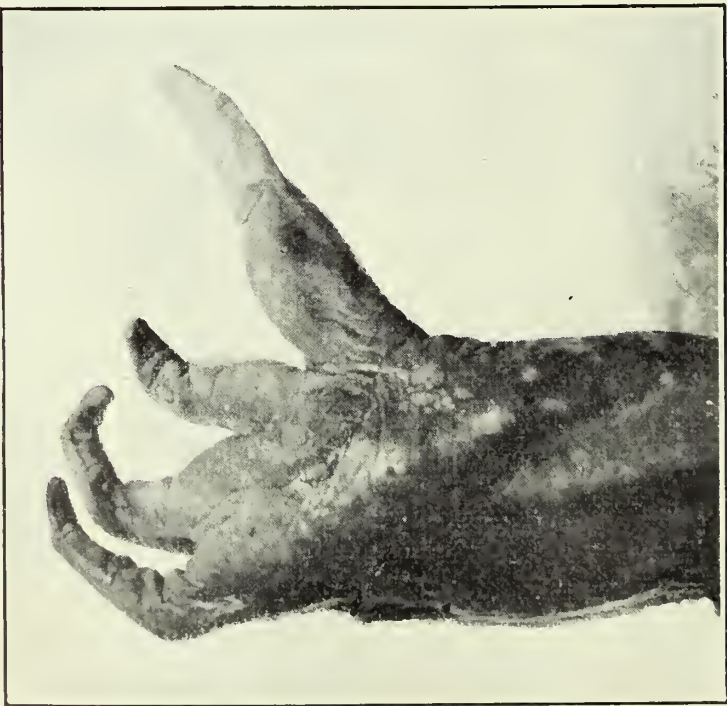


FIG. 3.—BULLFROG. FOREFINGER OF FEMALE NOT SWOLLEN.



FIG. 4.—BULLFROG. FOREFINGER OF MALE VERY MUCH SWOLLEN.

The author found the southern bullfrog at the breeding season in the swampy tangles of buttonbushes and white alders, where the water was waist deep and the bushes 8 to 12 feet high. In southern Alabama he recorded croaking males as not uncommon in overflowed areas and swamps (Pl. IX, fig. 2) of clear streams, especially if overgrown with a thick mat of cat briars (smilax) and arrow arums. In the main their croakings consist of four or five notes and are wholly unlike the call of the northern bullfrog. To some people there is something of the human voice in their call; to others it sounds like an alligator. If the ventriloquial males be in tangles they are hard to discover. These croaking males may also occur along the deep-wooded, overflowed banks of southern rivers. The males have the eardrums enlarged (see green frog, Pl. XI, fig. 1) and the first finger swollen. (See bullfrog, Pl. XII, fig. 4.)

POSSIBLE SPECIES.—At all seasons, except the breeding time, the wood frog is silent and retiring. In water at the spring congress they are difficult of approach. At ordinary approach the best one can hope for is only a series of surface ripples. Such assemblies may not last more than a day or so each year. Anywhere from 50 to 200 males have thus been observed floating at the surface. The scene resembles a small toad assembly, in which there is the same scrabbling and zeal of mating. They disappear simultaneously on seeing anyone, and on going through the pond a minute later one would wonder where the 200 males could be, to say nothing of the females. At the approach of the breeding season the males have the thumb much swollen and the webbing in the hind feet with margin convex, not concave, as in the females at all seasons and in males at other seasons of the year (Pl. XII, figs. 1 and 2). The period of mating has begun in some years as early as the middle of March and may rarely extend to May 1. The species is customarily at the height of sexual ardor the last week of March or the first week in April. They mate to some extent by day, but more frequently during the night.

In the common toad the males are noticeably smaller than the females, have dark throats, and at the breeding season possess dark-brown excrescences on the inner upper side of the first two fingers (rarely on the inner edge of third finger) and on the inner carpal tubercle. Both sexes repair to the water about the same time. The migrations begin early in April, but the toads have been recorded migrating to breeding localities as late as June 14, by which date many of the early breeders are leaving or have left the ponds.

The males far outnumber the females, and the furious actions incident to the first meetings of the two sexes, or following the arrivals of other toads, are long sustained and exhausting. The male embraces the female by digging its forearms into the axilla of the female, the fore fingers of the male being folded up. (See tree toad, Pl. XI, fig. 3). In this way it is clearly seen how the dorsal horny excrescences of the first three fingers of the male come into use.

In the west and southwest six species of toads may continue to breed as late as July or August, dependent on the rains, and in each species the male has the same kind of excrescences on the fingers and the same form of embrace as already described for the common toad. Because of their greater size two of these six might be of more commercial importance than our common toad. They are *Bufo woodhousii* and *B. alvarius*.

The hermit spadefoot toad^a appears suddenly after prolonged rains in April and May or sometimes June or July. At the breeding season it is fond of sprawling out on the surface of the water as a wood frog does; and it is from this position that it croaks. This species gathers in large breeding assemblies like toads, and the matings are as spirited. The male seizes the female just ahead of the hind legs (inguinal fashion), a form of embrace not known in any other American forms except in the narrow-mouthed toads and possibly *Ascaphus truei* of Washington.

The same form of embrace (Pl. XI, fig. 4) and dependence on rains seems to hold true of Couch's and Hammond's spadefoots of the southwest and west, where the writer has observed their breeding habits. In these regions, after long droughts, these creatures and other species of toads at night almost literally pour down from the mountains or in the desert to any temporary streams (Pl. IX, fig. 1), pools, or "tanks," and their strange choruses can sometimes be heard from one-half to a mile away. The croaks of the Couch's spadefoot are given from the edges of swift-flowing, temporary streams or ponds and resemble the mewling of a cat. The males of Hammond's spadefoot float more or less on the surface of the water and, like the hermit spadefoot, dip the posterior portion of the body as they croak. Sometimes when both species are breeding in the same place at the same time cross embraces between the species ensue.

UNDESIRABLE SPECIES.—In the undesirable species such as tree frogs, like the peeper and tree toad (*Hyla*), the cricket frog (*Acris*), and the swamp cricket frog (*Pseudacris*), the mating embrace is axillary (Pl. XI, fig. 3), and any mated pair with such a form of embrace is an undesirable species, unless it be the possible form, the toad. The narrow-mouthed toads (*Gastrophryne*) have the inguinal form (Pl. XI, fig. 4) of embrace, and no desirable form normally mates in this way. The possible form, the hermit spadefoot (*Scaphiopus*) does mate in this manner, and sometimes a weakened male toad (*Bufo*) with normal axillary embrace or a weakened male frog (*Rana*) with normal pectoral embrace may seize a female just ahead of the hind legs (inguinal fashion) in lieu of the normal embrace.

EGGS.

Several experimenters have suggested that to rear frogs for the market one could best start with eggs easily procured in nature. This apparent ease, however, has often led people to work with undesirable stock; and even some of the experimenters themselves have not been absolutely sure to which species of frogs the eggs belonged. With certain precautions as to the identity of the material, it is a convenient point at which to begin the work. It is, however, highly essential that one know the undesirable frogs and their eggs—the tree frogs, swamp cricket frog, peeper, cricket frog, and the large tree frogs; the narrow-mouthed toad; and the oak toad; and also the possible forms—the wood frog, other smaller frogs, the toad, and the spadefoot.

DESIRABLE SPECIES.—In the early spring the leopard frog is the second true frog to begin ovulation. It prefers cat-tail swamps

^a Overton, Frank: Long Island fauna and flora. The frogs and toads. Museum, Brooklyn Institute of Arts and Sciences. Science Bulletin, vol. 2, No. 3, pp. 28-30. The author wishes to thank Dr. Overton and the Brooklyn Museum for the generous loan of Pl. IV, fig. 1, and Pl. XVIII, fig. 4.

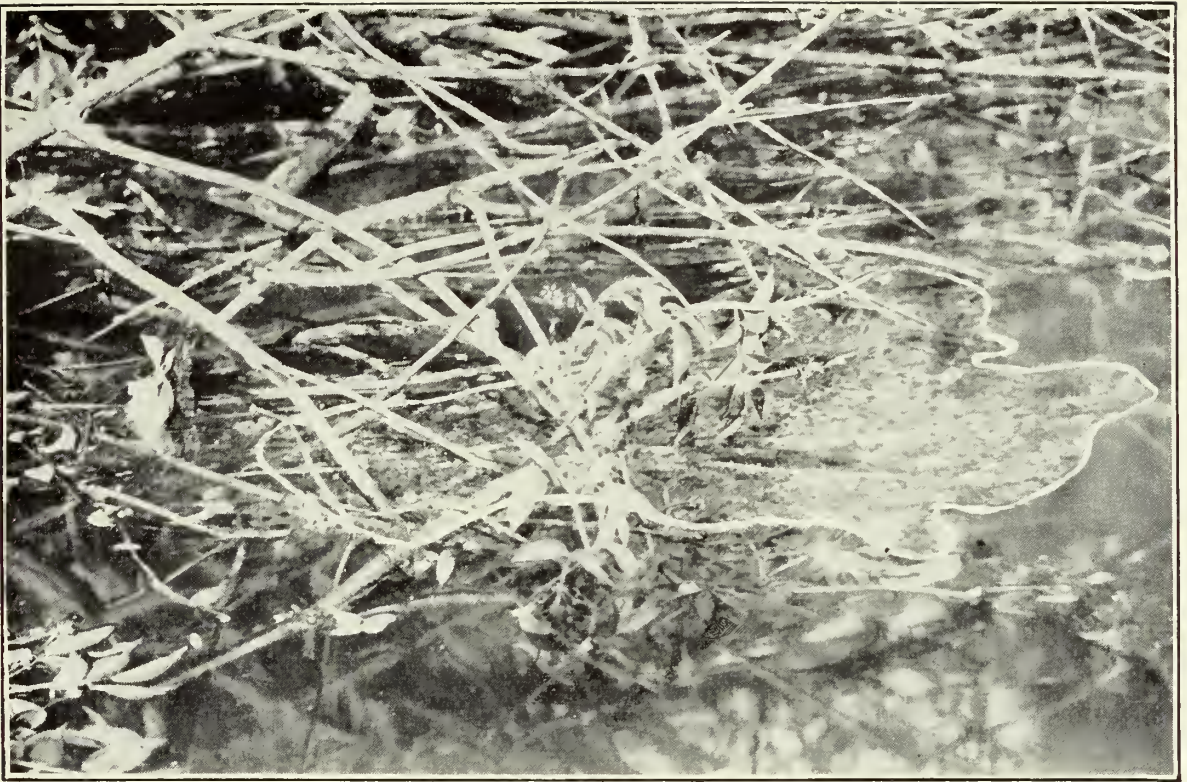


FIG. 1.—A SURFACE FILM OF BULLFROG EGGS ATTACHED TO THE TIPS OF ELDERBERRY BUSHES.



FIG. 2.—AN EGG AREA OF LEOPARD-FROG EGGS, THE EGG MASSES ON THE BOTTOM OR ATTACHED TO VEGETATION.

(After Wright, Carnegie Publ. No. 197.)



FIG. 3.—A SURFACE FILM OF GREEN-FROG EGGS AMONG VEGETATION.

(After Wright, Carnegie Publ. No. 197.)

(Pl. V, fig. 1), marshy expanses of other types, grassy overflows (Pl. VII, fig. 1), and shallow, dead streams. In other situations than these it breeds sparingly. In some places it begins laying before April 1, and the period of ovulation may extend to May 15. In general, when the air temperature reaches 43 to 48°, and certainly when it averages 51 to 55°, the leopard frog begins spawning. The temperature of the water varies from 43 to 45° at the beginning of breeding to 50 to 65° at its crest. The leopard frog may lay at any time of day, even at noon, but more frequently it spawns at night. Leopard frogs have a tendency to congregate in large numbers and often 40 or more bunches of eggs are recorded within small circumscribed areas (Pl. XIII, fig. 2). At such times, when an area is approached, the mated pairs often seek cover under the bunches which have already been laid.

The egg masses of the leopard frog may be attached to submerged cat-tails, twigs, sticks, grass, etc., or as often may rest on the bottom unattached. Several times the water's surface has been observed to be so low that the tops of the bunches appeared at the surface. The bunches of eggs occur in the open, unprotected, marshy expanses, or in overflows where the edges and bottoms have plenty of grass. One will often find the egg masses interspersed with algæ and dead leaves, which so fill the shallows that the bottom can not be seen. As a rule, the leopard frog tends to seek shallower water and more swampy localities than the wood frog. The egg mass at ovulation is 1 or 2 inches in diameter. After it has expanded it is plinthlike or flat, the greater diameter varying from 3 to 6 inches, the smaller from 2 to 3 inches (Pl. XIV, fig. 2). The eggs of this species might be confused with those of the wood frog, which lays during the same period. The differences between the two are elaborated under the wood frog (p. 28). Under normal field conditions the eggs hatch in from 13 to 20 days.

The southern leopard frog, as well as the northern leopard frog, breeds normally in the spring, and hence is called the "spring frog," but occasionally its breeding period may extend until July 4, or later, after the first eggs of the species are hatched and the tadpoles transformed.

The egg mass of the southern leopard frog is plinthlike (Pl. XVIII, fig. 2), and the individual eggs are hardly distinguishable from those of the northern form. These masses may occur attached to vegetation along the quiet side shallows of streams or unattached upon the bottoms of pools, or they may be laid in swampy situations.

The pickerel frog, as far as the recorded situations show, seeks clear water, and, in the main, is usually found in the upper stretches of our clear streams. It frequents ponds heavily laden with dead leaves of quiet backwaters (Pl. V, fig. 2). The eggs are frequently found in the shallows of mill ponds, rocky holes of ravines, or lowland pools of wide, meandering streams. The bulk of egg laying occurs during the last week in April and the first week of May. Usually the period extends from April 23 to May 15. One may expect this species to begin laying when the temperature of the air reaches 50 to 61° and most certainly when 65 to 69° are recorded, provided the temperature of the water is 51 to 64°.

The eggs of the pickerel frog are almost invariably submerged and attached to sticks, twigs, or tufts of grass stems. The species

usually seeks the shallows for egg laying, although not exclusively. Almost every year some egg masses are found in the middle of ponds where the water is 3 feet deep or more. It tends to lay in special areas (Pl. XVII, fig. 3), as do the wood frog and the leopard frog. At one time, in an area 3 by 3 feet, 18 bunches were deposited. In another spot of the same dimensions 31 bunches were found. All of these areas gave excellent illustrations of the placing of bunches one upon another. The greatest number of bunches observed upon one support was a case in which 7 were noted. Quite frequently on one tuft of grass, or on a stick, one finds one or more bunches of eggs of the spotted salamander, a bunch of leopard frogs' eggs, and as many as two bunches of pickerel frogs' eggs immediately above them—seldom below, because laid later. At the time of deposition a bunch may be 1 to 2 inches in diameter, but it soon expands to $3\frac{1}{2}$ or 4 inches. It is usually firm and globular (Pl. XV, fig. 3). The egg complement of the pickerel frog may be from 2,000 to 3,000. The bright yellow or orange lower and the brown upper halves of the eggs of the pickerel frog make them the most easily distinguishable of all our true frogs' eggs. In nature the eggs may hatch within 11 to 21 days.

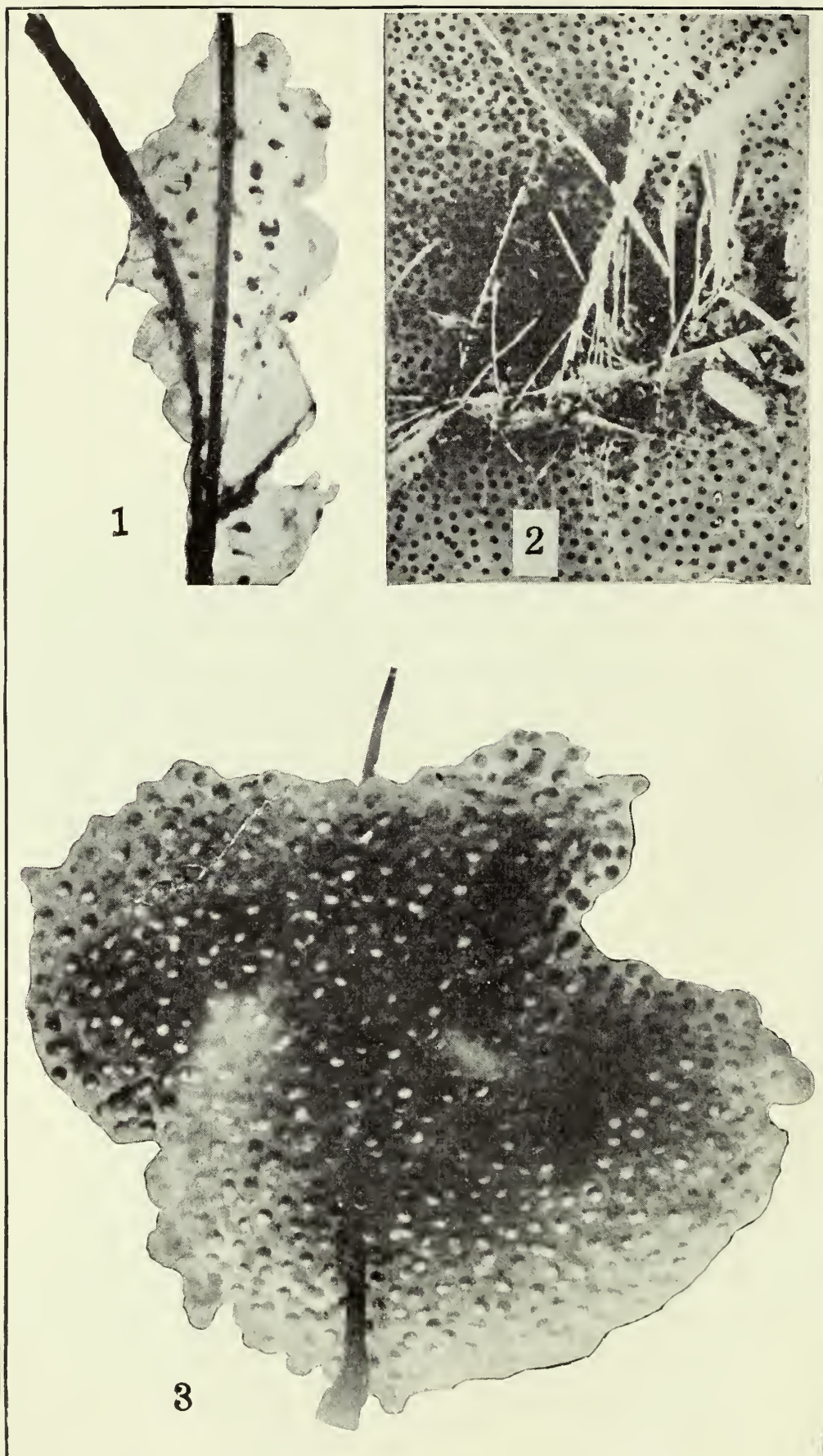
The green frog begins ovulation in the late spring or early summer, the extreme dates being May 23 and August 10. When the air temperature reaches 65 to 74°, or the temperature of the water surfaces 68 to 76°, the green frog may be expected to begin breeding. Surface temperatures are probably very influential in controlling the breeding habit, because of the position of the eggs after they are laid. When the air temperature reaches 80°, the species breeds commonly. During June and the first part of July the eggs of this form are very common; thereafter they diminish in numbers until the last of July or the first of August, when a few stragglers deposit the last eggs of the breeding season. This species lays mainly at night, but the author has twice seen it laying during the day.

The mass of the green frogs' eggs floats on the surface of the water. The typical form (Pl. XV, fig. 2) is a disklike film of a single layer of eggs, loosely attached or free. The eggs have the upper halves black and the lower halves white or creamy white. They may be found in the middle of the pond, where it is filled with a cover of algæ at the surface, or with hornwort, water milfoil, *Chara*, *Nitella*, or similar water plants, which make a mat of vegetation from the bottom to the surface, or where isolated patches of grass, water plantain, etc., grow in the middle of a pond. Usually, without such conditions, the masses occur about the edges of the pond (Pl. XIII, fig. 3), attached to grass, smartweed, etc., either growing in or extending into the water. In 100 or more cases hardly an exception to the surface deposition has been noted, but a few apparent exceptions have occurred. One egg complement was found in a somewhat scattered mass on leaves and twigs partially submerged. In another instance some of the complement was at the surface and the rest in water 4 to 6 inches deep. Inasmuch as such masses were found some time after deposition, a rise in the level of the pond could easily have brought about this anomalous condition. Another variation in the location of the egg mass is occasionally recorded. The mass may be attached to grass stems, the point of



FIGS. 1 AND 2.—FORM OF EGG MASSES.

1, Egg masses of wood frog, both masses globular; 2, egg mass of the leopard frog, mass plinthlike, not globular. (After Wright, Carnegie Publ. No. 197.)



FIGS. 1 TO 3.—FORM OF EGG MASSES.

1, Egg mass of the swamp cricket frog, several such bunches laid by one female;
 2, egg mass of green frog, a surface film among vegetation; 3, egg masses of
 the pickerel frog, globular mass, frequently in tiers. (After Wright, Carnegie
 Publ. No. 197.)

attachment being some 4 or 5 inches below the surface of the water. This attachment serves as the apex of an inverted cone, and the base of the cone spreads out on the surface of the water. This also may be due to a rise in the level of the water. Rarely a mass more than a foot square is recorded. Some of these masses may be composite. In a certain pond, where numerous frogs had laid, two bunches had been placed so close together as to make a film 15 by 10 inches. In another case a mass just as large was secured, and the evidences of its double nature were even more evident than in the preceding instance.

For several years small isolated packets of eggs were found on the water's surface, distributed in the manner of tree toads' eggs, but without their individual characteristics. They could not have been those of the swamp cricket frogs' eggs, for this species lays very early in the spring. At last it was discovered that, as egg development went on, the egg masses of the green frog often lost their circular disklike form, assumed irregular shapes, and separated into small masses of 25 or more eggs, a natural process due to the jelly becoming loose as hatching approached. But the egg packets observed were composed of fresh eggs. In those instances the wind or strong currents, or both, caused them to float away from the original mass.

The bullfrog begins egg laying at air temperatures of 71 to 72°, or at water temperatures of 66 to 71°. On the average, however, breeding comes at an air temperature of 80° and at a water temperature of 70 to 71°. The bullfrog lays the last of June or in July. The author's breeding record for this frog extends from June 16 to July 10. Doubtless it begins earlier some years or extends beyond July 10 in belated seasons. The writer has taken females with ripe ova the last of July. Ovulation usually occurs at night, at which time the species is most active. The bullfrog is a solitary form, yet at the height of breeding a mill pond (Pl. VI, fig 2) may have a dozen or more pairs in it, and some lakes may be well enough supplied with them to furnish the famed bullfrog choruses of June and July.

Usually the egg masses of the bullfrog are found among brush or under similar cover (Pl. XVI, fig. 1). The disk form so prevalent in the egg masses of the green frog obtains with this species as well. In one instance the egg mass covered a space of 2 by 2½ feet, or 5 square feet; in a second case, 2 by 2 feet; and in a third, 2 by 1½ feet. The size of these masses is a sufficient criterion for identification, since it is very unusual to find an egg mass of the green frog which covers a square foot. The first of these three egg films was deposited upon a mass of driftwood and brush, which was at the surface; the second was found among some fresh white branches that extended into the water from the edge of the pond. In rare cases the masses become stringlike, due to shifting water levels. One such mass was found attached to the roots of an overturned stump in shallow water and another in brush beneath a boathouse float. Sometimes bullfrogs lay their films in midpond around stumps, or attach the surface egg film to the tips of overhanging bushes which extend into the water (Pl. XIII, fig. 1). The winds often break these films into pieces and distribute them along the shores of the lake or pond. The mass is glutinous and is not firm

and hard, as in the wood-frog, leopard-frog, and pickerel-frog eggs, which are laid earlier in the season. In the last of June and through July only one other common frog is breeding; namely, the green frog. The green frogs usually deposit their eggs upon vegetation. They lay on or among grass, water plants, and algæ, or along grassy edges of ponds, while the bullfrog almost invariably lays in brush. The egg complements of the two species are also different in size. The green frog seldom lays more than 3,500 or 4,000 eggs, while the bullfrog may lay from 10,000 to 20,000. Usually, the egg of the bullfrog has not the distinct middle envelope of jelly which is found in the green frog's egg (fig. 1, *F* and *D*). Furthermore, this middle envelope in the eggs of the green frog often is elliptical, and not round, as in the eggs of the leopard and pickerel frogs (fig. 1, *G* and *B*). In nature, the eggs hatch in four days or less.

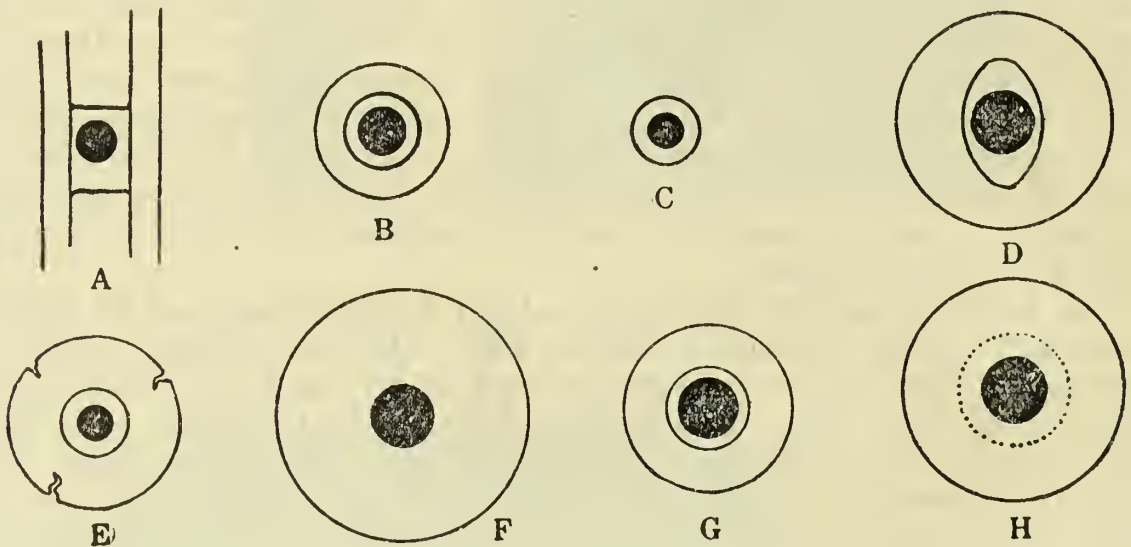


FIG. 1.—INDIVIDUAL EGGS (three times natural size).

A. Egg of common toad in two jelly envelopes or tubes, the inner of which is divided by cross partitions. *B.* Egg of pickerel frog. Inner envelope and egg proper of same size as egg of leopard frog (*G*) but outer envelope smaller. *C.* Egg of peeper. The one envelope and the egg proper together appear the duplicate of the egg of the tree toad (*E*) when it is stripped of its outer envelope. *D.* Egg of green frog. Unlike the egg of the bullfrog, it has an inner envelope. *E.* Egg of tree toad. The outer envelope often ragged in outline. *F.* Egg of bullfrog. Unlike the other four frogs, it has no inner envelope. *G.* Egg of leopard frog. Egg proper black and white, not brown and orange as in pickerel frog (*B*). *H.* Egg of wood frog. It has the largest egg proper of these eight species and larger envelopes than the confusing pickerel-frog (*B*) and leopard-frog (*G*) eggs. (After Wright, Carnegie publication No. 197.)

The eggs of the southern bullfrog are not known, and we are not very familiar with its breeding habits. In Georgia, Florida, and Alabama the writer has chanced upon this species in full croaking season in June and July. This species is reputed to lay small eggs in large masses on or at the surface of the water in the early summer, and if this be true the habits of this form are closely similar to those of the northern bullfrog.

POSSIBLE SPECIES.—The hermit spadefoot toad is one of the most erratic and transient of our toads or frogs. It suddenly appears after a shower, and egg laying is soon over after an ear-splitting chorus of croaking lasting a few days. Breeding usually occurs in April but occasionally persists until August. This species breeds in quiet pools and ponds (Pl. VII, fig. 2). The eggs are enveloped in a gelatinous band (Pl. XVIII, fig. 4), the cross section of which includes several eggs. In the common toads the eggs occur in one



FIG. 1.—EGG MASS OF BULLFROG; A SURFACE FILM 18 INCHES IN DIAMETER LAID AMONG DEAD STICKS AND OLD BOARDS.

(After Wright, Carnegie Publ. No. 197.)



FIG. 2.—A SURFACE PACKET OF TREE-TOAD EGGS ATTACHED TO A POND-WEED LEAF.

(After Wright, Carnegie Publ. No. 197.)



FIG. 1.—COMMON TOAD EGG STRINGS CURLED ABOUT VEGETATION.
(After Wright, Carnegie Publ. No. 197.)

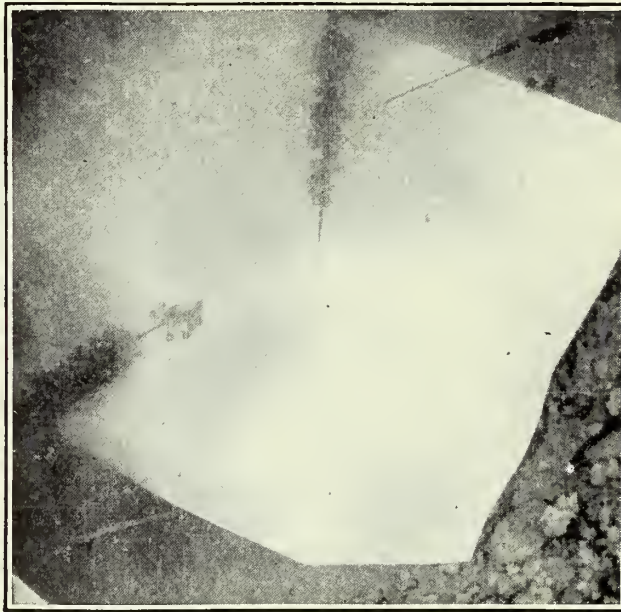


FIG. 2.—THE STALKED EGGS OF THE DESERT
TREE TOAD (?).



FIG. 3.—AN EGG AREA OF THE PICKEREL FROG AND TWO MATED
PAIRS; EGG MASSES ATTACHED TO VEGETATION AND STICKS ON
THE BOTTOM.

(After Wright, Carnegie Publ. No. 197.)

or two lines or files within one jelly tube. The eggs of the spadefoot usually hatch in a very short period.

While the hermit spadefoot lays eggs in bands like the European forms of this family, the spadefoots of the Southwest—namely, Couch's and Hammond's spadefoots—may strew them on the bottom of the ponds. These eggs may be singly placed or be in more or less agglutinated masses usually one egg deep and may be laid as late as mid-August. This peculiar arrangement of the egg complements may be due to the absence of suitable vegetation, since Strecker^a has seen Couch's spadefoots lay egg bands which became attached to grass, etc.

The life histories of several smaller true frogs are unknown. These, including Cope's frog, the yellow-legged frog, and *Rana onca*, are too small to be considered.

The wood frog usually chooses still water for spawning, rarely backwaters or bayous of streams. It prefers the leaf-laden ponds (Pl. VIII, fig. 1) and transient pools of wooded districts, though not wholly restricted to such localities. Occasionally the author has seen the frogs migrating to swampy cat-tail stretches for spawning and has both observed and heard them in such situations. Two of his best collecting spots were a grassy pool and a high upland pond, both of which were out in the open and ordinarily dried up in midsummer. In wooded districts he has found them even using pools no more than $1\frac{1}{2}$ by 4 feet in area. When the air temperatures average 53 to 58°, one may go out with some expectation of finding the wood frogs spawning, provided the water temperature is at least 41 to 48°. Spawning reaches its height usually at about 53 to 60°. The average date of spawning is about April 4; the author's earliest record is March 19; his latest first record, April 14. In general, wood frogs spawn most frequently in the first half of April, though occasionally earlier or later, depending on the season. In some years, when spring opens early, as the last of March, the spawning begins with a rush, and the species may be practically through laying within from four to six days after the beginning of ovulation. Most of the egg complements are laid at night, yet the author has frequent instances in which the eggs were laid during the day, both in the laboratory and in the field. In the laboratory, they have been observed to lay throughout the day; in the field, there have been numerous indications that eggs were laid during the day. This species is gregarious at the breeding season. Where the first bunch of eggs of the season is laid, one is quite certain to find other wood frogs depositing their complements later. In this way the whole egg content of a large pond may frequently be massed in a small limited area (Pl. XVIII, fig. 3).

The eggs of the wood frog may be deposited either near the edges or in the middle of the pond. They are usually attached to grass stems, weed stalks, twigs, or brush; but, in rare cases, they may rest free on the bottom. In this species the egg bunches tend to be attached more frequently than in the case of the leopard frog. In rare cases, wood-frog and leopard-frog masses are found on the same twig. The egg mass, at the time of laying, may be an inch in diameter. Within one-half hour to two hours it assumes a diameter

Found at
Adams Co
Ohio -
Mar 18,
1931

^a Strecker, J. L.: Notes on the life history of *Scaphiopus couchii* Baird. Proceedings, Biological Society of Washington, Vol. XXI, p. 203. Washington, 1908.

of 2 or 3 inches. Freshly laid masses are always of a very bluish tinge. The eggs are usually found in shallow water, 6 inches to 2 or 3 feet deep, though occasionally eggs have been in water of a greater depth. The eggs of the wood frog are to be confused only with those of the leopard frog. In the former, the egg mass is globose (Pl. XIV, fig. 1); in the latter it is plinthlike. In the leopard-frog egg, the middle envelope is evident to the naked eye, which is not true of the wood-frog egg (fig. 1, *G* and *H*). The eggs of the wood frog are free, and the outer envelope of each egg keeps its spherical form more exactly than in the case of the leopard frog, where the eggs are closer together and both they and the outer envelopes smaller. The eggs of the wood frog are 3.6 to 5.5 mm. from each other, while in the leopard frog the eggs are 2.6 to 3.6 mm. apart. The two egg masses can be separated easily in the field by inverting the mass, thus revealing the lower side of each egg. In the eggs of the leopard frog the whiteness of the egg mass becomes very apparent, but in those of the wood frog the general effect is not decidedly that of whiteness, because of the evident encroachment of the black of the upper half upon the lower side.

The northern wood frog doubtless has breeding habits similar to those of the eastern wood frog.

The life history of the common toad will serve well enough as an example of the life histories of our more common toads. At the spawning season hundreds of pairs may be recorded laying at one time; and in one instance 10 pairs were secured within an area $1\frac{1}{2}$ feet square. Any water hole, ditch, or transient pool may contain one or more toads at this season. They seemingly prefer the shallower waters and are apparently not particular whether it be grassy (Pl. VII, fig. 2), weedy, or swampy (Pl. VII, fig. 1), or whether the bottom be free or covered with fresh or dead vegetation. So long as water is at hand, their main desideratum is met. In choice of a breeding spot, then, the toad is easily suited and will use a greater variety of localities than any other anuran. This species may begin spawning when the temperature of the air is 50 to 51° , but the crest of the breeding season is reached at about 70° . Spawning may begin when the water temperature is as low as 51° but reaches a maximum when the water temperature is about 56 to 66° . The toad begins ovulation about April 23, the earliest examples recorded being April 5. The crest of ovulation comes about April 30. Thereafter the number of spawning pairs diminishes. By May 15 or 20 the bulk of the laying is about completed, and by May 20 or 25 nearly all the toads' eggs are hatched. In June there are a few stragglers. In rare instances the species lays through July. So, spawning in this species occasionally extends far beyond the transformation time of the first-hatched toad tadpoles of the season. Egg laying takes place both by day and by night. The female toad lays from 4,000 to 7,000 eggs. The eggs are laid ordinarily in quiet water; it may be shallow, but not always so. The eggs are found in pools and ponds, artificial or natural, in marshes, backwaters, ditches, etc. The strings may rest merely on the bottom or be twined about vegetation or sticks which happen to be near at hand (Pl. XVII, fig. 1). The eggs are laid in long, spiral tubes of jelly (Pl. XIX, fig. 2). Each egg, with its quadrangular envelope, is incased in two tubes of jelly, one tube within the other. (See fig. 1, *A*.) The hatching period is

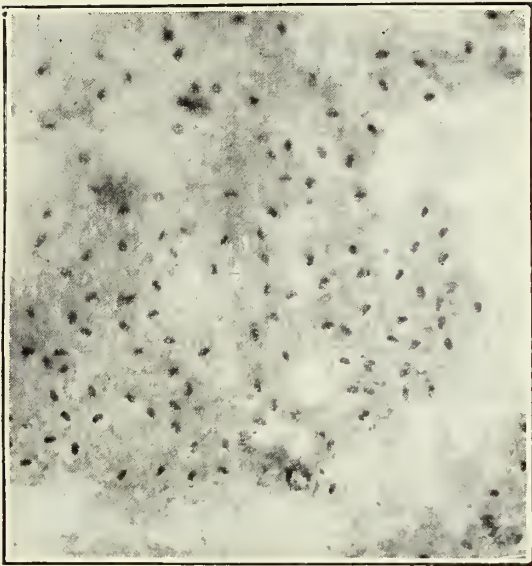


FIG. 1.—A SURFACE FILM OF TREE-TOAD EGGS.



FIG. 2.—A PLINTHLIKE EGG MASS OF THE SOUTHERN LEOPARD FROG.



FIG. 3.—AN EGG AREA OF THE WOOD FROG, THE EGG MASSES ATTACHED TO STICKS.

(After Wright, Carnegie Publ. No. 197.)



FIG. 4.—AN EGG BAND OF THE SPADEFOOT ATTACHED TO VEGETATION.

(After Overton. Mus. Brooklyn Inst. Arts & Sci. Sci. Bull., Vol. 2, No. 3.)



FIG. 1.—EGGS OF PEEPERS LAID
IN THE AQUARIUM.

(After Wright, Carnegie Publ. No. 197.)

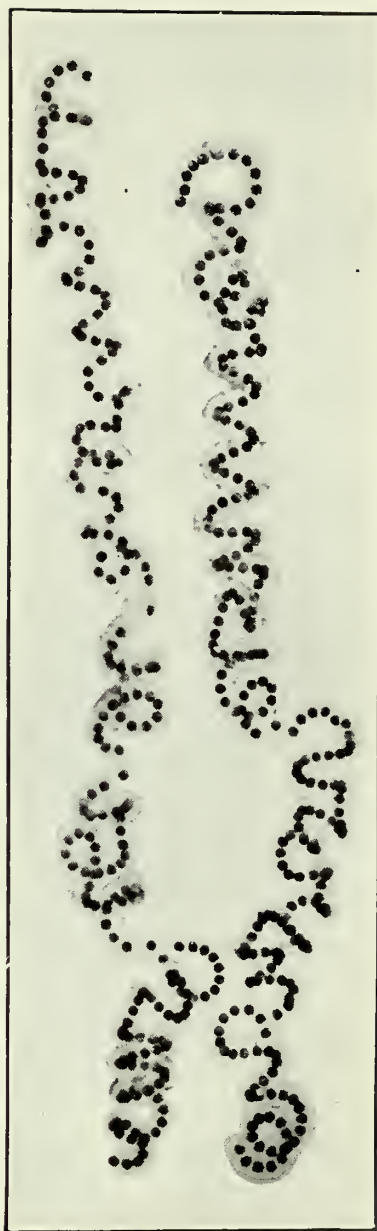


FIG. 2.—TWO EGG STRINGS OF
THE TOAD; A STRING FROM
EACH OVIDUCT.

(After Wright, Carnegie Publ. No. 197.)

very short. In general the eggs hatch within from three to five days. In colder seasons, the eggs may not hatch until 8 to 12 days have passed.

UNDESIRABLE SPECIES.—The swamp cricket frog, one of the first to appear in the spring, lays small bunches of eggs attached to sticks, leaf stems (Pl. XV, fig. 1), etc., in every transient pool, pond, or ditch, as well as in the swamps. In each bunch are 20 to 100 eggs. Usually the bunches are beneath the surface, but the mass is seldom over 1 to 1½ inches in diameter. The eggs, however, are black on the upper half and white on the lower half. Besides, the largest individual eggs of this species may be as large as the smallest green frog or bullfrog eggs, which, however, are not laid until summer. Furthermore, the smallness of the mass enables one to distinguish the swamp cricket-frog eggs from any of the desirable frog-egg stock.

The peeper, together with the swamp cricket frog, makes up the shrill chorus from our swampy situations in early spring. They often occur in the same situations as the leopard frog, but the eggs of the peeper (fig. 1, *C*) are laid separately (Pl. XIX, fig. 1), do not occur in masses, and are hard to find. Hence there is little danger of their confusion with those of the leopard frog, though laid at the same time.

The cricket frog is one of the first forms to appear in the spring and according to several authors breeds in March, April, and May or even later. Abbott^a says the small masses of eggs are attached to blades of coarse grass along ditches in the meadows. The writer recently found them breeding actively on June 1. They had chosen a shallow (1 to 4 inches deep), grassy meadow pool (Pl. X, fig. 1). The eggs were attached singly to sedge stems or were strewn singly on the bottom. In one or two instances three or four eggs were close together. Many of the eggs were in water not more than an inch in depth.

The larger tree frogs, like the common tree toad, Carolina tree frog, and the pine wood's tree frog, lay their eggs from the very last of May to July. The color of the eggs is brown on the upper half and cream or yellowish on the lower half. On the criterion of color alone they might possibly be confused with those of the pickerel frog, which deposits eggs, the upper halves of which are brown and the lower yellow or orange. The latter species, however, lays its eggs from April 20 to May 20 before the tree frogs begin. Besides, its egg masses are spherical, 2 or more inches in diameter, and are found beneath the surface of the water. These tree frogs lay at the same period that the green frog and the bullfrog do and, as do these, lay their eggs in films on the water (Pls. XVI, fig. 2, and XVIII, fig. 1). But the bullfrog and green-frog eggs occur in large films 2 to 8 inches in diameter, while the tree-frog films are seldom over 1½ inches. Occasionally, the large egg films of the bullfrog and green frog break up into smaller films, but then they can be distinguished from the tree frogs by the fact that the egg is black above and white below.

The narrow-mouthed toad is a form whose life history is not wholly understood. Brimley^b holds that it breeds from May to August, and

^a Abbott, C. C.: Notes on the habits of the "Savannah Cricket Frog." *American Naturalist*, Vol. XVI, No. 9, p. 707, 1882.

^b Brimley, C. S.: *Batrachia* found at Raleigh, N. C. *American Naturalist*, Vol. XXX, p. 501. Philadelphia, 1896.

the author's limited experience with the species suggests that the eggs are usually laid during the spring or early summer. Deckert^a found their eggs on August 28. The eggs were "laid in oblong, jelly-like sheets or flat masses about 1½ inches long and 1 inch wide. The egg masses contain about 100 to 150 eggs."

The oak toad breeds in May and June, most of the egg laying doubtless occurring before June 15. The egg string is laid in warm, shallow ponds, and many of these eggs or the subsequent tadpoles are dried up by the rapid evaporation of the very transient breeding pools. The egg string or file is a small edition of the southern toad's egg string, the former being much smaller in diameter than the latter. A female oak toad may deposit 500 to 600 eggs, while a common toad produces 4,000 or more. The eggs of the oak toad are slightly smaller than those of the common toad.

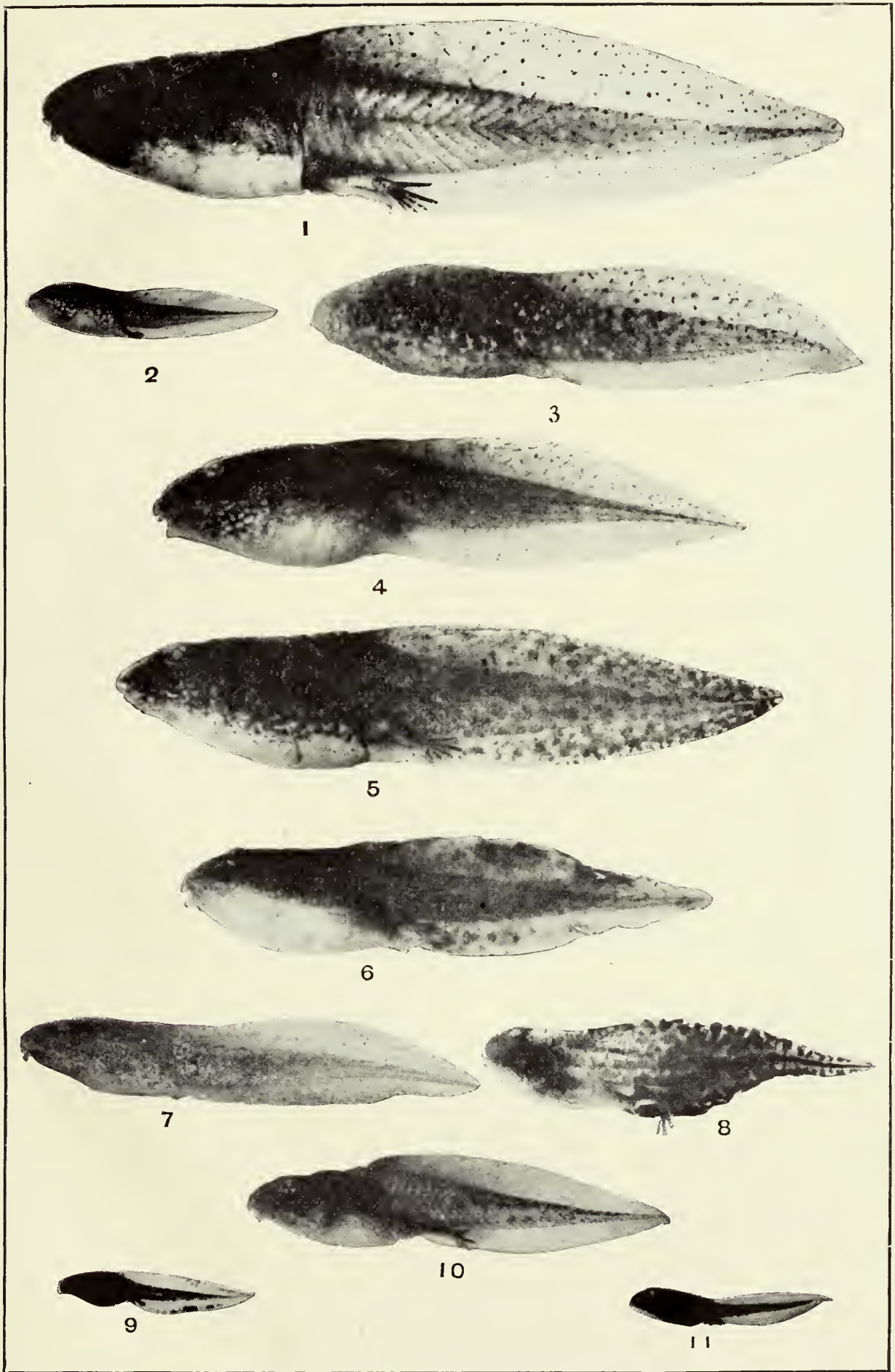
TADPOLES (PL. XX).

For the average layman the tadpole might prove the easiest starting point in attempting frog culture: Individual breeders must be secured just before mating; to take mated pairs is more difficult; the egg period is short and the chances of finding eggs restricted by time and the expertness of the seeker; but the tadpoles of some of the best species may be had at almost any time, the green frog remaining a year in the tadpole stage and the bullfrog two years. There are a few cardinal considerations to be borne in mind: Any large tadpole of the eastern United States found in the spring before May 1 is, so far as we now know, either a green frog or a bullfrog tadpole. Usually tadpoles taken after September 1, and almost surely after October 1, must be of the green-frog or the bullfrog species. Throughout the summer, when the other tadpoles are present, if a tadpole be at least 2 inches or more in length, it is generally either that of a leopard frog, pickerel frog, or bullfrog, all desirable species. In proportion to their size, these commercial frogs have smaller eggs than the smaller species of frogs, and, consequently, the period of tadpole development and growth to adult form may also consume more time both actually and relatively.

DESIRABLE SPECIES.—The tadpoles of the leopard frog transform during the same season in which the eggs are laid. The eggs are relatively larger and the size at transformation is smaller than in the green frog and the bullfrog. Usually 71 to 111 days elapse between egg laying and the change to small frogs, or 60 to 80 days elapse between the hatching of the eggs and transformation. The tadpoles of the leopard frog are very seldom found after August 15. The distinctive marks are: Crests of the tail (not muscular portion) conspicuously lighter than the body, almost transparent, and marked with widely scattered fine spots or specks; belly deep cream color with bronzy iridescence; greatest length, 3 to 3.4 inches. (See Pl. XX, fig. 4.)

The pickerel-frog tadpoles change into frogs the same season the eggs are laid. The developmental period from the egg to transformation consumes from 87 to 100 days; the period from egg hatching to transformation 76 to 85 days. The distinctive marks of the tadpole are: Tail crests not transparent or translucent, as in the leopard frog, but opaque, very dark, sometimes almost purplish

^a Deckert, R. F.: Further notes on the Salientia of Jacksonville, Fla. Copeia, No. 9, p. 1, 1914.



FIGS. 1 TO 11.—MATURE TADPOLES, NATURAL SIZES.

1, 2-year-old bullfrog tadpole; 2, 3 to 5 months old bullfrog tadpole; 3, 1-year-old bullfrog tadpole; 4, leopard-frog tadpole; 5, 1-year-old green-frog tadpole; 6, pickerel-frog tadpole; 7, 3 to 6 months old green-frog tadpole; 8, tree-toad tadpole; 9, peeper tadpole; 10, wood-frog tadpole; 11, common toad tadpole. (After Wright, Carnegie Publ. No. 197.)

black, and usually marked with aggregate spots or blotches somewhat like the green-frog tadpole. In the pickerel-frog and leopard-frog tadpoles, in spite of the coppery iridescence on the belly, the elongate intestine shows through the skin, while in the green-frog tadpole the deep cream color hides the view of the intestine. The pickerel-frog tadpoles never reach 3 inches in length. (See Pl. XX, fig. 6.)

The green-frog tadpole requires one year for growth before it becomes a small fully formed frog. The same factors operate for this extension of time as in the case of the bullfrog tadpole. The tadpole of the green frog, however, has to attain a size slightly more than one-half that of the mature bullfrog tadpole, and the larval or tadpole period is, therefore, one-half as long. The distinctive marks are: Tail greenish, mottled with brown; belly deep cream color with very little or no iridescence; no round black spots; never over $3\frac{1}{2}$ inches in length. (See Pl. XX, figs. 5 and 7.)

The bullfrog tadpole requires two years or more for growth before it transforms or becomes a frog in form. This long period of development results from several causes, among which are these: The eggs are relatively small and are laid late in the season; and the larvæ or tadpoles are hatched in an immature state and have to grow to a comparatively large size before they change into small bullfrogs; that is, the mature bullfrog tadpole may be three times as long as a wood-frog tadpole or twice that of a pickerel-frog or leopard-frog tadpole. Any tadpole over $3\frac{1}{2}$ inches in length will prove to be that of a bullfrog. The distinctive marks are: Belly of a straw or maize yellow color; the body and the tail (except the lower crest of fin) with regular round black spots; and fine yellow dots all over the body. (See Pl. XX, figs. 1, 2, and 3.)

POSSIBLE SPECIES.—With the exception of the toad, the tadpoles of several possible forms are not well enough known to describe positively. The toad tadpoles seldom reach more than from 1 to $1\frac{1}{4}$ inches in length. The small size required enables the tadpole to develop quickly into the toad form. The period of development from the egg to transformation is from 50 to 65 days; from the hatching to transformation, 41 to 60 days. The distinctive marks of the tadpole are: Body very dark or black (not greenish) in appearance; crests of the tail cloudy transparent or milky translucent and not high; tail tip often more or less rounded. (See Pl. XX, fig. 11.)

The tadpole of the wood frog develops in one season; usually the period of development from the eggs to transformation extends over about 90 days, though the range may be from 61 to 115 days. The tadpole period and breeding time of the wood frog coincide with those of the leopard frog. The tadpole of the wood frog never becomes more than 2 inches long. Like that of the leopard frog the belly of the wood frog has a bronzy iridescence, but it is more pinkish in the latter along the upper-jaw region, while the wood-frog tadpole has a cream-colored line; finally, the mouth of the tadpole of the wood frog has three rows of teeth on the upper jaw and four rows on the lower jaw, while all the desirable species have two rows of teeth on the upper jaw and three on the lower. (See Pl. XX, fig. 10.)

UNDESIRABLE SPECIES.—Some of the more frequent tadpoles which should be avoided are those of the narrow-mouthed toad, the tree toad, the peeper, the swamp cricket frog, and the cricket frog.

The narrow-mouthed toad, so far as known, transforms the same season during which the eggs are laid. This period was formerly considered to be 90 to 100 days, but Deckert's^a captives required only 16 days from hatching to transformation, an amazingly short period. The largest of the tadpoles of this species reach a length of $1\frac{2}{3}$ inches and are very easily distinguished from those of other species. The body is very flat, and the depth of it is contained $1\frac{1}{2}$ times in the width, while other tadpoles have round bodies; there is no spiracle; there are no horny-edged mandibles, and the lower lip of ordinary tadpoles is not present, while the upper has either a faint row of teeth or none at all. The color of the tadpole is quite conspicuous. On the back and sides it is a uniform brown or olive black. Along the middle of the muscular part of the tail there is a bright, clear, white band one-fourth to one-half inch long. Along either side of the belly there is a similar white line, and most of the belly is of this clear white. All in all, it is our most remarkable tadpole.

The known tree-frog tadpoles of this country, with the exception of the peeper, have the two rows of teeth on the upper lip and two on the lower, thus differing from the desirable frogs which have two rows on the upper and three on the lower. Furthermore, the upper tail crest (this is also true of the peeper tree frog) extends onto the back almost to between the eyes, which are lateral, visible both from the back and belly. In the tree-frog tadpoles the eyes are not visible from the lower side of the animal, and the tail crest seldom reaches onto the back beyond the vertical of the spiracle.

The common tree-toad tadpole takes about 50 or 60 days for development from the egg to the transformed tree toad. Sometimes the period may be no longer than 45 days or, in other cases, as great as 65 days. These tadpoles can be distinguished at once by their long tails, which are 2.2 to 3.5 times the length of the body and scarlet or orange vermilion in color, with black blotches more prominent near the margins of the crests. The belly is conspicuously of a white or light cream color, slightly iridescent, and the intestine does not show through. These tadpoles reach a length of 2 inches. (See Pl. XX, fig. 8.)

The peeper tadpole may have the rows of teeth two and two, as in American tree frogs in general, or some of the tadpoles may have a small third goateelike row on the edge of the lower lip. The peeper tadpole transforms about 90 or 100 days after egg laying and never exceeds 1.3 inches in length. The tail is only 1.4 to 2.1 times the length of the body. The tail crests are clear and usually heavily pigmented with purplish black blotches near the outer edges. (See Pl. XX, fig. 9.)

The swamp cricket frog spends about 75 to 100 days in passing from the egg to transformation. The tadpole is the darkest in color of any tree-frog tadpole; the body is brownish black all over, and the back and the upper two-thirds of the muscular part of the tail have the same color. The lower third of the muscular portion of the tail is whitish. The tail crests are transparent and practically unspotted, a character which is distinctive in an adult tadpole. The rows of teeth are 2-2, or 2-2 with a slight suggestion of a third lower row.

^a Deckert, R. F.: Loc. cit., pp. 1, 2.

The tadpole of the cricket frog develops in about the same length of time as that of the peeper. The tadpoles of the former transform the same season the eggs are laid and seldom exceed $1\frac{1}{2}$ inches in length. They are larger than peeper tadpoles, have the crests blotched like tree-toad tadpoles, but have not the scarlet color of these creatures. The conspicuous character is the arrangement of coloration on the muscular part of the tail. There are four long bands—the first a brown band from body to tip of the tail; above this a cream white band, followed by another brown band to tail tip; and this surmounted by another short cream white band. There are two rows of teeth on the upper lip and three complete rows on the lower, as in the case of some of the frogs.

TRANSITION STAGES (PLS. XXI AND XXII).

Many of the attempts at frog culture have consisted in carrying eggs through hatching or even in carrying tadpoles through to transformation; but the efforts have ended at the latter stage. In nature, there is always considerable loss of tadpoles particularly just before transformation, and hitherto, in captivity, the same trouble has often been encountered. Some culturists might, therefore, prefer to begin their first efforts with the transformed frogs which have passed the critical stage, and thus avoid this large percentage of loss of stock. In many ways it is easier than gathering mated pairs or eggs and ought to be almost as successful as the capture with a seine of tadpoles or of individual adults at breeding time. At the approach of the transformation the tadpoles continually remain in the shallows. To be forehanded, a person might pull a minnow seine along such an area, particularly if it be somewhat or quite weedy, and obtain four-legged stages with the stumps of the tail remaining. These complete the tail absorption in a few days and are often easier of capture than the spry small frogs along the bank. If one try to make the captures immediately after transformation is wholly completed, he will have considerable success with leopard frogs and pickerel frogs and often secure 50 to 100 frogs at one time. The aquatic forms, the small green frogs and bullfrogs, however, immediately leap into the water at one's approach and never start landward through the vegetation, as the young leopard frogs and pickerel frogs so commonly do.

DESIRABLE SPECIES.—All of the four principal desirable species for the frog market (the leopard frog, the pickerel frog, the green frog, and the bullfrog) transform at an average size of 1 to 2 inches, while all the possible or undesirable species usually transform at sizes below that of 1 inch. Of course, the danger comes in the layman mistaking a growing undesirable form for a transformed frog of a desirable species; but if he thoroughly learns the cardinal characters of the four adult commercial frogs no error should occur, for the young frogs are sufficient replicas or duplicates of the adults to make their identification easy.

Most of the leopard-frog tadpoles change to small frogs in July, although a few may wait until August before complete transformation. The average range of dates extends from June 30 to July 25, with the bulk of the transformations occurring in mid-July, the latest ones recorded being on August 6. At the approach of transformation

the young come out into the open shallows or rest at the edges of the ponds in the thick mats of vegetation. If the season has been very rainy and the mortality consequently low, a region may have almost a plague of small frogs. Then temporary ditches, holes, and transient diggings are filled with these creatures migrating from the water over the land, and these constitute the so-called rain of frogs. This shows the apparent ease with which young transformed leopard frogs can be captured at such rare occasions with pitfalls, but ordinarily the operation is less easy. If the pond about which the frogs are transforming have a heavy growth of vegetation the frogs prove

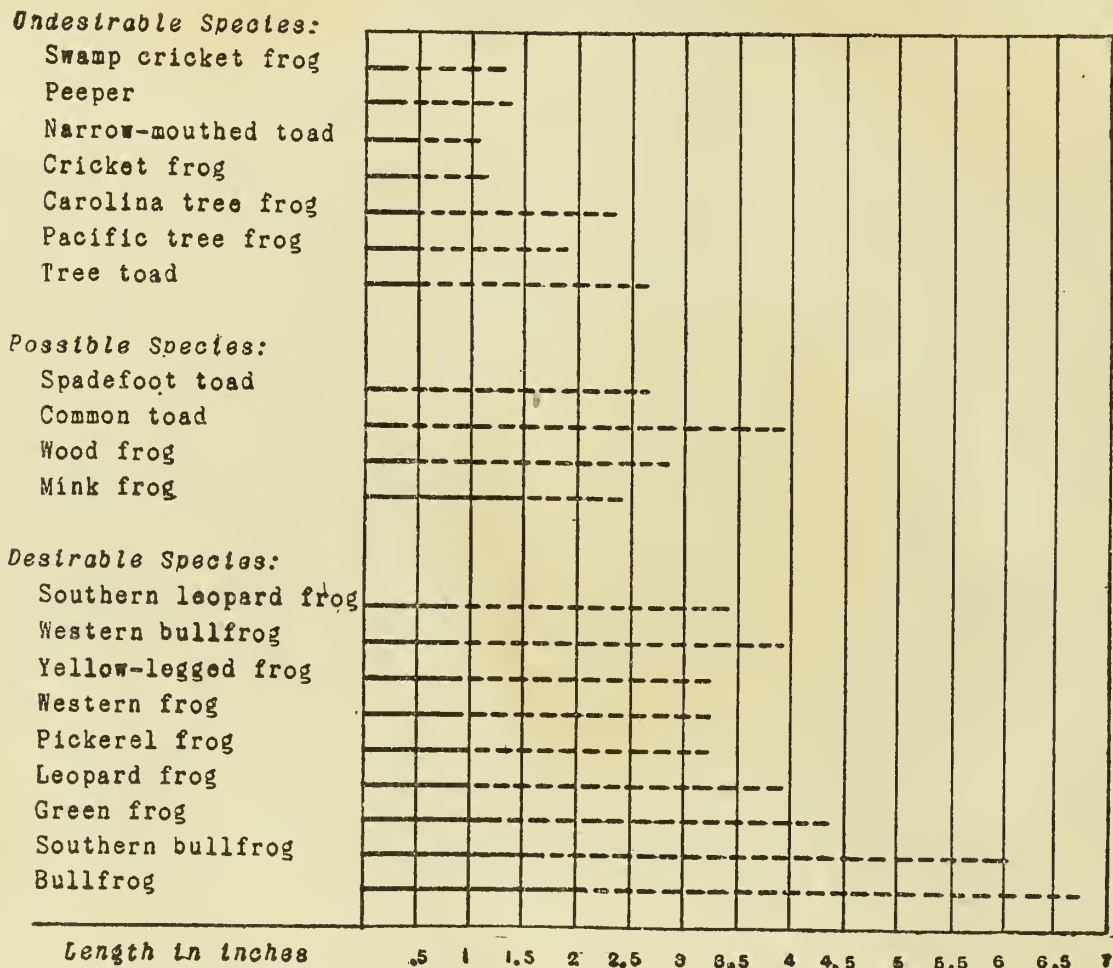
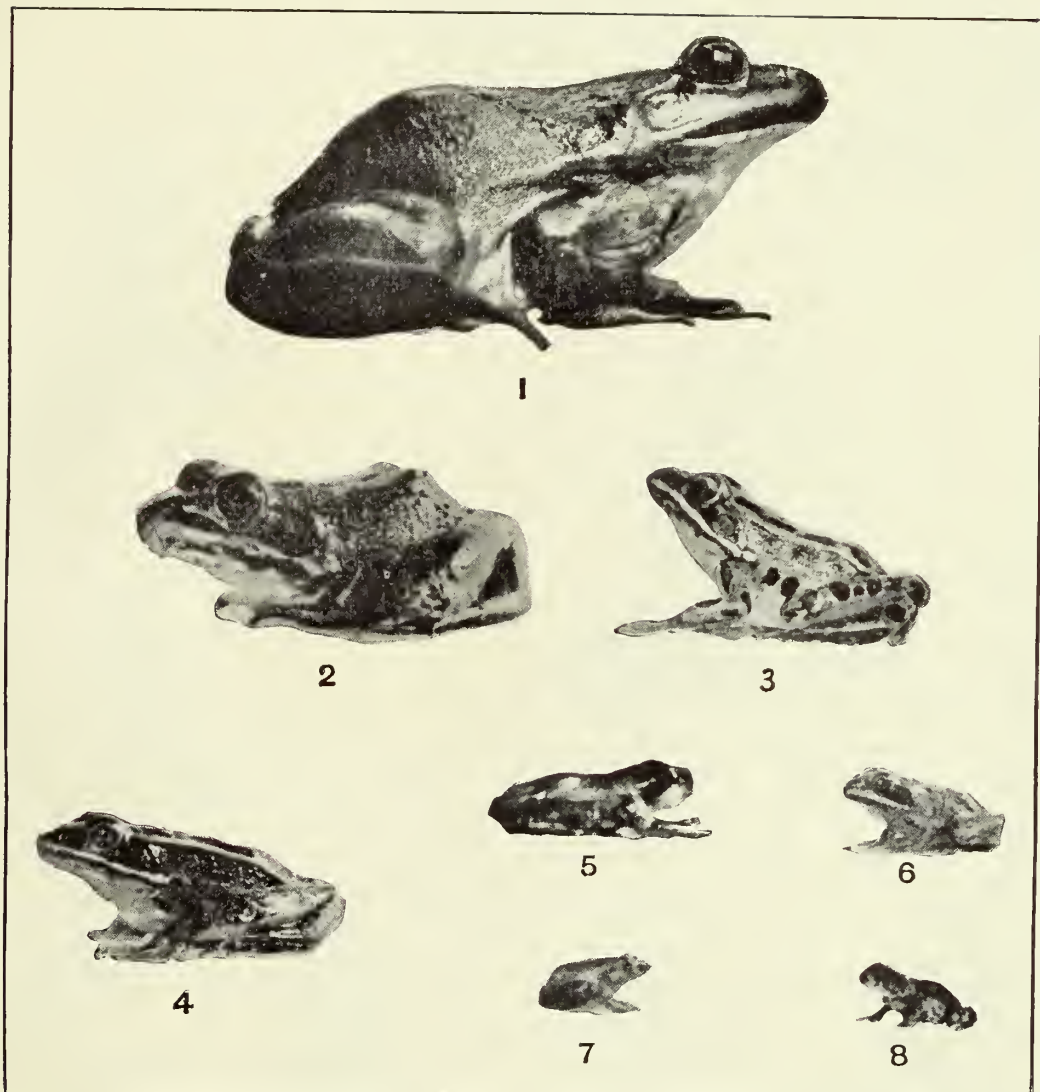


FIG. 2.—Transformation and adult sizes of frogs. Length of continuous line equals the transformation size. Length of continuous and broken lines gives adult size. Adult size determined by largest adult in author's collection.

difficult of capture and are quickly lost in the weeds; therefore, the sure method is to seine the swampy area or pond just before the final stage is reached. At transformation a young leopard frog is, on the average, 1 inch long, the range of size being 0.75 to 1.25 inches. (See fig. 2 and Pls. XXI, fig. 4, and XXII, fig. 6.)

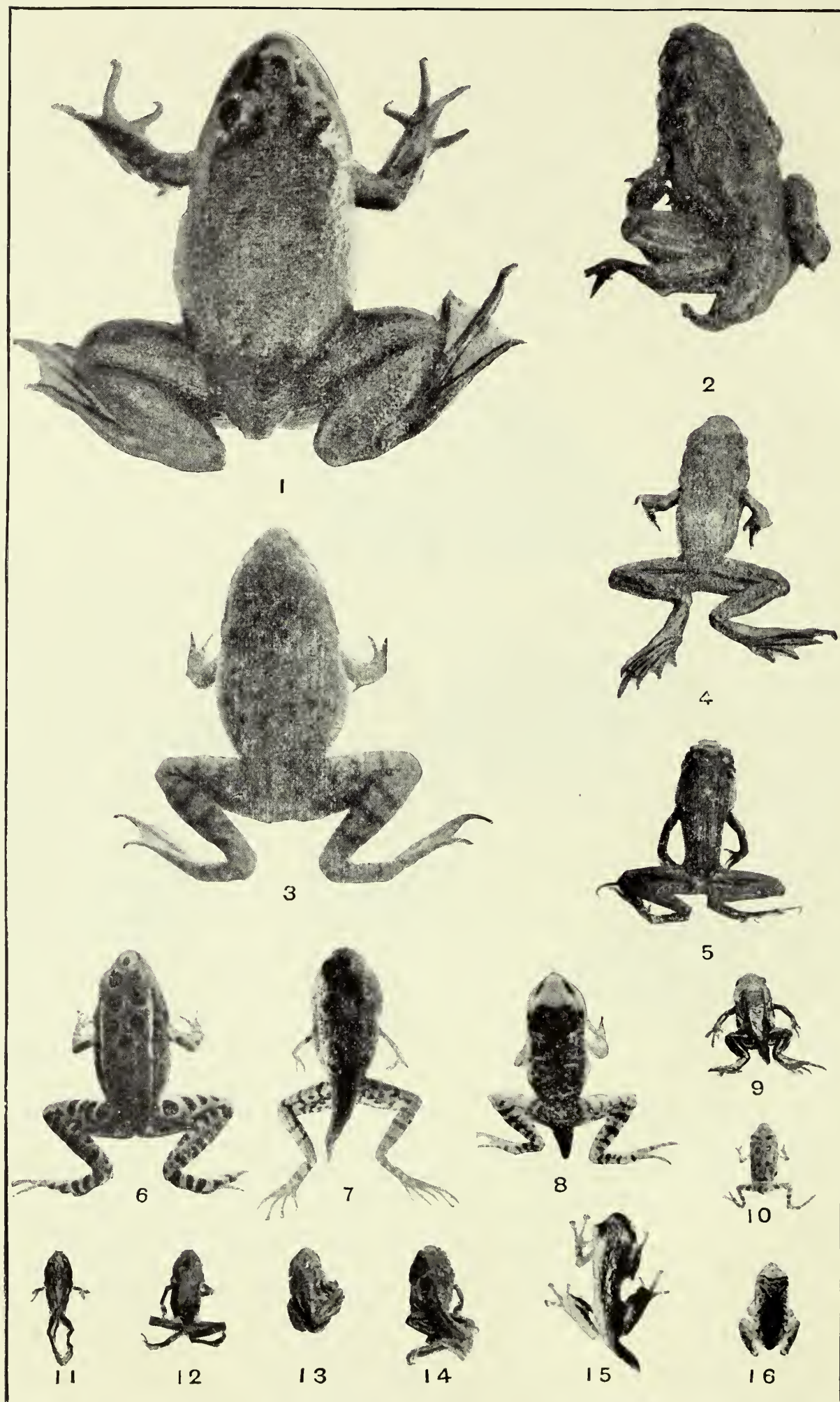
The southern leopard frog transforms during the last of June and in July. The transformed frogs range from 0.75 to 1 inch in length, the average being seven-eighths of an inch. (See fig. 2 and Pl. XXII, fig. 5.)

The pickerel-frog tadpoles may begin to transform the last week in July, but by far the greater number of larvæ transform in August. Occasionally some tadpoles do not transform until September 1 or rarely until October 1. The length at transformation averages 1 inch, and the range of size is 0.75 to 1.1 inches. What has been said



FIGS. 1 TO 8.—TRANSFORMATION SIZES, NATURAL SIZES.

1, Bullfrog; 2, green frog; 3, pickerel frog; 4, leopard frog; 5, tree toad; 6, wood frog, 7, peeper; 8, common toad. (After Wright, Carnegie Publ. No. 197.)



FIGS. 1 TO 16.—TRANSFORMATION SIZES, NATURAL SIZES.

1, Bullfrog; 2, mink frog; 3, green frog; 4, western frog; 5, southern leopard frog; 6, leopard frog; 7, pickerel frog; 8, wood frog; 9, narrow-mouthed toad; 10, common toad; 11, spadefoot toad; 12, Pacific tree frog; 13, swamp-cricket frog; 14, cricket frog; 15, tree toad; 16, peeper. (Photos of 2, 4, 5, 9, 11, 12, 13, 14 from spirit specimens.)

of the leopard frog is more or less true of the pickerel frog. A capital place to secure transformed and half-grown pickerel frogs is along the banks of the headwaters of our clear streams. (See fig. 2 and Pls. XXI, fig. 3, and XXII, fig. 7.)

The newly transformed green frogs vary in length from 1.1 to 1.5 inches, the average being 1.3 inches. Most of the transformations occur in the latter part of June and throughout July. Usually, by the first of August transformation for this species is largely, but not wholly, completed. In a species which lays from the last of May to the middle of August, or later, it is evident that some transformations may occur at any time within the same limits. This form spends one winter in the tadpole stage and is a year old before it changes to the frog form. Of all the commercial forms, this has proved the hardest to collect in numbers at the transformation stage. The long period of transformation, the smallness of some of the ponds and of their green-frog tadpole content, and the shyness of the species make it more difficult to secure a quantity of young green frogs than a similar number of young bullfrogs. It does not seem at present a convenient starting point in the culture of the green frog. (See fig. 2 and Pls. XXI, fig. 2, and XXII, fig. 3.)

The bullfrog tadpole spends two winters as a tadpole. Inasmuch as the eggs are small and deposited late in the season (usually the last of June or in July), the tadpoles are small when winter arrives. The whole of the next season is consumed in growth, and it is not until another winter is passed that the larvæ begin to approach transformation, which usually comes in July—that is, two years after egg deposition. More rarely does the tadpole spend a third winter before transformation. According to all of our data, transformation occurs in July or later. An average of the first dates recorded places the beginning of transformation at July 15. The species evidently does not begin transformation before July 1, and the period of transformation often extends to August 15. In one year, when first recorded on July 30, tadpoles were found which would require two weeks more before transformation. In another year several were found transforming on August 20, and a few other tadpoles which appeared as if they might transform in October or November or during the next season were found. The mature tadpoles begin to come out in the shallow water in early summer. Here they hide in the Chara, Nitella, hornwort, water milfoil, etc., or they rest beneath the lily pads, pond weeds, and other surface plants. Another favorite place of transformation is among the pickerel weed, arrowhead, and water plantain, which afford an overhead cover. Occasionally, around ponds where shallows are absent, stumps of trees, fallen logs, and trees fringe the edge, and their roots extend out into the water. These are favorite transformation sites for the species. At this period they are present in hundreds, or even thousands. The transformed individuals present a spirited sight as one approaches. They are shy, and long before one gets within range start skipping over the vegetation, giving the alarm note so characteristic of the species when surprised. Equally interesting is it when they occupy perches along the stumpy edges of deep ponds. It seems as if a wave of little bullfrogs keeps going before one as he skirts the pond. Inasmuch as this species requires two years to mature, it might naturally be expected that with varying conditions the tadpoles would be of diverse sizes at transforma-

tion, due to inequalities of growth. This supposition is borne out by observation. In none of the species under consideration is there such a range of size at transformation as in the bullfrog, which at this period varies from 1.7 to 2.35 inches in length, with an average of 2.1 inches. (See fig. 2 and Pls. XXI, fig. 1, and XXII, fig. 1.)

Some of the southern bullfrog tadpoles may transform in the very last of May, and the minimum transformation size recorded is $1\frac{3}{4}$ inches. (See fig. 2.)

POSSIBLE SPECIES.—The toad tadpole is among the first of the season to transform. When transformation is taking place, the shores of some ponds are black with myriads of little toads, their numbers being particularly noticeable when they leave the shores and cross near-by roads and streets. Transformation begins the last of June and may continue into August and rarely into September. The author's earliest record of transformation is June 8. The average date is June 21. The size at transformation is small, ranging from 0.3 to 0.5 inch in length, the average being 0.4 inch. (See fig. 2 and Pls. XXI, fig. 8, and XXII, fig. 10.)

The wood frog usually begins transformation about July 1. The transformation may begin as early as June 8 or extend to August 1, and the transformation size varies from 0.5 to 0.85 of an inch, the average being 0.6 of an inch. (See fig. 2 and Pls. XXI, fig. 6, and XXII, fig. 8.)

The hermit spadefoot toad transforms from June to August and ranges in size from 0.3 to 0.5 of an inch at the time of transformation. (See fig. 2 and Pl. XXII, fig. 11.)

UNDESIRABLE SPECIES.—The undesirable forms, when full grown, are small and the young transformed frogs are also small of size, none of them ranging over 0.8 of an inch, and most of them having an average size of 0.3 to 0.7 of an inch.

The narrow-mouthed toad tadpole may transform from the middle of June to September or October. The average size at transformation is 0.5 of an inch. (See fig. 2 and Pl. XXII, fig. 9.) The tree toad transforms largely during the last of July and the first of August. The size at transformation varies from 0.5 to 0.8 of an inch, the average being 0.6 of an inch. (See fig. 2 and Pls. XXI, fig. 5, and XXII, fig. 15.) The peeper tadpole usually begins to transform as early as July 1, although the average date is July 6. The range of transformation is from June 12 to August 1, and the range of size is 0.35 to 0.55 of an inch, the average being 0.4 of an inch. (See fig. 2 and Pls. XXI, fig. 7, and XXII, fig. 16.) The swamp cricket frog usually has finished transformation by July 1 and may transform as early as June 1. At transformation the frog is 0.3 to 0.5 of an inch in length. (See fig. 2 and Pl. XXII, fig. 13.) The cricket frog transforms from June 1 to July if the eggs be laid early, or in August if the eggs be laid in June. At transformation it averages a greater length than the swamp cricket frog, being 0.5 of an inch in length. (See fig. 2 and Pl. XXII, fig. 14.)

RATE OF GROWTH.

The rate of growth from transformation to the full-grown adult condition (fig. 2) is very important. If a frog requires a long period to reach adult estate, then such a factor is one item which militates

against the species as a desirable frog for cultural purposes; and other favorable factors must counterbalance if the species is to be kept in the preferred list. If, in nature, two years are required for the bullfrog to pass through the tadpole stage and five or six years more to reach a length of 6 inches, in order to make its cultivation worth while, the dangers and enemies to which it is subjected during those seven or eight years must be overcome or reduced, or else the numbers of bullfrogs must be increased by careful handling to allow for the great losses in the course of their growth. Through many years the growth of our food fishes has been observed at our numerous fish hatcheries, but there is next to nothing in the literature of this country concerning the growth of frogs. Some authors have assumed that if, just previous to hibernation in the fall or at the outcoming in the spring, the collector found three or four groups of different sizes, these groups had been hatched in as many succeeding years. There are, however, great variations. A species which laid from May to August might, in the following August, include some frogs $1\frac{1}{3}$ of a year old and some 1 year old. For growth studies it is imperative that not only the average and range of transformation size, but also the time of transformation, be known; for example, a small frog little beyond the transformation size if found in May must be almost a year old, because rarely, if ever, does any frog transform earlier than June. The results which the writer presents in the following table are merely tentative conclusions based only on measurements of frogs of all sizes collected at random over a period of 10 years.

ESTIMATED SIZES, RANGE, AND AVERAGE OF CERTAIN FROGS AT YEARLY INTERVALS OF GROWTH, SHOWN IN INCHES.

	Transformation.		1 year old.		2 years old.		3 years old.		4 years old.	
	Range.	Average.	Range.	Average.	Range.	Average.	Range.	Average.	Range.	Average.
Pickereel frog.....	0.75-1.1	1.0	1.1 -1.75	1.5	1.75-2.1	1.875	2.1 -2.45	2.3	2.45-2.75	2.6
Leopard frog.....	.72-1.25	1.0	1.25-1.75	1.5	1.75-2.2	2.0	2.2 -2.5	2.35	2.5 -3.0	2.7
Green frog.....	1.1 -1.5	1.3	1.5 -2.05	1.8	2.05-2.6	2.25	2.6 -3.15	2.85	3.15-3.85	3.5
Bullfrog.....	1.7 -2.35	2.1	2.35-2.85	2.6	2.85-3.6	3.25	3.6 -4.4	4.0	4.4 -5.2	4.75
Wood frog.....	.5 -0.84	.62	.84-1.15	1.0	1.15-1.59	1.375	1.59-2.05	1.8	2.05-2.55	2.25
Tree toad.....	.56-0.81	.62	.81-1.15	1.0	1.15-1.6	1.375	1.6 -2.0	1.8

In most of these forms the frog reaches the breeding condition in four years, and in the case of the pickerel frog, leopard frog, and green frog some individuals may possibly breed when 3 years old. The bullfrogs which reach 7 or 8 inches in length must require seven or eight years for such a growth. In all the forms, a growth of an inch a year is unusual, the normal rate being from 0.35 to 0.75 of an inch a year. The wood frog reaches maturity in four years, and the tree toad in three years. In both, the rate of growth is apparently about 0.35 inch a year.

FOOD.

The food problem is one of the crucial questions in the feasibility of frog culture. No very systematic seasonal study of the food of

our frogs has ever been undertaken and successfully completed. The toad has been quite thoroughly studied throughout its feeding season.^a The best food investigation of any of our frogs (*Rana pipiens*) covers a very short feeding period from August 8 to 22,^b while the food of the bullfrog has aroused interest and some attention because of some of its bizarre tendencies. As a consequence, the food of the tadpoles, transformed frogs, and adults of our commoner species can not be spoken of as positively as would become scientific parlance. A summary of what has appeared will have to suffice until comparative studies which are in progress are forthcoming.

FOOD OF TADPOLES.

In the earlier days armchair scientists held that the food of a tadpole had to be almost or quite wholly vegetable in nature, because of the elongate intestine the creature possessed; but even casual observers have noted with what avidity tadpoles assemble around a dead fish. The taxidermist knows very well to what a bone-clean condition tadpoles reduce carcasses of mammals, birds, or cold-blooded vertebrates. Several experimenters in frog culture have maintained that they could raise tadpoles on dressed submerged fish or on liver, a well-known fish food. These animal tendencies in the diet of an apparent vegetarian extend even to the devouring of their own kind under stress of unusual circumstances. It must, however, be remembered that most of this animal food, if not all of it, is dead and immobile. Seldom do they prey on larger aquatic animals or even on the smaller forms, unless these incidentally occur in the food stream which is mainly vegetable in character. Their animal-feeding proclivities are mainly those of scavengers, and it is therefore hardly correct to call them carnivorous or omnivorous, as has been done by some. Up to the present time there has been no serious extended examination of the food of tadpoles, because of the enormity of the task and on account of the previous uncertainty of the identification of the frog species to which they belonged.

FOOD OF TRANSITION STAGES.

This period when the tadpole changes to a small frog is a critical time in the life history of any individual frog and is in many ways the most important point of attention for the frog culturist. The creature makes a complete change of form, becomes truly carnivorous, spends some of its life on the banks or in the fields, and therefore can not be expected to adjust itself in an instant to a new existence. Dr. Philip A. Munz, who is studying the food of transforming and transformed frogs, presents the following preliminary and provisional summary from his examinations:

Thus far a fairly representative series of each of the following species of *Rana* has been studied: *R. catesbeiana*, the bullfrog; *R. clamitans*, the green frog; *R. sylvatica*, the wood frog; and *R. palustris*, the pickerel frog. In each species the same general tendencies are evident:

^a Kirkland, A. H.: The habits, food and economic value of the American toad. Hatch Experiment Station of the Massachusetts Agricultural College, Bulletin 46, April, 1897, Amherst, Mass.; also, Usefulness of the American toad, U. S. Department of Agriculture, Farmers' Bulletin No. 196. Washington, 1904.

Garman, H.: Kentucky Experiment Station Bulletin No. 91. 1901.

Hodge, C. F.: Nature study leaflet. Worcester, Mass., 1898.

^b Drake, Carl J.: The food of *Rana pipiens* Schreber. Ohio Naturalist, March, 1914, Vol. XIV, No. 5, pp. 257-269. Columbus.

(1) The larval alimentary canal is very long, but slightly differentiated in its various portions and filled with ooze and silt scraped up from the objects in the pond and containing many species of diatoms, blue-green and green algæ of filamentous and nonfilamentous forms, small pieces of green plant tissue, and bits of fibers and other nondecaying material found in ooze. As yet I have found no tadpoles containing animal tissue, but as is generally known, they nibble off small pieces of flesh when it is available. Insects, mites, spiders, etc., are quite universally absent from the larval food; even the small water crustacea are rarely met with.

(2) After the fore and hind legs are both in evidence and the horny plates of the tadpole mouth are shed, the tail is gradually shortened and the alimentary canal shortens to become dilated anteriorly and posteriorly, forming the stomach and the rectum, the latter communicating with the cloaca. During this time there is practically no food taken in, although the fat in the body cavity is scarcely reduced in amount; evidently the material available as the result of the absorption of the tail is sufficient. The epidermis is evidently shed often during the absorption of the tail; for in many cases, especially in the bullfrog which is large enough for it to be more apparent, epidermis is present in the alimentary canal; this tendency to swallow the cast epidermis seems quite universal. Occasionally a few algal filaments seem to become entangled in it and are then present in the stomach contents.

(3) After the tail is reduced to a mere remnant with a length of 1 to 2 millimeters (0.4 to 0.8 of an inch) and the mouth has increased to several times its former size, the alimentary canal has become from one-sixth to one-tenth of its larval length, and the young frog again begins feeding, now taking mostly animal food. The range of forms consumed is very great, each species of frog apparently eating anything alive and moving and yet small enough to swallow. Crustacea, Isopoda, Acarina, Arachnida, and almost every group of Insecta have been found. The forms fed upon are not aquatic to any extent, but feeding is done largely above and near the water. Naturally such life as is to be found on or near the ground is most available and the stomach content is largely ground beetles, plant lice, springtails (*Collembola*), leaf hoppers, snout beetles, spiders, mites, sow bugs, ants, and small flies. Of the molluscs, snails are occasionally met with, and of the vertebrates only a few have been observed, such as young frogs and toads in young bullfrogs.

The differences in selection of food may come under two categories: (a) Those due to the size of the species of frog—the bullfrog, for example—can and does eat much larger forms than can the smaller species, and yet it also takes the smallest mites; and (b) those due to the location and nature of the ponds from which the specimens were taken; for in different locations are to be found different food materials. But as yet I have been able to observe no difference in the range of insects or other forms eaten by each species,

By way of summary, then, the tadpole is largely herbivorous; the transforming individual does but little or no feeding, and the young frog is carnivorous, eating plant and inorganic materials perhaps as a matter of accident while seizing insects or other prey.

FOOD OF ADULTS.

Growing and adult frogs are carnivorous. To be sure, they may accidentally take in vegetation or mineral matter, but this is an incident to their pursuit of moving prey or synchronous with the swallowing of their own cast skins. If their prey remains quiet it may escape. If our frogs pursued their prey in the water as do fishes there would be no particular need for a tongue, and some of the most aquatic frogs of the world have little or no tongue as a consequence. Practically all of the frogs of the United States are possessed of a good, thick, adhesive protrusible tongue, which is fastened at its forward end. The posterior end of the tongue can be shot forward and then quickly retracted with the prey affixed or held.

It must be remembered that our frogs do not pursue their prey beneath the water; therefore it becomes evident that practically all food prehension for our species takes place at or above the water's surface, on the shores of bodies of water, on the banks of streams, in the meadows, or in some cases in the trees. Some remain in favorable position and capture the passing prey; others hop toward

their prey until within range; still others occasionally stalk their prey; and a fourth group, like the tree frogs, may at times leap into mid-air for their game.

The tongue is the main organ of prehension, but the forefeet are often used in a ludicrous manner to help in forcing into the mouth a difficult or cumbersome object. If one tries to force food or other objects into the mouth of a captive frog, however, the same feet may often be employed to prevent the operation.

A general summary of the various food elements as thus far determined by previous authors follows.

VEGETABLE MATTER.—What Kirkland ^a found true for the toad obtains more or less for our species of true frogs. He held that—

Vegetable material formed less than 1 per cent and from its character appears to have been taken by accident and can not be properly considered as food. Since the toad takes the greater part of its food from the ground by means of its large, fleshy tongue, nothing can be more natural than that a small quantity of vegetable detritus should be swept into the mouth along with the insects on which the animal feeds. The most common vegetable substance found in the stomachs is grass, both dry and fresh. Bits of rotten wood, broken acorn shells, seeds of the linden (*Tilia americana*) and maple (*Acer saccharinum*) and bits of apple parings have also been detected. All these vegetable substances were usually associated with a large quantity of ants and other terrestrial insects.

Possibly the more aquatic frogs, like the bullfrog and green frog, might take more vegetable matter than the more terrestrial leopard frog or wood frog. The former have a feeding ground where the algal carpet of the water's surface may be the alighting ground for the prey, or where the wet, broken vegetation of the shore may be the hiding ground of numerous insects.

MINERAL MATTER.—Of this habit Kirkland writes the following:^a

The mineral matter found in the stomach forms slightly more than 1 per cent of the total contents and consists of gravel, sand, and, in a few cases, coal ashes. When a large piece of gravel is swallowed it is regurgitated; this I have proven by experiments on toads in confinement. Otherwise the gravel passes through the alimentary canal and may be found in the castings. Since the toad does not masticate its food, but depends on the stomach for the whole process of trituration, it is probable that the gravel when present assists in grinding the strongly chitinized bodies of beetles, etc., yet in the majority of the toads examined there was no gravel present in the alimentary canal, although many of the stomachs contained finely ground beetles. A proper inference from the above is that gravel is not essential to digestion in the toad, and the writer inclines to the opinion that, as in the case of the vegetable matter, the presence of gravel in the stomachs is the result of accident rather than of design.

ANIMAL MATTER.—No doubt, in the case of our four principal commercial species this element constitutes from 97 to 98 per cent of the food, as in the toad.

Mollusks.—Mollusca are seldom eaten by the wood frog and pickerel frog and constitute about 1 per cent of the food of the toad and about 3 per cent of that of the leopard frog. Mollusca no doubt enter to an appreciable extent into the diet of the more aquatic forms of anurans. Surface ^b found the green frog alone had eaten mollusks to any extent, while Dyche ^c found 12 of his 30 bullfrogs had eaten snails, one having 9 in its stomach.

Worms.—These enter into the nocturnal toad's diet more than into that of any other species and constitute 1 per cent of its diet. Worms

^a Kirkland, A. H.: Loc. cit., pp. 13-14.

^b Surface, H. A.: Bi-Monthly Zoological Bulletin. Division of Zoology, Pennsylvania Department of Agriculture. Vol. III, Nos. 3 and 4. 1913.

^c Dyche, L. L.: Ponds, pond fish, and pond-fish culture; pp. 150-153. State Department of Fish and Game, Kansas. Topeka, 1914.

have been recorded in the food of the leopard frog but are rare in the food of the other four common species of frog.

Spiders.—Spiders and their relatives are eaten by the smaller forms like the cricket frog, swamp cricket frog, peeper, and tree toad, as well as by all of the larger forms. "Spiders occur in the stomachs of the toad in all months, but form only 2 per cent of the total food."^a In the case of the leopard frog, according to Drake,^b they constitute 27 per cent of the food of the species and are, next to beetles, the largest single item, while in the wood frog, pickerel frog, green frog, and bullfrog, spiders form 8 to 12 per cent of the food of these forms.

Crustaceans.—The smaller forms, like the cricket frog, swamp cricket frog, peeper, and tree toad, very rarely, if ever, eat small crayfish, and only in very shallow water or in pools which are drying up do the leopard frogs attempt an extensive diet of crayfish. There are no records of these creatures being used as food by the pickerel frog, wood frog, or toad, the two latter being quite terrestrial. The more aquatic creatures—that is, the green frog and the bullfrog—eat them, the first to the amount of 4 or 5 per cent, while the last, being larger, makes them 20 or 25 per cent of its whole diet. The opposite condition obtains in the case of the sow bugs, since the bullfrog does not eat them and the green frog very seldom, while the more terrestrial leopard frog may make sow bugs 4 or 5 per cent of its food. These creatures form 2 per cent of the toad's food, and the pickerel frog also occasionally eats them.

Myriapods.—"Myriapods [according to Kirkland ^a] form a constant article of diet for the toads. * * * These creatures form 10 per cent of the food for the season." They constitute 1 or 2 per cent of the food of the leopard frog, 4 or 5 per cent of the food of the pickerel frog, and 5 or 6 per cent of the food of the green frog.

Insects.—Insects are the main food reliance for frogs, tree frogs, and toads. Five orders, possibly a sixth (Diptera), enter largely into their dietary list. The five principal orders are Coleoptera, Lepidoptera, Hymenoptera, Hemiptera, and Orthoptera. The evidence serves again to prove that these amphibians get most, if not all, of their food above the water or outside of it.

Coleoptera, mainly ground, lamellicorn, and click beetles, and weevils constitute 27 per cent of the food of the toad, while in the animal food of the leopard frog beetles form 33 per cent of the whole, the principal groups being ground, tiger, and snout beetles. In the food of the wood frog, pickerel frog, and green frog the proportion is equally large, while in the diet of the bullfrog the beetle element is surprisingly large; no doubt, water beetles of the surface enter into the food of the bullfrog more than into that of the other species of frog.

Lepidopterous (moths and butterflies) larvæ prove very tempting morsels to toads and make up 28 per cent of their food, while this order constitutes 13 per cent of the leopard frog's diet, about 15 to 17 per cent of that of the wood frog, pickerel frog, and green frog, and only about 5 or 6 per cent of that of the bullfrog.

Hymenoptera form an appreciable part (19 per cent) of the food of the terrestrial forms like the toad. In the diet of the smaller tree frogs and of the young of the larger forms, hymenoptera (ants, etc.),

^a Kirkland, A. H.: Loc. cit., p. 15.

^b Drake, Carl J.: Loc. cit., p. 265.

together with flies, replace the beetles of the adults. In the food of the wood frog and of the pickerel frog this order of insects constitutes 4 per cent, or less, and is a negligible factor in the green frog's and bullfrog's diet.

Orthoptera: Roaches, crickets, and grasshoppers make up a prominent part of the food of the adult leopard, wood, and green frogs, while mole crickets not infrequently enter into the diet of the bullfrog. Orthoptera furnish 3 per cent of the animal food of the toad.

Hemiptera: Bugs enter but slightly into the food of the wood frog and bullfrog, form less than one-half per cent of the food of the toad, 4 per cent or less of the leopard frog's diet, 8 per cent of that of the green frog, and 12 per cent or more of that of the pickerel frog.

Diptera: Flies and their relatives form $1\frac{1}{2}$ per cent of the food of the leopard frog and one-half per cent of that of the toad. They are rather a negligible factor in the food of the large forms, while in such creatures as the cricket frog they may play a prominent rôle.

Vertebrates.—Vertebrates enter but seldom into the diet of any but the largest forms, such as the bullfrog. Dyche^a records the finding of bullheads, crappies, sunfish, goldfish, bullfrog, and other frog tadpoles in the stomachs of bullfrogs. There are extant records of unusual food, like young ducklings, sparrows, mice, snakes, and young newly hatched alligators, in the food of this same species. The other frogs are too small of maw to essay the devouring of any vertebrates.

ENEMIES.

No article is more sought for or more relished as a food by a diversity of animals from fish to man than frogs. The latter's defense consists in concealment and in the possession of poison glands in the skin, neither of which means is aggressive in its nature. Insects and plants may prove a more constant fare, but to any fair-sized animal a frog diet is one of the preferable menus, if obtainable.

INVERTEBRATES: One would naturally think the insect and small animal life of the inland waters was a negligible factor in the reduction of the number of frogs, tree toads, and toads. But for the tender early larval stages and even for the more mature tadpoles these are very serious foes. Anyone who has collected a miscellaneous mass of aquatic life and put it all in one jar knows from dear and sad experience that these small creatures of the water often prey upon and kill the confined tadpoles and small frogs. In the open, especially at night, has the writer seen adult peepers and swamp cricket frogs or their tadpoles in the fatal grip of giant water bugs. Other aquatic bugs, like the well-known *Zaitha*, walking sticks, and, not least, the back swimmers, make life precarious for tadpoles or miserable for adult frogs in the water. The water beetles, especially their larvæ (water tigers) and dragonfly nymphs also take their heavy toll of tadpole lives. Many of the smaller, almost microscopic, crustaceans, like daphnia and others, are reputed to be incessant enemies covering the whole bodies of the tadpoles. Some of the larger crustacea, like the crayfish, may possibly take the live tadpoles, but it can not be definitely stated that they do. Mosquitoes, gnats, etc., pester frogs and tree frogs when out of the water, but in general little is known of this matter, because it usually happens at night when man is seldom observant.

^a Dyche, L. L.: Loc. cit., pp. 150-153.

FISHES.—Fish which are almost wholly restricted to the same habitat as frogs might be considered the most serious foe of the early aquatic stages of the frogs and toads. It is very doubtful, however, if their depredations compare with those of the aquatic snakes. In the quiet waters where tadpoles frequently resort the worst depredators are the members of the pike family. From the lunge down to the little grass pike is a series of forms which revel in frogs and their tadpoles. Equally appreciative of small frogs and tadpoles are basses, but some of the larger, like the smallmouthed bass, are not abundant in the habitat of frogs. Forms of the quiet water, like the largemouthed bass and sometimes the rock bass and others of similar habits and of equally large maws, feed on them. The omnivorous catfishes sometimes eat the young tadpoles, the growing frogs and the trouts especially do. The horned dace and some of the larger voracious minnows occasionally eat the newly hatched larvæ of frogs.

AMPHIBIANS.—The aquatic salamanders, like the newt, frequently pull off eggs from a frog's egg mass for food. The larger forms, like the mudpuppy (*Necturus*) and hellbender (*Cryptobranchus*), may eat frog's eggs or larvæ if favorably situated. Among frogs there are several species whose adults do not stop at fratricide or cannibalism. In fact, it is one of the factors which has led some frog culturists to abandon bullfrogs, which will feed on anything from insects to small alligators, not even sparing their own progeny.

REPTILES.—In this group we find some of the most inveterate and merciless foes of frogs. In the southern States an archenemy is the alligator. Among the turtles the snapping turtles lie in wait for frogs and their tadpoles, while the more alert and active soft-shelled turtles may at times pursue them. The equally vicious musk turtle also is a foe of the frog. The spotted and painted turtles and some of the other "sliders" or so-called terrapins are said to feed on tadpoles, but of this the writer has no first-hand evidence.

The snakes, both aquatic and semiaquatic, are the worst pests the frog has to meet. Among the cold-blooded vertebrates there is no more relentless preying of one thing upon another than the persistent hunting by day or, better, by night of a ribbon snake or water snake for frogs. In fact, frogs are, par excellence, the food of the aquatic snakes. Several of the semiaquatic garters eat or prefer true frogs, cricket and swamp cricket frogs. The very aquatic water snakes (*Tropidonotus*) of several species, are the worst offenders and at times feed exclusively on frogs. The rainbow and red-bellied (*Farancia*) snakes also feed on frogs or their tadpoles. On the land the spreading adder is the main enemy. The black snake and garter snakes are quite partial to them, and the pilot snake, copperhead, or ground rattlesnake do not scorn them.

BIRDS.—Whoever plans to raise frogs must beware of several of our largest and most distinctive forms of birds. The herons and bitterns are the most serious frog eaters. Their long legs and toes equip them for wading, and their long necks and bills are adapted either for a silent waiting game or a slow, stalking search. They frequent the shallows where the tadpoles and transforming frogs are abundant. The great blue heron, the little green heron, the little blue heron, and some of the less familiar forms of the South wait

long periods or slowly patrol in the open stretches of lakes, ponds, and streams for their game. The bitterns inhabit the cover of the marshes and stalk their prey. Among the hawks, the various species of kites feed upon frogs, but because of their rarity are a negligible factor. The marsh hawks eat some frogs. The despised Cooper's hawk rarely takes to a frog diet, while the red-shouldered hawk and sometimes the broad-winged hawk eagerly seek frogs. Into the diet of owls frogs seldom enter, the barred owl most frequently being the depredator. W. B. Barrows^a found that no food occurs more regularly in the crow's stomach than frogs and toads. In April to July it is the largest live animal item, except insects, in the crow's diet. Of the kingfisher frogs need to beware, though they are seldom seen with frogs or tadpoles, fish being the usual fare. Bronzed grackles eat frogs but rarely. The totipalmate birds, like the snakebird, cormorant, and pelican, are largely fish eaters, but they, no doubt, pursue and capture some frogs. Several ducks are reputed to eat frogs, and one, the hooded merganser, is often called the "frog duck." It would also be well to bear in mind the charge that domestic ducks eat the tadpoles and occasionally the transformed and transforming stages.

MAMMALS.—In this country the four-footed mammals which eat frogs are very few. Most of these belong to the weasel tribe. The skunk enjoys a good frog when he can catch it, and the mink quite frequently varies his diet with them. The weasels are occasional depredators, but are not comparable to the house or brown rat, which tries anything and everything it can catch. The muskrat is a nuisance in any pond and should be held with suspicion, as should the raccoon. Some individual domestic cats have been known to develop a fondness for frogs, and particularly for tadpoles.

Man is not content with cleaning up and draining the "frog holes" or swampy stretches, but he kills the frogs at all seasons. Few, if any, of our State legislatures see fit to protect them and establish open and closed seasons. As a result, they are taken mainly when they congregate for breeding purposes, and such a toll hardly accords with the ideas of conservation held at the present day.

Nine-tenths of the wild supply is secured at the breeding season or just before breeding. Such a profligate expenditure can not long escape our attention. As thoughtless youths many of us often counted our strings of 100, and some of us hunted them regardless of the season.

In the eastern United States the four important commercial forms should not be killed in the wild state before the following dates:

Leopard frog.....	May 1, or, better, May 15.
Pickrel frog.....	May 10, or, better, May 20.
Bullfrog.....	July 1, or, better, July 15.
Green frog.....	July 15, or, better, August 1.

^a Barrows, W. B., and Schwarz, E. A.: The common crow of the United States. U. S. Department of Agriculture, Division of Ornithology and Mammalogy, Bulletin No. 6, pp. 50, 51. Washington, 1895.

