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The food habits of Rana catesbeiana Shaw and other ranids from five different pond types

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The Food Habits of *Rana catesbeiana* Shaw and Other Ranids From Five Different Pond Types

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Introduction

The amphibian family Ranidae is world wide in distribution, occurring on all continents and forming one of the largest families of frogs. Rana, the only genus found in the United States, contains about 400 species, 27 of which are found in the New World (Blair et. al., 1957). Species such as R. catesbeiana, R. clamitans, R. pipiens, and R. grylio have considerable economic importance; prized as food by man, they are also often used as experimental animals in biological research. Only four species normally occur in Central Virginia; R. catesbeiana, R. clamitans, R. pipiens, and R. palustris.

In the present study an effort was made to determine if differences existed in the food habits among the four species of Rana. R. catesbeiana, by far the most abundant species, was studied specifically to determine if differences in the food habits existed between sexes, size groups, habitat types, and seasons.

A number of food habit studies have been made on the various members of the genus Rana. A complete and seasonal study of the food habits of 455 bullfrogs from Missouri ponds was given by Korschgen and Moyle (1955). They found that insects and crayfish were the two most important food items by volume in the diet of R. catesbeiana. Frost (1935) examined 25 specimens of R. catesbeiana and found that insects comprised the main food item. Needham (1905) in Korschgen and Moyle (1955), in a study of 30 bullfrogs from New York State, noted that insects and spiders were the food items most often taken. The food habits of R. catesbeiana in Puerto Rico were studied by Perez (1951) to determine if bullfrogs preyed on introduced toads. As in other

studies, insects were found to be the staple diet. Occasional notes have been published on the occurrence of unusual food items in the bullfrog's diet. Birds as food have been reported by Howard (1950) and Hewitt (1950). Holman (1957) records bullfrog predation on eastern spadefoots (Scaphiopus holbrooki), and Heller (1927) reports the occurrence of a Brewer's mole (Parascalops breweri) as food of R. catesbeiana. Minton (1949) noted a most unusual occurrence of a coral snake (Micrurus fulvius) in one bullfrog from Texas.

Several papers which concern the food of R. pipiens reported this frog to be primarily insectivorous. Ninety-one specimens of R. pipiens examined by Knowlton (1944) were found to contain primarily insects. In the same study, cannibalism was reported for one specimen. Other cases of cannibalism in R. pipiens have been reported by Kirn (1949). In a study by Moore and Strickland (1954), R. pipiens from Alberta, Canada were found to feed primarily on arthropods and to a lesser extent on earthworms and snails. Humming birds were one of the most unusual organisms recorded as food for R. pipiens (Norris-Elye, 1944).

The food and feeding habits of R. clamitans from New York State have been studied by Hamilton (1948). He found that, as in the other two species, insects constituted the most important food item in the diet of the green frog.

Although searched for, there were no papers found which discussed the food habits of the pickerel frog, R. palustris.

A relatively thorough reveiw of the literature of Rana failed to reveal any significant comparative study of habitats as effecting

food habits. Accordingly, in the present study, the food habits of frogs from five different types of pond habitats in Southeastern Hanover County are described.

Materials and Methods

One hundred and sixty-three frogs were captured in forty-nine collection trips between June 18, 1958, and November 1, 1958. Four species were taken; 138 Rana catesbeiana, 14 R. clamitans, 10 R. pipiens, and one R. palustris. The procedure followed was to make one complete encirclement of the pond, either by boat or by wading. Although weather was considered as a factor affecting available food, definite conclusions as to its influence could not be reached because of insufficient data. Frogs were located with the aid of a strong light, and regardless of size, taken by hand or gig. The natural wariness of frogs made capture, in attempted daytime collections, impracticable, and the presence of nearby houses prevented the use of a rifle; therefore, all specimens examined were captured after sunset. Time of collection, water condition, temperature of air and surface water in degrees C., weather, and the presence of frogs and other organisms were noted on a field data sheet. Upon capture, frogs were placed in 10 per cent formalin; large specimens (body length of approximately 50 mm. and above) were first injected to insure preservation of the internal organs.

In the laboratory, the specimens were catalogued and stored in 10 per cent formalin until examined. Three measurements were taken on

each specimen: 1) total weight; 2) body length (distance from tip of snout to tip of cloacal aperature); and 3) mouth width (shortest distance between corners of mouth). Length measurements were to the nearest one-half mm. by means of dividers; weight was recorded to nearest tenth of a gram. A size-ratio number for each specimen of R. catesbeiana was obtained by dividing the true weight (weight of frog minus weight of stomach contents) by the width of the mouth. Three artificially determined size groups were chosen after plotting body length in mm. against size-ratio number of each specimen (Graph 1). The line of best fit for each size group was obtained by the method of moments (Wilson and Tracey, 1949). The region of the alimentary tract examined included the posterior part of the esophagus and the stomach. A longitudinal incision was made and the contents removed; these were weighed to the nearest one hundredth of a gram, first collectively, then each item separately. After identification, the items were preserved in 33 per cent isopropyl alcohol. Sex was determined by a gross examination of the gonads.

Three different data which concerned stomach contents were devised: 1) per cent of stomachs with item (obtained by dividing the number of stomachs which contained a specific item by the total number of stomachs with any type of material); 2) per cent occurrence of item (obtained by dividing the number of a specific item taken by the total number of items); and 3) per cent weight of item (obtained by dividing the weight of a specific item taken by the total food weight of all items).

Abbreviations used in tables are as follows:

(A) - Adult,
(L) - Larva,
(N) - Nymph,
Veg. - Vegetative,
Invert. - Invertebrate,
Vert. - Vertebrate.

The following abbreviations were only used in Table 2:

Pct.S. C. - Per cent of stomachs with item,
Pct. Occ. - Per cent occurrence of item,
Pct. Wt. - Per cent weight of item.

Statistical analyses which concerned differences of mean weight of stomach contents per stomach between sexes, and specimens of the different ponds, follow Fyrer (1954), Lacey (1953), and Snedecor (1953).

Description of the Collection Areas

The five ponds used in the study are dispersed throughout an area of approximately ten square miles in Southeastern Hanover County, totally within the Coastal Plain (Plate 1). A part of the Chickahominy River system, the drainage area is composed of a mixture of woodland, pastures and cultivated land. All ponds were artificially constructed and are privately owned. They have a diversity of uses, i.e., recreation, irrigation, and as a source of water for livestock. A brief account of the characteristics of the individual ponds follows below.

Pond A, located in a dense growth of hardwoods, was first built in 1946. The present pond was formed in 1955 following destruction of the original by floodwaters (Plate 2). The long axis lies in a north-

south direction, with an earthen dam at the south end. Fed by springs and a small creek at the north end, the pond has a surface area of approximately three acres, and a maximum depth of 13.5 feet near the dam. Only a small portion of the drainage area is cultivated, the rest is wooded; consequently the water was clear throughout the collection period with but little fluctuation in level. Surface temperature ranged from 28 degrees C. in July to 14 degrees C. in October.

Profuse vegetation overhung the water line except at isolated open areas on the dam and east bank. The west end of the dam was covered with smooth alder (Alnus rugosa) and honeysuckle (Loniceria japonica), while numerous species of unidentified grasses and annuals grew on the east end. Dominant vegetation on the southwestern bank was Alnus rugosa and sweet pepper bush (Clethra alnifolia), while that of the northwestern bank was a composite of hardwoods with an undercover of Loniceria japonica. The hardwood flora consisted of sweet gum (Liquidambar styraciflua), tulip tree (Liriondendron tulipifera), bitter nut hickory (Carya cordiformis), and red maple (Acer rubrum). A zone of river birch (Betula nigra) and crack willow (Salix fragilis) was present on the southeastern bank; vegetation on the northeastern side was similar to that of the northwestern. Black gum (Nyssa sylvatica) grew in the marshy headwaters.

The aquatic vegetation consisted of small, widely distributed growths of epiphytic and littoral filamentous algae. Three species dominated the emergent vegetation, yellow water lillies (Nuphar advena) at the north end, rushes (Juncus effusus) in the southwestern shallows, and cattails (Typha latifolia) on the southeastern bank.

Pond B was built in 1952 as a source of water for irrigation (Plate 3). The long axis lies in an east-west direction; an earthen dam, at the south end forms the impoundment. Supplied by springs, the pond has a surface area of approximately one and one-half acres, and a maximum depth of 12 feet near the center. The drainage area is divided almost equally between woods and cultivated land. After hard rains, the water was observed to increase greatly in turbidity. As water was removed periodically for irrigation, the surface level fluctuated, at times as much as six inches. Surface temperature ranged from 31 degrees C. in July to 15 degrees C. in October.

Only on the northwestern bank did vegetation overhang the water line. Dominant vegetation on the eastern and western banks was composed of a mixture of Carya cordiformis, Liriondendron tulipifera, Acer rubrum, beech (Fagus grandifolia), and white oak (Quercus alba). A sandy projection, covered with Lonicera japonica, unidentified grasses, and blackberry (Rubus argutus), divided the northern bank. The primary undercover plant on the eastern and northwestern banks was Lonicera japonica. Nyssa sylvatica was the dominant plant in the headwaters. Major plants found on the dam were dog fennel (Eupatorium capillifolium) and broom straw (Artholophis sp.).

The southwestern, south, and southeastern water lines supported numerous clusters of Juncus effusus. Pondweed (Potamogton sp.), and filamentous algae grew in the shallows except where vegetation overhung the water.

Pond C, built in 1924, is a recreational pond open to the public

for fishing and swimming (Plate 4). The long axis lies in a north-south direction, with an earthen dam at the north end. Fed by numerous creeks and springs, the pond has a surface area of 11 acres, and a maximum depth of 26 feet near the dam. Woods comprise the greater portion of the drainage area with the remaining in cultivation. The water, usually clear, became slightly turbid after hard rains, and no pronounced fluctuation in water level was observed. Surface temperature ranged from 30 degrees C. in July to 14 degrees C. in October.

A small bay divided the west bank into two distinct regions. Predominant vegetation on the northern portion, a picnic and fishing area, was separated into three zones. The most southerly was dominated by short leaf pine (Pinus echinata); the middle zone by weeping willow (Salix babylonica) and S. fragilis, and the northern, a beach, was devoid of vegetation. The southern portion was predominantly hardwoods, consisting of Liquidambar styraciflua, post oak (Quercus stallata), swamp white oak (Q. bicolor), Q. alba, and Acer rubrum. The character of the vegetation growing on the east bank was similar to that of the northeastern, except at the extreme northeast end where a clear area occurred. This area was dominated, as was the dam, by unidentified grasses.

Aquatic vegetation was composed of thick growths of Nuphar advena and filamentous algae in the shallow regions of the pond.

Pond D was built in approximately 1884, and has been used primarily as a private fishing pond (Plate 5). The long axis lies in an east-west direction, with the bed of a secondary state road (route 642)

functioning as a dam at the west end. Fed by springs and a small creek at the east end, the pond has a surface area of approximately one and one-half acres, and a maximum depth of six feet near the center. Woods, cultivated land, and road ditches form the drainage area. After hard rains, the water became slightly muddy, and the surface level rose as an undersized outlet could not handle the increased volume of water. Surface temperature ranged from 31 degrees C. in July to 14 degrees C. in October.

The south bank was separated into two sections, overhanging vegetation on the southwestern sector was button bush (Cephalanthus occidentalis) , Alnus rugosa, Clethra alnifolia, and sand vine (Gonolobus laevis); on the southeastern sector, Nyssa sylvatica, blackjack oak (Quercus marilandica), and Q. alba. The owner's house and lawn, located on a projection of land, divided the north bank into two equal parts. Pinus echinata and an undercover of lawn grass composed the major vegetation on the western portion of the north bank. Dominant vegetation on the northeastern bank was similar to that of the southeastern. Nyssa sylvatica was the dominant plant at the headwaters. The dominant plants on the dam were Lonicera japonica and horse brier (Smilax rotundifolia).

The emergent aquatic vegetation was composed of Nuphar advena in the shallow areas, and Juncus effusus in the eastern half of the pond. Potamogton sp. and filamentous algae grew profusely off the northwestern bank.

Pond E, built in 1947, is an open body of water completely surrounded by pasture land (Plate 6). The long axis lies in an east-

west direction, with an earthen dam located at the west end. A small gravel pit is present near the dam on the south bank. Supplied with water from two upstream ponds and by intrinsic springs, Pond E has a surface area of approximately one and one-half acres, and a maximum depth of five feet. Pasture constituted the major part of the immediate drainage area, the rest was cultivated. After hard rains the water was slightly turbid, but the surface level was not observed to fluctuate. Surface temperature ranged from 32 degrees C. in July to 15 degrees in October.

Both north and south banks, covered with unidentified grasses, were grazed by cattle. Alnus rugosa, growing in clusters in the water off the east bank, and a huge willow oak (Quercus phellos), at the extreme south corner of the dam, were the only woody plants present. A vine, arrow-leaved tearthumb (Polygonium sagittatum), grew profusely on the southeastern bank. The dam, devoid of vegetation, was used as a walkway by cattle.

The important aquatic vegetation was composed of Juncus effusus, which occurred all along the south bank, and dense mats of filamentous algae, which covered the entire littoral area.

Food habits of Rana catesbeiana

Of the 138 specimens of R. catesbeiana examined, 129 stomachs contained material. The major food items are given below; a complete list of the stomach contents are shown in Table 1.

Insects were the most abundant food item taken by R. catesbeiana, as they were found in 78 per cent of the stomachs. Although they comprised only 21 per cent of the total food weight, they made up 52 per cent of all items taken. Of the seven orders, representing 30 families, coleopterans occurred most often (53 per cent) in stomachs, and among the insects comprised the largest percentage (10 per cent) of the total food weight. Lepidopterans were second in importance, occurring in 19 per cent of the stomachs and constituting four per cent of the total food weight. Hymenopterans, next in importance, comprised only one per cent of the total food weight, but were found in 23 stomachs (18 per cent). Fourteen per cent of the stomachs contained one or more hemipterans. This order of insects composed only 0.3 per cent of the total food weight. Adult and larval dipterans were found in 13 stomachs (10 per cent), and like the hemipterans, comprised only 0.3 per cent of the total food weight. Odonatan adults and nymphs formed two per cent of the total food weight, and were found in 13 stomachs. Orthopterans were also found in 13 stomachs, but because of their relatively large size, made up three per cent of the total food weight.

Arachnoids, found in 30 per cent of the stomachs, constituted the second most abundant class of food items taken. True spiders (Araneae) were found in 28 per cent of the stomachs, and comprised four per cent of the total food weight. The remaining 0.6 per cent of the total food weight was composed of four harvestmen (Phalangiida) found in three stomachs.

Although ranked third in per cent of stomachs with item (nine per cent), ranids because of their large size were first in per cent of

total food weight (27 per cent).

Occasional food items taken included millipedes, snails, crayfish, isopods, fish, and earthworms. A 10 gr. shrew (Sorex sp.) and a 13 gr. garter snake (Thamnopsis sauritus) which measured 39.5 cm. in total length, were found in two stomachs.

Unclassified vegetative material was found in 52 per cent of the stomachs and composed 12 per cent of the total food weight. Partly digested, unclassified invertebrate remains were found in 44 per cent of the stomachs.

It appears from the results that R. catesbeiana fed on those organisms which were most abundant and readily available in its environment. The large number of insects taken verifies this, as they were certainly the most abundant food item present. This is in accord with Korschgen and Moyle (1955) who stated that "principal foods consumed closely parallel availability ...". Penn (1950) and Korschgen and Moyle (1955) found that crayfish played an important role in the diet of the bullfrog, however, in the present study, crayfish were noticeably scarce in the various habitats and consequently were insignificant as food items. Spiders, on the other hand, were observed to be extremely numerous at four of the ponds and thus were found in a large per cent of the stomachs examined. At the fifth pond, Pond E, spiders were seldom observed while tadpoles and young frogs were very numerous. Consequently anurans replaced spiders as an important food item, comprising over one-half of the total food weight at this pond.

The presence of other vertebrates such as the shrew and snake is not unexpected, as was noted in the literature citations in the

introduction large bullfrogs will feed on any organism they can capture and swallow.

Although searched for, no information was found concerning the utilization of vegetation as a food by frogs. Thus vegetative material, though found in over one-half of the stomachs, is assumed to have been taken accidentally with the capture of food items. However, it is possible that while vegetation cannot be utilized as food, the capture by the frog of this material is not accidental. A moving leaf or floating stick probably evokes the same response that is produced by a moving food organism.

Comparison of the food habits of *Rana catesbeiana* by month

The food habits by month of *R. catesbeiana* for a five month period are shown in Table 2. Insects, which ranged from 57 per cent of stomachs with item in June to 95 per cent in October, proved to be the most important food item taken during the period. The per cent occurrence of coleopterans varied but slightly during the period (20 to 30 per cent) as did the less important odonatans (3 to 5 per cent). Orthopterans and lepidopteran larvae, which reach their peak population in late summer and early fall were taken, as would be expected, in the greatest number in August through October (5, 15, and 30 per cent respectively for orthopterans, and 10, 24, and 25 per cent respectively for lepidopterans). The percentage of stomachs containing spiders fluctuated by month (22 to 50 per cent) as did the number

taken (7 to 16 per cent). Of the other invertebrates, snails and millipedes were taken most often. While anurans comprised over 50 per cent of the total food weight in June and September, both tadpoles and adults were taken indiscriminately as food in all months. As the season progressed, the percentage of stomachs with vegetative material decreased from 79 per cent in June to 35 per cent in October; conversely, the percentage of stomachs with unclassified invertebrate parts increased from 14 per cent in June to 60 per cent in October.

Since the food items taken parallel their availability in the frogs habitat, the results provide further evidence for the statement made in the preceding section, i.e., R. catesbeiana fed on those organisms most available in their environment. Major food items found in the stomach, i.e., insects, therefore can be correlated with the reproductive cycle of the food organism. The decrease in the per cent of stomachs which contained vegetative material is not readily explainable.

Comparison of the food habits of Rana catesbeiana by sex

Table 3 shows the food habits of male and female specimens of R. catesbeiana. Major food items occurred in approximately the same per cent of stomachs with item, and per cent occurrence of item in both sexes, however, females consistently contained more food by weight. The statistical "student t" test was applied to the average weight of food per sex. A null hypothesis to determine whether the two sexes

were taken from the same size-population was set up. From this test a "t" value of 1.73 was obtained. With 127 degrees of freedom this value was significant at the 95 per cent level, thus indicating that the two sex groups came from the same size-population. A null hypothesis concerning the mean weight of the stomach contents of the sexes was then tested. A "t" value of 2.57 was obtained, since this was not significant at the 99 per cent level, the mean weight of the stomach contents of the two sexes was different, the females larger.

Other than the small possibility of a sampling error, there is no obvious reason why the females contained a significantly larger average weight of food than males. Biologically and physically the organisms appeared similar and, as the frogs were past the spawning season, the importance of gonadal development was minimized. Smith and Bragg (1949) studying toads, found a great difference in the quantity of food taken by members of the two sexes of Bufo w. woodhousii and B. cognatus, females taking the larger amount. No explanation was offered for these results.

Comparison of the food habits of three size groups of Rana catesbeiana

The food habits of three size groups of R. catesbeiana are shown in Tables 4 through 6.

Group I (size-ratio range 0.36 to 1.81) contained 78 specimens, three of which were empty. Insects, the most important food item, were found in 83 per cent of the stomachs. They comprised 47 per cent

of the total food weight and 62 per cent occurrence of all items taken. Coleopterans were taken most often, present in 60 per cent of the stomachs.

Arachnoids comprised the second most important food item in the diet. They were found in 31 per cent of the stomachs and made up 12 per cent of the total food weight. Only four per cent of the stomachs contained anurans, but they composed 11 per cent of the total food weight. Vegetative material was found in 41 per cent of the stomachs; unclassified invertebrates, in 51 per cent.

Size group II (size-ratio range 1.82 to 4.10) contained 42 frogs, of which six were empty. Insects, found in 72 per cent of the stomachs, were again the most abundant food item taken. Twenty-four per cent of the total food weight and 38 per cent of all items taken were composed of insects. Coleopterans, as in group I, were the most frequently taken insect, found in 53 per cent of the stomachs.

Spiders, present in 31 per cent of the stomachs and comprising five per cent of the total food weight, after insects were the second most abundant food item taken. Anurans, more important as a food item in this group than in smaller frogs, were found in 14 per cent of the stomachs and comprised 29 per cent of the total food weight. Vegetative material was found in two-thirds of the stomachs; 44 per cent of the stomachs contained unclassified invertebrate parts.

All 18 specimens of group III (size-ratio range 4.11 to 6.89) contained food material. While insects were found in the most stomachs (61 per cent), they comprised, however, only seven per cent of the total food weight. As in group II, insects occurred approximately

one-third of the time. Again coleopterans were found to occur in the most stomachs (33 per cent).

Spiders, though found in 28 per cent of the stomachs and comprising 10 per cent of all items taken, made up only two per cent of the total food weight, much less than in the other groups (less than one-half that of group II and only one-sixth that of group I). Anurans constituted 32 per cent of the total food weight and were found in 11 per cent of the stomachs. Two large vertebrates, Sorex sp. and Thamnopsis sauritus , comprised 27 per cent of the total food weight. Vegetative material was found in 78 per cent of the stomachs, but only three stomachs (17 per cent) contained unclassified invertebrates.

As shown in Tables 4 through 6, group III frogs contained relatively few small invertebrates in comparison to the stomach contents of the frogs of the two smaller size groups; also, the percentage of stomachs with unclassified invertebrate parts was shown to decrease as the size of the frog increased. These results indicate that the role of small food items in the frogs diet decreases somewhat as the frogs increase in size, with larger food items, i.e., anurans, snakes, and mammals comprising much of the total food weight. Reference to the change in the food habits of larger frogs is given by Frost (1935), who states "available information shows that, as a rule, small frogs eat small insects and conversely". Although there is a great increase in the number of stomachs containing vegetative material for the larger frogs, no plausible explanation can be given as to why the number of stomachs with vegetative material increased as frog size increased.

The food habits of *Rana catesbeiana* from five different pond types

A complete list of the food items taken by frogs from Ponds A, B, C, D, and E are shown in Tables 7, 8, 9, 10, and 11 respectively. Comparisons of the food items taken by frogs from each pond are shown by Tables 12 through 14. Tables 15 through 19 show, for each order of food item, the number of occurrences of a food item, the mean number of item per stomach with the item, and the mean number of an item per all stomachs with material. The "student t" distribution test was applied to the average weight of material in frogs per pond. Null hypothesises were set up to determine if frogs from each pond came from the same size-population as those of other ponds. Results of these tests are shown in Table 20. Null hypothe//ses concerning the mean weight of the stomach contents of frogs from one pond as compared with that of frogs from other ponds were then run. Results of these tests are shown in Table 21. An additional test which concerned the mean number of insects per all stomachs with insects, was run to determine if frogs from one pond contained a significantly larger number of insects than those of another. No significant differences were found; results are shown in Table 22. In Table 23 several data are included, i.e., number of frogs caught at each pond, number with food material at each pond, the total weight of stomach contents from each pond, average weight of stomach contents per frog for each pond, and the average size-ratio number per frog for each pond. In Table 24, the data from Table 23 is listed by sex.

Insects were found in the highest percentage of stomachs at all ponds. They ranged in per cent of stomachs with item from 65 per cent at Ponds B and E, to 97 per cent at Pond D, and in per cent occurrence, from 40 per cent at Ponds C and E, to 61 per cent at Pond D. Frogs from Pond D also contained, as would be expected, the highest average number of insects per stomach with insects, and in average number of insects per all stomachs with material (Tables 15 through 19). In per cent weight a great difference was noted among ponds; insects comprised from 31 to 49 per cent of the total food weight at Ponds A, B, C, and D, but only six per cent at Pond E, the open pasture pond.

Spiders often were utilized as food but their importance varied greatly among the ponds. Sixty-two per cent of the stomachs from Pond C contained spiders, whereas only seven per cent contained them at Pond E. The per cent of stomachs with spiders from the other ponds ranged from 26 per cent at Ponds A and B, to 37 per cent at Pond D. The difference in spider utilization by frogs at the different ponds is also evident in Tables 13 and 14, which show per cent occurrence of item and per cent of total food weight respectively.

Ranids were taken as food items at Ponds B and E, where they comprised a large part of the total food weight (Pond B - 20 per cent, Pond E - 50 per cent). Crayfish were utilized as food items at three ponds, but only at two, A and B, did they comprise an appreciable amount of the total food weight (19 per cent and 21 per cent respectively). Millipedes, as would be expected since they are usually found in forest litter, were taken as food items only by frogs from ponds located in wooded areas. Land snails, relatively unimportant in the diet of the frogs, were taken in small numbers at Ponds A, C, and D.

Earthworms and a shrew were taken at Pond C; a snake from Pond E.

The frogs from Ponds C and E are shown in Table 20 to have been collected from a different size-population than those of the other ponds. Also, frogs from these ponds are shown to contain a significantly larger amount of food than those of the other ponds (Table 21). It is to be expected that large frogs take large food items, but not shown in these data is the fact that to obtain large size, frogs would have had a greater food supply. Therefore it appears that frogs taken from clear areas, as opposed to wooded areas, live in a habitat that supplies more available food per frog.

Food habits of Rana clamitans

R. clamitans while found in large ponds shows a preference for pools, ditches, and along creek banks. A perfect habitat for R. clamitans, composed of small, shallow ponds located in a pastured field, was described by Hartof (1952). In the area studied, R. clamitans was very uncommon, however, in the nearby streams and small pools it occurred abundantly. Out of the 14 specimens examined, 12 contained food material. Five specimens were taken at Pond A, six at Pond B, one at Pond C, and two at Pond D. A complete list of the stomach contents is shown in Table 25.

As in R. catesbeiana and R. pipiens, insects were found in the most stomachs (75per cent). They comprised 70 per cent of both total food weight and number of items taken. Coleopterans, lepidopteran adults, hymenopterans (ants) and orthopterans were the insects most often taken. Spiders, which occurred in 17 per cent of the stomachs,

made up the remainder of the animal food. Vegetative material was found in 50 per cent of the stomachs examined.

The small sample examined, while not conclusive, does show an insect food pattern for R. clamitans; it would be expected that other small invertebrates, such as millipedes, snails, and earthworms would probably be taken if available. This was found to be true in the study by Hamilton (1948).

Food habits of Rana pipiens

R. pipiens is usually found in meadows, swamp lands, grassy woodlands, and hay or grain fields. Consequently, few were collected from the five ponds. All ten specimens of R. pipiens were females and contained food material. Three specimens were taken at Pond C, and seven at Pond E. A complete list of the stomach contents is shown in Table 26.

Insects, the most available food item, formed the major item in the diet, and were found in 70 per cent of the stomachs. Of the five orders of insects taken, coleopterans and lepidopterans occurred most often (32 per cent and 30 per cent respectively). Thirty per cent of the stomachs contained arachnoids, the only other animal class utilized. Vegetative material was found in only two stomachs, as compared with 50 per cent or more in R. clamitans and R. catesbeiana.

Apparently R. pipiens is primarily insectivorous, as these organisms form the major food item in its diet. Knowlton (1944), with a much larger sample of 91 specimens, also found that insects were the most

often taken food item. Although small numbers of R. pipiens and R. clamitans were examined, the results show a distinct difference in amount of vegetation taken by the three species. Vegetative material composed only one per cent of the total food weight in R. pipiens, where as in R. catesbeiana and R. clamitans it composed 12 and 23 per cent respectively.

Food habits of Rana palustris

R. palustris is typically found on the banks of woodland streams and creeks. The one specimen examined was taken at the woodland pond, Pond A. The specimen while small, only 5.6 gr. in weight, contained a relatively large amount of food. One curculio beetle, one unidentified beetle larva, three short-horned grasshoppers, one cricket, vegetative material, and unclassified invertebrate parts were found in its stomach. Obviously no conclusions as to food habits could be made from the study of one specimen.

Summary

Data were obtained from the examination of 163 ranids from five different pond types in the southeastern section of Hanover County. One hundred and thirty-eight Rana catesbeiana, 14 R. clamitans, 10 R. pipiens, and one R. palustris were collected. Specimens were captured with the aid of a strong light by hand or gig at night. The stomach contents were weighed and identification of the food items made with the use of a dissecting microscope. Where applicable,

statistics were used to interpret the data. The important findings of this study are listed below.

1. All species were found to feed on those organisms most available in their habitat, i.e., insects and spiders. Insects were found in 70 per cent of the stomachs and spiders in 30 per cent for R. catesbeiana; in 75 and 17 per cent respectively for R. clamitans, and in 70 and 30 per cent respectively for R. pipiens.

2. There is substantial evidence to indicate that ponds located in relatively clear areas provide more available food for frogs than do woodland areas (Table 23).

3. Results show that as the size of the frog increases the role of insects in the diet decreases somewhat, with larger food items comprising much of the total food weight (Tables 4 through 6).

4. The data for R. catesbeiana indicates that vegetative material plays a more important role in the frogs diet than can be explained by accidental capture, since it was found in 52 per cent of the stomachs.

5. Female R. catesbeiana were shown to contain a significantly higher average weight of stomach contents than males.

6. The food habits of R. catesbeiana when compared by month show that food items taken parallel seasonal availability (Table 2).

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Plate 1. Map of collection area.

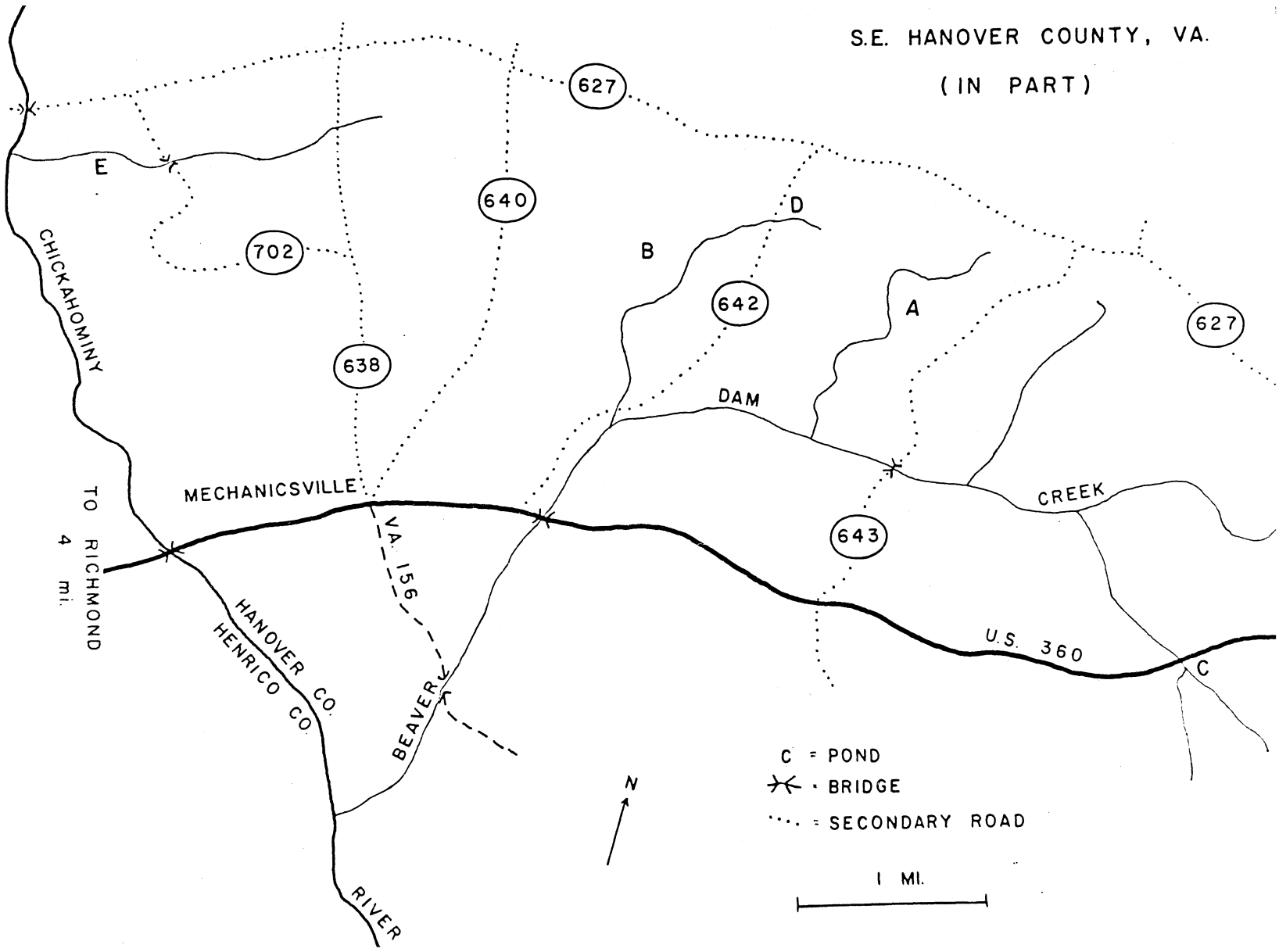
S.E. HANOVER COUNTY, VA.
(IN PART)
627
640
702
638
642
643
627
E
D
B
A
CHICKAHOMINY
DAM
MECHANICSVILLE
TO RICHMOND
4 mi.
VA. 156
CREEK
HANOVER CO.
HENRICO CO.
BEAVER
U.S. 360
C
RIVER
N
C = POND
BRIDGE
= SECONDARY ROAD
1 MI.

Plate 2- Pond A. View of headwaters at north end.

View of dam at south end.

Plate 3- Pond B. View of headwaters at north end.
View of east bank.

Plate 4- Pond C. View of headwaters at north end.
View of southwestern bank.

Plate 5- Pond D. View from dam of headwaters at east end.

View of dam at west end.

Plate 6- Pond E. View of entire pond. Dam at west end.

Close up of dam and northwestern bank.

Graph 1. Graphical presentation of three size groups of *Rana catesbeiana*.

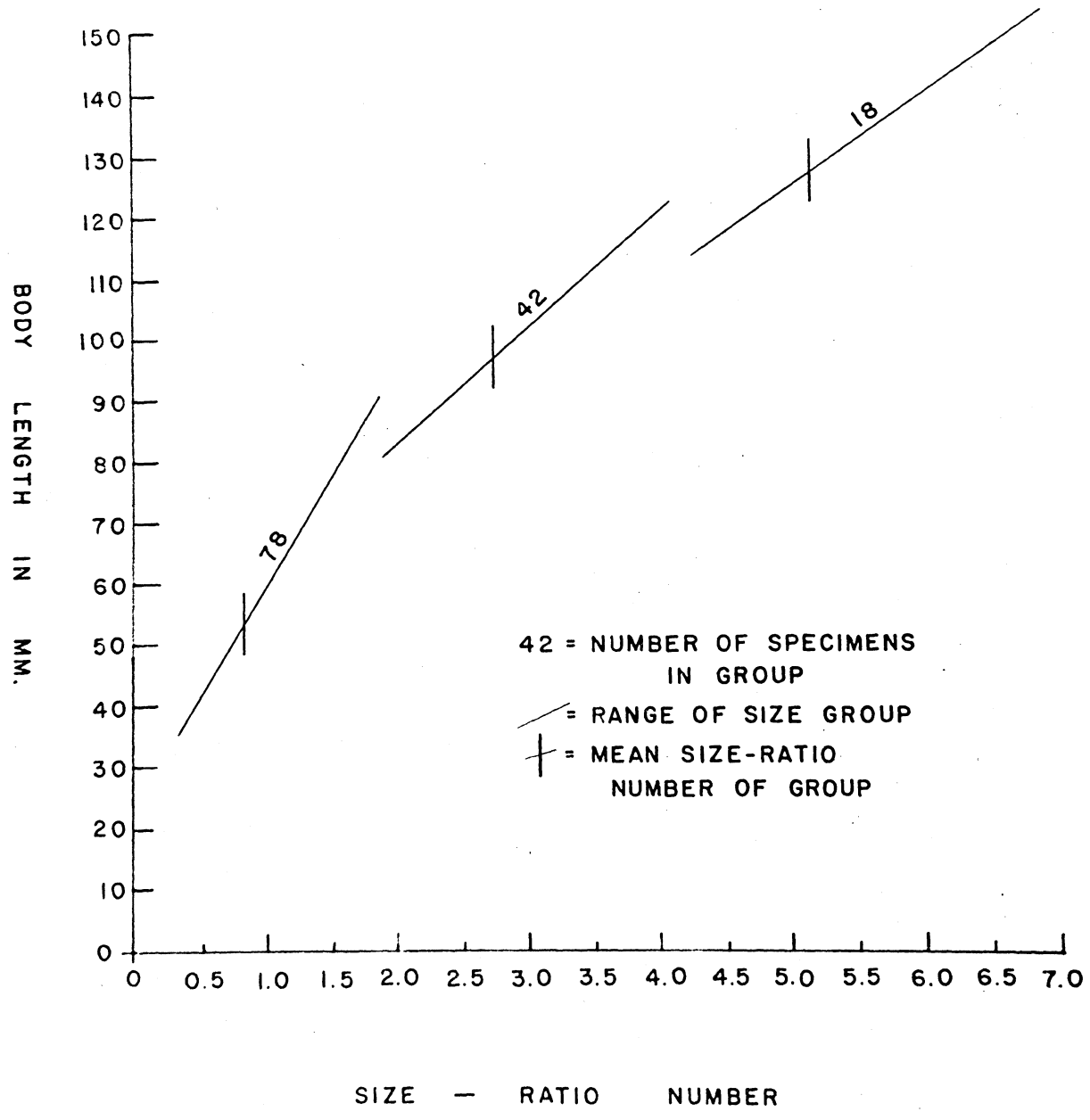
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
BODY LENGTH IN MM.
78
42
18
42 = NUMBER OF SPECIMENS IN GROUP
= RANGE OF SIZE GROUP
= MEAN SIZE-RATIO NUMBER OF GROUP
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
SIZE — RATIO NUMBER

Table 1. Stomach contents of 129 specimens of Rana catesbeiana listed by per cent of stomachs with item, per cent occurrence of item, and per cent weight of item.

Item	Per Cent of Stomachs With Item	Per Cent Occurrence of Item	Per Cent Weight of Item
Insecta	70.3	51.8	20.6
Coleoptera	52.7	22.4	10.1
Curculionidae	20.9	7.3	0.4
Unidentified (A)	20.9	6.4	2.7
Carabidae	10.9	3.2	2.6
Scarabaeidae	3.1	0.9	1.2
Chrysomelidae	2.3	2.2	0.1
Coccinellidae	2.3	0.6	0.1
Elateridae	2.3	0.6	0.2
Erotylidae	1.6	0.4	0.0*
Lucanidae	1.6	0.4	2.7
Melandryidae	0.8	0.2	0.0*
Rhyncophora**	0.8	0.2	0.0*
Unidentified (L)	0.8	0.2	0.3
Lepidoptera	19.4	6.9	3.9
Unidentified (L)	17.1	6.2	3.7
Unidentified (A)	3.1	0.8	0.2
Hymenoptera	17.8	8.4	1.0
Formicidae	12.4	6.7	0.3
Vespidae	3.9	0.9	0.6
Apidae	0.8	0.2	0.1
Braconidae	0.8	0.2	0.0*
Serphidae	0.8	0.2	0.0*
Unidentified (A)	0.8	0.2	0.0*
Hemiptera	14.0	4.3	0.3
Gerridae	7.0	2.1	0.1
Cicadellidae	3.1	0.8	0.0*
Unidentified	3.1	0.8	0.0*
Aphididae	0.8	0.6	0.0*
Nepidae			
Ranatra sp.	0.8	0.2	0.2
Diptera	10.1	3.7	0.3
Culicidae	3.9	1.1	0.0*
Unidentified (A)	3.1	0.8	0.1
Unidentified (L)	1.6	1.5	0.1
Tipulidae	0.8	0.2	0.1
Syrphidae	0.8	0.2	0.0*

Table 1 continued.

Item	Per Cent of Stomachs With Item	Per Cent Occurrence of Item	Per Cent Weight of Item
Odonata	10.1	2.8	1.7
Libellulidae (N)	3.1	0.8	0.3
Gomphidae (N)	2.3	0.6	0.1
Cordulegasteridae (A)	1.6	0.4	0.7
Aeschnidae (A)	0.8	0.4	0.3
Aeschnidae (N)	0.8	0.2	0.1
Gomphidae (A)	0.8	0.2	0.2
Unidentified (A)	0.8	0.2	0.0*
Unidentified (N)	0.8	0.2	0.0*
Orthoptera	10.1	3.2	3.4
Tettigoniidae	4.7	1.5	1.7
Unidentified	2.3	0.6	0.4
Acrididae	1.6	0.6	0.8
Gryllidae	1.6	0.4	0.4
Gryllotalpidae	0.8	0.2	0.1
Arachnoidea	30.2	11.2	4.8
Araneae	27.9	10.5	4.2
Unidentified	16.3	5.2	2.8
Argiopidae	13.2	5.2	1.4
Phalangiida			
Phalangiidae	2.3	0.8	0.6
Amphibia			
Anura			
Ranidae	8.5	2.8	27.4
Rana catesbeiana (A)	2.4	0.8	15.0
R. catesbeiana (L)	1.6	0.4	3.5
Rana sp. (A)	3.1	0.8	7.2
Rana sp. (L)	3.1	1.0	1.8
Myriapoda			
Diplopoda			
Polydesmidae	5.4	1.3	0.3
Gastropoda			
Pulmonata	3.9	1.3	1.0
Planorbidae	2.3	0.9	0.9
Lymnaeidae	0.8	0.2	0.0*
Unidentified	0.8	0.2	0.0*

Table 1 continued.

Item	Per Cent of Stomachs With Item	Per Cent Occurrence of Item	Per Cent Weight of Item
Crustacea	4.7	1.4	4.3
Decapoda			
Astacidae	3.1	0.8	4.2
Isopoda			
Unidentified	1.6	0.6	0.1
Teleostomi			
Perciformes			
Centrarchidae	3.1	1.1	0.6
Mammalia			
Insectivora			
Soricidae			
Sorex sp.	0.8	0.2	5.0
Oligochaeta			
Opisthopora			
Lumbricidae	0.8	1.3	1.3
Reptilia			
Serpentia			
Colubridae			
Thamnopsis sauritus	0.8	0.2	6.4
Miscellaneous			
Pebbles and Sand	9.3	3.4	8.9
Veg. Material	51.9	12.5	12.3
Digested Invert.	44.2	10.8	5.3
Digested Vert.	3.1	0.8	2.0

* Less than 0.05 per cent.
** Sub order.

Table 2. Stomach contents of 129 specimens of Rana catesbeiana listed by per cent of stomachs with item, per cent occurrence of item, and per cent weight of item, by month.

Item	June			July			August			September			October		
	Pct. S.C.	Pct. Occ.	Pct. Wt.	Pct. S.C.	Pct. Occ.	Pct. Wt.	Pct. S.C.	Pct. Occ.	Pct. Wt.	Pct. S.C.	Pct. Occ.	Pct. Wt.	Pct. S.C.	Pct. Occ.	Pct. Wt.
Insecta	57.1	31.0	12.2	85.2	50.7	14.2	81.8	61.5	30.6	71.7	51.0	21.1	95.0	57.4	39.0
Coleoptera	42.9	25.0	10.7	59.3	22.5	11.9	59.1	29.7	22.9	41.3	19.6	5.1	80.0	23.2	7.9
Hemiptera	—	—	—	25.9	8.5	0.3	9.1	2.2	0.1	8.7	3.3	0.2	20.0	3.7	1.5
Orthoptera	—	—	—	—	—	—	4.6	1.1	0.6	15.2	5.2	6.5	30.0	7.4	11.9
Hymenoptera	—	—	—	33.3	8.5	1.1	13.6	17.6	0.7	19.6	9.2	1.3	10.0	2.8	1.6
Odonata	14.3	4.6	1.1	11.1	2.8	0.3	13.6	3.3	4.6	6.5	2.0	0.9	10.0	2.8	3.0
Diptera	—	—	—	14.8	7.0	0.3	4.6	2.2	0.0*	8.7	2.6	0.2	20.0	3.7	1.3
Lepidoptera	7.1	2.3	0.4	7.4	1.4	0.5	18.2	5.5	1.7	23.9	9.2	7.1	25.0	13.9	11.7
Arachnoidea	28.6	11.4	2.9	37.0	15.5	3.4	27.3	9.9	7.6	21.7	7.2	3.2	50.0	12.0	10.6
Araneae	28.6	11.4	2.9	37.0	15.5	3.4	27.3	9.9	7.6	19.6	5.9	2.2	40.0	10.2	7.7
Phalangiida	—	—	—	—	—	—	—	—	—	2.2	1.3	1.0	10.0	1.9	3.0
Others															
Perciformes	7.1	2.3	0.2	7.4	2.8	1.9	—	—	—	2.2	0.7	0.2	—	—	—
Decapoda	7.1	2.3	7.0	—	—	—	—	—	—	4.4	1.3	6.8	5.0	0.9	8.2
Diplopoda	7.1	2.3	0.3	—	—	—	—	—	—	4.4	1.3	0.3	20.0	3.7	1.3
Pulmonata	—	—	—	7.4	1.4	2.6	4.6	1.1	0.6	2.2	0.7	0.1	5.0	2.8	1.5
Serpentia	—	—	—	3.7	0.7	25.0	—	—	—	—	—	—	—	—	—
Anura	7.1	2.3	50.7	7.4	1.4	5.4	4.6	1.1	4.9	13.0	6.5	50.9	5.0	0.9	10.5
Insectivora	—	—	—	—	—	—	4.6	1.1	29.7	—	—	—	—	—	—
Isopoda	—	—	—	—	—	—	—	—	—	—	—	—	10.0	2.8	0.4
Opisthopora	7.1	15.9	7.5	—	—	—	—	—	—	—	—	—	—	—	—
Miscellaneous															
Pebbles and Sand	7.1	2.3	0.9	18.5	6.3	29.9	4.6	1.1	1.7	10.9	3.9	2.8	5.0	0.9	0.1
Veg. Material	78.6	25.0	16.6	74.1	14.1	16.0	50.0	12.1	10.8	39.1	11.8	9.1	35.0	6.5	6.3
Digested Invert.	14.3	4.6	1.8	37.0	7.0	1.6	40.9	9.9	7.0	50.0	15.0	5.3	60.0	11.1	15.6
Digested Vert.	—	—	—	—	—	—	9.1	2.2	7.1	2.2	0.7	0.2	5.0	0.9	6.5

* Less than 0.05 per cent.

Table 3. Comparison of the stomach contents of 86 male and 43 female *Rana catesbeiana*, showing per cent of stomachs with item, per cent occurrence of item, and per cent weight of item.

	Per Cent of Stomachs With Item		Per Cent Occurrence of Item		Per Cent Weight of Item	
Item	Male	Female	Male	Female	Male	Female
Insecta	79.1	76.6	50.4	54.5	27.5	15.2
Coleoptera	52.3	53.5	21.0	25.3	12.8	8.1
Hemiptera	10.5	20.9	2.5	7.9	0.5	0.1
Orthoptera	10.5	9.3	3.1	3.4	4.6	2.4
Hymenoptera	19.8	14.0	10.4	4.5	1.7	0.4
Odonata	8.1	14.0	2.0	4.5	2.1	1.3
Diptera	9.3	11.6	3.9	3.4	0.4	0.2
Lepidoptera	20.9	16.3	7.6	5.6	5.5	2.7
Arachnoidea	33.7	23.3	12.6	8.4	8.2	2.2
Araneae	30.2	23.3	11.5	8.4	6.7	2.2
Phalangiida	3.5	—	1.1	—	1.5	—
Others						
Perciformes	3.5	2.3	1.4	0.6	1.2	0.1
Decapoda	1.2	6.5	0.3	1.7	0.6	7.0
Diplopoda	5.8	4.7	1.4	1.1	0.5	0.1
Anura	8.1	9.3	2.2	3.9	11.7	39.6
Pulmonata	3.5	4.7	1.4	1.1	0.6	1.2
Isopoda	2.3	—	0.8	—	0.1	—
Insectivora	—	2.3	—	0.6	—	8.8
Serpentia	1.2	—	0.3	—	14.6	—
Opisthopora	—	2.3	—	3.9	—	2.4
Miscellaneous						
Pebbles and Sand	8.1	11.6	3.1	3.9	11.2	7.1
Veg. Material	52.3	51.2	12.6	12.4	13.2	11.6
Digested Invert.	51.2	30.2	12.6	7.3	7.5	3.6
Digested Vert.	3.5	2.3	0.8	0.6	1.0	1.1

Table 4. Comparison of the stomach contents of the size groups of *Rana catesbeiana* by listing per cent of stomachs with item.

Item	Group I $\bar{x}$ 0.84 (0.36–1.81)	Group II $\bar{x}$ 2.76 (1.82–4.10)	Group III $\bar{x}$ 5.07 (4.11–6.89)
Insecta	82.7	72.2	61.1
Coleoptera	59.5	52.8	33.3
Hemiptera	21.3	2.8	5.6
Orthoptera	14.7	2.8	5.6
Hymenoptera	10.7	11.1	5.6
Odonata	9.3	11.1	11.1
Diptera	21.3	11.1	—
Lepidoptera	18.7	25.1	16.7
Arachnoidea	30.7	30.6	27.8
Araneae	29.3	25.0	27.8
Phalangiida	1.3	5.6	—
Others			
Perciformes	4.0	2.8	—
Decapoda	1.3	5.6	5.6
Diplopoda	5.3	8.3	—
Anura	4.0	13.9	11.1
Pulmonata	4.0	5.6	—
Isopoda	1.3	2.8	—
Insectivora	—	—	5.6
Serpentia	—	—	5.6
Opisthopora	—	2.8	—
Miscellaneous			
Pebbles and Sand	6.7	16.7	11.1
Veg. Material	41.3	66.7	77.8
Digested Invert.	50.7	44.4	16.7
Digested Vert.	—	11.1	—

Table 5. Comparison of the stomach contents of the size groups of Rana catesbeiana by listing per cent occurrence of item.

Item	Group I $\bar{x}$ 0.84 (0.36–1.61)	Group II $\bar{x}$ 2.76 (1.82–4.10)	Group III $\bar{x}$ 5.07 (4.11–6.09)
Insecta	61.5	37.8	35.4
Coleoptera	25.2	19.2	14.6
Hemiptera	6.5	0.6	2.1
Orthoptera	3.4	2.6	4.2
Hymenoptera	11.7	3.2	4.2
Odonata	2.6	3.2	4.2
Diptera	5.8	0.6	—
Lepidoptera	6.5	8.3	6.3
Arachnoidea	11.1	12.2	10.4
Araneae	10.8	10.3	10.4
Phalangida	0.3	1.9	—
Others			
Perciformes	0.9	1.3	—
Decapoda	0.3	1.3	2.1
Diplopoda	1.2	1.9	—
Anura	1.5	5.1	4.2
Pulmonata	0.6	1.3	—
Isopoda	0.3	1.3	—
Insectivora	—	—	2.1
Serpentia	—	—	2.1
Opisthopora	—	4.5	—
Miscellaneous			
Pebbles and Sand	1.5	5.1	10.4
Veg. Material	6.9	15.4	27.1
Digested Invert.	12.0	10.3	6.3
Digested Vert.	—	2.6	—

Table 6. Comparison of the stomach contents of the size groups of Rana catesbeiana by listing per cent weight of item.

Item	Group I $\bar{x}$ 0.84 (0.36-1.81)	Group II $\bar{x}$ 2.76 (1.82-4.10)	Group III $\bar{x}$ 5.07 (4.11-6.89)
Insecta	47.1	23.8	7.3
Coleoptera	14.6	12.9	5.3
Hemiptera	0.9	0.0*	0.4
Orthoptera	14.9	2.5	0.1
Hymenoptera	2.8	0.9	0.4
Odonata	5.6	1.4	0.5
Diptera	1.7	0.0*	—
Lepidoptera	6.5	6.1	0.7
Arachnoidea	12.2	5.0	2.1
Araneae	11.2	3.8	2.1
Phalangiida	0.9	1.2	—
Others			
Perciformes	2.1	0.6	—
Decapoda	1.7	6.3	3.0
Diplopoda	0.6	0.5	—
Anura	11.2	29.1	31.8
Pulmonata	0.2	1.8	—
Isopoda	0.2	0.0*	—
Insectivora	—	—	11.9
Serpentia	—	—	15.2
Opisthopora	—	3.1	—
Miscellaneous			
Pebbles and Sand	0.7	5.1	15.8
Veg. Material	11.1	14.2	11.0
Digested Invert.	13.0	5.8	1.9
Digested Vert.	—	4.7	—

* Less than 0.05 per cent.

Table 7. Stomach contents of 19 specimens of Rana catesbeiana from Pond A, showing per cent of stomachs with item, per cent occurrence of item, and per cent weight of item.

Item	Per Cent of Stomachs With Item	Per Cent Occurrence of Item	Per Cent Weight of Item
Insecta	84.2	58.5	49.0
Coleoptera	47.4	13.0	8.2
Unidentified (A)	21.0	5.2	4.9
Curculionidae	15.8	3.9	0.4
Carabidae	5.3	1.3	1.7
Elateridae	5.3	1.3	1.1
Erotylidae	5.3	1.3	0.1
Hemiptera	26.3	10.4	1.1
Gerridae	26.3	9.1	1.0
Unidentified	5.3	1.3	0.1
Hymenoptera	26.3	13.0	1.8
Formicidae	26.3	11.7	1.5
Braconidae	5.3	1.3	0.3
Diptera	15.8	5.2	0.9
Unidentified (A)	10.5	2.6	0.8
Culicidae	5.3	2.6	0.1
Lepidoptera	15.8	7.8	23.8
Unidentified (L)	15.8	6.5	23.0
Unidentified (A)	5.3	1.3	0.8
Orthoptera	15.8	5.2	7.8
Acrididae	5.3	2.6	5.9
Gryllidae	5.3	1.3	0.5
Unidentified	5.3	1.3	1.4
Odonata	10.5	3.9	5.5
Aeschnidae (A)	5.3	2.6	5.2
Gomphidae (N)	5.3	1.3	0.3
Arachnoidea			
Araneae	26.3	10.4	3.0
Argiopidae	15.8	5.2	2.0
Unidentified	15.8	5.2	1.0

Table 7 continued.

Item	Per Cent of Stomachs With Item	Per Cent Occurrence of Item	Per Cent Weight of Item
Crustacea			
Decapoda			
Astacidae	5.3	1.3	18.8
Myriapoda			
Diplopoda			
Polydesmidae	5.3	1.3	0.6
Gastropoda			
Pulmonata			
Lymnaeidae	5.3	1.3	0.3
Miscellaneous			
Pebbles and Sand	5.3	1.3	0.6
Veg. Material	52.6	13.0	21.7
Digested Invert.	47.4	13.0	5.9

Table 8. Stomach contents of 23 specimens of Rana catesbeiana from Pond B, showing per cent of stomachs with item, per cent occurrence of item, and per cent weight of item.

Item	Per Cent of Stomachs With Item	Per Cent Occurrence of Item	Per Cent Weight of Item
Insecta	65.2	52.4	27.8
Coleoptera	43.5	28.6	11.5
Curculionidae	26.1	11.9	1.5
Unidentified (A)	21.7	10.7	5.8
Carabidae	13.0	3.6	3.3
Coccinellidae	4.4	1.2	0.1
Melandryidae	4.4	1.2	0.5
Hymenoptera	21.7	7.1	2.0
Formicidae	13.0	4.8	0.7
Apidae	4.4	1.2	1.1
Serphidae	4.4	1.2	0.2
Hemiptera	17.4	4.8	0.5
Gerridae	8.7	2.4	0.2
Cicadellidae	4.4	1.2	0.1
Unidentified	4.4	1.2	0.2
Odonata	13.0	3.6	5.7
Libellulidae (N)	8.7	2.4	4.9
Cordulegasteridae (A)	4.4	1.2	0.8
Orthoptera	13.0	3.6	5.8
Gryllotalpidae	4.4	1.2	1.5
Tettigoniidae	4.4	1.2	2.8
Unidentified	4.4	1.2	1.5
Diptera	8.7	2.4	0.1
Culicidae	4.4	1.2	0.1
Unidentified	4.4	1.2	0.1
Lepidoptera			
Unidentified (L)	8.7	2.4	2.5
Arachnoidea			
Araneae	26.1	10.7	8.3
Argiopidae	13.0	4.8	3.2
Unidentified	13.0	6.0	5.1

Table 8 continued.

Item	Per Cent of Stomachs With Item	Per Cent Occurrence of Item	Per Cent Weight of Item
Amphibia			
Anura			
Ranidae			
Rana sp. (L)	13.0	4.8	19.6
Crustacea			
Decapoda			
Astacidae	8.7	2.4	21.4
Myriapoda			
Diplopoda			
Polydesmidae	4.4	1.2	0.4
Teleostomi			
Perciformes			
Centrarchidae	4.4	1.2	0.9
Miscellaneous			
Pebbles and Sand	13.0	3.6	0.8
Veg. Material	43.5	11.9	12.2
Digested Invert.	43.5	11.9	8.5

Table 9. Stomach contents of 21 specimens of Rana catesbeiana from Pond C, showing per cent of stomachs with item, per cent occurrence of item, and per cent weight of item.

Item	Per Cent of Stomachs With Item	Per Cent Occurrence of Item	Per Cent Weight of Item
Insecta	76.2	40.2	30.6
Coleoptera	61.9	25.0	19.6
Carabidae	23.8	8.7	4.0
Curculionidae	14.3	5.4	0.3
Scarabaeidae	14.3	4.4	4.5
Unidentified (A)	14.3	3.3	2.2
Chrysomellidae	4.8	1.1	0.1
Elateridae	4.8	1.1	0.5
Lucanidae	4.8	1.1	8.0
Lepidoptera			
Unidentified (L)	23.8	7.6	4.1
Orthoptera	9.5	4.4	5.8
Acrididae	4.8	1.1	2.2
Tettigoniidae	4.8	2.2	2.7
Unidentified	4.8	1.1	0.9
Diptera			
Syrphidae	4.8	1.1	0.1
Hymenoptera			
Vespidae	4.8	1.1	0.3
Odonata			
Libellulidae (N)	4.8	1.1	0.6
Arachnoidea	61.9	18.5	11.6
Araneae	57.1	16.3	10.3
Argiopidae	33.3	8.7	3.6
Unidentified	28.6	7.6	6.7
Phalangiida			
Phalangiidae	4.8	2.2	1.3

Table 9 continued.

Item	Per Cent of Stomachs With Item	Per Cent Occurrence of Item	Per Cent Weight of Item
Gastropoda			
Pulmonata			
Planorbidae	9.5	4.4	1.1
Myriapoda			
Diplopoda			
Polydesmidae	9.5	2.2	0.4
Mammalia			
Insectivora			
Soricidae			
Sorex sp.	4.8	1.1	21.2
Oligochaeta			
Opisthopora			
Lumbricidae	4.8	7.6	5.6
Miscellaneous			
Pebbles and Sand	4.8	1.1	0.1
Veg. Material	66.7	15.2	21.7
Digested Invert.	47.6	9.8	7.7

Table 10. Stomach contents of 35 specimens of Rana catesbeiana from Pond D, showing per cent of stomachs with item, per cent occurrence of item, and per cent weight of item.

Item	Per Cent of Stomachs With Item	Per Cent Occurrence of Item	Per Cent Weight of Item
Insecta	97.1	61.2	48.4
Coleoptera	65.7	24.7	19.1
Curculionidae	28.6	7.9	1.5
Unidentified (A)	25.7	6.2	7.4
Carabidae	5.7	1.1	1.5
Chrysomelidae	5.7	6.2	0.6
Coccinellidae	2.9	0.6	0.0*
Erotylidae	2.9	0.6	0.0*
Lucanidae	2.9	0.6	6.7
Rhyncophora**	2.9	0.6	0.1
Scarabaeidae	2.9	0.6	1.0
Unidentified (L)	2.9	0.6	0.3
Lepidoptera	34.3	10.7	12.1
Unidentified (L)	31.4	10.1	11.6
Unidentified (A)	2.9	0.6	0.5
Hymenoptera	22.9	13.5	3.1
Formicidae	20.0	12.4	1.2
Vespidae	5.7	1.1	1.9
Hemiptera	17.1	4.5	0.4
Cicadellidae	8.6	1.7	0.2
Gerridae	5.7	1.1	0.2
Aphididae	2.9	1.7	0.0*
Diptera	14.3	2.8	1.0
Culicidae	8.6	1.7	0.1
Tipulidae	2.9	0.6	0.5
Unidentified (A)	2.9	0.6	0.4
Odonata	14.3	3.4	4.8
Gomphidae (N)	5.7	1.1	0.3
Cordulegasteridae (A)	2.9	0.6	3.2
Libellulidae (N)	2.9	0.6	0.8
Unidentified (A)	2.9	0.6	0.3
Unidentified (N)	2.9	0.6	0.1

Table 10 continued.

Item	Per Cent of Stomachs With Item	Per Cent Occurrence of Item	Per Cent Weight of Item
Orthoptera	8.6	1.7	8.0
Tettigoniidae	5.7	1.1	5.0
Gryllidae	2.9	0.6	3.0
Arachnoidea	37.1	13.5	11.2
Araneae	31.4	12.4	8.4
Unidentified	22.9	6.2	6.1
Argiopidae	8.6	6.2	2.2
Phalangiida			
Phalangiidae	5.7	1.1	2.8
Myriapoda			
Diplopoda			
Polydesmidae	8.6	1.7	1.0
Crustacea			
Isopoda			
Unidentified	5.7	1.7	0.4
Gastropoda			
Pulmonata	5.7	1.1	5.6
Planorbidae	2.9	0.6	5.4
Unidentified	2.9	0.6	0.1
Miscellaneous			
Pebbles and Sand	2.9	0.6	0.1
Veg. Material	48.6	9.6	13.0
Digested Invert.	48.6	10.1	14.2
Digested Vert.	2.9	0.6	6.2

* Less than 0.05 per cent.
** Sub order.

Table 11. Stomach contents of 31 specimens of Rana catesbeiana from Pond E, showing per cent of stomachs with item, per cent occurrence of item, and per cent weight of item.

Item	Per Cent of Stomachs With Item	Per Cent Occurrence of Item	Per Cent Weight of Item
Insecta	64.5	40.4	6.1
Coleoptera	41.9	18.3	3.9
Unidentified (A)	19.4	6.7	1.2
Curculionidae	16.2	6.7	0.1
Carabidae	9.7	2.9	2.3
Coccinellidae	3.2	1.0	0.1
Elateridae	3.2	1.0	0.1
Hymenoptera	12.9	3.9	0.6
Vespidae	6.5	1.9	0.5
Formicidae	3.2	1.0	0.0*
Unidentified	3.2	1.0	0.0*
Hemiptera	9.7	2.9	0.3
Unidentified	6.5	1.9	0.0*
Nepidae			
Ranatra sp.	3.2	1.0	0.3
Lepidoptera	9.7	2.9	0.2
Unidentified (A)	6.5	1.9	0.1
Unidentified (L)	3.2	1.0	0.1
Diptera	6.5	7.7	0.1
Unidentified (A)	3.2	1.0	0.0*
Unidentified (L)	3.2	6.7	0.1
Odonata	6.5	1.9	0.5
Aeschnidae (N)	3.2	1.0	0.1
Gomphidae (A)	3.2	1.0	0.4
Orthoptera			
Tettigoniidae	6.5	2.9	0.5
Arachnoidea			
Araneae	6.5	1.9	0.1
Argiopidae	3.2	1.0	0.0*
Unidentified	3.2	1.0	0.1

Table 11 continued.

Item	Per Cent of Stomachs With Item	Per Cent Occurrence of Item	Per Cent Weight of Item
Amphibia			
Anura			
Ranidae	25.8	10.6	49.6
Rana catesbeiana (A)	9.7	3.9	28.6
Rana sp. (A)	9.7	3.9	13.7
R. catesbeiana (L)	6.5	1.9	6.7
Rana sp. (L)	3.2	1.0	0.7
Teleostomi			
Perciformes			
Centrarchidae	9.7	4.8	1.0
Crustacea			
Decapoda			
Astacidae	3.2	1.0	3.3
Reptilia			
Serpentia			
Colubridae			
Thamnopsis sauritus	3.2	1.0	12.1
Miscellaneous			
Pebbles and Sand	19.4	11.5	16.7
Veg. Material	51.6	15.4	7.0
Digested Invert.	35.5	10.6	1.7
Digested Vert.	9.7	2.9	2.4

* Less than 0.05 per cent.

Table 12. Stomach contents of Rana catesbeiana, showing per cent of stomachs with item, listed by pond.

Item	Pond A	B	C	D	E
Insecta	84.2	65.2	76.2	97.1	64.5
Coleoptera	47.4	43.5	61.9	65.7	41.9
Hemiptera	26.3	17.4	—	17.1	9.7
Orthoptera	17.8	13.0	9.5	8.6	6.5
Hymenoptera	26.3	21.7	4.8	22.9	12.9
Odonata	10.5	13.0	4.8	14.3	6.5
Diptera	15.8	8.7	4.8	14.3	6.5
Lepidoptera	15.8	8.7	23.8	34.3	9.7
Arachnoidea	26.3	26.1	61.9	37.1	6.5
Araneae	26.3	26.1	57.1	31.4	6.5
Phalangiida	—	—	4.8	5.7	—
Others					
Perciformes	—	4.4	—	—	9.7
Decapoda	5.3	8.7	—	—	3.2
Diplopoda	5.3	4.4	9.5	8.6	—
Anura	—	13.0	—	—	25.8
Pulmonata	5.3	—	9.5	5.7	—
Isopoda	—	—	—	5.7	—
Insectivora	—	—	4.8	—	—
Serpentia	—	—	—	—	3.2
Opisthopora	—	—	4.8	—	—
Miscellaneous					
Pebbles and Sand	5.3	13.0	4.8	2.9	19.4
Veg. Material	52.6	43.5	66.7	48.6	51.6
Digested Invert.	47.4	43.5	47.6	48.6	35.5
Digested Vert.	—	—	—	2.9	9.7

Table 13. Stomach contents of Rana catesbeiana, showing per cent occurrence of item, listed by pond.

Item	Pond A	B	C	D	E
Insecta	58.5	52.4	40.2	61.2	40.4
Coleoptera	13.0	28.6	25.0	24.7	18.3
Hemiptera	10.4	4.8	—	4.5	2.9
Orthoptera	5.2	3.6	4.4	1.7	2.9
Hymenoptera	13.0	7.1	1.1	13.5	3.9
Odonata	3.9	3.6	1.1	3.4	1.9
Diptera	5.2	2.4	1.1	2.8	7.7
Lepidoptera	7.8	2.4	7.6	10.7	2.9
Arachnoidea	10.4	10.7	16.5	13.5	1.9
Araneae	10.4	10.7	16.3	12.4	1.9
Phalangiida	—	—	2.2	1.1	—
Others					
Perciformes	—	1.2	—	—	4.8
Decapoda	1.3	2.4	—	—	1.0
Diplopoda	1.3	1.2	2.2	1.7	—
Anura	—	4.8	—	—	10.6
Pulmonata	1.3	—	4.4	1.1	—
Isopoda	—	—	—	1.7	—
Insectivora	—	—	1.1	—	—
Serpentia	—	—	—	—	1.0
Opisthopora	—	—	7.6	—	—
Miscellaneous					
Pebbles and Sand	1.3	3.6	1.1	0.6	11.5
Veg. Material	13.0	11.9	15.2	9.6	15.4
Digested Invert.	13.0	11.9	9.8	10.1	10.6
Digested Vert.	—	—	—	0.6	2.9

Table 14. Stomach contents of Rana catesbeiana, showing per cent weight of item, listed by pond.

Item	Pond A	B	C	D	E
Insecta	49.0	27.8	30.6	48.4	6.1
Coleoptera	8.2	11.5	19.6	19.1	3.9
Hemiptera	1.1	0.5	—	0.4	0.3
Orthoptera	7.8	5.8	5.8	8.0	0.5
Hymenoptera	1.8	2.0	0.3	3.1	0.6
Odonata	5.6	5.7	0.6	4.8	0.5
Diptera	0.9	0.1	0.1	1.0	0.1
Lepidoptera	23.8	2.5	4.1	12.1	0.2
Arachnoidea	3.0	8.3	11.6	11.2	0.1
Araneae	3.0	8.3	10.3	8.4	0.1
Phalangiida	—	—	1.3	2.8	—
Others					
Perciformes	—	0.9	—	—	1.0
Decapoda	18.8	21.4	—	—	3.3
Diplopoda	0.6	0.4	0.4	1.0	—
Anura	—	19.6	—	—	49.6
Pulmonata	0.3	—	1.1	5.6	—
Isopoda	—	—	—	0.4	—
Insectivora	—	—	21.2	—	—
Serpentia	—	—	—	—	12.1
Opisthopora	—	—	5.6	—	—
Miscellaneous					
Pebbles and Sand	0.6	0.8	0.1	0.1	16.7
Veg. Material	21.7	12.2	21.7	13.0	7.0
Digested Invert.	5.9	8.5	7.7	14.2	1.7
Digested Vert.	—	—	—	6.2	2.4

Table 15. Stomach contents of 19 specimens of Rana catesbeiana from Pond A, showing number of occurrences of item, average number of item per stomach with item, and average number of item per all stomachs with material.

Item	Number of Occurrences	Average Number of Item Per Stomach With Item	Average Number of Item Per All Stomachs With Material
Insecta	45	2.81	2.37
Coleoptera	10	1.10	0.53
Hemiptera	8	1.60	0.42
Orthoptera	4	1.30	0.21
Hymenoptera	10	2.00	0.53
Odonata	3	1.50	0.16
Diptera	4	1.33	0.21
Lepidoptera	6	2.00	0.32
Arachnoidea	8	1.60	0.42
Araneae	8	1.60	0.42
Phalangiida	-	—	—
Others			
Perciformes	-	—	—
Decapoda	1	1.00	0.05
Diplopoda	1	1.00	0.05
Anura	-	—	—
Pulmonata	1	1.00	0.05
Isopoda	-	—	—
Insectivora	-	—	—
Serpentia	-	—	—
Opisthopora	-	—	—
Miscellaneous			
Pebbles and Sand	1	1.00	0.05
Veg. Material	10	1.00	0.52
Digested Invert.	10	1.00	0.52
Digested Vert.	-	—	—

Table 16. Stomach contents of 23 specimens of Rana catesbeiana from Pond B, showing number of occurrences of item, average number of item per stomach with item, and average number of item per all stomachs with material.

Item	Number of Occurrences	Average Number of Item Per Stomach With Item	Average Number of Item Per All Stomachs With Material
Insecta	44	2.93	1.91
Coleoptera	24	2.40	1.04
Hemiptera	4	1.00	0.17
Orthoptera	3	1.00	0.13
Hymenoptera	6	1.20	0.26
Odonata	3	1.00	0.13
Diptera	2	1.00	0.09
Lepidoptera	2	1.00	0.09
Arachnoidea	9	1.50	0.39
Araneae	9	1.50	0.39
Phalangiida	-	—	—
Others			
Perciformes	1	1.00	0.04
Decapoda	2	1.00	0.09
Diplopoda	1	1.00	0.04
Anura	4	1.33	0.17
Pulmonata	-	—	—
Isopoda	-	—	—
Insectivora	-	—	—
Serpentia	-	—	—
Opisthopora	-	—	—
Miscellaneous			
Pebbles and Sand	3	1.00	0.13
Veg. Material	10	1.00	0.43
Digested Invert.	10	1.00	0.43
Digested Vert.	-	—	—

Table 17. Stomach contents of 21 specimens of Rana catesbeiana from Pond C, showing number of occurrences of item, average number of item per stomach with item, and average number of item per all stomachs with material.

Item	Number of Occurrences	Average Number of Item Per Stomach With Item	Average Number of Item Per All Stomachs With Material
Insecta	37	2.31	1.76
Coleoptera	23	1.77	1.10
Hemiptera	-	—	—
Orthoptera	4	2.00	0.19
Hymenoptera	1	1.00	0.05
Odonata	1	1.00	0.05
Diptera	1	1.00	0.05
Lepidoptera	7	1.40	0.33
Arachnoidea	17	1.31	0.81
Araneae	15	1.25	0.71
Phalangiida	2	2.00	0.10
Others			
Perciformes	-	—	—
Decapoda	-	—	—
Diplopoda	2	1.00	0.10
Anura	-	—	—
Pulmonata	4	2.00	0.19
Isopoda	-	—	—
Insectivora	1	1.00	0.05
Serpentia	-	—	—
Opisthopora	7	7.00	0.33
Miscellaneous			
Pebbles and Sand	1	1.00	0.05
Veg. Material	14	1.00	0.67
Digested Invert.	9	1.00	0.43
Digested Vert.	-	—	—

Table 18. Stomach contents of 35 specimens of Rana catesbeiana from Pond D, showing number of occurrences of item, average number of item per stomach with item, and average number of item per all stomachs with material.

Item	Number of Occurrences	Average Number of Item Per Stomach With Item	Average Number of Item Per All Stomachs With Material
Insecta	109	3.21	3.11
Coleoptera	44	1.91	1.26
Hemiptera	8	1.33	0.23
Orthoptera	3	1.00	0.09
Hymenoptera	24	3.00	0.69
Odonata	6	1.20	0.17
Diptera	5	1.00	0.14
Lepidoptera	19	1.58	0.54
Arachnoidea	24	1.85	0.69
Araneae	22	2.00	0.63
Phalangiida	2	1.00	0.06
Others			
Perciformes	-	—	—
Decapoda	-	—	—
Diplopoda	3	1.00	0.09
Anura	-	—	—
Pulmonata	2	1.00	0.06
Isopoda	3	1.50	0.09
Insectivora	-	—	—
Serpentia	-	—	—
Opisthopora	-	—	—
Miscellaneous			
Pebbles and Sand	1	1.00	0.03
Veg. Material	17	1.00	0.49
Digested Invert.	18	1.09	0.51
Digested Vert.	1	1.00	0.03

Table 19. Stomach contents of 31 specimens of Rana catesbeiana from Pond E, showing number of occurrences of item, average number of item per stomach with item, and average number of item per all stomachs with material.

Item	Number of Occurrences	Average Number of Item Per Stomach With Item	Average Number of Item Per All Stomachs With Material
Insecta	42	2.10	1.35
Coleoptera	19	1.46	0.54
Hemiptera	3	1.00	0.10
Orthoptera	3	1.50	0.10
Hymenoptera	4	1.00	0.13
Odonata	2	1.00	0.06
Diptera	8	4.00	0.26
Lepidoptera	3	1.00	0.10
Arachnoidea	2	1.00	0.06
Araneae	2	1.00	0.06
Phalangiida	-	—	—
Others			
Perciformes	5	1.67	0.16
Decapoda	1	1.00	0.03
Diplopoda	-	—	—
Anura	11	1.38	0.35
Pulmonata	-	—	—
Isopoda	-	—	—
Insectivora	-	—	—
Serpentia	1	1.00	0.03
Opisthopora	-	—	—
Miscellaneous			
Pebbles and Sand	12	2.00	0.39
Veg. Material	16	1.00	0.52
Digested Invert.	11	1.00	0.35
Digested Vert.	3	1.00	0.10

Table 20. Results of "student t" test to determine if the size of frogs from one pond was significantly different from that of frogs from any of the other ponds.

	Pond				
Pond	A	B	C	D	E
A	—	0.18*	5.40**	1.20*	3.65**
B	0.18*	—	5.29**	1.04*	3.68**
C	5.40**	5.29**	—	4.68**	1.20*
D	1.20*	1.04*	4.68**	—	2.93**
E	3.65**	3.68**	1.20*	2.93**	—

* Significant at the 95 per cent level.
** Not significant at the 95 per cent level.

Table 21. Results of "student t" test to determine if the mean weight of the stomach contents of frogs from one pond was significantly different from that of frogs from any of the other ponds.

	Pond				
Pond	A	B	C	D	E
A	—	1.04*	2.25**	0.62*	2.77**
B	1.04*	—	2.41**	0.36*	3.01**
C	2.25**	2.41**	—	2.75**	1.03*
D	0.62*	0.36*	2.75**	—	3.43**
E	2.77**	3.01**	1.03*	3.43**	—

* Significant at the 95 per cent level.
** Not significant at the 95 per cent level.

Table 22. Results of "student t" test to determine if the mean number of insects per all stomachs with insects of frogs from one pond was significantly different from that of frogs from any of the other ponds.

	Pond				
Pond	A	B	C	D	E
A	—	0.19*	0.60*	0.47*	0.19*
B	0.19*	—	0.79*	0.32*	1.43*
C	0.60*	0.79*	—	0.90*	0.60*
D	0.47*	0.32*	0.90*	—	1.44*
E	0.19*	1.43*	0.60*	0.60*	—

* Significant at the 95 per cent level.

Table 23. Comparison of ponds showing number of frogs caught at each pond, number with food material at each pond, the total weight of stomach contents of frogs from each pond, the mean weight of stomach contents per frog for each pond, and the mean size-ratio number of frogs at each pond.

Pond	Number of Frogs Caught	Number With Food	Total Weight of Stomach Contents	Mean Weight of Stomach Contents	Mean Size-Ratio Number
A	20	19	9.89	0.52	1.11
B	24	23	13.81	0.60	1.17
C	23	21	46.44	2.21	3.27
D	37	35	23.79	0.68	1.51
E	34	31	103.79	3.35	2.71
Total	138	129	197.72	1.53	1.97

Table 24. Comparison of ponds showing number of frogs caught at each pond, number with food material at each pond, the total weight of stomach contents of frogs from each pond, the mean weight of stomach contents per frog for each pond, and the mean size-ratio number of frogs at each pond, by sex.

	Number of Frogs Caught		Number With Food		Total Weight of Stomach Contents		Mean Weight of Stomach Contents		Mean Size-Ratio Number	
Pond	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
A	12	8	11	8	2.41	7.48	0.22	0.94	0.75	1.61
B	15	9	15	8	9.86	3.95	0.66	0.49	1.12	1.26
C	14	9	14	7	19.84	26.60	1.42	3.80	2.90	4.01
D	25	12	24	11	14.48	9.31	0.60	0.85	1.39	1.79
E	23	11	22	9	40.02	63.77	1.82	7.09	2.46	3.30
Total	89	49	86	43	86.61	111.11	1.01	2.58	1.78	2.33

Table 25. Stomach contents of 12 specimens of Rana clamitans, listed by per cent of stomachs with item, per cent occurrence of item, and per cent weight of item.

Item	Per Cent of Stomachs With Item	Per Cent Occurrence of Item	Per Cent Weight of Item
Insecta	75.0	70.0	70.1
Coleoptera	41.7	22.5	20.6
Unidentified (A)	25.0	7.5	1.7
Carabidae	8.3	2.5	4.1
Curculionidae	8.3	2.5	0.6
Erotylidae	8.3	2.5	3.7
Scarabaeidae	8.3	5.0	7.6
Unidentified (L)	8.3	2.5	2.9
Lepidoptera	33.3	25.0	31.3
Unidentified (A)	25.0	12.5	4.7
Unidentified (L)	8.3	12.5	26.6
Hymenoptera			
Formicidae	25.0	7.5	2.5
Orthoptera	25.0	7.5	14.4
Acrididae	16.7	5.0	10.5
Blattidae	8.3	2.5	3.9
Diptera	16.7	5.0	0.8
Tipilidae	8.3	2.5	0.4
Unidentified (A)	8.3	2.5	0.4
Hemiptera			
Unidentified	8.3	2.5	0.4
Arachnoidea			
Araneae			
Argiopidae	16.7	5.0	2.5
Miscellaneous			
Pebble	8.3	2.5	1.0
Veg. Material	50.0	15.0	22.9
Digested Invert.	25.0	7.5	3.5

Table 26. Stomach contents of 10 specimens of Rana pipiens, listed by per cent of stomachs with item, per cent occurrence of item, and per cent weight of item.

Item	Per Cent of Stomachs With Item	Per Cent Occurrence of Item	Per Cent Weight of Item
Insecta	70.0	72.3	65.7
Coleoptera	60.0	31.9	36.0
Curculionidae	30.0	12.8	1.9
Scarabaeidae	20.0	8.5	31.1
Carabidae	10.0	8.5	2.0
Elateridae	10.0	2.1	1.1
Lepidoptera	50.0	29.8	15.5
Unidentified (A)	30.0	23.4	13.3
Unidentified (L)	20.0	6.4	2.2
Orthoptera	30.0	6.4	13.3
Tettigoniidae	20.0	4.3	8.0
Gryllidae	10.0	2.1	5.3
Hemiptera			
Pentatomidae	10.0	2.1	0.3
Hymenoptera			
Unidentified	10.0	2.1	0.6
Arachnoidea			
Araneae	30.0	8.5	3.1
Argiopidae	20.0	4.3	1.9
Unidentified	20.0	4.3	1.2
Miscellaneous			
Veg. Material	20.0	4.3	1.1
Digested Invert.	50.0	14.9	30.1

Vita

Garnett Ryland Brooks, Jr. was born November 25, 1936 in Richmond, Virginia. He attended public school in Hanover County, and was graduated from Washington-Henry High School in June, 1953.

He entered the University of Richmond in September, 1953, and received the Bachelor of Science degree in Biology in June, 1957.

Admitted to the Graduate School of the University of Richmond in September, 1957, he was recipient of a William's Fellowship for the years 1957-58, and 1958-59. While a graduate student, he served as assistant in classes of Invertebrate Zoology, Genetics, General Bacteriology, and Applied Bacteriology.

He expects to receive the Master of Science degree in June, 1959, and has accepted a graduate assistantship from the University of Florida, where he plans to continue his graduate work.