1979

A Population Study of the Cave Beetle Neaphaenops tellkampfi (Coleoptera, Carabidae) in Mushroom Cave, Hart County, Kentucky

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A Population Study of the Cave Beetle

Neaphaenops tellkampfi (Coleoptera, Carabidae)
(TITLE)
In Mushroom Cave Hart County, Kentucky

BY

Robert E. Bon Durant Sr.

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

Master of Science

IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY
CHARLESTON, ILLINOIS

1979
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I HEREBY RECOMMEND THIS THESIS BE ACCEPTED AS FULFILLING
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Neaphaenops tellkampfi (Coleoptera, Carabidae)

in Mushroom Cave, Hart County, Kentucky

By

Robert E. Bon Durant Sr.

B.S. in Ed., Indiana State University, 1964

ABSTRACT OF A THESIS

Submitted in partial fulfillment of the requirements for the degree of Master of Science at the Graduate School of Eastern Illinois University

CHARLESTON, ILLINOIS

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Abstract

A two year census of the cave beetle Neaphaenops tellkampfi (Coleoptera, Carabidae) was conducted in Mushroom Cave, Hart County, Kentucky. Three methods were used to estimate populations of this beetle. A rise in population in certain areas of the cave was shown to occur in Mid-winter. The population as reported is felt to represent a portion of a much larger population which migrates toward the cave entrance beacuse of food shortages in winter with a summer movement back into deep cave habitat when the eggs of Hadenoecus subterraneus are plentiful.

The undersigned, appointed by the Head of the Department of Zoology, have examined a thesis entitled

A Population Study of the Cave Beetle *Neaphaenops tellkampfi* (Coleoptera, Carabidae) in Mushroom Cave Hart County, Kentucky

Presented by

Robert E. Bon Durant Sr.

a candidate for the degree of Master of Science and hereby certify that in their opinion it is acceptable.

TABLE OF CONTENTS

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List of Figures

INTRODUCTION

The cave as a habitat presents a unique situation to the biologist. The environment remains relatively stable most of the time. Caves in the temperate zones maintain at near saturation humidity level (Poulson and White, 1969). The temperature within the cave remains at or about that of the mean temperature for its geographical location (Poulson and White, 1969). Some air movements, caused by fluctuations in the above ground barometric pressure, are noted in caves.

It is theorized that ancestors of modern day troglobites (obligate cavernicoles) entered caves as either troglophiles (facultative cavernicoles) or as accidentals during the Pleistocene. Following this movement underground, surface populations became extinct, leaving geographically isolated micropopulations of these organisms. As time passed these populations became genetic isolates and new subspecies or species were formed.

The distributional tendencies of cave insects have been under study for the past two decades. Several researchers have dealt with intercave distribution (Van Zant and Poulson 1975, Culver 1971, Poulson and Culver 1969, Barr 1967, Reichle et al 1965, Barber 1931). Results of work on intracave distribution has been published by Poulson and White (1971), Norton et al (1975), Culver (1970), Mitchell (1968) and Barr (1968). The primary purpose of this paper is to report further investigation of the intracave population of the insect Neaphaenops tellkampfi (Erickson 1844).

Neaphaenops tellkampfi (Coleoptera; Carabidae) of the tribe Trachini, was first described in 1844 by Erickson as Anopthalmus tellkampfi.

Furthur work was done on the monotypic genus Anopthalmus by Packard (1886). Jeannel (1928) erected the genus Neaphaenops for the cave beetle Anopthalmus tellkampfi. Jeannel (1931) revised the genus and later (1949) described the new species N. henroti. Barr (1959) divided the species Neaphaenops tellkampfi into subspecies. In addition to the nominate subspecies N. tellkampfi tellkampfi he described N. tellkampfi meridonalis and reduced N. henroti to a subspecies of N. tellkampfi. In personal communication with Barr, I have been advised that he is currently in the process of further revision of this group.

The geographical distribution of N. tellkampfi is limited to an area of central Kentucky known as the Pennyroyal Plateau (Fig. 1). The Pennyroyal is approximately 15–30 km wide and 175 km long. The distribution of N. tellkampfi is delimited on the east by the joining of the Saint Lewis and Warsaw limestone, and on the west by the Western Kentucky Coal Basin (Barr 1967).

It seems that most cave insects obtain their food in one of three ways. Some live close to the cave entrance in the crepuscular zone and feed in this zone or above ground. Others are dependent on flooding and the influx of organic food material from the epigeal environment. A third group are predatory, depending on other cave inhabiting organisms. Neaphaenops tellkampfi falls into the third group.

Neaphaenops tellkampfi, a deep cave beetle according to Kane and Poulson (1976), has developed a foraging technique based on a food preference for the eggs of the cave cricket, Hadenoecus subterraneus. Hadenoecus subterraneus deposits its eggs in loose sand or silt areas within the cave. Neaphaenops tellkampfi has been observed in these sandy areas in large populations (Kane and Poulson 1976, Norton et al 1975); however, this species is frequently observed in other cave environments such as stream banks, mud floors, walls and ceilings (Barr 1959). Kane and Poulson (1976) stated that *N. tellkampfi* spends much time and expends much energy in search of the eggs of *H. subterraneus* and suggested that *N. tellkampfi* changes foraging sites as the seasons change above ground.

If *N. tellkampfi* is food specific then its intracave movements should depend largely upon the availability of suitable food. It was the purpose of this research to investigate the population of this beetle within the total environment of one cave and to determine the relationship of this population to seasonality, substrata and the availability of suitable food.

METHODS

Mushroom Cave is a solution cave located in Hart County Kentucky, approximately three miles northwest of Bonnieville(Fig. 2). Permission was granted to use the cave as a research site. Mushroom cave is a relatively short cave (Barr 1968), with a roof collapse entrance, at the edge of a valley. The floor is mostly damp, compacted sand, with a thin mud crust. A small stream is present during wet seasons. Some minor flooding does occur but complete flooding of the cave is highly improbable since the stream is formed from surface water runoff. On a previous trip into Mushroom Cave I had noticed a population of "sand beetles" (Barr, 1962). It was known that these beetles inhabited other caves in the area but its existence in Mushroom Cave was unknown.

On August 12, 1977 four beetles were hand collected in the terminal regions of the cave. These were returned to the laboratory on August 13, 1977 for identification. On the same trip a Brunton Compass-steel tape survey was completed and a map of the cave produced (Fig. 3). The total depth of the cave was determined to be 1019 feet. Seventeen survey stations were set up with Station A1 at the entrance and A17 at the terminal end of the cave. Observations on the composition of the substratum were made at this time at each station (Fig. 4). The items considered were rock-sand content, visible organic matter, and moisture content. The general nature of the cave floor was moist to wet compacted sand with a thin mud crust. The extremes observed were exposed rock, mud, and dry sand. There were areas of the floor with rock breakdown and other areas with large amounts of organic debris. Plot thirteen contained the one area of dry uncompacted sand. This area measured thirteen feet by two feet and was determined to be an egg gallery of

Hadenoecus subterraneus by the presence of many cone shaped holes in the floor, which are indicative of the feeding mode of N. tellkampfi.

The initial censusing method employed consisted of unbaited pit fall traps. A disposable petri dish lid 150 mm x 15 mm was placed into the floor with its top edge level with the floor. Care was taken to bring the substrata over the exposed lip of the dish in an effort to eliminate beetle contact with the plastic. Traps were left open as predation was felt to be minimal. The survey stations were selected as the trap sites. On the evening of September 23, 1977 the traps were set for the first time. The traps were set as close to the exact site of each survey marker as possible. Pit fall traps were set each month upon entering the cave and examined twenty-four hours later. Monthly collections were made from September 24, 1977 to August 26, 1978.

When the traps were examined on September 24, 1977 no beetles were found so a second censusing method was implemented. Longitudinal measurements of five feet along the caves axis were made on each side of the survey sites. These measurements were then extended transversely across the cave passage and markers, were set so that sample plots were established. These plots ranged in size from 250 sq. ft. to 1450 sq. ft. (Fig. 4). Each area was then visually examined for beetles by crawling on hands and knees. Each beetle found was examined and placed behind the counters so that it would not be recounted. Rocks and debris were checked for beetles and then replaced. "Hands and knees" census techniques were carried out monthly until August 26, 1978. A total of fourteen censusing trips were made using the "hands and knees" method.

As a means of cross checking the findings of the "hands and knees" methods, a third censusing technique was used. On December 27, 1977 a bait trap technique was begun. Bait traps were of the basic design of Barber (1931). They were set at sites A6, A13, and A11. A disposable 150 ml beaker was used as the trap while bait (liver) in a small plastic cylinder was suspended by wire in the trap. Paper was placed in the bottom of the trap in the hope of providing some separation of the specimens so that cannibalism would be kept to a minimum (Fig. 5). So as not to interfere with the counts of the pit fall traps and the sample plots, the bait traps were deployed on the second day of each trip, immediately following the "hands and knees" method. Bait traps were checked and counts were made approximately twelve hours later. The bait traps used until August 26, 1978.

After the primary studies, I concluded that collection of data for a two year period would provide more reliable results. A count was made every three months from November 1978 to June 1979 using the "hands and knees" technique.

Results

No population data was gained through the use of fall traps. In contrast the"hands and knees" technique produced records of 230 beetles (Fig. 6). In March, 1978 two trips were necessary. The cave was found on the first trip in March to be in a flooded condition, with two plots (A12 and A13) under water. Forty-two beetles were counted on this trip. On the second trip in March, 16 beetles were counted. A total of 230 beetles were found on 13 trips. The monthly population varied from a low of seven on May 27, 1978 to a high of 41 on January 28, 1978. No beetles were found in A1 - 11. An average of 2.9 beetles per month were found in A12 - 17. Plot A13 produced the largest numbers of beetles throughout the study with 133 and the largest number of beetles collected per 100 sq. ft. with 15.3. The highest single plot count for one month was 26 at A13 during January of 1978.

The bait trap study conducted from January 1978 to August 1978 provided similar results (Fig. 7). A total of 255 beetles were taken at sites A12 and A17. Trap site A6 produced no beetles. The average count per trap per month (traps 6, 12, 17) was 10.6. If plot six is not included because of its failure to show beetle population then the average per plot, per month was 15.9. Total beetles observed during the "hands and knees" survey and the bait trap survey are compared in Fig. 8. Both graphs show higher collections during winter and a drop in late spring.

During the follow up quarterly survey no beetles were found in plots A1 - 11. Plots A12 - 17 produced a total count of 61 beetles for all trips (Fig. 9). A high count of 24 was recorded in January

1979. An average of 2.6 beetles were found for plots A12 - 17 for all months sampled.

Discussion

The negative results of the fall traps are an interesting subject for speculation. Possibly an odor which repelled the beetles was present on the trap or left on the trap during setting. A further possibility is that predation was underestimated. The live beetles taken to the laboratory early in the study were trap tested for escape. They were found to be unable to crawl out of the trap. If beetles did fall into open traps they may have become easy prey. The most likely prospect involves an understanding of the sensory capacity of the beetle. These are cave beetles, blind and highly adapted to their habitat. They are likely to possess well developed tactile senses and thus avoid such things as smooth vertical walls.

Although there was fluctuation in collections throughout the year, a sharp increase is seen during the winter months (Fig. 8). This apparent mid-winter peak in population does not correlate with the findings of Kane et al (1975) nor Kane and Poulson (1976). Both of these studies show a population peak in mid-summer to early fall. They concluded that the seasonal abundance of *Neaphaenops* reflects availability of food. They further show that *Neaphaenops* is food specific for eggs of *Hadenoecus subterraneus*. As the eggs of *Hadenoecus* become more plentiful *Neaphaenops* populations increase and as the egg number decreases *Neaphaenops* switches to other food sources and its population decreases. Their findings show a direct relationship between peaks of *Hadenoecus* eggs, spring pupation of *Neaphaenops*, and summer maturation of beetles and therefore higher summer-fall population of beetles. According to Kane and Poulson (1976) *N. tellkampfi* shows a preference for dry uncompacted sand. It seems likely the high collections in Plot A13 shown in Figure 6 reflect the presence of an area of dry uncompacted sand.

When the total numbers of beetles found in each plot during the study are converted to beetles per 100 sq. ft. an interesting change can be observed in the interpretation of the data. The raw data tends to indicate plot A13 has a very large population while the other plots have populations which are relatively equal. When considering beetles per 100 sq. ft. plot A13 has the highest density however, the density of plot A12 is approximately two times less. Plots A14 - 17 are shown to have populations of much less density than shown by the raw data. It should be noted that other than the Hadenoecus egg gallery of plot A13 suitable habitat was not considered in this study. If considered the amount of suitable hatitat per plot could alter the relationships demonstrated between these beetles and the plots.

If the raw data from the monthly "hands and knees" censuses are compared with the data from the quarterly study a notably similar result is observed. The average for the monthly "hands and knees" technique was 2.6 beetles per plot per month and for the quarterly study 2.9 beetles for comparable plots and months.

There are several possibilities for the lack of correlation between this study and others. Although the species of beetle is the same, the studies were conducted in different caves. Van Zant and Poulson (1975) stated that "Caves may be more 'island like' than previously thought by Barr (1967)." If this is true, then the population of Neaphaenops in Mushroom Cave may be different in its feeding habits in that its food specificity for Hadenoecus eggs may be reduced so that this aspect of population seasonality is not seen.

A further prospect is that Mushroom Cave, as mapped, constitutes only that part of a cave which is accessible to man. This may be true since the cave has a terminal syphon. If there is more cave in existence beyond survey marker seventeen then this research deals only with an area relatively close to a cave entrance. Assuming the above is true then this study may be reflecting a seasonal migration which corresponds with food availability. Kane and Poulson (1973) noted a population shift in mid-winter toward the cave entrance in which they were working. This could be thought of as movement toward more organic material in winter and a deeper cave movement in summer when Hadenoecus eggs are more plentiful.

Conclusions

It is felt that Mushroom cave, as mapped, is only the entrance portion of a much larger cave system. Sites twelve through seventeen are considered to be the beginning of deep cave. The population of N. tellkampfi reflects the presence, in the mapped area, of the Hadenoecus egg gallery. The population as reported is felt to represent a portion of a much larger population. Changes in population are thought to be caused by normal mid-winter migration toward the cave entrance because of food shortages and summer movement back into deep cave when Hadenoecus eggs become plentiful.

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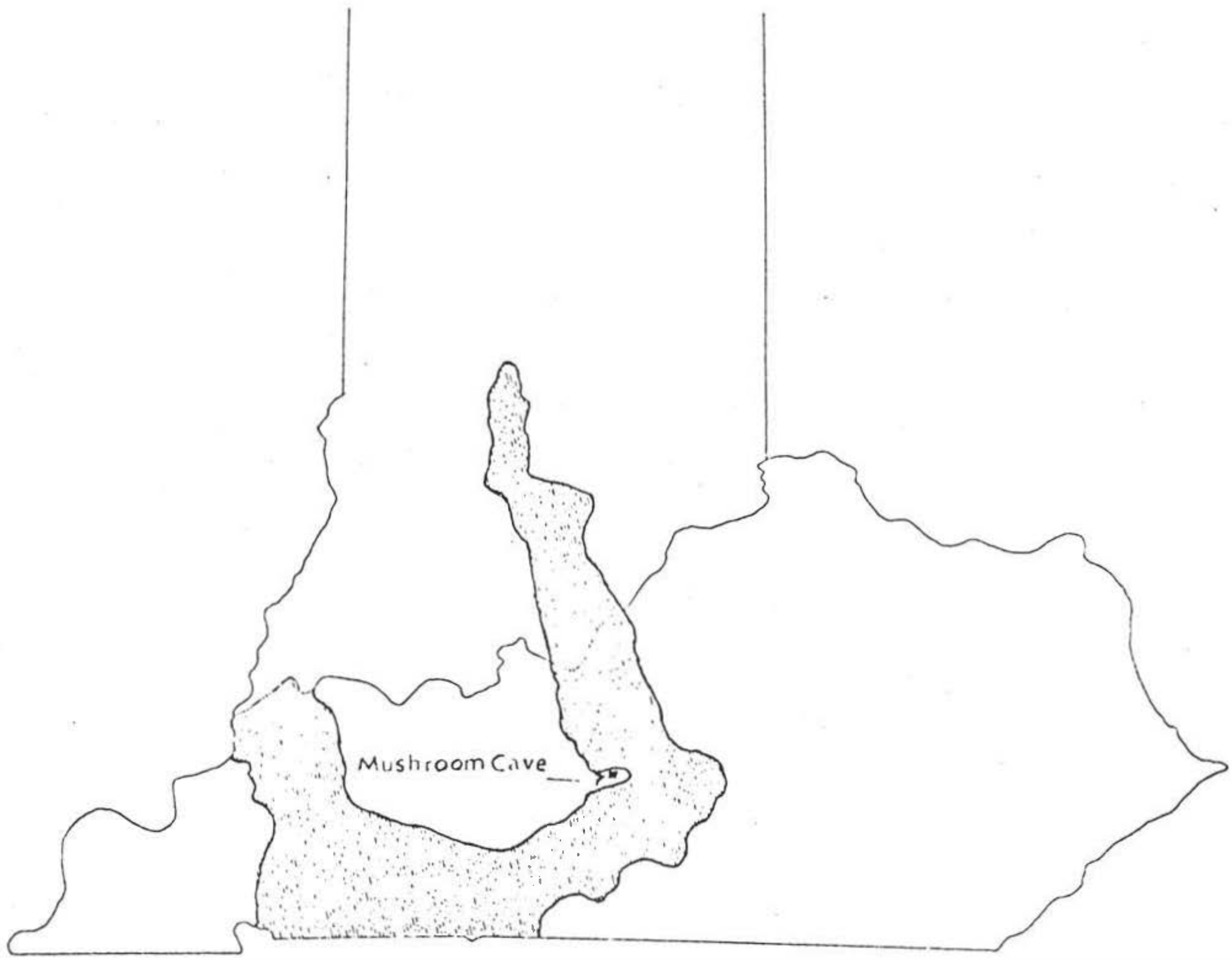


Figure 1. The Pennyroyal Plateau of Indiana and Kentucky showing the location of Mushroom Cave.

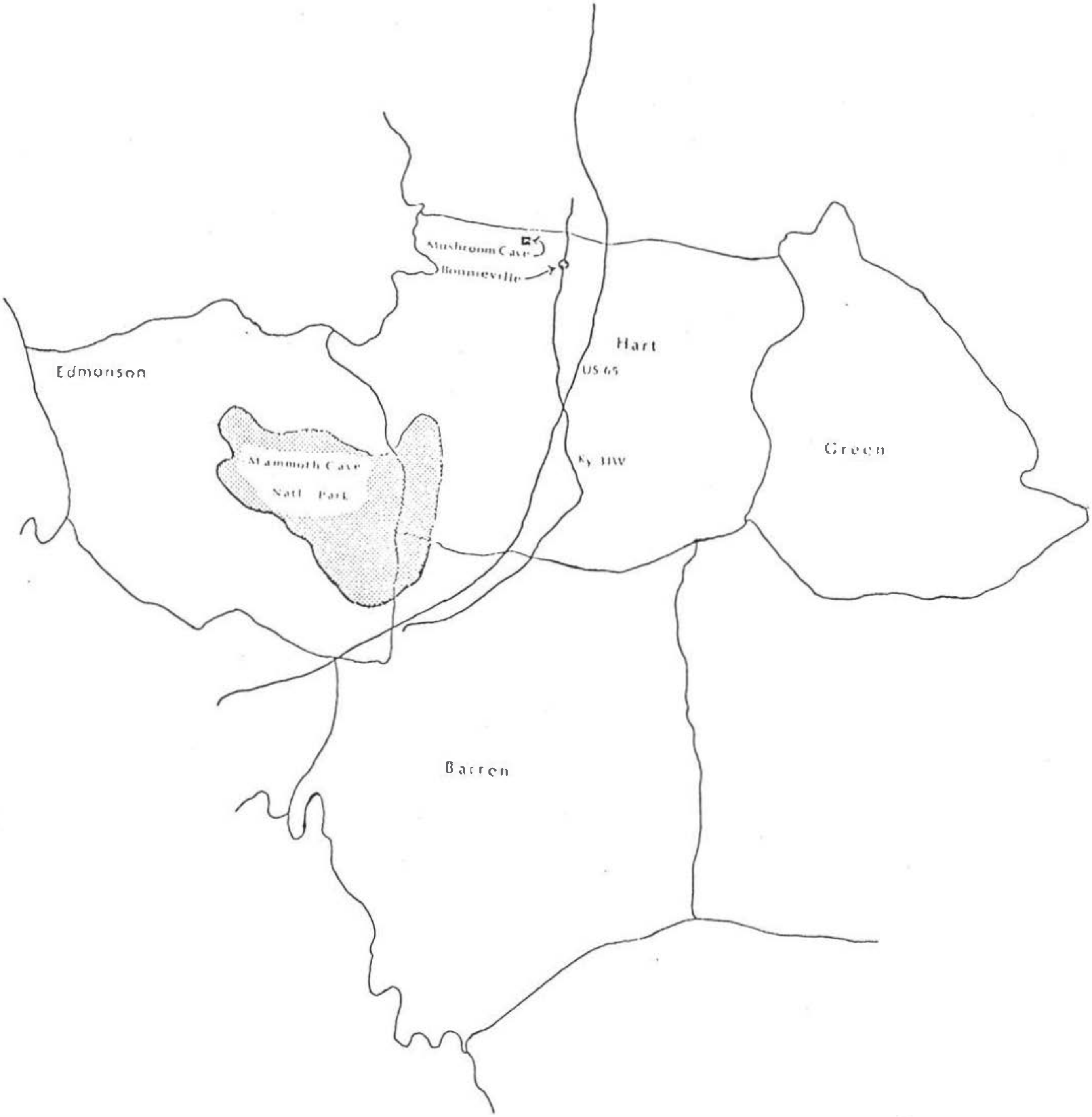


Figure 2. Map of Central Kentucky showing the location of Mushroom Cave in Hart County.

KEY

scale 1"=100'

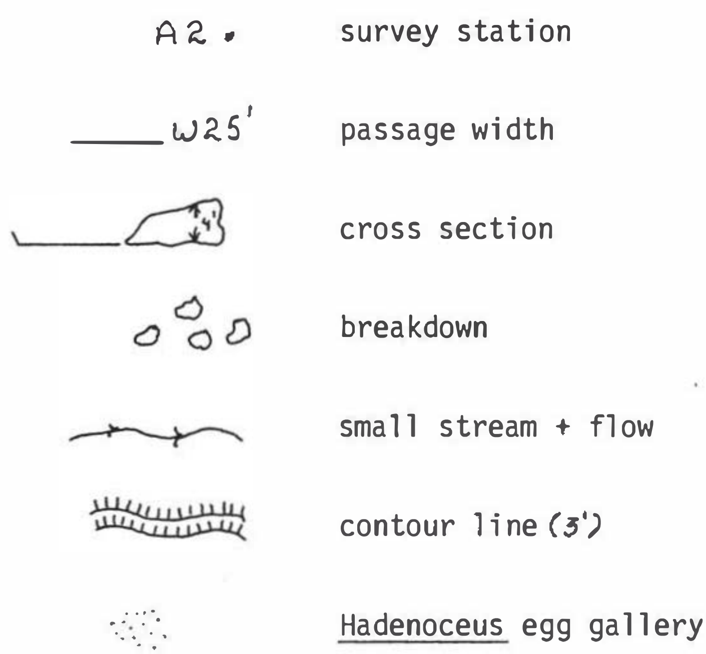
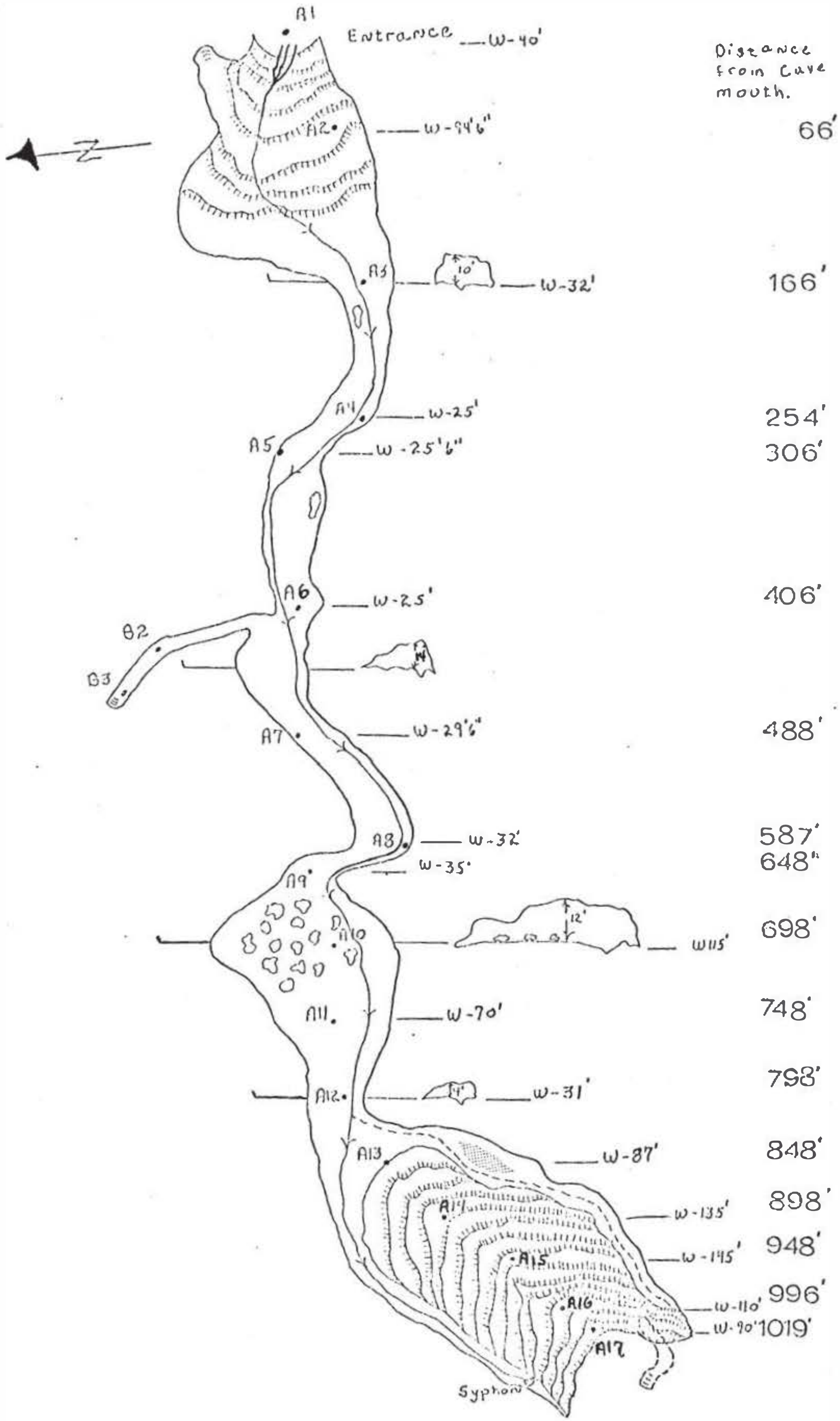


Figure 3. Mushroom Cave, Hart Co. Kentucky. Map produced by R. Bon Durant Sr. August 27, 1977, using the Cave Research Foundation guidelines (1967).


A1
Entrance — W-40'
Distance from Cave mouth.
A2 — W-34'6"
66'
A3 — W-32'
10'
166'
A4 — W-25'
254'
A5 — W-25'6"
306'
A6 — W-25'
406'
B2
B3
4'
A7 — W-29'6"
488'
A8 — W-32'
587'
W-35'
648"
A9
A10
12'
W115'
698'
A11 — W-70'
748'
A12 — W-31'
4'
798'
A13 — W-87'
848'
A14 — W-135'
898'
A15 — W-145'
948'
A16 — W-110'
996'
A17 — W-90'
1019'
Syphon

Plot #	Plot sq.'	Floor description
A1	....	outside cave
A2	946	gravel, large amounts of organic matter, wet*
A3	320	fine gravel, some organic matter, wet
A4	250	sand, little organic matter, wet
A5	256	compact sand, no organic matter, wet
A6	250	compact sand, no organic matter, wet
A7	296	compact sand, no organic matter, wet
A8	320	compact sand, no organic matter, wet
A9	350	compact sand, some organic matter, moist
A10	1150	rock (loose), some organic matter, moist
A11	700	compact sand, no organic matter, moist
A12	310	compact sand mud crust, no organic matter, moist
A13	870	compact sand must crust, no organic matter, moist-dry
A14	1300	compact sand, no organic matter, wet
A15	1450	compact sand, no organic matter, wet
A16	1100	compact sand, no organic matter, wet
A17	900	exposed rock, no organic matter, wet

*Degree of moisture was determined by pressing the thumb into the substrate and checking for moisture in the depression.

Figure 4. Sample plot size and floor description, Mushroom Cave, Hart County Kentucky.

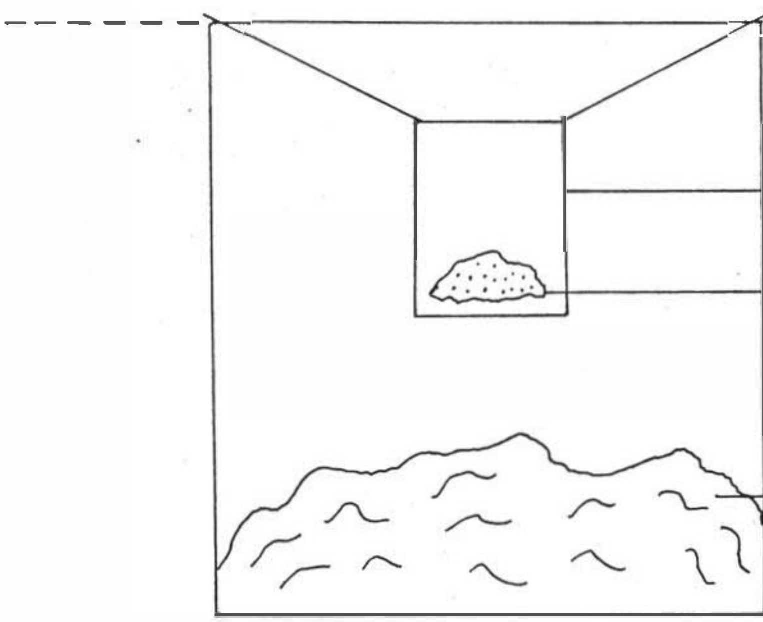


Figure 5. Trap design of Barber (1931) modified by use of paper in the bottom.

Trip date	Plot A12	Plot A13	Plot A14	Plot A15	Plot A16	Plot A17	Total sighted	Ave./Plot
August 27, 1977	3	5	2	4	1	2	17	2.8
September 23, 1977	5	2	0	0	0	0	8	1.3
October 7, 1977	2	6	4	3	2	1	18	3.0
November 29, 1977	2	12	2	0	0	0	16	2.7
December 27, 1977	1	19	1	0	1	0	22	3.7
January 28, 1978	0	26	8	5	1	1	41	6.8
February 18, 1978	0	17	0	7	2	2	28	4.7
March								
11, 1978	-	-	9	6	18	9	42	7.0
24, 1978	1	11	4	0	0	0	16	2.7
April 22, 1978	3	5	1	0	0	0	9	1.5
May 27, 1978	0	7	0	0	0	0	7	1.2
June 24, 1978	0	2	1	3	5	0	11	1.8
July 29, 1978	1	12	0	2	1	0	16	2.7
August 26, 1978	3	9	1	5	2	1	21	3.5
TOTAL	21	133	25	29	15	7	230	
Average/Plot/month								2.9
Beetles/100 sq.'Plot	6.8	15.3	1.9	2.0	1.4	.8		
Ave./Plot/100 sq.'								3.2

Figure 6. Monthly "hands and knees" Census data for *Neaphaenops tellkampfi* Mushroom Cave, Kentucky.

Trip date	Trap site A6	Trap site A12	Trap site A17	Total
January 28, 1978	0	27	12	39
February 18, 1978	0	19	9	28
March 24, 1978	0	21	19	40
April 22, 1978	0	17	16	33
May 27, 1978	0	19	13	32
June 24, 1978	0	15	11	26
July 29, 1978	0	20	12	32
August 26, 1978	0	17	9	26
Total	0	154	101	255

Figure 7. Monthly bait trap collections of *Neaphaenops tellkampfi* for Mushroom Cave, Ky.

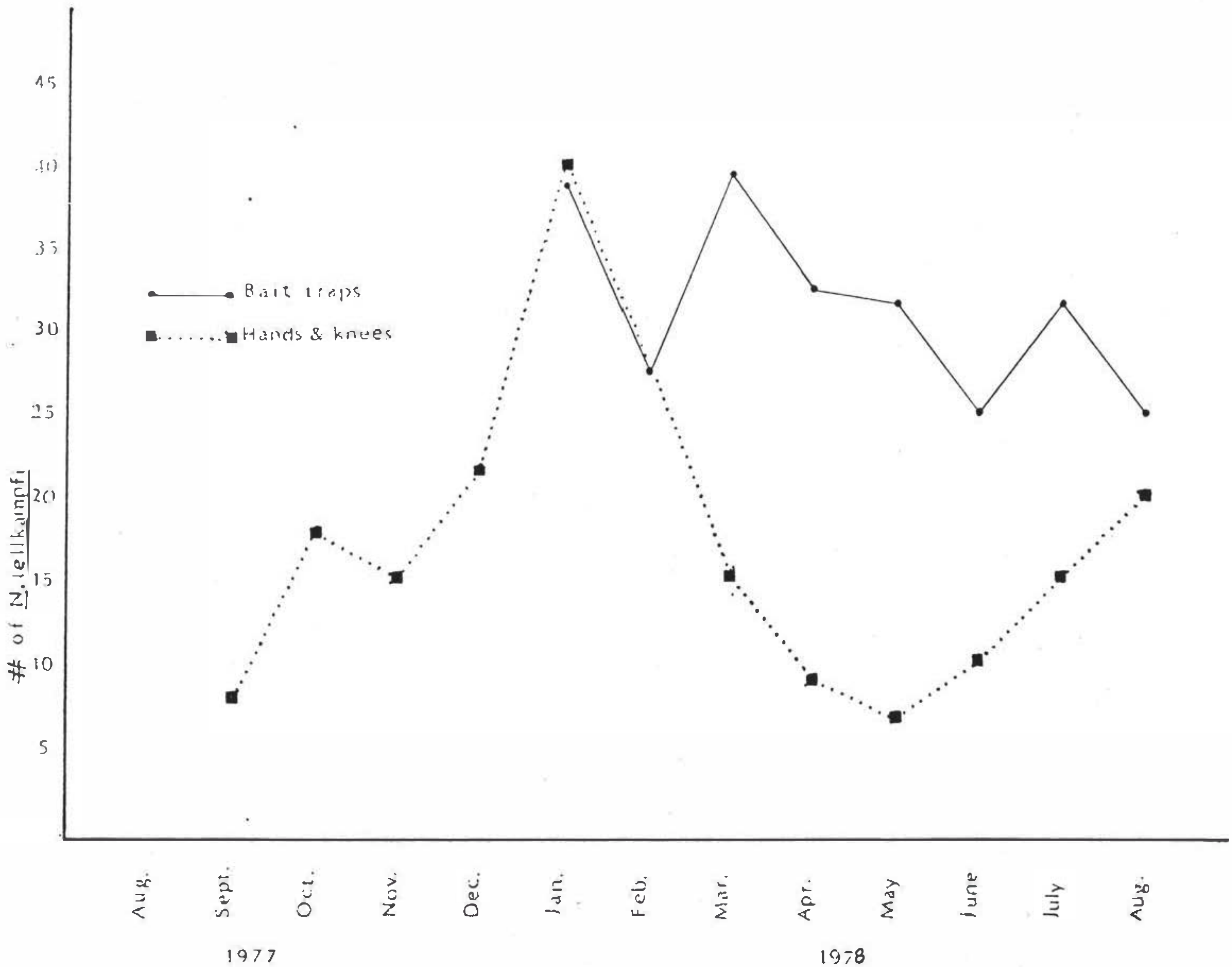


Figure 8. Comparison of the populations of N. tellkampfi using two different censusing techniques.

Trip date	Plot A12	Plot A13	Plot A14	Plot A15	Plot A16	Plot A17	Total # sighted	Ave./ plot
November 18, 1978	4	4	3	1	0	0	12	2.0
January 20, 1979	2	8	11	0	0	3	24	4.0
April 14, 1979	6	5	0	0	1	1	13	2.2
June 2, 1979	1	5	4	1	0	1	12	2.0
Total	13	22	18	2	1	5	61	2.6

Figure 9. Quarterly "Hands and Knees" collections of *Neaphaenops tellkampfi* for Mushroom Cave, Ky.