

# FURTHER STUDIES ON THE LIFE HISTORY AND DISTRIBUTION OF *EUBRANCHIPUS VERNALIS* (VERRILL)<sup>1</sup>

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During the winter and spring seasons of 1943 and 1944, field studies on the distribution and life history of the fairy shrimp *Eubbranchipus vernalis* (Verrill) in northeastern Ohio were continued. Results of the studies made during the two previous years have been published earlier (Dexter and Sheary 1943; Dexter 1943b). Additional data have been secured on the geographic and seasonal distribution, limits of temperature and hydrogen ion concentration, fluctuations of abundance, new appearances and disappearances, sex ratio, and color characteristics of *E. vernalis*. Also, information on the life history of this species has been obtained by a weekly study of one pond over a period of several months each year and by observations of laboratory cultures of this fairy shrimp.

## REVIEW OF FIELD COLLECTIONS. PORTAGE, SUMMIT, AND STARK COUNTIES—1943

During the third consecutive year of this study (1943), 61 pools and ponds in Portage, Summit, and Stark Counties, northeastern Ohio, were examined, including all of those from which any records of fairy shrimps had been known previously. Fifty-eight pools were restudied and three new stations were added. Because of the war-time restrictions on travel, it was necessary to drop 59 stations which had been included in the annual survey. Five others had dried out by the time they were reached, and many pools did not contain as much water as had been found in previous years. Table I gives a summary of the field collections for each year, and Figure 1 shows the location of all positive records.

The first specimens collected in the winter of 1943 were taken on February 4. These were smaller than those first collected in previous years, but the collection of February 11 compared very favorably in size with specimens collected from the same pond (Pond P7) on March 15, 1942, which in turn were comparable in development to those collected a week earlier the previous year. The last collection of the original population from this pond in 1943 was made on April 1. Five days later the pool dried up. The last collection there in 1942 was made on April 23, at which time the pond had become very nearly dry. A second population developed in this pond after refilling on April 13, 1943. Small numbers of *E. vernalis* were collected between May 10–25. Only three ponds (Ponds P43, S1, C2) had more abundant specimens of *E. vernalis* in 1943 than in 1942, while twelve ponds (P17, P18, P79, S3, S5, S12, S18, C6, C7, C9, C10, C12) were found to contain a smaller population in 1943 than during the preceding year.

No species of the anostracan phyllopods was collected in 1943 other than *E. vernalis*. *Pristicephalus bundyi*, which had been collected in one pool in 1942, was not found again. Because of the much smaller population of fairy shrimps in that pool and the limitation of time for collecting, only 31 specimens were taken. Had a more thorough sampling been made, it might have disclosed the presence of *P. bundyi* for another year.

<sup>1</sup>Acknowledgment is made to those persons who have kindly contributed records as indicated in the paper, especially to Mr. Charles H. Kuehnle, who has assisted the writer on collecting trips in Stark County, and to Dr. N. T. Mattox, who has read the manuscript. Portions of this paper have been read before the Zoology Section of the Ohio Academy of Science and before the Ecological Society of America.

A total of 24 stations was found inhabited by *E. vernalis* during the spring of 1943 (7 in Portage, 7 in Summit, and 10 in Stark Counties). Altogether 30 pools have been known to contain this species at some time during the period between 1941 and 1943.

REVIEW OF FIELD COLLECTIONS. PORTAGE, SUMMIT, AND STARK COUNTIES—1944

During the season of 1944, fifty-five of the established stations and five new pools were investigated (35 in Portage, 12 in Summit, 13 in Stark Counties). Again, all pools from which any collections of fairy shrimps had been made in the past were restudied. During the fall of 1943 and the winter of 1944, most of the temporary pool depressions contained no water, and for the most part did not fill with water until the first week of March. The month of December, 1943, was the driest since 1925. The spring rains, however, filled the pools. (See Table I and Figure 1 for collecting data).

TABLE I  
FLUCTUATIONS OF POPULATIONS OF THE FAIRY SHRIMP, *Eubbranchipus vernalis*  
IN THREE COUNTIES OF NORTHEASTERN OHIO

STATIONS	1940	1941	1942	1943	1944
P7, P18, P79, S1*, S5, S11, S14, C7* (*S1, C7, also + in 1940)		+	+	+	+
S18, C2, C3, C6, C9, C11, C12		-	+	+	+
P88, P89, C13		-	-	+	+
P91, P92, C14		-	-	-	+
P17, P43, S12		0	+	+	+
P40, P55, P58		0	0	0	+
C8	+	+	0	+	+
P30, P50		+	0	0	+
P80		+	+	0	+
S2	+	0	+	0	+
S4		+	+	0	0
S3	+	+	+	+	0
C10		-	+	+	0
P37		+	0	0	0
P1, P8, P12, P14, P22, P42, P47, P48, P49, P54, P66, P68, P69, S7, S8, S13		0	0	0	0

+ = *E. vernalis*; 0 = No fairy shrimps; - = Not Studied.

Out of a grand total of 127 pools studied in the three counties over a period of four years, thirty-six have contained *E. vernalis* at one time or another, and thirty-two of these had records in 1944. This year was a very favorable year for the fairy shrimps. Eleven of the pools (P17, P79, P89, S1, S11, S18, C2, C7, C8, C12, C13) had definitely more abundant populations than they had had during the preceding year, while only four (P7, S14, C6, C9) had populations that were

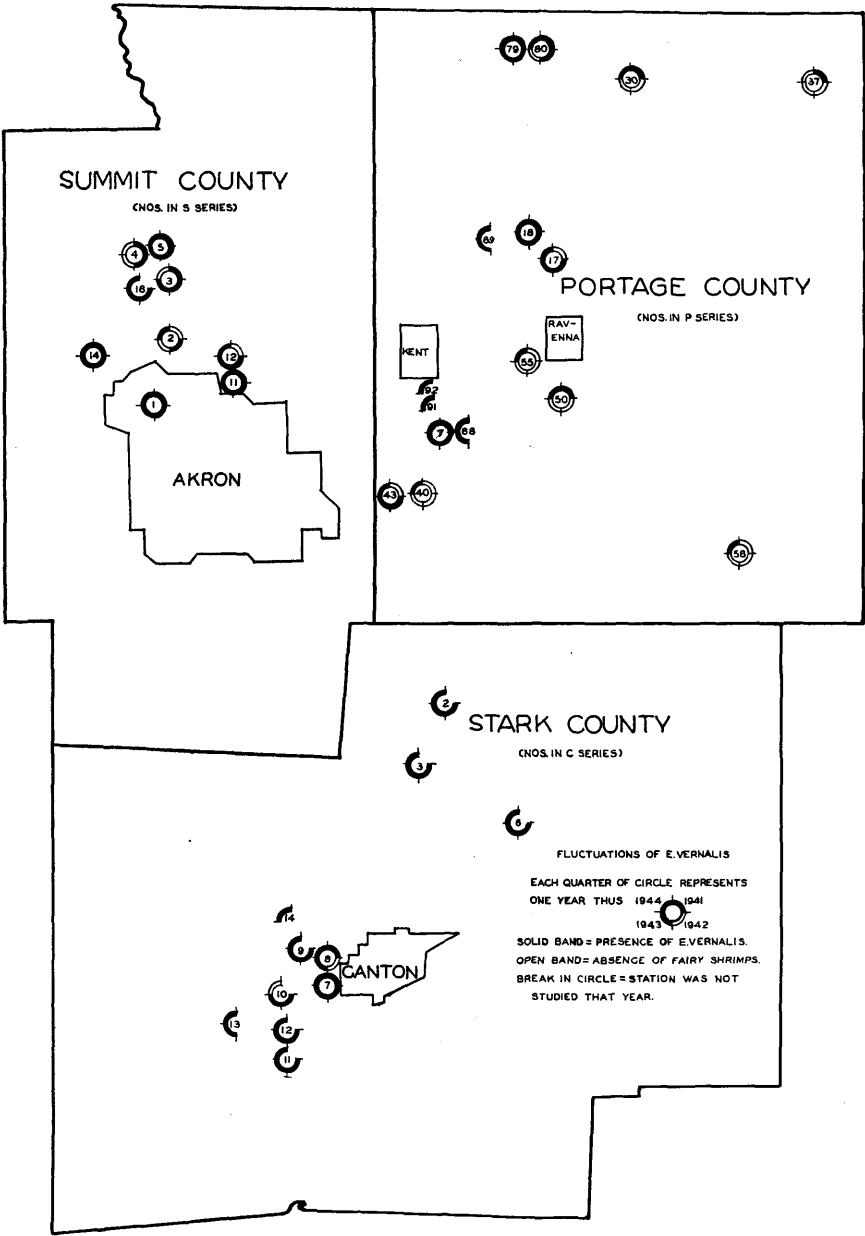


FIG. 1. Map of Portage, Summit and Stark counties, Ohio, showing the locations from which *Eubbranchipus vernalis* has been collected.

less abundant in 1944 than in 1943. Nearly all of the observed annual changes are of such a magnitude as to be easily detected. Sixteen stations have had no records of fairy shrimps for four consecutive years, six others, for three years; and two of the new stations did not contain specimens. The 1944 populations were about six weeks later in appearing than during the previous year. Specimens collected on March 25, 1944, were about equal in size and development to those collected on March 4, 1943. Egg sacs were first found developed in the season of 1944 on April 2, on specimens collected at Canton.

#### OBSERVATIONS ON THE LIFE HISTORY AND ECOLOGICAL RELATIONS OF *E. VERNALIS*

When specimens were first collected on February 4, 1943, they were already 4.65 mm. in length, which fact was rather unexpected because of the long, cold winter weather which preceded this date. A sample was collected each week after February 4, until the pool (P7, near Brimfield) dried up on April 6. A rather uniform sample of ten individuals was measured from the collection of each week. Table II gives the measurements of total length which were made from the anterior margin of the head to the extremity of the caudal furca, but not including the filaments. Data are also presented on the temperature and hydrogen ion concentration of the pool on the dates of collecting. The rate of growth was erratic. Egg sacs first appeared on the females in this pond on March 25. The average maximum size attained was 15.44 mm. which was reached by April 1. Comparison should be made between these data and the growth of *E. serratus* studied in a pond of east central Illinois (Dexter and Ferguson, 1943). As nearly as could be determined only one generation of *E. vernalis* was present, and the samples were for the most part very nearly uniform in size on any one day.

The week following the drying out of Pond P7, it filled up again from a series of snow squalls and rainy spells. On April 17, 1943, and again one week later, a plankton sample was taken throughout this pasture pool, but neither time were the nauplii or metanauplii of *E. vernalis* found. Great quantities of copepods and ostracods and a number of insect larvae had hatched and given rise to a very rich plankton population. It was as rich in species and in quantity as the first plankton sample which had been taken on February 4. On May 10, however, three immature, female fairy shrimps which averaged 10.7 mm. in length were collected. Nine days later two males were taken in the net after a careful search, and on May 25 one male and two females were found. Those of the last collection were of the characteristic colors for fully developed, mature individuals, and were the largest specimens seen during that season, averaging 25.8 mm. in length.

While it may be possible that this second population came from eggs laid by the first generation, which lived in the pool during the preceding months, it is more likely that it came from eggs which had been deposited during some earlier year. Weaver (1943) has shown experimentally that the eggs of *E. vernalis* can hatch without being frozen, contrary to a common belief that freezing is necessary before hatching will take place. However, Avery (1939) and Weaver (ibid.) found that a considerable rest period seems to be required before hatching will occur. Whether the eggs are dried or frozen or not some of them will hatch after a lapse of time. Weaver found an interval of twelve days between the "shock" of drying or freezing and the hatching of the eggs. The number of individuals which he succeeded in hatching under various controlled conditions in regard to freezing and drying was not great, and in no case did all of the eggs hatch. Contrary to the work of Weaver, Castle (1938) observed that some eggs of *E. vernalis* hatched in an aquarium without having been dried, and Avery (1939) succeeded in hatching eggs which had never been dried, but had had a resting period of one year. His experimentally dried eggs failed to hatch. Mathias (1937) had stated earlier that desiccation is not necessary for the development of phyllopod eggs.

TABLE II  
COMPARISON OF LIFE HISTORY OF *Eubbranchipus vernalis* IN POND P7 IN 1943 AND IN 1944

1943						1944				
Date (both years)	°C	pH	MM in Length	Amt. of Growth in MM	Notes	°C	pH	MM in Length	Amt. of Growth in MM	Notes
Feb. 4	3.0	5.9	4.65	.....	First collection of season: under ice; pool not full; specimens orange-pink.					
Feb. 11	0.0	5.9	4.83	0.18	Under ice.					
Feb. 18	0.5	6.0	6.25	1.42	Under ice.					
Feb. 25	4.5	6.0	6.87	0.62	Under ice.					
Mar. 4	0.5	6.1	8.31	1.44	Under ice.					
Mar. 11	1.0	6.3	9.03	0.72	Under ice.	2.0	5.3	2.53	.....	First collection of season; under ice.
Mar. 18	9.0	6.3	11.76	2.73	Males light green; females bluish-gray.	5.5	5.9	5.11	2.58	Pond about half full.
Mar. 25	11.5	6.4	12.43	0.67	Egg sacs developing.	16.6	6.15	8.56	3.45	
April 1	21.0	6.4	15.44	3.01	Pond half dried.	4.7	6.1	11.92	3.36	Second antennae of males well developed.
April 8					Pond dried up April 6; refilled April 13.	8.8	5.9	14.40	2.48	Pond nearly dry; egg sacs developing; eggs small.
April 15						10.5	6.1	16.75	2.35	Pond refilled to about half full; males greenish; fe- males bluish-gray; egg sacs large.
April 22						13.5	6.1	19.00	2.25	All mature except one speci- men — probably a late hatching.
April 29										Pond dried out.
May 10			10.7		Pond nearly full; 3 imma- ture females collected; colorless.					
May 19	21.0	6.4	22.5	11.8	2 males collected; colorless.					
May 25	17.5	6.8	25.8	3.3	1 male, light green; 2 females, bluish-gray. Last collection.					

Weaver did not succeed in hatching eggs which had not been allowed to dry, and had been kept in water for nine months. The writer has attempted to hatch eggs of fairy shrimps by drying, freezing, and the prevention of drying and freezing, but without success. In these experiments, however, small numbers of eggs were used, and it is apparent that the factors regulating the hatching of eggs of fairy shrimps are little understood. Weaver concluded that drying, freezing, and a long rest period are usual before hatching occurs. He believes that drying is important and that freezing seems to induce hatching.

From the experiments of Avery (1939) and Weaver (1943) and their finding that a period of rest is required before hatching will take place regardless of environmental factors, and from the results of field observations reported here, especially of sudden appearances and disappearances of populations of considerable size, the following interpretation first developed by Hesse (1924) from observations reported from Europe and Africa has been adopted. The eggs of *E. vernalis* are without doubt widely distributed in the soil of depressions and dried-out pools. Probably myriads of such places contain some eggs which have been present over varying lengths of time. The question of how fairy shrimps or their eggs are introduced into these temporary pools is at the present time largely a matter of conjecture. Mathias (1937) in his monograph on the biology of the phyllopods explains the dissemination of the eggs as being carried by the wind, and on amphibians, water birds, and other animals which travel from pool to pool. He also states that phyllopod eggs pass through the digestive tracts of amphibians, birds, and possibly mammals, and still remain viable. Some years, when conditions are favorable, many of these latent eggs which have been scattered about will hatch in the spring when the depressions are filled by melting snow and ice. Other years they may fail to hatch in any certain pool, but remain viable for another season. Some eggs may not hatch for a number of years. The radical changes from year to year are probably the result of a successful hatching or a failure to hatch rather than being a new introduction or a total elimination of the species since it was last recorded. This explanation seems the most plausible in view of what is known of the life history of the species and the sporadic nature of its geographic and seasonal occurrence.

It has been noted that sometimes fairy shrimps do not appear in deep pools as early as they do in shallow water. Specimens of *E. vernalis* collected from pond P88 on March 18, 1943, for example, were only 4.05 mm. in length. The same day, specimens from Pond P7 nearby had an average length of 11.76 mm. Those from the deeper pool were at that time approximately the size of specimens collected from station P7 six weeks earlier. After the fairy shrimps from the deeper pool reached maturity they averaged only 13.8 mm. in length (May 5, 1943).

In the season of 1944 most of the pools did not fill up until March 6. *E. vernalis* was not found in Pond P7 until March 11. At that time the fairy shrimps were only 2.53 mm. in length, while they were 9.03 mm. on that date of the preceding year and had been active in the water for some five weeks preceding that time. However, the individuals of the 1944 population grew rapidly, reached maturity in a short time, and attained great size. During the development of the 1944 population, the pond water was somewhat warmer than during the period of development of fairy shrimps of the same size in the 1943 population. This difference explains without question the different rates of development and maturity. The fairy shrimps were present in Pond P7 in 1944 until it dried out sometime between April 22 and 29.

During the month of March and early in April of 1944 pond P88 for some reason failed to fill with water. No more than an inch or two collected in the lowest portion of the trough, and much of that was in the form of scattered puddles. A plankton sample taken from these shallow puddles on March 18 contained two-

metanauplii of fairy shrimps. No others were found in earlier or later samples. On April 11 a rainstorm of 1.49 inches filled this pond. On April 22 a large population of fairy shrimps was found in the water. They grew and matured rapidly in the warm water (see Table III). The eggs were developing on the females within two weeks after hatching, and the population completed its entire existence as free-swimming organisms in little more than thirty-two days. The population disappeared after May 13. Water remained in the pond for several weeks longer, but had an afternoon temperature of over 21 degrees C. which seems to be the limit beyond which *E. vernalis* does not live for long.

TABLE III  
DEVELOPMENT OF *Eubranchipus vernalis* IN POND P88, SEASON OF 1944

Date	°C	pH	MM in Length	Amt. of Growth in MM	Notes
April 22	.....	.....	4.20	.....	Pond filled April 11; late hatching; specimens orange-pink.
April 29	15.0	5.8	12.90	8.7	Orange-pink in color; egg sacs developing.
May 6	14.0	5.5	15.35	2.45	Males light green; females bluish-gray; egg sacs well developed.
May 13	21.1	5.6	16.30	0.95	Last collection.
May 20	21.7	5.9	.....	.....	<i>E. vernalis</i> not present; pond still contained 1.5 ft. water.

*E. vernalis* has been found in a range of water temperature from 0° to 21° C. Individuals kept in aquaria in the laboratory with an average water temperature of around 20° C. lived on an average of 6.5 days. The longest surviving individual of each culture averaged 16.5 days. The longest surviving of any one individual was 30 days. This species has been found in a pH range from 5.3 to 7.6 with instances for almost every graduation between these limits. Mathias (1937) reported that phyllopods in general prefer alkaline water and do not withstand acid water. The experience of the writer has been that *E. vernalis* has a wide range of tolerance and probably could live in hydrogen ion concentrations found in most natural pools of water whether acid or alkaline.

It has been observed that on cloudy days fairy shrimps have a tendency to remain at or near the bottom while on sunny days they swim near the surface of the pools.

It is commonly believed and often repeated in textbooks that the first generation of fairy shrimps consists entirely of females which reproduce parthenogenetically by means of "summer eggs." Later in the season, it is believed by some, males are produced which fertilize the winter eggs. These presumably produce the first generation of females the following season. A number of specimens of *E. vernalis* collected early in the season before any were mature and kept in an aquarium developed into males, hence they must have hatched from "winter" eggs. Also, many males were collected in the pond before mature females had developed. In addition, egg sacs were not fully formed in the specimens of Pond P7 until 5 days before the pond dried out. It is evident that for this species the males hatch from winter eggs, and sometimes, at least, there is but a single generation in a season.

In another pond nearby, however, it seems quite possible that more than one generation was produced in one season. This pond (Station P88) is a deep depression which does not dry out completely every year, although usually it does. It has steep banks, but they are at least partly exposed during the summer months. Specimens collected from this pond on March 18, 1943, were only as much devel-

oped as those collected in the shallow water of Pond P7 on February 11. However, the population in Pond P88 continued until May 10, some five weeks after the first population in Pond P7 disappeared. During April, specimens of all sizes and in all stages of development could be collected at the same time from the deep pond. A number of other pools, especially deep ones, contained specimens in various stages of development suggesting that more than one generation might be present. Some pools had two distinct size groups. Pond P43, for example, had two distinct size groups collected under ice as early as March 21. Whether these represent two generations (one group was sexually mature) or whether they simply hatched at different times is not known. Mathias (1937) claims that two kinds of eggs are produced—those which hatch immediately, and resistant eggs which can withstand desiccation for a number of years. The writer has not been able to obtain a second generation of fairy shrimps in an aquarium.

Avery (1939) reported collecting *E. vernalis* from a body of water not known to be dry over a period of seven years. From this fact and from the results of hatching experiments he concluded that the common belief that this shrimp occurs only in temporary springtime pools does not agree with the evidence. An abstract of his paper (Biological Abstracts 15:3340) conveys a false impression through the unfortunate omission of the word "only" in the above statement. As the writer has already pointed out, (Dexter, 1943a) nearly all records of fresh-water fairy shrimps are from temporary spring pools, although a few records are known as the one reported by Avery where fairy shrimps are found in ponds which do not dry out entirely, but which have a dry margin during the summer months. Shelford (1937) has quoted an observation made by Child in the Chicago region that fairy shrimps sometimes appear in ponds which seldom dry out, but which after a long period of drought do dry out. The following season, after refilling with water, the pond is found to contain fairy shrimps. It may be that other records of fairy shrimps found in ordinarily permanent ponds can be explained by the same situation. In such ponds, fairy shrimps might be an important item of food for fishes, as it is sometimes mentioned in zoological literature. Usually, however, fishes are not found in the same community with fairy shrimps.

#### SEX RATIO

Textbooks and manuals often state that the males of fairy shrimps are relatively scarce. Very little is to be found in original literature concerning the sex ratio. Weaver (1943) found five females to one male on March 18, 1940, but later in the season the proportion of males increased as the shrimps got larger. After March 30 the males began to disappear. In regard to this problem, samples have been taken by the writer from a variety of ponds and over a period of time to determine the proportion of sexes as found for *E. vernalis*. A sample of 145 specimens collected in the spring of 1941 had a ratio of 55 males: 90 females (1 : 1.6). Of 240 specimens collected during the following spring a ratio of 100 males: 140 females (1 : 1.4) was found. On March 3, 1943, 100 specimens taken from Pond P7 showed a ratio of 32 males: 68 females (1 : 2.1). One week later another sample of 100 removed from the same pond had nearly the same ratio—35 males: 65 females (1 : 1.9). A mixed sample of 141 specimens taken from various pools during the same spring had a ratio of 55 : 86 (1 : 1.6). A similar sample of 364 individuals collected in 1944 also had a ratio of 1 : 1.6. In contrast to these a sample of 122 individuals collected from several pools in Stark County on April 3, 1943, showed the reverse trend with a ratio of 80 males: 42 females (1 : 0.5). This is the only time the writer has collected a sizable sample in which the males predominated. The average of all of these (1212 individuals) gives a ratio of 1 male: 1.5 females. It is clearly evident that for *E. vernalis* in the years and regions covered in this study, the males have been much more abundant than is commonly



believed. Contrary to the finding of Weaver, the writer has not observed the sex ratio to change during the season.

#### COLOR

While all of the specimens of *E. vernalis* of comparable age and development collected from the same pool have been uniform in color, the color does change as the individuals mature (Dexter 1943b). In the report cited, observations of the change in color were made by successive collections from the same pools. During the spring of 1943 this observation was confirmed by individual specimens kept in culture in the laboratory. On February 18, 4 specimens of the typical orange-pink or salmon color were placed in an aquarium. On March 4 this color began to fade in a surviving male specimen and by the next day it was light green in color as reported earlier for mature males of *E. vernalis*. The specimens in the pond from which the collection was made were still orange-pink at this date. Another sample was taken at this time and also placed in an aquarium. Six days later the orange-pink color began to fade and the egg sacs developed. On March 23 the females were entirely bluish-gray in color as reported earlier for the mature females. Four days later they turned the same cream color observed in old specimens of *E. serratus* when kept in culture for several days beyond the time of maturation. A number of females collected on March 11, 1943, developed egg sacs and turned bluish-gray on March 18. On this day, the largest female specimens in the pond were just developing the color characteristic of the adults, while the majority of the pond specimens were still orange-pink.

In the season of 1943 a population of *E. vernalis* was discovered which had a most unusual color. On April 3 the writer with Mr. Charles H. Kuehnle, collected a sample of *E. vernalis* from a shallow swamp-pond near Canton, all of the specimens of which were light blue in color. Not only those collected, but all of the individuals seen swimming about in the water had the same characteristic coloring. This pigment was found throughout the body, but was particularly noticeable in the head and on the tips of the appendages. The writer had never before seen a fairy shrimp population of such a color. It was suggested by Dr. C. E. Venard that the light bluish color might be caused by blue-green algae attached to the cuticle of the fairy shrimps. A sample from the Canton pond was sent to Dr. C. E. Taft for examination, but no algae were found. Dr. Taft reported that he has seen fairy shrimps with algae, usually of the genus *Characium*, attached to the animals, but he knows of no record where blue-green algae have been similarly found. The following year Mr. Kuehnle and the writer collected again from this swamp-pond. On April 2, 1944, all of the specimens found were of the usual orange-pink or salmon color, and not a single one had the peculiar light blue color found the preceding year. On April 15 Mr. Kuehnle made another collection from this location and the specimens were still normal and uniform in color. It is possible that some chemical property of the swamp water during the season of 1943 was responsible for the unique coloring of the shrimps that season.

#### ADDITIONAL RECORDS OF ANOSTRACAN PHYLLOPODS COLLECTED IN OHIO

In addition to the records of this survey and the references which have been cited (see Dexter and Sheary, 1943; Dexter, 1943b), a number of collections and records from Ohio have come to the attention of the writer which are presented in Table IV. Specimens from the following collectors have been identified by the writer: Vickers, Azary, Chiavetta, Surrarrer, Kuehnle, Wilson, Geist, Venard and Gerberich, Blaydes, and Rice. Dr. N. T. Mattox identified those collected by Clark as well as his own specimens. Dr. R. M. Bond identified those collected at Oberlin. The following made their own determinations: Linscheid, Hazard, Dreyer, Stehr, and Gier. All of the specimens which have been identified to

TABLE IV  
ADDITIONAL RECORDS OF ANOSTRACAN PHYLLOPODS COLLECTED IN OHIO

County	Collector	Location	Species	Notes
Mahoning	Ernest Vickers, Park Naturalist, Mill Creek Park	Mill Creek Park, Youngstown	<i>E. vernalis</i>	Fairy shrimps have been observed at various times over many years. One collection only, without date, has been saved.
Lake	Kenneth Chiavetta	North Chagrin Reservation	Unknown	Abundant specimens collected from single pool on April 12, 1942. None found in several other nearby pools. Specimens disintegrated before determination could be made.
Cuyahoga	Ross Azary	Eastern edge of Painesville	<i>E. vernalis</i>	Abundant specimens collected from a pasture pool on April 8, 1944. None found in two nearby pools.
	Alfred G. Linscheid, Shaker Heights Schools	Warrensville Heights	<i>E. vernalis</i>	Abundant specimens found in March of each year between 1931 and 1943 in an extensive swamp-pond opposite the Warrensville Farm buildings.
	Kenneth Chiavetta	Fairview	<i>E. vernalis</i>	Specimens collected on April 20, 1942, from a temporary pool.
	Thomas C. Surrarrer, Baldwin-Wallace Col.	Berea	<i>E. vernalis</i>	Specimens collected about April 1, 1930, from a pool 1,000 yards from Biology Laboratory.
Lorain	Members of Biology Dept., Oberlin College	Rocky River Reservation	<i>E. vernalis</i>	Specimens collected about May 10, 1941, from a temporary pool in woods just beyond junction of the East and West Branches of Rocky River.
		Oberlin	<i>E. vernalis</i>	Collections have been made from many pools over many years time, but especially "Cemetery Pond" which Dr. Hope Hibbard says has had specimens every year since first examined.
		Wooster	Unknown	Fairy shrimps have been collected every year from pools near Wooster for a number of years. Specimens have not been preserved. (Information from Dr. R. V. Bingham and Dr. W. P. Spencer.)
Wayne	Members of Biology Dept., College of Wooster	Wooster	Unknown	Some years ago his daughter collected from a pool which has since been filled in road construction.
	James Anderson	Wooster	Unknown	Fairy shrimps found just once in Mansfield area. A collection was made in about 1929 at southern edge of city. Return visits year after year failed to find them again. Later, pond was drained and a road bed was made there. Other pools examined have never contained specimens.
Richland	Mariel J. Aberle, Mansfield Senior High School	Mansfield	Unknown	Of 8 pools examined on April 9, 1944, 6 contained <i>E. vernalis</i> . Specimens in a flooded, cultivated field were very abundant; in one pasture pool they were common; in three others fairly common; and in one, occasional specimens were found.
Crawford	Charles H. Kuehnle, Lincoln High School, Canton	Bucyrus	<i>E. vernalis</i>	
Marion	Thomas D. Bain, Harding High School, Marion	Marion	Unknown	Fairy shrimps have been collected for a number of years in temporary woodland-pasture pools. In some pools they have been abundant in the early spring.

Seneca	Ira T. Wilson, Heidelberg College, Tiffin	Tiffin	<i>E. vernalis</i>	Great abundance of <i>E. vernalis</i> was found in some woodland pools 1½ miles northeast of Tiffin in March of either 1924 or 1925. Collections were made just as ice began to break up.
Wood	Edwin L. Moseley, Bowling Green State University C. H. Otis, Bowling Green State Univ.	Weston, Portage, Scotch Ridge, Pemberville, Bowling Green	Unknown	Fairy shrimps have been collected in early spring months in various parts of Wood County over a period of years.
Lucas	Archie N. Solberg, University of Toledo	Ottawa Hills Village	Unknown	Preceding 1943, collections of fairy shrimps were made every spring for a number of years in many pasture pools in the county, but especially in Weston Cemetery Pond. None has been collected in recent years because of dry seasons and travel restrictions. One pond near Pemberville has been drained.
Paulding	Clarence F. Clark, Ohio Div. of Conser. and Nat. Resources	Brown Township	<i>E. vernalis</i>	Fairly common specimens have been collected for several years from a single pond. Two collections from hog wallows were made on April 15, 1937.
		Auglaize Township	<i>E. vernalis</i>	One collection from a Beech-Maple woodland pool was made on May 1, 1939.
Mercer	Clarence F. Clark	Franklin Township	<i>E. vernalis</i>	Specimens collected on April 2, 1942, in a temporary woodland pool.
Auglaize	Clarence F. Clark	St. Marys, Washington and Moulton Townships	<i>E. vernalis</i>	Twelve pools of various types—roadside, woodland, pasture pools, ditches, and hog wallows—were found inhabited by <i>E. vernalis</i> during March and April of 1942.
		Logan Township	<i>E. vernalis</i>	Specimens were collected from a roadside pool on April 1, 1944.
Shelby	Clarence F. Clark	McLean Township	<i>E. vernalis</i>	The first known record of <i>E. vernalis</i> from Auglaize County is a locality record cited by Daday (1910) for Wapakoneta. Two woodland pools were found inhabited by <i>E. vernalis</i> on April 24 and 25, 1942.
Logan	Donald E. Geist, Bellefontaine High School	Bellefontaine	<i>E. vernalis</i>	Abundant fairy shrimps were found in a temporary pool 1½ miles south of Bellefontaine on April 1, 1937. About a week later not a single specimen could be found. Later that year the pool was made into a corn field.
Montgomery	Charles A. Dambach, Ohio State University	Dayton	Unknown	Abundant fairy shrimps in a series of temporary pasture pools four miles east of Dayton were collected in early April of 1939. The specimens were lost through poor preservation before identification could be made.
Warren	Norman T. Mattox, Miami University	Fort Ancient	<i>E. vernalis</i>	On April 17, 1940, and again in April of 1941, <i>E. vernalis</i> was collected from temporary pools on top of the ridge inside the old earthen-works.
	Frank O. Hazard, Wilmington College	Fort Ancient	<i>E. vernalis</i>	A collection was made on April 11, 1944, at the same location as above.
Clinton	Frank O. Hazard	Clarksville	<i>E. vernalis</i>	Many collections have been made from pools in a pin oak swamp-forest on an upland flat over a period of years.

TABLE IV—(Continued)

County	Collector	Location	Species	Notes
Clermont	William L. Dreyer, Univ. of Cincinnati	Goshen	<i>E. vernalis</i>	A collection was made on March 6, 1942, from the same pool from which collections were made by Ward (1940) in 1937 and 1938.
Franklin	Carl E. Venard and John B. Gerberich, Ohio State University Glenn W. Blaydes, Ohio State University	Columbus	<i>E. vernalis</i>	Collections were made from 8 pools in the "dyke area" of Columbus in the spring months of 1942-1944. They were common each year.
		Worthington and Columbus	<i>E. vernalis</i>	Observations and collections have been made from 3 pools over a number of years. Fairy shrimps were present every year, and collections were made as follows: On March 3, 1936, on Route 161 east of Worthington; on March 19, 1938, and April 16, 1944, from two pools on Cooke Road north of Columbus. Abundant specimens have been found in all three pools.
Delaware	Members of Zoology Dept., Ohio Wesleyan University	Delaware	<i>E. vernalis</i>	Dr. E. L. Rice made a collection of <i>E. vernalis</i> in 1911. Burton (1916) made 7 collections between March 3 and April 13 from a pool northwest of Delaware. Hooker (1938) made 16 collections between January 6 and April 15 from the same pool. Both of these list identification as <i>Chirocephalus</i> , which is probably incorrect. Dr. Rice has collected fairy shrimps from the same pool and from another nearby; also from 2 swamp pools south and south-east of Delaware. Members of the department have collected fairy shrimps for many years from the above pools. (Information from Dr. W. F. Hahnert.)
Central Ohio (Portions of Franklin, Delaware, Licking, Knox, Mor- row Cos.) Hocking	Lawrence E. Hicks, Ohio State University	A belt some 10 miles wide between Worth- ington and Mt. Vernon	Unknown	Between 1928-1934, some 600 pools were examined for Algae. Approximately 40 were found inhabited by fairy shrimps.
Athens	J. Arthur Herrick, Kent State University	Sugar Grove Region	Unknown	On April 4, 1942, fairy shrimps were observed in a single pool in which they were common.
	William C. Stehr, Ohio University	Athens	<i>E. vernalis</i>	Specimens were collected from a pool along R. R. tracks in Athens every year between 1932-1942. None was found there in 1943. On March 24, 1942, a collection was made from a pond on U. S. Route 50, two miles east of Athens, but in the spring of 1944 none was found there.
	H. T. Gier, Ohio University	Athens	<i>E. vernalis</i>	Specimens were collected in April of 1942 from a pond 1½ miles north of Athens.

species are *Eubbranchipus vernalis* (Verrill). In all likelihood the specimens recorded in Table IV as "unknown" were *E. vernalis* inasmuch as it is the only common, widely distributed species in Ohio. The specimens from Delaware County listed by Burton and Hooker as *Chirocephalus* were probably misidentified as this genus has been recorded but once from North America (Creaser 1940), and collections from the same pool studied by them and from nearby pools during other years, so far as known, have been *E. vernalis*.

#### SUMMARY

The third and fourth seasons of an annual survey of fairy shrimp populations in Portage, Summit, and Stark Counties, Ohio, have yielded the following results:

1. Twenty-four pools out of sixty-one studied in 1943, and thirty-two out of sixty studied in 1944 contained *Eubbranchipus vernalis*, the only species collected during those years.

2. The populations of *E. vernalis* varied considerably each season. Some pools formerly inhabited failed to contain fairy shrimps during a certain season, while some other pools which lacked them in former years developed large populations. Considerable fluctuation of abundance was found from year to year in some pools.

3. In the season of 1943 the fairy shrimps appeared early, and the eggs had probably hatched in the winter months of 1942. Most of the pools dried up early, however, and very few fairy shrimps could be collected after April 6.

4. The spring of 1944 was a very favorable one for *E. vernalis*, which was found in more pools and in greater abundance in most cases than during the preceding three years. In 1944 the spring pools did not fill with water until the first week of March. However, the fairy shrimps developed rapidly after that time and matured by the middle of April. Some populations continued until May 13.

5. A sample was collected and measured from pond P7 each week during both years from the time they were first observed until they disappeared from the pond. All data are presented in tabular form.

6. Evidence is presented to prove that males as well as females hatch from the "winter" eggs.

7. In many cases only a single generation is present during one season.

8. If dried-out pools are refilled in the spring before the onset of hot weather, another population may develop as was observed in pond P7 in the spring of 1943. If a pool does not fill up until late in the spring, it may develop a population which will develop rapidly as occurred in pond P88 in the late spring of 1944.

9. The sporadic distribution of fairy shrimps and the sudden annual changes which occur in many ponds, together with published experimental data on hatching, would indicate that the eggs of fairy shrimps are widely distributed over the ground, and they may or may not hatch any one year. Some of the eggs probably remain viable over a number of years before hatching. Thus, sudden changes of appearance and disappearance can best be explained.

10. *E. vernalis* has been found in temperature ranging between 0° and 21° C., and in hydrogen ion concentration ranging from pH 5.3 to 7.6.

11. The sex ratio of *E. vernalis* averages 1 male to 1.5 females.

12. Color changes have been observed in specimens maintained in the laboratory. The orange-pink or salmon colored immature forms change to light-green males and bluish-gray females. A population of light-blue individuals of both sexes was found in one pond in 1943. All specimens of this pond had the same unique coloring.

13. Recent records of fairy shrimps are reported from 24 of the 88 counties of Ohio.

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