FINAL REPORT ON

THE NEW MELONES CAVE HARVESTMAN TRANSPLANT

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ABSTRACT

The New Melones Lake project of the U.S. Army Corps of Engineers, Sacramento District, will inundate at least 30 caves on the Main and South Forks of the Stanislaus River in Calaveras and Tuolumne Counties, California. In 1975 the Corps sponsored a small transplant project of cave fauna from McLean's Cave, Tuolumne Co., to the Transplant Mine, an inactive horizontal shaft 1.6 mi away. Uncertain as to the success of the first effort, the Corps sponsored a second transplant from December 1977 to March 1978. The primary concern of both projects was the cave-dwelling harvestman, *Banksula melones* Briggs, which is known only from McLean's Cave (to be flooded) and McNamee's Cave (to be destroyed by quarrying).

The second transplant resulted in the transfer of 27 of the 35 or more species which inhabit McLean's Cave, for a total of 1355 individuals. Despite a considerable collecting effort, only 26 adult *B. melones*, 9 9 *B. grahami* and 26 juvenile *Banksula* were transferred to the mine. Seven other local caves were biologically studied, but *B. melones* was not found in any of them. Details are given on the history of the problem, techniques employed, theoretical and logistical problems encountered, fauna observed and collected and observations on *Banksula* behavior. It is concluded that the transplant is a probable failure. Recommendations are made to

permanently perserve the mine as a study site for biologists and mineralogists. It is also recommended that no further transplants be made until this one can be shown to be a success, and that a more thorough biological study of caves in the area be made.

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INTRODUCTION

History of the Problem

The New Melones Lake Project of the U.S. Army Corps of Engineers, Sacramento District, will cause permanent or periodic inundation of at least thirty caves along the Main and South Forks of the Stanislaus River in Calaveras and Tuolumne Counties, California (McEachern and Grady, 1978). McLean's Cave is one of the more interesting and scientifically valuable caves that will be flooded sometime after November 1978. It is located on the north side of the South Fork, about 1100 ft east of the confluence with the Main Fork. With an entrance elevation of 1008 ± 5 ft, McLean's Cave will be submerged at a depth of 13 ft at "Recreational Pool Level and 82 ft at "Gross Pool Level". The date of inundation is dependent on the actual completion date of the dam, the weather and possible legal and political complications. The author has not been informed of the projected date of inundation if any such date has been computed. Conceivably, the cave could be flooded sometime in 1979 at the earliest.

McLean's Cave harbors a diverse fauna of at least 35 species, the majority of which are arthropods (see annotated systematic list). Because some of these species have not yet been identified or described by systematists, it is impossible to say if any species is unique to McLean's Cave. A new species of Collembola is known only from McLean's Cave but could conceivably be found in nearby caves once they are thoroughly investigated. It is also possible that a newly discovered fulgoroid planthopper is unique to McLean's Cave. However, a similar form has been found in Windeler Cave, Tuolumne Co., which will not be flooded. Several unidentified species of mite will probably be new once examined.

McLean's Cave is unique in that it is the only cave known to harbor two species of the harvestman genus Banksula, known only from caves in the Mother Lode Region of California. Banksula grahami Briggs is a troglobitic form (an obligate cave-dweller) which is known from six caves in Calaveras and Tuolumne Counties. Of these, only McLean's Cave will be inundated by the lake. Banksula melones Briggs, also a troglobite, is known only from McLean's Cave and McNamee's Cave (Quarry Cave), located on the south side of the South Fork (Briggs, 1974). McNamee's Cave is in a privately owned quarry and eventually will be destroyed by quarrying.

In December 1971, Mr. Thomas Briggs, a harvestman systematist and Field Associate with the California Academy of Sciences, informed the Corps of Engineers of the possibly endangered status of B. melones, which was undescribed at that time. Briggs requested that efforts be made to preserve this harvestman and other associated cave life upon which it might be dependent. Further discussions with Briggs led to his suggestion that the harvestmen could probably be moved from

McLean's Cave to other nearby caves or mines which will not be affected by the new lake. In the New Melones Lake environmental statement of 1972, the Corps of Engineers made this statement: "Consideration is being given to relocating cave-dwelling biological specimens that will be affected by the project to other caves" (Corps of Engineers, 1977).

On 14 March 1974 Briggs published a paper describing Banksula californica (known only from Alabaster Cave, El Dorado Co.), B. tuolumne (known only from Crystal Tuolumne Cave, Tuolumne Co.), B. galilei (known from Lime Rock Caves and Lime Rock Cave #3, Placer Co.), B. grahami and B. melones.

In April 1975 Briggs informed the Corps that McLean's Cave might contain other species which have not been identified or described. He also stated the requirements for a relocation of B. melones and associated fauna:

"a. A mine shaft, preferably in limestone, is best because it is so recent in origin that it does not have established cave fauna which would be competition for introduced fauna.

b. The mine must be moist year around.

c. The mine must have a constant temperature zone in total darkness" (Corps of Engineers, 1977).

At approximately the same time Briggs notified the Office of Endangered Species of the status of B. melones so that it might be studied for endangered species status.

1975 Transplant

In May 1975 the Corps hired Briggs to transplant fauna to a mine shaft within the project boundary, hereinafter referred to as the Transplant Mine. The mine is 1.3 mi ESE of McLean's Cave, on the south side of the South Fork, at approximately 1400 ft elevation. The land around the mine is government property and currently administered by the U.S. Bureau of Land Management. An agreement between the Corps and the Bureau provided for protection of the mine from mining claims. This agreement has been ineffective, as will be related below. Both the mine and cave were equipped with tubular steel gates with padlocked lids to protect the sites from intruders.

Six transplant operations were performed from 19 July to 2 November 1975. Approximately 142 man hours were spent in the field, with each transplant requiring two days. At least sixteen species of arthropods were transplanted (Table 1), as well as two unidentified species of imperfect fungi. About 100 lbs of soil, rock and roots were transplanted from the cave to the mine in styrofoam containers (to minimize temperature and humidity changes). The live specimens were placed in vials containing moist soil and leaf litter. The vials were also carried in styrofoam containers. A constant temperature of 61.0°F and 100% relative humidity were monitored throughout the study at the collection sites 80 ft from the cave entrance. A brief rise in temperature within the containers, to a maximum of 74.8°F, had no apparent adverse effects on the animals. The materials and specimens were placed in a 6 ft diameter wall pocket about 209 ft from the entrance. This transplant site is hereinafter referred to as "T1". Follow-up inspections were made on 1-2 November and 22-23 November 1975 and revealed that "...only B. grahami and the collembola appear to be present in sufficient numbers to suggest a partially successful transplant " (Briggs, 1975).

Briggs carried out another inspection of T1 on 6-7 November 1976 (Briggs, 1976). See Table 1 for data from this inspection. From the two 1975 inspections through the 6-7 November 1976 inspection, the numbers of adult B. melones observed at T1 were, respectively, 4, 6 and 5.

Unbeknownst to Briggs and the Corps of Engineers, a mining claim had been filed on the mine on 30 October 1976. The location notice was recorded by A.H. Uvelli, Tuolumne Co. Recorder, on 1 November 1976, and shows that Edward Lee Kafton and Cynthia Marie Kafton had claimed the mine under the name of "The Wild Cat Wonder Quartz Mine" (Uvelli, 1976).

Briggs again inspected T1 on 20-21 August 1977 (Table 1) and reported that no B. melones were observed. Briggs (1977a) reported that, "The site was found to have been disturbed, partly by miners who entered earlier in the year and drilled nearby and partly by a striped skunk which was observed in the mine. Wood scraps and sticks had been moved off the

TAXON	# TRANSPLANTED	11-2-75	11-23-75	11-18-76	8-24-77
Imperfect fungi	2+ species			1	
Collembola: Entomobryidae	22+	12	39		1
Symphyla: *Scutigerella*	1+				
Diptera: Phoridae	13+	2	4		
Coleoptera: Leiodidae	3+	2	7	2	
Carabidae	1+	1	1	3	
Tenebrionidae	2				
Thysanura	1+				1
Diplopoda: sp. A	1				1 dead
sp. B	1				
Xistocher				1	
Acarina: Oribatidae	22				
Araneida: *Usofila* (*Telema*)	2				
Liocranoides	4	2	3		1
Leptonetidae		2	2	1	2
egg sac (small)	1				
Phalangida: *Banksula grahami*	17	9	5	5	4
Banksula melones	22	4	6	5	
juveniles	5	1	5	4	
Pseudoscorpionida: Neobisiidae	6	1			
Isopoda	9	1	3	5	6

Table 1. Fauna transplanted and observed by Briggs, 1975-77.

transplant soil...In spite of the drought the inner wall of the site was moist. Drought conditions, however, may account for less life being observed. Wood scrap was replaced on the site...". Briggs (1977b) soon concluded that the site was damaged by mining activity and resulting exposure to drying conditions. He recommended that additional and larger transplants be made. Presumably, the Kaftons were persuaded to drop their claim on the mine.

1977 Cave Inventory

In April 1977 the Corps contracted with Southern Methodist University, Archaeology Research Program, to evaluate the caves to be impacted by the New Melones Lake. In April and May 87 caves were investigated, about 80% of them in Calaveras Co. and almost all of them within the immediate vicinity of the future lake. The inventory employed the services of about fourteen field personnel and sixteen other professionals in the disciplines of speleology, geology, paleontology, archaeology and biology. Only one field biologist, Andy G. Grubbs, was employed to manage the biological collecting program. About 27 caves in Calaveras Co. and 2 caves in Tuolumne Co. were biologically investigated. The final report of this project is still in press at the time of this writing. The biological investigation did not discover any new localities for B. melones, but did discover two new species of Banksula: one eyeless species from Pinnacle

Point Cave, Tuolumne Co., and an eyed form, similar to *B. melones*, from caves 006, 011 and 041 (in Skunk Gulch, Calaveras Co.), 025 (on the Main Fork, Calaveras Co.) and cave 051 (on Coyote Creek, Calaveras Co.). An unidentified *Banksula* adult was taken in cave 018 (in Skunk Gulch). None of the above caves will be inundated except for cave 025 (Coral Cave), which will be 16 ± 5 ft below recreational pool level (McEachern and Grady, 1978).

1977-78 Transplant

On 16 November 1977 the Corps contracted with the author to perform the following work:

"a. Investigate McLean's Cave and develop and estimate of the size of the population of Harvestmen and other lifeforms existing in the cave.

b. Check other caves and mine shafts located in the general project area above the new lake (approximately 15 locations) and provide a description of species located.

c. Conduct a transplant program to move the necessary biological specimens and associated habitat (rocks, soil, organic litter) from McLean's Cave to the Transplant Mine and establish a potentially viable colony of Harvestmen at the transplant site.

d. Provide an interim report listing the number of individuals of each species transplanted and the dates transplanted.

e. Conduct a followup inspection of the Transplant Mine and provide a final report on the transplant program. The report shall include a description of the biological specimens transplanted (common name, family, and genus and species if possible), the number of each transplanted, a description of the methods utilized, an assessment of the transplant program's success, and a proposed followup study program to monitor the continuing success, corrective actions needed, etc."

The personnel for the project included:

Dr. William R. Elliott: Principal Investigator, graduate training in cave biology at Texas Tech University (PhD, 1976), field experience in Texas, Mexico, New Mexico, Washington and Oregon; Georgetown, Texas.

Mr. Andrew G. Grubbs: Consulting Speleologist, background in cave biology and general speleology, field experience in Texas, Mexico, Montana and California (Field Asst. on New Melones cave inventory project); Austin, Texas.

Mr. Stephen A. Winterath: Consulting Speleologist, background in general speleology in western U.S. (Field Asst. on New Melones cave inventory project); Sacramento, California.

Mr. Thomas Briggs: Part-time Research Specialist, PhD candidate in chemistry at Univ. California, Berkeley, Field Associate with California Academy of Sciences, harvestman systematist, background in cave biology in western U.S.; Berkeley, California.

Mr. David Cowan: Part-time Consulting Speleologist, background in general speleology in western U.S. (Field Asst. on New Melones cave inventory project); Carmichael, California.

The project was begun on 5 December 1977 and the field work was completed on 28 February 1978. An interim report was filed by the author on 3 March 1978.

METHODS, MATERIALS AND RESULTS

Practical Problems

The project was beset with three practical problems from the beginning: the logistics of getting to and from the cave and mine on a day-to-day basis, flooding in the Transplant Mine and working with a number of species which were unidentified or not easily identifiable in the field. These problems are outlined below. Some even thornier theoretical problems will be treated in the discussion.

Access to both the cave and the mine requires driving over steep, treacherous roads in a four-wheel drive vehicle. In mid-December 1977, the great drought of recent years broke with the result that these roads became even more treacherous and frequently required the use of tire chains. For example, the road to the mine is composed of a very slick clay and there is an incline of 34% at the bottom. The truck became mired on four different occasions on this road and about six hours of total work time were lost in freeing it. Approximately two more days of total work time were lost because of having to drive slowly, changing tire chains (often on both the cave road and the mine road), moving road obstacles, and cleaning and maintaining the truck beyond what would normally be necessary. Another example of lost time was the frequent flooding of the South Fork of the Stanislaus River. The river crossing at McLean's Cave is normally 1 or 2 ft deep, but it was frequently too deep and swift to ford safely by truck or on foot. This problem was partially overcome by rigging a 150 ft steel cable between large trees and doing a manual traverse above the river by means of hauling ropes, seat slings and a large pulley. Heavy containers of cave soil and fauna often had to be transported in this way. The traverse was used on 7 days and was a great aid in keeping the project on schedule. However, an extra 45 minutes or more was spent in rigging-up and traversing on each such day. In sum, about 3½ days of work time were lost to the vagaries of weather, time that could have been spent on the transplant or investigating other caves.

In addition to weather problems, it soon became clear that the trails to the cave and the mine were far from safe for personnel, especially when wet and when we were carrying heavy loads. A new trail had to be constructed by hand to get safely from the river to McLean's Cave. The trail from the mine road required much manual labor to make it safe and negotiable. Altogether, about 3 days of work were lost in constructing trails.

Another unforseen problem was the flooding of the Transplant Mine from within. Until the heavy rains which began about mid-December, the mine contained little or no free water and the walls were quite dry. Relative humidities (Table 2) ranged from 80% just inside the gate, to 90% at T1, to 99% at the end of the mine. By 10 January the mine was becoming wet and by 17 January it was seeping considerable amounts of water even at the end. With time the mine had become progressively wetter from the entrance toward the end, as one advances under greater overburden (see Fig. 1). By 18 January a 9 in deep pool had formed in the first straight section of the mine, being fed by continual sheet flow along the floor toward the entrance. At his time we installed a siphon hose through the gate in an attempt to drain the pool. A dead millipede and a dead spider were observed floating in the pool and some concern arose as to the fate of any transplant specimens in such an environment. By 19 January the siphon had drained 1339 gal/24 hours, but the pool level had not dropped. A rough calculation of the pool's volume (5 ft wide, 117 ft long, and 0 to 9 in deep) showed that it could not contain more than about 1360 gal. Therefore, the pool was being filled at about the same rate as it was being drained, or else it was seeping out somewhere else. The flow into the pool seemed considerably greater than the siphon flow rate. On 25 January an attempt was made to tunnel under the soil and rubble beneath the entrance gate to establish a drain. This was done with the assistance of Mr. Bill Pay of the Corps of Engineers. A portable gasoline powered water pump, hose and plastic pipe were used to blast away soil while tunneling under the gate. The attempt was stopped by large boulders blocking the way under the gate. By 1 February we discovered, by moving some large rocks against the right wall 20 ft from the gate, that a natural joint acted as an overflow route for the pool. This joint had been dammed off by a 9 in high wall of calcite deposited by water flow in the 50-55 years the mine has existed. A trench was cut into this joint and the pool was drained to 3 or 4 in depth. By this time, seepage in the mine had reached a peak and it was felt that no further flooding would occur if the drainage joint were kept clear. Sheet flow continued along the floor throughout the mine until the end of the project. The placement of transplant sites in the mine was greatly influenced by floor topography and drainage patterns. These matters will be discussed more fully below.

Identifying the species transplanted to the mine proved to be a problem with some of the minute forms, such as Collembola and mites. Laboratory identification with sophisticated equipment is necessary in such cases. The fact that many of the species were as yet unidentified created some doubt as to whether our tallies were completely accurate. For this reason the transplant data on Acarida (mites) are perhaps inaccurate, although there probably are at least six species of mite in McLean's Cave. Another example of this problem is the fact that I reported three species of spider transplanted in my interim report, whereas I have since learned there were only two: "sp. B" is only the juvenile stage of "sp. C" (*Telema* n.sp.) in that report (W.J. Gertsch, pers. comm.).

The most important instance of the species identification problem was with the *Banksula* harvestmen. As in many harvestman species, the structure of the male penis is the important taxonomic character for distinguishing two closely related species such as *B. melones* and *B. grahami* (see Briggs, 1974). This would require preserving the specimen, dissecting it and examining its genitalia on a compound microscope -- clearly an impossible procedure under our conditions and ineffective for females anyway. Briggs demonstrated to us in the field that *B. melones* is generally larger, darker in coloration and has larger eyes than *B. grahami*. Thus, among a collection of live harvestmen it is possible to tell, with the aid of a hand lens, which species is which. This is not always foolproof as *B. grahami* exhibits considerable individual variation in eye size, at least in the McLean's Cave population. We obtained lower ratios of *B. melones* to *B. grahami* than did Briggs in his transplant work, and this may suggest that our identifications were "biased" toward *B. grahami*. However, I feel this is not the case as Briggs agreed with our identification of 21 *B. grahami* and 1 *B. melones* transplanted during his on-site visit of 7-8 January 1978.

Preliminary Census in McLean's Cave

McLean's Cave is one of the larger and more complex caves in Tuolumne Co. Although no survey length is available, the cave is formed mainly on two joints which strike NW-SE. The cave has 138 ft of horizontal extent in this direction, and 85 ft of horizontal extent in the SW-NE direction. Total depth is 108 ft. Two small entrances lead to the Entrance Room, 50 ft long and 20 ft wide. A short passage at the end opens into the second chamber which is 82 ft long and about 13 ft wide. Each room has side passages leading to smaller rooms on either side. The Entrance Room is floored with breakdown blocks, talus and soil. A descending passage on the left side leads down to a confused jumble of dusty rooms in bedrock and among breakdown beneath the Entrance Room. The second chamber is divided by flowstone into three different levels. Old cave sediments, now largely gone, were covered with flowstone at different times and subsequent erosion has left thick false floors suspended across the chamber. One may climb about in these three levels, usually without the aid of a rope.

Preliminary work in McLean's Cave began on 8 December with an attempt to census as many arthropod species as possible. By 13 December, 60 pit traps were placed in the floor throughout the cave, but concentrated in the second chamber and the lower levels beneath the entrance. The traps were pint mason jars buried with the lip flush with the floor. Each contained a 9 oz, plastic drinking cup which fit flush in the jar. These cups facilitated the removal of bait and specimens. The traps were checked on eight days until 22 December. Various traps were baited with water, banana peel, fudge pudding, peanut butter, liver, cheese, or left empty. Although at least 233 Collembola, 63 Psocoptera and 86 Ptomaphagus nevadicus beetles were trapped, neither species of Banksula seemed to be attracted to any of the baits. As Briggs (1975) found, the most effective method of collecting harvestmen was by hand. They are more frequently found under large rocks or in wall crevices, especially near roots. Less often one may find them on walls or on the floor. A considerable amount of time and effort is required to collect even a few harvestmen. A total of 450 trap checks during this census period yielded only two adult and one juvenile Banksula. According to Briggs (pers. comm.) and our own observations, the harvestmen probably are predators on microarthropods. By the end of the census period fair numbers of

Collembola and Psocoptera were found on moldy cheese in the traps, but no harvestmen were attracted to them. Nor is it likely that they were visiting the traps and leaving. One adult harvestman was left in a trap for seven days and was not able to escape (it died on the seventh day). The same trap contained a juvenile which disappeared after four days. We placed other adult Banksula in traps and observed that they were rather clumsy and seemed incapable of escape from the rather slippery cups.

During the same period at least 17 of the traps were visited by rodents, as evidenced by feces in or near the traps. Many of the traps were robbed of their bait. Ten rat traps were set to alleviate this problem and to identify the species involved. Three Rattus norvegicus were trapped between 12 and 22 December. There was no more evidence of rodent activity after 22 December.

The fauna trapped from 8-22 December included 1 Brackenridgia heroldi, 3 Liocranoides n.sp., 9 Telema n.sp., 2 unidentified spiders, 1 Microcreagris grahami, 1 Neochthonius troglodytes, 2 adult and 1 juvenile Banksula, 1 Ortholasma rugosa, 6 mites, 17 Paeromopus sp., 2 Thysanura, 208 Collembola, 63 Psocoptera, 1 adult and 1 nymphal Fulgoroidea, 3 adult and 1 larval Tenebrionidae, 86 adult and 1 larval Ptomaphagus nevadicus, 1 Carabidae, 1 Formicidae, 48 Diptera and 1 Taricha torosa (California Newt).

Although sufficient numbers of Collembola and Psocoptera were available for a mark-recapture study, we had no suitable means of marking these minute insects. A standard, two census mark-recapture study of Ptomaphagus nevadicus, a leiodid beetle, was carried out on 19 and 22 December 1977 in McLean's Cave. Forty-two beetles were taken from traps in the Register Room (about 65 ft from the entrance), at the bottom of a slope just past the Register Room and in lower level breakdown passages beneath the entrance. The beetles were marked with small daubs of orange tempera paint and released in the vicinity of their capture points. On 22 December 24 beetles were taken from 9 traps; 3 of these beetles were marked. Bailey's (1951) estimate of the Lincoln Index was used to compute $\hat{N}$, the population estimate, and other statistics. The results are reported in Table 2.

No statistical estimate of N for either species of Banksula in McLean's Cave could be carried out because of the low numbers recovered and the need to transplant those few that were captured. It would be rash to guess at the population sizes and call the guesses "estimates" (most biologists consider a "population estimate" to be one arrived at through some sort of strictly objective methodology). However, I would guess that B. grahami is far more abundant than B. melones, judging from its known distribution (6 caves vs 2) and our collecting success during the transplant phase (see p.37 and Fig. 2). Judging from the numbers transplanted, I would guess that the

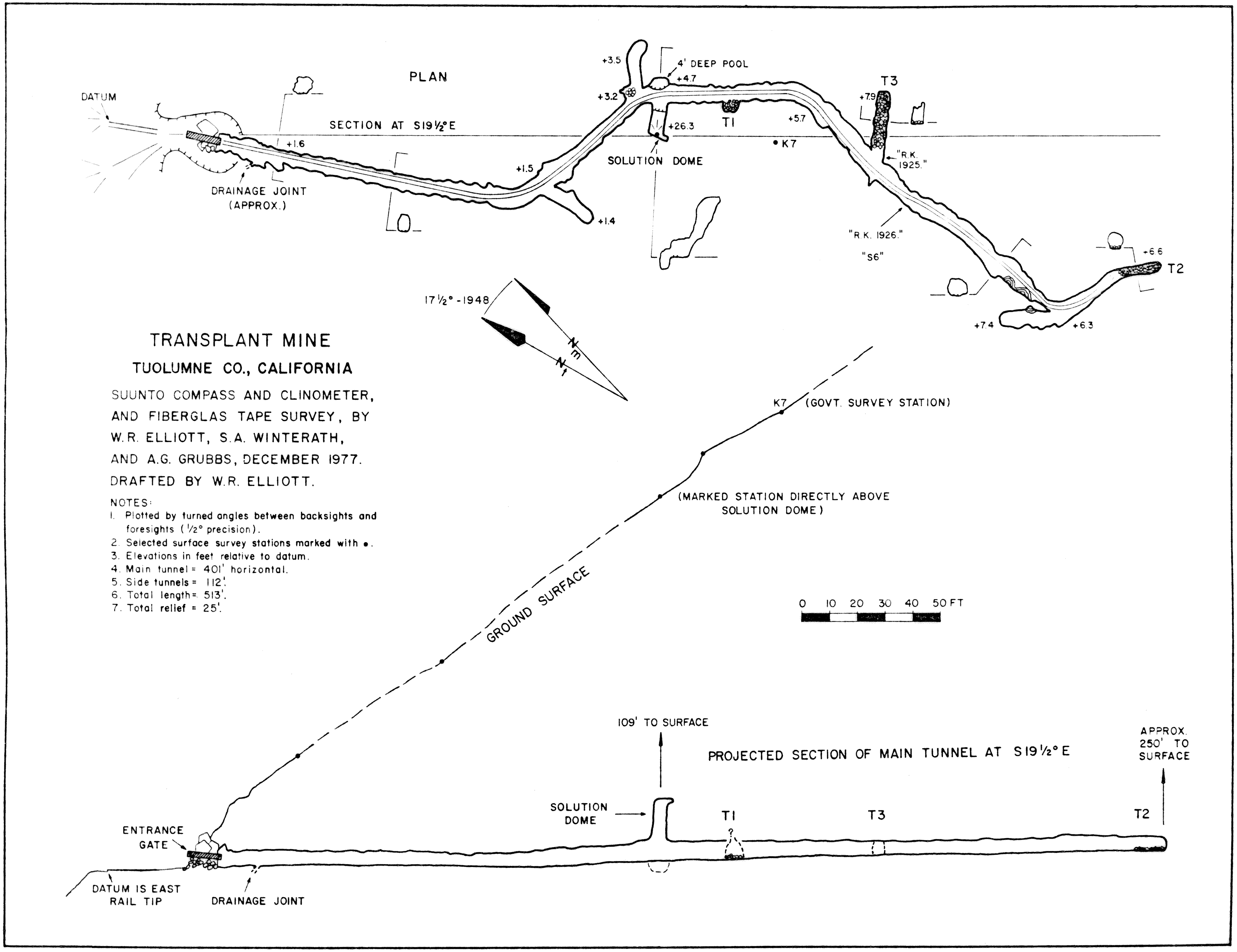
SPECIES & DATE	M	T	R	$\hat{N}$	S	95% CL	$\frac{S \times 100}{\hat{N}}$
Ptomaphagus nevadicus 12-23-77	42	24	3	263	107.6	52-474	40.99
B. melones @ T1 12-23-77 (yellow)	4	7	4	6	1.6	3-10	26.67
B. grahami @ T1 12-23-77 (yellow)	8	11	8	11	1.7	7-14	15.82
B. grahami @ T1 5-14-78 (yellow)	8	9	5	13	3.2	7-20	23.90
B. grahami @ T2 5-14-78 (pink)	11	3	2	15	3.7	7-22	25.02
B. grahami @ T3 5-14-78 (white)	7	9	2	23	9.8	4-42	41.83
B. grahami @ mine 5-14-78	26	21	9	57	12.7	32-82	22.27

Table 2. Population estimates at McLeans' Cave (*Ptomaphagus nevadicus*) and the Transplant Mine (*Banksula melones* and *Banksula grahami*). M= number of individuals marked in first census, T= total number taken in second census, R= number of marks recaptured, $\hat{N}$= population estimate, S= standard deviation of $\hat{N}$, 95% CL= 95% confidence limits, $\frac{S \times 100}{\hat{N}}$ = percent standard error, $\hat{N} = \frac{M(T+1)}{R+1}$.

Note that for *B. melones*, $\hat{N} = 6$ while $T = 7$. $\hat{N} = 6$ is an artifact of the equation, the small numbers involved and rounding ($\hat{N}$ is actually 6.4). The parametric (true) $N \geq 7$.

Site	Date	Dry, °F	Wet, °F	% Rel. Hum.
outside air	12-7-78	44.6		
air 3' inside ent.	"	58.5		
air, Register Rm.	"	56.7		
soil, Register Rm.		55.8		
air, Register Rm. 10' up		57.3		
outside air	12-18-78	49.3	44.5	67
air, Entrance Rm. 3" up	"	56.5	53.4	82
air, Register Rm. 4" up, air flow	"	56.3	54.0	87
soil, Register Rm.	"	55.9		
air 2" up, 2nd Rm. 1st level	"	56.4	54.3	90
air 2" up, 2nd Rm. 2nd level	"	56.7	55.6	93
air 1" up, 2nd level near Mud Walls	"	58.5	56.5	90
lake, 3rd level	"		57.5	
air 2" up, Mud Walls 2nd level	"	60.0	59.0	95
air 3' up, halfway down to lower level	"	57.0	55.3	90
air 3' up, lower level	"	57.1	56.5	97
soil, lower level	"	56.6		
outside air	1-3-78	55.5		
outside air	1-4-78	50.5		
air, Register Rm.	1-7-78	56.6	55.1	92
air, 2nd Rm., 1st level	"	56.7	55.3	93
outside air	"	53.6		
air, lower level	1-8-78	57.7	56.4	92
outside air	1-15-78	46.3		
outside air	1-21-78	55-57		
South Fork	"		45.8	
outside air	1-22-78	55.6		
outside air	1-31-78	54.0		
South Fork	"	44.0		
outside air	2-2-78	56.6		
outside air	2-4-78	52.2		

Table 3. Temperatures and relative humidities for McLean's Cave and vicinity.


TRANSPLANT MINE
TUOLUMNE CO., CALIFORNIA
SUUNTO COMPASS AND CLINOMETER, AND FIBERGLAS TAPE SURVEY, BY W.R. ELLIOTT, S.A. WINTERATH, AND A.G. GRUBBS, DECEMBER 1977.
DRAFTED BY W.R. ELLIOTT.
NOTES:
1. Plotted by turned angles between backsights and foresights (1/2° precision).
2. Selected surface survey stations marked with •.
3. Elevations in feet relative to datum.
4. Main tunnel = 401' horizontal.
5. Side tunnels = 112'.
6. Total length = 513'.
7. Total relief = 25'.
PLAN
DATUM
SECTION AT S19½°E
DRAINAGE JOINT (APPROX.)
+1.6
+1.5
+1.4
+3.5
+3.2
4' DEEP POOL
+4.7
+26.3
SOLUTION DOME
T1
+5.7
K7
T3
+7.9
"R.K. 1925."
"R.K. 1926."
"S6"
+6.6
T2
+7.4
+6.3
17½° - 1948
MN
N
K7 (GOVT. SURVEY STATION)
(MARKED STATION DIRECTLY ABOVE SOLUTION DOME)
GROUND SURFACE
0 10 20 30 40 50 FT
109' TO SURFACE
PROJECTED SECTION OF MAIN TUNNEL AT S19½°E
APPROX. 250' TO SURFACE
SOLUTION DOME
T1
?
T3
T2
ENTRANCE GATE
DATUM IS EAST RAIL TIP
DRAINAGE JOINT

McLean's Cave population of *B. melones* has an N on the order of 100 to 1000 and that the McLean's Cave population of *B. grahami* has an N of 1000 to 10,000. These guesses may still apply even after the ecological trauma caused by the transplant. It would be futile to try and refine these guesses here as behavioral differences between the two species could account for much of the difference in their apparent population sizes.

Atmospheric Conditions in McLean's Cave

Dry and wet bulb temperatures were taken in the cave on three days and outside on 11 days during the project (Table 3). Except for May temperatures at the mine, all temperatures were taken with an electronic thermometer (IMC Instruments Inc., model 2100) of 0.1°F precision. Air temperatures in the cave in December and January averaged 57.3°F with a range of 56.4° in the main level to 60.0° in the third (topmost) level. Relative humidities ranged from 82-97%. Conditions in the cave were generally dry and dusty until January when considerable dripping began. Afterwards, the atmosphere was probably saturated in most places except the Entrance Room.

Survey of the Transplant Mine

Although a survey of the mine was not stipulated in the contract, the author judged that an accurate map was needed to document the locations of the transplant sites, to locate a point on the surface directly above the solution dome (to be discussed later) and to accurately locate all parts of the mine in relation to government property lines. Elliott, Grubbs and Winterath surveyed the Transplant Mine on 14 and 20 December 1977 (see map, Fig. 1). Our survey of the mine was tied-in to station "K7" of a nearby government transect. The author hopes that the Transplant Mine map provided in this report will be of use to future researchers and to government planners who may need the information to set aside a natural area around the entire mine to protect it. It is unfortunate that a highly accurate transit survey of the mine could not be made before this project. Such a survey would have been of great value in future studies of the mine. A transit survey now would possibly damage the transplant by accidental trampling of specimens on the transplant sites or in the main tunnel.

The Transplant Mine has a true horizontal length of 513 ft and a vertical relief of about 25 ft. The mine slopes upward slightly from the entrance and seepage water runs along the floor toward the entrance where it pools and exits through a natural joint in the west wall. Apparently most of the mine was excavated as a quartz-gold mine in the 1920's, according to a personal communication from Mr. Al Ponce of Sonora, California, whose boyhood home was in Fox Gulch near the mine. The initials "R.K." are engraved on the wall in two places near T3 (see map), along with the dates 1925 and 1926. R.K.

probably is Robert N. Konrad, who still lives in Sonora, California. In the 50-55 years of the mine's existence there has been considerable calcite deposition such that parts of the mine resemble a cave. Ore cart rails are still in place but are encrusted with flowstone throughout the mine. The floor of the main tunnel has accumulated several inches of flowstone. The area from T3 to T2 is especially well decorated. Many pisolites (cave pearls) are nested in floor pockets in several places. Small rimstone dams (gours) of translucent calcite have formed along the wall in several places. The walls and ceiling are decorated with short tubular stalactites and thin draperies. Since it seems possible to obtain an accurate date on the mine, these deposits could be of research value to speleological mineralogists interested in calcite deposition rates.

The mine tunnel intersects what appears to be a natural solution dome, the highest point in the mine. A proposed entrance shaft into this dome will be discussed later.

Atmospheric Conditions in Transplant Mine

Temperatures and relative humidities for the mine are summarized in Table 4. Dry bulb air temperatures at the three transplant sites averaged 57.7°F at T1, 58.6° at T2 and 58.6° at T3. T1 ranged from 57.2° -58.3°, T2 from 57.2°-59.1° and T3 from 58.1°-59.2°. These temperatures closely match those of McLean's Cave (average = 57.3°). The mine has about the

Site	Date	Dry, °F	Wet, °F	% Rel. Hum.
outside air	12-14-77	53.3	48.8	75
air, outer gate	"	54.9	51.5	80
air, inner gate	"	54.5	52.1	86
air 1' up, 33' from gate	"	52.7	51.0	90
air 1" up, 109' from gate	"	55.8	52.2	71
air 1" up, entrance of 1st side tunnel	"	57.0	52.4	70
air 2" up, T1	"	57.2	56.1	90
air, top of solution dome	"	58.4	57.3	95
air 2" up, 2nd side tunnel	"	57.6	55.0	87
wood & soil, 2nd side tunnel	"	57.7		
soil, T1	"	56.2		
air 4" up, between T1 and T3	"	57.0	55.9	95
air 1' up, T3	"	58.1	57.8	99
air, end of 4th side tunnel	12-20-77	58.7	58.8	100
air, T2	"	59.1	58.8	99
outside air	1-10-78	54.6	48.2	62
outside soil	"	48.2		
air, T2	2-2-78	59.1	59.4	100
air, T2	2-27-78	59.1	59.3	100
air, T3	"	59.2	59.2	100
air, T1	"	58.3	58.4	100
air, T1	5-13-78	57.7	59.0	100
air, T2	"	57.2	59.0	100
air, T3	"	58.6	60.0	100
air, end of 4th side tunnel	"	59.0	59.0	100
air, end of 4th side tunnel	5-14-78	59.0		
pool	"	58.5		

Table 4. Temperatures and relative humidities for Transplant Mine and vicinity.

same spatial temperature variation as the cave. Temporal variation in temperature in the mine is probably less than in the cave because of the relatively small ratio of volume to linear extent and the somewhat "sealed" or insulated nature of the mine (no side passages leading to the surface). The transplant sites probably enjoy a higher year-round humidity than do many places in the cave. If anything, the mine may be too wet when compared to the cave. There are few dry refugia for the fauna to take shelter in when water is flowing in the mine.

Preliminary Census at T1

A mark-recapture census of adult Banksula at T1 was performed before transplanting began. Juveniles were not marked because of their delicate nature. However, 10 juveniles were collected and released on 20 December 1977, and 12 juveniles were observed on 23 December. Other fauna observed in the mine at this time were Brackenridgia heroldi and Paeromopus sp.

The adult harvestmen were hand collected and marked with yellow tempera paint on 20 December and recaptured on 23 December. Results of the census are summarized in Table 2. Because of the low numbers involved, $\hat{N}$ for B. melones is 6 whereas 7 individuals were actually taken in the second census. This is simply an artifact of computation. The upper limit of the 95% confidence limits is 10, still not an encouraging number in view of the fact that Briggs (1975) transplanted 22 adult B. melones. However, our census was limited to the approximately 30 ft^2 of T1. The harvestmen may have wandered to other points in the mine. In fact, we found one B. melones adult at the entrance of the future T3 site on 20 December 1977. It was marked but not included in the calculation (had it been included, $\hat{N}$ would still only be 7). The same difficulty holds true for B. grahami, whose $\hat{N} = 11$ and whose upper limit is 14 (compare to 17 transplanted by Briggs). Such numbers only allow the speculation that the harvestmen had experienced some mortality since 1975 or had dispersed through the mine. Briggs transplanted 5 juveniles but we found 12. This suggests that the harvestmen are reproducing in the mine, but I should emphasize that the 7 excess juveniles could have been unknowingly transported to the mine, as eggs perhaps, by Briggs in soil or roots. Since the tiny juveniles are indeterminable as to species, we cannot know if one or both species of Banksula would be reproducing in the mine anyway. All that can be said is that at least 32% of adult B. melones and 65% of adult B. grahami survived in the mine from 1975 to 1977.

Transplant Work

The T1 site (209 ft from the entrance) was stocked with new transplants from 3-8 January 1978. Table 5 summarizes the data for T1. Specimens were taken by hand and from pit traps, placed in vials with cushioning material, which were then placed in vacuum bottles, which were placed in insulated metal chests, and transferred to the mine. The vials were not used for some of the more robust specimens, which were placed directly into the vacuum bottles. The move generally took 1 to 1½ hours from exiting the cave to entering the mine. Specimens were identified and tallied as they were placed on the site. The same procedure was used for T2 and T3. A total of 392 live individuals of at least 18 species were moved to T1.

By early January the flooding problem in the mine was quite apparent. Selection of the new transplant sites was limited to areas out of the water flow of the main tunnel. T2 and T3 were judged to be the best sites. The side tunnel just to the NE of T1 perhaps would be suitable. The first and last side tunnels are unsuitable because of local ponding.

Mine tailings were transported from just outside the mine to the end, 401 ft from the entrance, to build up the floor for T2. the rocks were placed to keep the colony out of the water and to provide hiding places for the highly secretive harvestmen and other species. A total of 2876 lb of rocks were placed on T2, which covers about 70 ft^2. Over a period of several days we covered this site with 636 lb of soil from the Entrance Room of McLean's Cave. This soil occurs throughout the lower and main levels of the cave and it contains tiny mites, probably Oribatei, and probably many other microarthropods. Soil was carried in insulated chests to minimize temperature changes. To this were added 175 lb of wet, rotting wood from the area around the mine. This served as a substrate for fungi, which would develop naturally, and thus as a food source for fungivores and detritivores, a necessary part of most cave ecosystems. Table 6 summarizes the transplant data for T2, the transplant period for which extended from 15 January to 2 February 1978. A total of 448 individuals of at least 21 species were moved to T2.

Before transplants were made to T3, it also was built up with mine tailings and loose rocks from the walls and floor of the mine. A total of 2821 lb of rocks were moved onto T3, which is 276 ft from the entrance. This site covers about 90 ft^2. We had observed that T2 had become quite mucky after the dry soil had been placed over its entire surface. T3 was covered along the left half only with 396 lb of cave soil. This left a corridor of "clean" rocks on the right side, and thus an easier route of infiltration for arthropods. To this were added 175 lb of rotting wood from the mine area. Table 7 summarizes the data for T3, and for all the sites. A total of 515 individuals of at least 24 species were moved to T3. A grand total of 1355 individuals of at least 27 species were moved to all three sites.

In all, 26 adult *B. melones*, 99 adult *B. grahami* and

TAXON	Jan 3	4	7	8									TOTAL	
CLASS ARACHNIDA														
ORDER PHALANGIDA														
Banksula melones	1?			1									2	
Banksula grahami			18	3									21	
Banksula juveniles			4	2									6	
ORDER ARANEAE														
Liocranoides n.sp.	3	1		1									5	
Telema n.sp., imm.				2									2	
Telema n.sp		4		3?									7	
ORDER PSEUDOSCORPIONIDA														
Microcreagris grahami														
Neochthonius troglodytes			1										1	
Larca chamberlini?				1?									1?	
sp.				1									1	
ORDER ACARIDA														
sp. A		1											1	
sp. B	2			1									3	
sp. C														
sp. D														
sp. E														
sp. F	4												4	
CLASS CHILOPODA														
sp.														
CLASS DIPLOPODA														
ORDER SPIROBOLIDA														
Paeromopus sp.	13	7	1	3									24	
ORDER POLYDESMIDA														
sp.														
CLASS SYMPHYLA														
Scutigerella sp.?														
CLASS INSECTA														
ORDER DIPLURA														
Japygidae														
ORDER COLLEMBOLA														
several species?	32	77	26	4									139	
ORDER PSOCOPTERA														
sp.	70	31	10	2									113	
ORDER COLEOPTERA														
Tenebrionidae, adults	1			1									2	
" larvae				1									1	
Ptomaphagus nevadicus, adults	22	21		5									48	
Ptomaphagus nevadicus, larvae														
Carabidae, adults			1										1	
" larvae														
ORDER HOMOPTERA														
adults														
nymphs				1									1	
ORDER DIPTERA														
several species?	1	8											9	
CLASS CRUSTACEA														
ORDER ISOPODA														
Brackenridgia heroldi														

Table 5. Data for T1 (original transplant site).

TAXON	Jan 15	17	21	22	26	27	28	31	Feb 2				TOTAL	
CLASS ARACHNIDA														
ORDER PHALANGIDA														
Banksula melones	1	2	1		1	2	5		2				14	
Banksula grahami	4	3	1	3	5	3	3	2	6				30	
Banksula juveniles	2				1		2						5	
ORDER ARANEAE														
Liocranoides n.sp.		2	3	2	2			1	2				12	
Telema n.sp., imm.	1	2	3	2	1	3	1	2					15	
Telema n.sp		2	1	4	6	4	17	13	4				51	
ORDER PSEUDOSCORPIONIDA														
Microcreagris grahami			1										1	
Neochthonius troglodytes				1	1	1		1	2				6	
Larca chamberlini?				1									1	
sp.														
ORDER ACARIDA														
sp. A	1	1	1	2									5	
sp. B				1					1				2	
sp. C			1										1	
sp. D														
sp. E														
sp. F														
CLASS CHILOPODA														
sp.														
CLASS DIPLOPODA														
ORDER SPIROBOLIDA														
Paeromopus sp.	5	3	6	4	5		2	2	5				32	
ORDER POLYDESMIDA														
sp.														
CLASS SYMPHYLA														
Scutigerella sp.?		2					2		3				7	
CLASS INSECTA														
ORDER DIPLURA									1				1	
Japygidae														
ORDER COLLEMBOLA														
several species?			20	27	20	1	2		9				79	
ORDER PSOCOPTERA														
sp.		5	44	3	26		2		38				118	
ORDER COLEOPTERA														
Tenebrionidae, adults			2						2				4	
" larvae			2										2	
Ptomaphagus nevadicus, adults			16		11				12				39	
Ptomaphagus nevadicus, larvae			1		4				1				6	
Carabidae, adults		1		2	1	2	2		1				9	
" larvae									1				1	
ORDER HOMOPTERA														
adults														
nymphs			1										1	
ORDER DIPTERA														
several species?			1										1	
CLASS CRUSTACEA														
ORDER ISOPODA														
Brackenridgia heroldi						3	1		1				5	

Table 6. Data for T2.

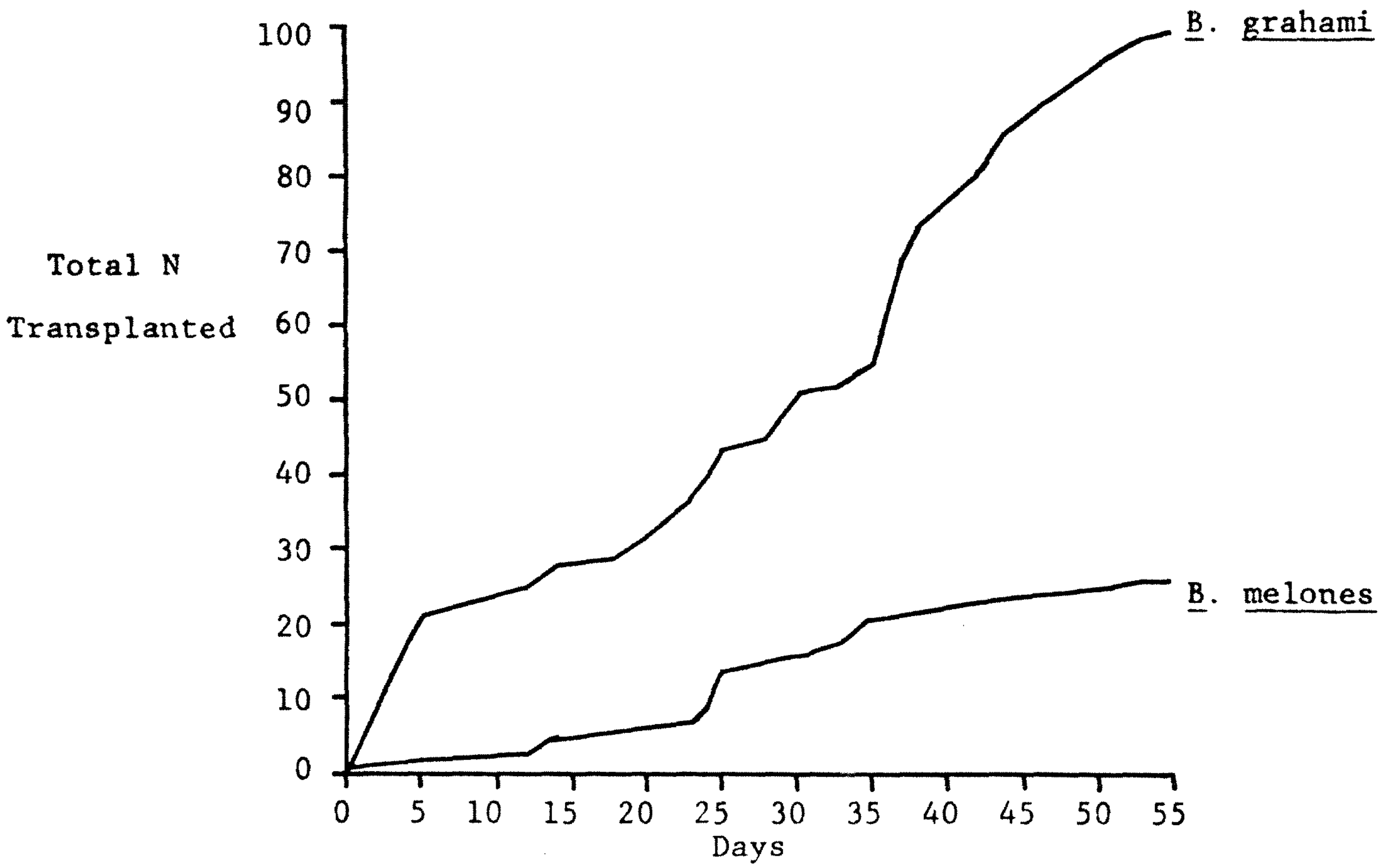
TAXON	Feb 5	7	9	10	14	15	16	18	22	23	25	27	TOTAL	GRAND TOTAL
CLASS ARACHNIDA														
ORDER PHALANGIDA														
Banksula melones	2		3		2		1			1	1		10	26
Banksula grahami	1	3	14	4	7	2	4	3		7	2	1	48	99
Banksula juveniles	1		3	4	1	2		2		2			15	26
ORDER ARANEAE														
Liocranoides n.sp.	1	2	1	2	2		3	1	1		1	1	15	32
Telema n.sp., imm.	4	8	1	1	3		3	2	1	4		1	28	45
Telema n.sp	11	8	11	2	7	2	2	2	1	10	1	2	59	117
ORDER PSEUDOSCORPIONIDA														
Microcreagris grahami			1				1	1		1	2		6	7
Neochthonius troglodytes				1		1	4			2			8	15
Larca chamberlini?														2
sp.	1						1						2	3
ORDER ACARIDA														
sp. A	1							1					2	8
sp. B					1			1					2	7
sp. C					1								1	2
sp. D							1						1	1
sp. E			1										1	1
sp. F														4
CLASS CHILOPODA														
sp.									1				1	1
CLASS DIPLOPODA														
ORDER SPIROBOLIDA														
Paeromopus sp.	4		1		1	1	2						9	65
ORDER POLYDESMIDA														
sp.				1	2							3	6	6
CLASS SYMPHYLA														
Scutigerella sp.?	3	1			1		2		1				8	15
CLASS INSECTA														
ORDER DIPLURA														
Japygidae		1					2						3	4
ORDER COLLEMBOLA														
several species?	9		7		1	15	21	6	3	3	15	16	96	314
ORDER PSOCOPTERA														
sp.	30		6		23	5	9	7	2	8	5	26	121	352
ORDER COLEOPTERA														
Tenebrionidae, adults														6
" larvae														3
Ptomaphagus nevadicus, adults	11		1		6	1	13	1			3	9	45	132
Ptomaphagus nevadicus, larvae							1				2		3	9
Carabidae, adults	3		1			2	5	1	1	1			14	24
" larvae														1
ORDER HOMOPTERA														
adults		1		1			1					1	4	4
nymphs										1			1	3
ORDER DIPTERA														
several species?												1	1	11
CLASS CRUSTACEA														
ORDER ISOPODA														
Brackenridgia heroldi			1	1	2					1			5	10

Table 7. Data for T3 and Grand Total.

26 _Banksula_ juveniles were transplanted alive to the mine (151 total). During the transplant period 2 adults and 1 juvenile were found dead in pit traps, 3 adults and 2 juveniles died en route to the mine and 4 adults and 1 juvenile were not accounted for during the tally at the mine. These last 5 specimens may have been lost in cushioning material provided for the specimens en route.

A total of about 300 man hours were spent in actually checking pit traps and hand collecting from 2 January to 28 February 1978. Twenty-eight days were spent in this activity at the cave. Transplants to the mine occurred on 25 days. On t`e average, about 2 man hours were required to locate each harvestman in the cave.

By the end of the project the numbers of harvestmen captured in the cave per unit time appeared to decline (fig. 2). Our proficiency at finding specimens increased with time and this may have resulted in the upward inflections seen in fig. 2. The curve for _B_. _melones_ becomes nearly asymptotic earlier on than the one for _B_. _grahami_. Although neither species was driven to extinction by our work in the cave, by the end of the project we had gained the impression that both species were immigrating into the accessible parts of the cave in a random fashion and at a very low rate. It would be interesting to inspect the cave now and see if the numbers of both _Banksula_ species have increased again. An attempt to do this



B. grahami
B. melones
Total N
Transplanted
100
90
80
70
60
50
40
30
20
10
0
0 5 10 15 20 25 30 35 40 45 50 55
Days

Fig. 2

was made on 14 May 1978, but the South Fork was in high flood, preventing access to the cave.

Observations on *Banksula* Behavior

Practically nothing is known of the ecology and behavior of *Banksula*. During the transplant period we performed six simple feeding experiments at the mine to determine food preferences of *B. melones* and *B. grahami*. These experiments were too limited to allow any certain conclusions regarding their natural food items, but the experiments do confirm Brigg's assertion (pers. comm.) that the harvestmen are predatory. All *Banksula* species possess raptorial pedipalps. Given their small body size, about 2.2 mm body length for *B. melones* and 1.6 mm for *B. grahami* (Briggs, 1974), it seems reasonable to guess that they are predators of microarthropods such as one typically finds in California caves: Collembola, Psocoptera, Acarida, etc.

Results of the feeding experiments are given in Table 8. The specimens were each isolated in a 1 oz, capped jar with 3 food items. Six harvestmen were used for the six experiments. At no time were any of the harvestmen actually observed eating the insects, nor did we ever observe them feeding in the cave.

Hand collecting both *Banksula* species was usually quite easy once they were located. The harvestmen move rather slowly in comparison to say, spiders of the same size. We formed the impression that *B. melones*, the larger species, can move

EXPMT.	DATE	SPECIES	FOOD ITEMS	HRS.
#1	2-9-78 2-10-78	1 B. melones "	3 live Psocoptera 1 dead (mashed), 2 alive	0 24.1
#2	2-15-78 2-16-78	1 B. melones "	3 live Psocoptera "	0 24.2
#3	2-23-78 2-25-78	1 B. melones "	3 live Collembola 2 consumed, 1 alive	0 48.3
#4	2-9-78 2-10-78	1 B. grahami "	3 live Psocoptera 2 dead (mashed), 1 alive	0 24.1
#5	2-15-78 2-16-78	1 B. grahami "	3 live Psocoptera "	0 24.2
#6	2-23-78 2-25-78	1 B. grahami "	3 live Collembola all 3 consumed	0 48.1

Table 8. Feeding experiments with *Banksula melones* and *B. grahami* at the Transplant Mine.

considerably faster than B. grahami. This may have contributed to the great disparity in collecting success between the two species. Both species often assume a catatonic posture when touched or disturbed: the legs are appressed to the body and the animal "freezes". This condition may last up to several minutes.

Collecting activities in McLean's Cave usually were concentrated in the second primary chamber, 80-140 ft from the entrance, on the main (first) level. More harvestmen were collected here than in any other area. They were also common in a descending side tunnel on the east side of this room, beginning 122 ft from the entrance. This side tunnel may have yielded more B. melones than other areas, but this is a subjective impression since most harvestmen were not identified to species until we were able to place them in a contiguous group at the mine. The "Register Room", 66 ft from the entrance, was apparently a good source of harvestmen for Briggs in 1975 (pers. comm.), but we took relatively few specimens there. The second level above the second primary room is formed on a false floor of old flowstone. Pit traps were checked there daily and considerable searching was done for harvestmen, but few specimens were taken. The third level above this is a combination of false floors and bedrock passages. No traps were placed here, but occasional visits did yield a few specimens, including a B. melones on at least one occasion. The dusty, lower level breakdown passages beneath the entrance yielded many specimens despite the fact that this area was usually visited for briefer periods because of the nearly intolerable dust conditions which required us to wear dust masks.

Follow-up Inspections

A follow-up inspection at the Transplant Mine was made on 13-14 May 1978 by Elliott, Winterath and Cowan. Conditions seemed much the same as when last seen on 27 February. Water was still flowing along the floor and the atmosphere was saturated at all three transplant sites (Table 4). At least three species of fungus were growing on the rotten wood (samples were collected in sterile containers for culturing and identification). About 24 man hours were spent at all three sites collecting harvestmen and observing other fauna. No *B. melones* were observed on either date. A total of 26 *B. grahami* were marked with tempera paint. Of these, 3 at T1 were included which still exhibited faint marks from the 23 December 1977 census. The recapture on 14 May yielded a total of 21 individuals, 9 of which were marked. Population estimates per site and for the entire mine are given in Table 2. A total of 7 juvenile *Banksula* were observed in the mine. A great effort was made to search out as many harvestmen as possible. This involved carefully moving wood and rocks down to several inches depth. Most of the harvestmen were under large rocks.

Other fauna observed in the mine were as follows:

T1 -- 13 Brackenridgia heroldi, 3 Collembola, 1 small Paeromopus, flies and fly larvae, several Telema n.sp., 3 Ptomaphagus nevadicus and at least 3 juvenile Banksula.

T2 -- 1 small, pale centipede, Collembola, Psocoptera, flies and fly larvae, 1 immature Telema n.sp., mites, 1 Liocranoides n.sp., several Ptomaphagus nevadicus, several Brackenridgia heroldi, a salticid spider and at least 2 juvenile Banksula.

T3 -- 1 male, 2 female and 1 immature Liocranoides n.sp., 4 Collembola, at least 4 adult Ptomaphagus nevadicus and 1 larva, 4 flies, 2 Telema n.sp., 2 termites and 2 juvenile Banksula.

Two other brief inspections of the mine were made at my request on 15 July and 5 August 1978 by Dave Cowan and other members of the Mother Lode Grotto (the Sacramento chapter of the National Speleological Society). On 15 July the mine was still damp although no water was flowing. The pool near the solution dome, which was 4 ft deep in January and February, was down about 1 ft. All transplant sites were very damp. Cowan observed a marked Banksula sp. and an isopod at T1. Fungus was still growing on rotten wood. On 5 August the following were observed: 1 adult Banksula sp. at T1, 1 juvenile Banksula on rotten wood in main tunnel between T1 and T3, and a very large adult *Banksula* sp. (probably *B. melones*) in main tunnel about 15 ft toward the entrance from T1.

Investigations of Other Caves

Although the Scope of Work for the contract called for collecting trips to "approximately 15" caves in the project area, only 7 could be visited because of time lost for the following reasons (see section on Practical Problems, pp. 14-17): difficulties due to weather (3½ days), surveying the mine (2 days), dealing with drainage problems in the mine (2 days), building trails (3 days), preparing the transplant sites with large amounts of rock to prevent drowning of the transplants (3 days) and the inordinate amounts of time needed for the attempted census in McLean's Cave and the search for harvestmen. Permission could not be obtained to enter McNammee's Cave and Heater Cave, which are on private land. One day each was spent biologically investigating the following sites:

1. Moaning Cave, Calaveras Co., 4 mi E of Angel's Camp, a commercial cave, 6 December 1977.

2. Crystal Palace Cave, Tuolumne Co., 3.1 mi N of Columbia, 21 December 1977.

3. Windeler Cave, Tuolumne Co., 4.5 mi NE of Columbia, 14 January 1978 (visited with members of the Diablo Grotto, N.S.S., which holds a claim on the cave for its protection).

4. Pinnacle Point Cave, Tuolumne Co., 7 mi NNE of Columbia, 20 January 1978.

5. Scorpion Cave, Tuolumne Co., 2.9 mi NNW of Columbia, 1 February 1978 (a new cave discovered by Winterath during the

project and about 80 ft above McLean's Cave).

6. Coral Cave (Cave 025, McEachern and Grady, 1978), Calaveras Co., 7 mi ENE of Angel's Camp, 24 February 1978.

7. Snell Cave (Cave 077, McEachern and Grady, 1978), Tuolumne Co., 2.3 mi NNE of Columbia, 26 February 1978.

8. Tailingsoutside the Transplant Mine, 10 January 1978.

These particular caves were visited for one or more of the following reasons: the cave had not been biologically investigated before (or only poorly), the cave had a reportedly diverse fauna, unidentified harvestmen had been seen in the cave, the cave was above the future lake level (except Coral Cave). A collection was made from the mine tailings since some of the species there may have been accidentally transported into the mine with rocks for the transplant sites.

Some of the species collected in these caves have not yet been identified or described. Such matters may require months or years before the requisite specimens are accumulated for accurate identifications. For example, many of the spiders collected were immatures or females (males are required for most spider identifications). No examples of B. melones were discovered in any of the 7 caves, although new localities for B. grahami were found (Crystal Palace and Snell Cave), a new locality for a Banksula n.sp. was found (Coral Cave) and additional specimens for another Banksula n.sp. was found (Pinnacle Point Cave). The Annotated Systematic List summarizes the information on these caves. Temperatures and relative humidities for three of the caves are detailed in Table 9.

Site	Date	Dry, °F	Wet, °F	% Rel. Hum.
MOANING CAVE:				
50' below Lake Rm. (mud)	12-6-77	61.4		
S. wall Mud Flat Rm. (mud)	"	61.2		
N. wall Mud Flat Rm. (mud)	"	61.3		
halfway up stairs (mud)	"	61.4		
Bone Room (mud)	"	61.3		
Mud Flat Rm. (mud)	"	61.3		
halfway from Bone Rm. to Tourist Rm. (mud)	"	61.2-61.3		
under Hanging Wall	"	60.3		
CRYSTAL PALACE CAVE:				
air, lower level dry stream	12-21-77	50.0	49.5	92
"amphipod stream"	"		55.6	
"amphipod stream" air 3' up	"	56.0	56.0	100
air in 5" deep pocket above Register Rm.	"	59.9		
air 3' below ceiling, Register Rm.	"	56.9	54.6	87
air 10' from register	"	54.4	53.5	87
WINDELER CAVE:				
bottom of ladder at dig, air	1-14-78	52.4	51.8	97
air, Discovery Rm.	"	52.1		

Table 9. Temperatures and relative humidities for Moaning Cave, Crystal Palace Cave and Windeler Cave.

Annotated Systematic List

The following ecological designations are used: TB -- troglobite, an obligate cave-dwelling species usually exhibiting some degree of eye reduction and depigmentation; TP -- troglophile, a species which is often found in caves or similar habitats and which may exhibit some morphological adaptations to subterranean life; TX -- trogloxene, a species which frequents caves, especially entrance areas; EP -- epigean, a species not normally found in caves. Many of the following records are drawn from a checklist by Andy Grubbs which was assembled after the 1977 cave inventory project.

Phylum Mollusca (determined by B. Roth)
- Class Gastropoda (snails)
  - Order Pulmonata
    - Family Helminthoglyptidae
      - Monadenia mormonum mormonum (Pfeiffer), TP? McLean's Cave. This species has been found in at least 13 other caves in the project area.

Phylum Arthropoda
- Class Arachnida
  - Order Araneae (determined by W.J. Gertsch)
    - Suborder Orthognatha (tarantulas)
      - Family Ctenizidae
        - Aptostichus sp., poss. TX. Crystal Palace Cave. This or a similar species of trap-door spider is known from four caves in Calaveras Co.
    - Suborder Labidognatha (true spiders)
      - Family Agelenidae
        - Blabomma n.sp. A, TB. Snell Cave, Windeler Cave. Only immature individuals were collected. This species may eventually be placed in one of two other blind species known from Calaveras Co., or it may be distinct.
        - Blabomma n.sp. B, TP (6 eyes). Crystal Palace Cave. Known by one female only.
        - Blabomma sp., TP (6 eyes). Moaning Cave. Seven immature specimens were collected. This species occurs in two other Calaveras Co. caves. The genus contains many undescribed species.

Cybaeus sp., EP. Snell Cave, Transplant Mine tailings.

Family Anapidae

Chasmocephalon shantzi Gertsch, TX. Transplant Mine tailings. This species is also known from seven caves in Calaveras Co.

Family Clubionidae

Liocranoides n.sp., TP. McLean's Cave, Coral Cave, Crystal Palace Cave, Windeler Cave, Pinnacle Point Cave, Scorpion Cave. This is the rather large, striking spider frequently seen on walls in many caves of the area. It is also found in deep rock crevices along streams.

Scotinella californica (Chamberlin & Gertsch), EP. Transplant Mine tailings.

Family Gnaphosidae

Drassyllus sp., EP. Transplant Mine tailings.

Family Leptonetidae

Archoleptoneta schusteri Gertsch, TP? Moaning Cave, Coral Cave, Crystal Palace Cave.

Family Nesticidae

Nesticus silvestrii Fage, EP. Windeler Cave, Snell Cave.

Family Pholcidae

Physocyclus californicus Chamberlin & Gertsch, EP. Scorpion Cave.

Psilochorus n.sp., TX or TP? McLean's Cave, Coral Cave, Scorpion Cave, Transplant Mine tailings. This species is known from six other Calaveras Co. caves.

Family Telemidae

Telema gracilis (Marx), TP. Pinnacle Point Cave. This species is known from eight Calaveras Co. caves.

Telema n.sp., TB. McLean's Cave, Crystal Palace Cave. This species has evanescent (reduced and depigmented) eyes. It is also known from Shaw's Cave, Calaveras Co., and Crystal Tuolumne Cave. There could be more than one species. The entire family Telemidae will require revision to solve this problem.

Telema sp., TP? Transplant Mine tailings.

Family Theridiidae

Thymoites camano (Levi), EP. Crystal Palace Cave.

Family Thomisidae

Apollophanes texanus Banks, EP. Transplant Mine tailings.

Family ?

Mallos sp., EP? Snell Cave.

Spirembolus sp., EP. Transplant Mine tailings.

Order Phalangida (harvestmen, determined by T.S. Briggs)

Family Nemastomatidae

Hesperonemastoma modestum, EP. Transplant Mine tailings.

Ortholasma rugosa Banks, EP. Moaning Cave, McLean's Cave.

Family Phalangiidae

Liobunum sp.?, EP. Transplant Mine tailings.
Protolophus sp.?, EP. Transplant Mine tailings.

Family Phalangodidae

Banksula n.sp. A, TB. Coral Cave. This species is closely related to *B. melones*. Although Coral Cave will be flooded, this new species is known from four other Calaveras Co. caves which will not be flooded.

Banksula n.sp. B, TB. Pinnacle Point Cave. This species is closely related to *B. grahami*.

Banksula grahami Briggs, TB. McLean's Cave, Moaning Cave, Crystal Palace Cave, Snell Cave. This species is now known from three caves in Calaveras Co. and three caves in Tuolumne Co.

Banksula melones Briggs, TB. McLean's Cave, McNamee's Cave. No new localities for this species were discovered. Reports of a harvestman in Windeler Cave prompted us to collect there, but none were found.

Sitalcina sierra Briggs & Hom, TP. Transplant Mine tailings. This species is similar to *Banksula* spp. and is known from caves in Calaveras and Amador Counties, and from surface sites under rocks near Columbia.

Order Scorpionida (scorpions, determined by O. Francke)

Family Vaejovidae

Vaejovis gertschi striatus Hjelle, EP. Scorpion Cave. One specimen of this small, pale, mottled species was taken in the entrance room.

Order Pseudoscorpionida (pseudoscorpions, determined by W.B. Muchmore)

Family Chthoniidae

Apochthonius sp., EP. Transplant mine tailings.

Mundochthonius sp., EP. Windeler Cave, Transplant Mine tailings.

Neochthonius troglodytes Muchmore, TB. McLean's Cave, Crystal Palace Cave, Windeler Cave, Pinnacle Point Cave. The last three records are new.

Family Neobisiidae

Microcreagris grahami Muchmore, TB. McLean's Cave, Moaning Cave, Crystal Palace Cave, Scorpion Cave. This extremely attenuated, large species is now known from ten caves in Calaveras and Tuolumne Counties. The last two records are new.

Family Garypidae

Larca chamberlini Benedict & Malcolm, TP or TX. McLean's Cave (1 male), Pinnacle Point Cave.

Parbisium sp., EP. Transplant Mine tailings.

Order Acarida (mites)

Unidentified material. McLean's Cave. About five species are represented.

Family Oribatidae?

Unidentified material. McLean's Cave.

Class Crustacea

Order Amphipoda (amphipods, determined by J.R. Holsinger)

Family Gammaridae

Stygobromus harai Holsinger, TB. Windeler Cave, Pinnacle Point Cave.

Order Isopoda (isopods, determined by G. Schultz, W. Elliott)

Family Trichoniscidae

Brackenridgia heroldi (Arcangeli), TP. McLean's Cave, Moaning Cave, Crystal Palace Cave, Windeler Cave, Scorpion Cave. This species, though blind and depigmented, is known from the California sea shore at San Mateo to 4000 ft in Central California. It occurs in leaf litter and other organic debris.

Class Chilopoda (centipedes, determined by A.A. Weaver)

Order Geophilomorpha

Family Geophilidae

Arctogeophilus sp., EP. Pinnacle Point Cave.

Arenophilus sp., EP. McLean's Cave.

Unidentified material. McLean's Cave.

Class Diplopoda (millipedes, determined by W. Shear,W. Elliott)

Order Polydesmida

Family Trichopolydesmidae

Unidentified material, perhaps *Bidentogon* sp., TP or TB. McLean's Cave, Windeler Cave, Pinnacle Point Cave.

Unidentified material. McLean's Cave, Moaning Cave, Crystal Palace Cave.

Order Spirobolida

Family Paeromopidae

Paeromopus sp., TX? McLean's Cave, Crystal Palace Cave, Windeler Cave, Transplant Mine tailings. This large species is common in most caves in the area, but does not seem especially cave adapted. Adults reach several inches in length.

Order Platydesmida

Family Platydesmidae

Undetermined material, EP. McLean's Cave. One specimen was taken in the cave and appears to be the same as a species taken in the South Fork canyon.

Class Symphyla (symphylans)

Unidentified material, perhaps *Scutigerella* sp., EP. McLean's Cave, Transplant Mine tailings.

Class Insecta

Order Diplura (diplurans)

Family Japygidae

Unidentified material. McLean's Cave.

Order Collembola (springtails, determined by K. Christiansen)

Family Entomobryidae

Entomobryoides sp., EP? McLean's Cave

Oncopodura n.sp., TB. McLean's Cave. This species will soon be described by Christiansen and is unique to McLean's Cave at this time. It is unlike any other species.

Unidentified material. McLean's Cave.

Order Coleoptera (beetles, determined by S.B. Peck)
Family Carabidae
Undetermined material. McLean's Cave.
Family Leiodidae
Ptomaphagus nevadicus Horn. McLean's Cave.
Family Tenebrionidae
Undetermined material, perhaps *Eleodes* sp. McLean's Cave.
Order Homoptera
Superfamily Fulgoroidea
Undetermined material. McLean's Cave, Windeler Cave. This species is possibly troglobitic. Troglobitic planthoppers are exceedingly rare, being known from Hawaii and Mexico. Nymphs are pale and are found on roots in the cave. An adult taken in McLean's Cave exhibited somewhat dipigmented (red) eyes. These will be studied by R. Fennah of the British Museum.
Order Diptera (flies)
Undetermined material. McLean's Cave. Several species are probably involved.
Phylum Chordata
Class Amphibia
Order Urodela
Family Salamandridae
Taricha torosa (Rathke), California Newt, EP. McLean's Cave. One emaciated individual was found dead in a pit trap in the lower level beneath the entrance. Tentative identification by A.G. Grubbs.
Class Mammalia
Order Rodentia
Family Muridae (determined by R. Martin)
Rattus norvegicus Linnaeus, Norway Rat, EP. McLean's Cave. One was trapped in the second room 108 ft from the entrance. Two were trapped in the lower level beneath the entrance. All were in total darkness.

In addition to the above, at least three species of Fungi Imperfecti were collected and are being cultured and studied by T. Sayther, Austin, Texas. No identifications are available as yet.

DISCUSSION

Several points should be made regarding the projected chances of success or failure of the transplant. These points range from the practical to the theoretical, with some falling in between. I shall treat these points in two broad categories: encouraging and discouraging. Some points could be either, depending on one's viewpoint. Many of the points are highly interrelated.

Encouraging Points

1. The atmosphere in the Transplant Mine, or at least that part of it containing the transplants, was found to be very stable, temporally and spatially, in temperature and relative humidity.

2. More juvenile Banksula were found in the mine in December 1977 than had been knowingly transplanted in 1975.

3. Banksula melones did not become extinct in the mine during the 25 months from Briggs' transplant to the beginning of this project.

4. Some of the other species transplanted by Briggs were observed at the beginning of this project.

5. Larger numbers of individuals and more species were transplanted to the mine during this project.

6. A theoretically good food source (wood, fungus, microarthropods) was established in the mine by this project.

Discouraging Points

1. If anything, the Transplant Mine is too wet. An attempt to promote drainage in the mine was only partially successful. The high rates of seepage in the mine cause high

rates of calcite deposition which could eventually cause worse drainage problems and even calcification of materials on the transplant sites themselves.

2. The increased number of juvenile Banksula found in December 1977 could have been due to an unknown number of them being introduced with soil and wood.

3. The survival rate of B. melones in the mine from 1975-1977 seems to be about half that of B. grahami. An alternate possibility is that B. melones has dispersed in the mine and cannot be found readily.

4. Related to point 3, above, is the possibility that B. melones and B. grahami may be competing for habitat and food. In fact, this may be occuring in McLean's Cave itself. Too little is known of the ecology of the two species to speculate much further. Competition studies in biology are exceedingly difficult and time consuming -- large numbers of observations are usually required. There probably is no way of determining if B. melones is being naturally driven to extinction by B. grahami in McLean's Cave now that human activities have so heavily altered that ecosystem. The ecosystem established in the Transplant Mine may be so out of balance that it magnifies competitive interactions.

5. There is no easy way of judging for how long the artificial food source in the mine will be suitable, indeed,

if it be suitable now. Too many factors are involved to predict this.

6. Two possible major components of the McLean's Cave ecosystem are absent in the mine: live tree roots and an entrance and internal topography which tend to funnel detritus and other food materials into the system. The ecosystem in the mine will be dependent on human and animal introduction of food sources for an indefinite period.

7. The entire McLean's Cave ecosystem is poorly known in all its aspects: population sizes, species interactions, habitat requirements, food requirements and the relative importance of each component to the survival of the ecosystem. The survival of this ecosystem as a whole is of major importance to the survival of one possibly endangered species, such as _B. melones_. A species cannot exist in a vacuum. Although species of game animals and otherwildlife have been successfully transplanted to new habitats, this was largely because their biology was well understood and could be carefully managed. Those conditions do not obtain in this transplant.

8. Even if we knew the requirements of _B. melones_, the relative numbers of each species transplanted to the mine are probably all out of proportion compared to the natural ecosystem in McLean's Cave. This is because of the unavoidably haphazard nature of the collecting and trapping program in the cave. We can almost expect that some species

will "bloom" while others become extinct within a relatively short time (a few generations).

9. The small numbers of harvestmen and most other species transplanted will probably lead to considerable inbreeding and a phenomenon known as "genetic drift" (Wilson and Bossert, 1971). The genetic variability of the populations will perhaps be greatly limited, compared to natural populations. Low genetic variability could mean eventual extinction if the populations cannot adapt to changing conditions in the mine, such as species composition of the ecosystem, flooding, reduction of food sources, human and animal intrusions, etc. If B. melones, or any species, survive such conditions for 10 or 100 years and then become extinct anyway, we can hardly be satisfied with the time and effort expended in such a futile undertaking.

10. The Transplant Mine is still quite vulnerable to those who would stake mining claims and attempt to work the mine. Since claims are filed at the Tuolumne Co. courthouse, there still does not seem to be any easy way for government agencies to prevent such activities.

CONCLUSIONS

The points raised in the discussion impel me to conclude that the transplant of Banksula melones to the Transplant Mine is probably a failure. Continued inspections by a qualified biologist will be necessary to confirm this conclusion.

Even if a few _B. melones_ can be found in the mine, severe doubts would remain as to the effectiveness of the transplant. Since the adults probably live for several years, the reproductive success of the populations may not be apparent for many years. Considering the highly experimental nature of this transplant and its unpredictable fate, the Transplant Mine has considerably more putative value as a study site for biologists and mineralogists than as a viable solution to the possibly endangered status of _B. melones_ and other species. I am not aware of any other attempt to artificially establish an entire ecosystem in a nearly empty habitat. Experimental biologists have studied natural succession in habitats that were laid bare by one means or another. However, such experiments usually involve unconstrained immigration and emigration of colonizing species. Here we have a rather closed system that may be of research value since approximate numbers of all intentional colonizers are known.

My conclusions on the investigation of seven other caves in the area are as follows:

1. The search for _B. melones_ in other caves should not be considered complete. A single visit to a cave is usually not enough to discover all that lives there, especially secretive forms such as _Banksula_. This is complicated by seasonal cycles in some species, humidity conditions in the cave at any given time and the limited results one can obtain in just a

few hours of collecting.

2. Other caves along the South Fork of the Stanislaus River should be searched for *B. melones* (and other fauna) because *B. melones* occurs in two caves there and one might suppose that other populations, if they exist, would be nearby. The area has not been well-studied because of time limitations in this project and because the SMU project of 1977 was limited in scope, biologically, and was not required to search all areas.

RECOMMENDATIONS

1. The Transplant Mine should be permanently secured as a potential study site for biologists and mineralogists. The mine entrance should be accurately located by a transit survey and my survey of the mine's interior should be used to preserve a natural area completely surrounding the entire mine.

2. Better drainage should be promoted in the mine. Several solutions are possible, including a deeper trench into the drainage joint near the entrance (along with some trenching in the floor in the first part of the mine), installing a drainage pipe of at least 4 in diameter under the entrance gate (a smaller pipe may fill with calcite too quickly), or excavating the entrance area and installing a newer and larger gate which allows drainage directly. The last alternative is probably the best as it will help stabilize the rubble in the entrance. I would suggest a large diameter concrete or steel tube as the basic gate material. A grating type of steel door should be installed with holes large enough to admit flying bats which could establish colonies in the mine.

3. Continued annual inspections of the mine by a qualified biologist should be made. The following conditions should be met:

a. the investigator should be exceedingly careful in moving about, moving rocks and handling specimens,

b. all parts of the mine should be examined for fauna, not just the transplant sites,

c. a mark-recapture or other suitable census should be performed on the harvestmen and other species if at all possible,

d. other biota should be observed and noted,

e. temperatures and relative humidities should be taken throughout the mine,

f. photographs of the transplant sites should be taken to allow comparison with initial conditions (note that I have made 35 mm color transparencies of most parts of the mine, the transplant sites before and after transplanting, fungus growth, fauna, etc. -- these photographs will be available for a nominal copying cost).

4. Serious consideration should be given to drilling a vertical shaft entrance into the solution dome in the Transplant Mine to allow the natural infiltration of detritus and food, such as in a cave. This would involve drilling through about 109 ft of marble with a shaft diameter of perhaps 1 or 2 ft. The use of explosives should not be allowed if they would in-

troduce dust, fumes and excessive debris into the mine or cause excessive shocks in the mine. The following points should be considered before such an undertaking:

a. the outlook for the long-term success of the transplant, especially regarding B. melones, given the present artificial food source in the mine,

b. possible adverse meteorological effects on the mine. By establishing a vertical shaft, undesirable chimney effects could result in drying, heating and cooling of the mine. There are many speleologists who can calculate such theoretical effects given the dimensions of the mine, present air flow patterns and rates, temperatures, humidities, annual atmospheric cycles, etc. Thus, if the diameter of the shaft could not safely be less than about 1 ft, I would advise against the shaft as it would be relatively ineffective as a food source anyway. If the shaft be favorably indicated by preliminary studies, its efficacy could be enhanced by excavating a small sinkhole-like depression at the top so as to funnel debris downward. Note that a small shaft would become clogged if the sinkhole be too steep-sided. Careful consideration would have to be given to the design of such a system, natural vegetation should be planted in the sinkhole and a fence should enclose it to keep out intruders.

c. Cost considerations for a shaft entrance will no doubt be important, but they should not take precedence if both points 4a and 4b indicate that the shaft would aid the long-term success of the transplant.

5. No more transplants should be made unless this one can be shown to be a success.

6. A more thorough biological study should be made of caves in the general area of Calaveras and Tuolumne Counties, especially caves near the South Fork of the Stanislaus River. Such studies might yield new localities for _B. melones_ and other possibly endangered cave fauna such as _Oncopodura_ n.sp. and the cave-adapted Fulgoroidea in McLean's Cave. Such studies should include more than one visit to each cave, if at all possible, and preferably spaced out through different seasons of the year. Should the Corps of Engineers contract for mitigative archaeological studies on caves in the area (as recommended by McEachern and Grady, 1978), at least one cave biologist should be present at each excavation to collect cave animals as they come to light. Many cave animals, such as _Banksula_, are highly secretive and may only be discovered by the disturbance of floor deposits. This should not be missed.

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