1978

A Study of Symbiosis Involving the Fish-Eating Bat (Myotis vivesi), the Least Petrel (Halocyptera microsoma), the Black Petrel (Oceanodroma melania), and the Lizard (Cnemidophorus tigris)

Joel King
Eastern Illinois University

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(TITLE)

BY

Joel King

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Master of Science

IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY
CHARLESTON, ILLINOIS

1978
YEAR

I HEREBY RECOMMEND THIS THESIS BE ACCEPTED AS FULFILLING THIS PART OF THE GRADUATE DEGREE CITED ABOVE

July 6, 1978
DATE

ADVISER

Aug. 2, 1978
DATE

DEPARTMENT HEAD

A STUDY OF SYMBIOSIS INVOLVING THE
FISH-EATING BAT (*MYOTIS VIVESI*), THE LEAST PETREL
(*HALOCYPTENA MICROSOMA*), THE BLACK PETREL
(*OCEANODROMA MELANIA*), AND THE LIZARD
(*CNEMIDOPHORUS TIGRIS*)

BY

JOEL KING

B. S. in Ed., Eastern Illinois University, 1973

ABSTRACT OF A THESIS

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

CHARLESTON, ILLINOIS
1978

ABSTRACT

A field study was conducted on Partida Island in the Gulf of Mexico on the dates May 26 through July 26, 1977, inclusive.

Field observations were made of the lizard (*Cnemidophorus tigris*) preying on eggs and hatchlings of the least petrel (*Halocyptena microsoma*), and the black petrel (*Oceanodroma melania*). The petrels roost among rock slides with the fish-eating bat (*Myotis vivesi*).

In 24 trials of experimental boxes with lizards, bats, and petrels as subjects, 16 trials resulted in aggression of bats to lizards.

A symbiosis is postulated between bats and petrels.

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ACKNOWLEDGEMENTS

I am indebted to Dr. Jaime Maya for his help and direction in this study. Without his great personal sacrifice of time and money I would have been unable to have undertaken this project.

I am also indebted to Dr. Michael Goodrich, Dr. Fredrick Schram, Dr. Bill Ridgeway, and Patrick Malone. I would also like to thank my wife, Cindy, for her support and assistance.

Quiero tambien expresar mi agradecimiento a los hombres del Poseidon de San Felipe por su amistad.

INTRODUCTION

Partida Island is located in the Gulf of California at 28°55' N. Lat., 113°04' W. Long. The island consists of a microhabitat where relationships between organisms have evolved.

The fish-eating bat (Myotis vivesi), least petrel (Halocyptena microsoma), and black petrel (Oceanodroma melania) roost together under large rock slides or taluses on the Island (Maya, 1968) and (Burt, 1932). The vegetation consists mainly of cholla (Opuntia platyopuntia cf. bravoana) and cardon cactus (Pachycereus pringlei). Myotis vivesi is the only permanent land mammal on the island (Maya, 1968).

Burt (1932) reported that the bat and petrels live together beneath stones on Partida Island. Quoting from Donald R. Dickey's field notes, Burt (1932) stated the ratio of birds and bats: bats, 10; least petrels, 10; black petrels, 1 on Partida Island. Maya (1968) reported the population ratio of bats and petrels on Partida Island as follows: bats, 3; least petrels, 3; black petrels, 1. He stated that roost selection is non-random.

McLellan (1927) stated that the bat was found occupying roosts with breeding black petrels. Walker (1950), referring to taluses on Partida Island, reported a "strange association--nestling birds and suckling bats within inches".

Diguet supposed that the bat fed on excrement from the least petrel (Miller and Allen, 1928), but gave no evidence of this fact. According to Maya (1968) and the field notes of my co-worker, Pat Malone, the lizard (Cnemidophorus tigris) preys upon the young and eggs of the petrels against whose attacks the petrels are relatively defenseless. Maya (1968) postulated the presence of the bat as a deterrent to Cnemidophorous tigris from entering the roost to prey on the petrels' eggs and young.

Symbiotic relationships do exist among other vertebrates. Barabash-Nikiforov (1959) reported on symbiosis in beaver burrows with shrews, toads, grass snakes, and muskrats. Neuntefol (1953) reported on forest birds' symbiosis involving feeding and group warnings. Wymand and Ward (1972) and McCutcheon and McCutcheon (1964) report on cleaning symbiosis in fish. No information could be found in the literature to document such a relationship between bats and birds.

The present study investigated Maya's suggestion of a commensal relationship between the petrels and the bat.

MATERIALS AND METHODS

The field observations for this study were made on Partida Island in the Gulf of Mexico at 28°55' N. Lat., 113°04' W. Long. The dates of the observations were May 26 through July 26, 1977, inclusive. Some observations, as indicated, were contributed by co-worker, Pat Malone.

Bats used in controlled experimentation were obtained initially by mist netting at the entrance to a night roost. These bats were kept in flour sacks until daylight when they were utilized. Bats kept overnight for the experiments were used only in the May 27 results in Table I.

The vast majority of bats used were dug from taluses in the early morning, utilized, and then set free. The author felt the bats in the flour sacks were subjected to much stress, due to their fighting in the bags overnight, and results could be affected. The petrels used in the study were all obtained from beneath the taluses the morning of the experiment.

The majority of lizards, Cnemidophorous tigris, used in the study were captured in pit traps that were checked every morning. These consisted of gallon plastic containers buried with the opening even with ground level. They were buried around lizard burrows and moved every few days. A few lizards were captured by hand in a garbage pit. Captured lizards were held in flour sacks until their introduction and observation in the apparatuses. They were released after each trial other than the one used on May 27 in Table I. Whenever possible, all other animals utilized in the study were released unharmed to the taluses.

All observations and experimentation were done during daylight hours, the majority between 0700 and 1130.

Three enclosures were utilized in the experimentation in which various combinations of bats, lizards, and petrels were introduced. (See Figure I for dimensions of apparatuses and Table I for combinations of organisms).

Apparatus I consisted of two enclosures. Enclosure Ia was a narrow crevice with wooden base and sides. The top was screened and there was a screened opening at the base secured by thumbtacks.

Enclosure Ib was made up of the remainder of the wooden box. The top was screened as was most of one side.

Apparatus II was a roll of screen. A safety pin secured the front screen flap.

Apparatus III was made of cardboard and screen. The opening flap was cardboard and secured by masking tape. The top was screen as was the end of the rectangular corridor.

All trials with apparatuses were conducted on talus 1 near the bottom of the slide (see Figure II). The apparatuses were set on top of the rocks and results were observed. Rocks and dirt were placed at the bottom of all apparatuses to simulate natural conditions. Apparatus Ib was the largest and thus had the largest rocks in it. High temperatures in apparatuses and bright light were problems, but by testing mostly in early morning, placing apparatuses on top of the rocks, and by shading with cloth over screened areas the problems were alleviated.

Bats were given twenty to thirty minutes to adjust after introduction to apparatuses. This time span of adjustment was selected after observing the duration of squeaking and scurrying around behavior, exhibited after introduction into the apparatus during initial observations. When petrels were used, they were introduced first and immediately followed by the bats. All apparatuses were darkened by cloth before introduction of any organism.

Specific procedures for apparatuses are as follows:

Apparatus Ia. Bats were introduced through the side door. There was enough light to observe through the top screen. Lizards were introduced after the bat adjustment period and all encounters were noted through the top screen.

Apparatus Ib.. Bats, petrels, and lizards were introduced through the top. Enough light was present to observe through the top and side screens of the wooden box.

Apparatus II. Bats and lizards were introduced into the wire screen through screen flap opening. The flap was secured by a safety pin after introduction of the lizard. Observation was possible through uncovered screen areas.

Apparatus III. A single bat was introduced into cardboard tube through cardboard flap and observed through top and end screen. The flap was secured by masking tape.

Petrels and bats were acquired by rapidly lifting rocks from the slide and working outwards in an approximate two foot square area to dirt base.

Eleven quadrants one meter square on talus 1 were analyzed by lifting rocks from the middle rapidly and working to dirt bottom and out to the periphery. The meter was measured out with a meter stick before rocks were moved. Quadrant sites were randomly selected. Numbers of petrels and bats were noted.

A single transect was established on a study site utilized only for this purpose. It was analyzed twelve times between June 4 and July 14. The site was located on talus 5 on the north side of the island (see Figure II). The site was on an approximate 45° embankment with the base line of the transect at the foot of the embankment. Talus 5 consisted of larger rocks and more exposed ground than other taluses observed.

The transect was 10 meters at the base and top, with 20 meter sides up the embankment. It was then divided into five 2 by 20 meter strips for easier analysis. Orange cloth was used as markers for the 5 strips.

The transect was analyzed by walking slowly up and down the 5 strips one time. Sightings were noted of *Cnemidophorus tigris* and petrel egg fragments, and the fragments were collected.

Field glasses were utilized in many of the talus observations..

RESULTS

Thirty-one instances were recorded by the author and co-worker, Pat Malone, of the lizard preying on least and petrel eggs and hatchlings (see Table II). The first direct evidence of lizard predation on petrel eggs was observed on May 31, 1977, when a lizard shot with a sling-shot vomitted yolk. A lizard was last observed feeding on a least egg July 18, 1977. The last record of petrel predation was made July 20, when a lizard was seen eating a least hatchling.

Most predation on eggs was observed between May 31 and July 2. Between July 2 and July 20 most predation was on hatchlings.

Transect results of broken petrel eggs were observed between June 4 and July 14 (see Table III). On the first day of the transect, June 4, nine least eggs and one black egg were found broken. On the last day the transect was run, July 14, two least broken eggs were found. Spot checks of the transect after this date revealed no more egg fragments. Total eggs found in the transect were 52 least and 7 black.

As previously stated, Burt (1932) recorded the ratio of bats to least petrels to black petrels as 10:10:1. Maya (1968) had stated 3:3:1. Eleven quadrants run by the author showed a ratio of 2.5:1.5:1. A total of 45 sightings recorded of petrels and bats, while digging in the taluses for experimental subjects or just observing under the rocks, resulted in a total of 50 bats, 49 least petrels, and 12 black petrels.

Results from the experimental apparatuses are given in Table I. Four different types of responses were noted for the bat when encountering the lizard in the apparatuses. These were shaking, squeaking, biting, and no apparent reaction. Apparatus Ib was the most successful in showing bat aggression to the lizards. In six trials between bats and lizards, aggression was shown each time by the bats with the lizards rapidly retreating. Apparatus Ia had ten trials with five resulting in aggression. Apparatus II was run for three trials with one case of aggression. Apparatus III showed three out of four trials with aggression. The author felt Ib was the most successful because it was the largest enclosure and the bats were more secure beneath the larger rocks.

One incidence of a bat biting a lizard was seen in the field by Pat Malone. While pursuing a lizard over the talus, the lizard went in and out of the rocks. The lizard at one point was seen to be struggling in place on a rock with a squaking bat firmly attached to its tail by its teeth.

Daily observations were made of lizards entering the talus, followed by loud bat squeaking, and immediate reappearance of the lizards on top of the rocks. Maya (1968) reported the bat squeaked when moving in the talus and encountering other bats. Due to the large numbers of observations where lizards entered quiet areas and incited rapid squeaking of bats, the author feels it is valid to assume aggression of the bat to the lizard.

The reaction of petrels, when disturbed in taluses by the author, consisted of a high pitched cry, light pecking, and regurgitation of fish oil. Maya (1968) noted the same reaction for petrels when approaced by C. tigris. The only instance of testing an adult black petrel in apparatus Ib resulted in the black petrel flapping and attempting to flee the enclosure when confronted by the lizard as it crawled through the enclosure. In trials with least petrels and bats in Ib, the leasts remained under a rock and made clucking noises.

The low number of trials with organisms was due to the resulting destruction of habitat when escavating the taluses. Also, all organisms studied were involved with breeding and handling could be very destructive to the species.

Maya (1968) reported the bats gave birth from mid-May through mid-June. Many bats were found with young during this time. Palmer (1962) reported the petrels' hatchings occurred the last days of May through the first three weeks of June. The author found this to be true also.

DISCUSSION

Maya (1968) reported that *Cnemidophorus tigris* preyed on petrel eggs. He also observed an instance of a least petrel hatchling taken by a lizard. As previously stated Maya (1968) reported roost selection by petrels near bats to be nonrandom. He postulated a commensal relationship with the bat being a deterrent to the lizard's entry to the talus and subsequent predation on the petrels. According to Bert (1922) the least petrel egg averages 23.4 by 19.4 mm; the black petrel, 36.6 by 26.7mm. *Cnemidophorus tigris* is capable of easily seizing the egg. *Cnemidophorus tigris* are predators of least and black petrel reproduction at various levels.

In experiments with petrels, bats, and lizards, the bats' aggression was shown to be highly effective. Lizards would freeze at the sound of bats' squeaking or rush frantically around the enclosure to avoid being bitten by the bat. In trials where no apparent aggression was shown by the bat, stress is hypothesized as the reason. Handling of the bats being the stress producer.

Petrel distress calls of disturbances were heard daily through late May to mid-July. The petrels were ineffective in driving the lizards from their roosts in the talus due to their light pecking.

The petrels' hatching period coincides with the birth of the bats. It is possible that the petrels evolved a hatching period to coincide with the bat's maternity care since the aggression of mammals is usually at a high level during this time.

The remains of petrel eggs denoted the young of the petrels are not of the first clutch and that the petrels lay continuously through the summer months. This conclusion is reached due to the large number of broken eggs found daily in the same area.

No remains of bats were found in the lizard stomach analysis done by Pat Malone nor were any bats seen preyed upon by _C_. _tigris_.

In summary, heavy predation on petrel eggs and young by _C_. _tigris_, together with apparently effective defensive attacks of _Myotis vivesi_ on invading _C_. _tigris_, and the absence of remains of _Myotis vivesi_ in stomach analysis of _C_. _tigris_, suggests that there is a commensatistic relationship and Maya's hypothesis is reasonable.

Table I. Results of O. melania, H. microsoma, C. tigris, and M. vivesi behavior in three experimental apparatuses (refer to Fig. I for diagrams and dimensions of apparatus). f = female bat; m = male bat; yng = young; lz = lizard.

Date	Time	Apparatus	Subjects	Behavior
*5-27	0620	Ia	f lz	**f shaking and squeaking
5-27	0700	Ia	f m lz	m bites at lz
5-27	0710	Ia	2f m lz	lz moves over f no reaction
5-27	1300	Ia	2f m lz	m squeaks and bites at lz
6-3	0930	Ia	f m lz	no reaction f m bites; squeaks loudly at lz
6-9	0910	Ia	m lz	no reaction
6-11	0645	Ia	3m lz	no reaction
6-19	0900	Ia	2f m lz	no reaction
7-6	0800	Ia	2f m lz	no reaction
7-7	0700	Ia	m lz	no reaction
6-28	1500	Ib	B petrel lz egg	petrel flaps and attempts to get away; lz scurries around box
7-12	0830	Ib	2f-1yngf 1least w/ yng 2 lz	2f very aggressive to lz; petrel clucking

Table I cont.

Date	Time	Apparatus	Subjects	Behavior
7-21	0800	Ib	2f 3 yng, 2f, 1m yng black 1 lz	bats very aggressive to lz
7-22	0800	Ib	2m 1 least 1 lz	2m loud squeaking and biting at lz; petrel clucking
7-23	0800	Ib	m f 1 least w/ yng 1 lz	bats squeaking and very aggressive to lz
7-24	0815	Ib	2f 2 lz	2f aggressive to lz loud squeaking
7-25	0800	Ib	m lz	m aggressive biting and squeaking
6-3	1030	II	m f lz	f bites lz 4 times
6-11	0655	II	2f 1 lz	no reaction
6-19	0900	II	3m 2 lz	no reaction
5-28	0630	III	m lz	m bites at lz
6-3	1000	III	m lz	m bites and squeaks at lz
6-11	0650	III	m lz	m squeaking and biting
6-19	0900	III	3m 2 lz	no reaction

*same subjects used for all May 27 trials

**all trials where bat aggression noted resulted in lizards scurrying away

Table II. Observation date and notes of *Cnemidophorus tigris* preying on least petrel and black petrel embryoes and eggs. (l = least petrel; b = black petrel)

Date	Time	Observation
5-31	1015	lz shot w/slingshot and vomits yolk
6-2	0900	l egg set on rock - lz pokes it and runs off
6-3	0730	egg put in styrofoam tube on talus - 1030 egg gone
6-6	0800	lz seen with egg shell on leg
6-6	0840	fresh broken egg found on talus
6-7	0855	lz seen with egg shell on mouth
6-7	0917	lz seen with feather tufts on mouth
6-8	0830	lz seen dragging b egg out of talus
6-8	0930	lz seen retreating from broken b egg
6-8	1035	lz seen running with l egg in mouth
6-15	0910	lz exits talus with egg
6-15	0937	lz seen eating l embryo and yolk
6-17	0928	lz seen feeding on b egg
6-17	1055	lz exits with egg
6-22	0854	lz with embryo in mouth
6-22	0945	lz exits with egg in mouth
6-30	0855	lz eating embryo
6-30	0910	lz seen with egg
6-30	0917	lz seen eating yolk and embryo
7-2	1218	lz seen cracking l egg and eating embryo
7-2	1435	lz seen with large embryo
7-2	1445	lz seen with large embryo
7-3	0850	lz seen with embryo in mouth

Table II cont.

Date	Time	Observation
7-3	0925	1z seen with part of embryo in mouth
7-3	0935	1z heard dragging egg under rock - exits with 1 egg
7-3	0955	1z exits talus with large hatchling
7-11	1000	1z seen with feather in mouth
7-11	1010	1z with live chick in mouth
7-11	1050	1z with 1 egg
7-14	0900	1z seen by P. Malone with chick
7-14	0950	1z seen running with egg, cracking it, eating embryo
7-18	0755	1z chewing on old wing bone
7-20	1000	1z eating large hatchling

Table III. Results of Least and Black petrel broken eggs found and collected and _C. tigris_ sightings in 10 meter by 20 meter rectangular transect area at various times during June and July.

Date	Time	Least egg	Black egg	_C. tigris_
6-4	0815	9	1	2
6-5	1015	5	1	2
6-7	1530	7	0	1
6-8	1630	3	2	0
6-9	1015	8	0	2
6-11	0910	3	1	9
6-12	1200	1	0	1
6-16	1430	1	0	2
6-22	1100	4	1	4
6-29	1030	5	1	2
7-8	1130	4	0	1
7-14	1000	2	0	4
Totals		52	7	30

Table IV. Quadrant study of talus 1 on Partida Island. L = Least Petrel; B = Black Petrel; M = Male bat; F = Female bat; E = Egg; U = Sex unknown due to escape; yng = young.

Date	Quadrant No.	Bats	Petrels
5-29	1	1U	4L-1E each 1B-1E
6-1	2	1U	3L-2E
6-1	3	1M	1B & nestling 1L-1E
6-5	4	3F-3yngU	3L-1E each
7-10	5	1M	2B nestlings
7-10	6	1Fyng	1L 2B nestlings
7-10	7		1L nestling 1B nestling
7-10	8	1F-1Fyng	1L nestling 1B nestling
7-12	9	2F 2Fyng, 1Myng	1B nestling 1L
7-12	10	2F, 2yngU	1L nestling 1B nestling
7-21	11	2F 2Fyng, 1Myng	
Totals		27B	16L-11B

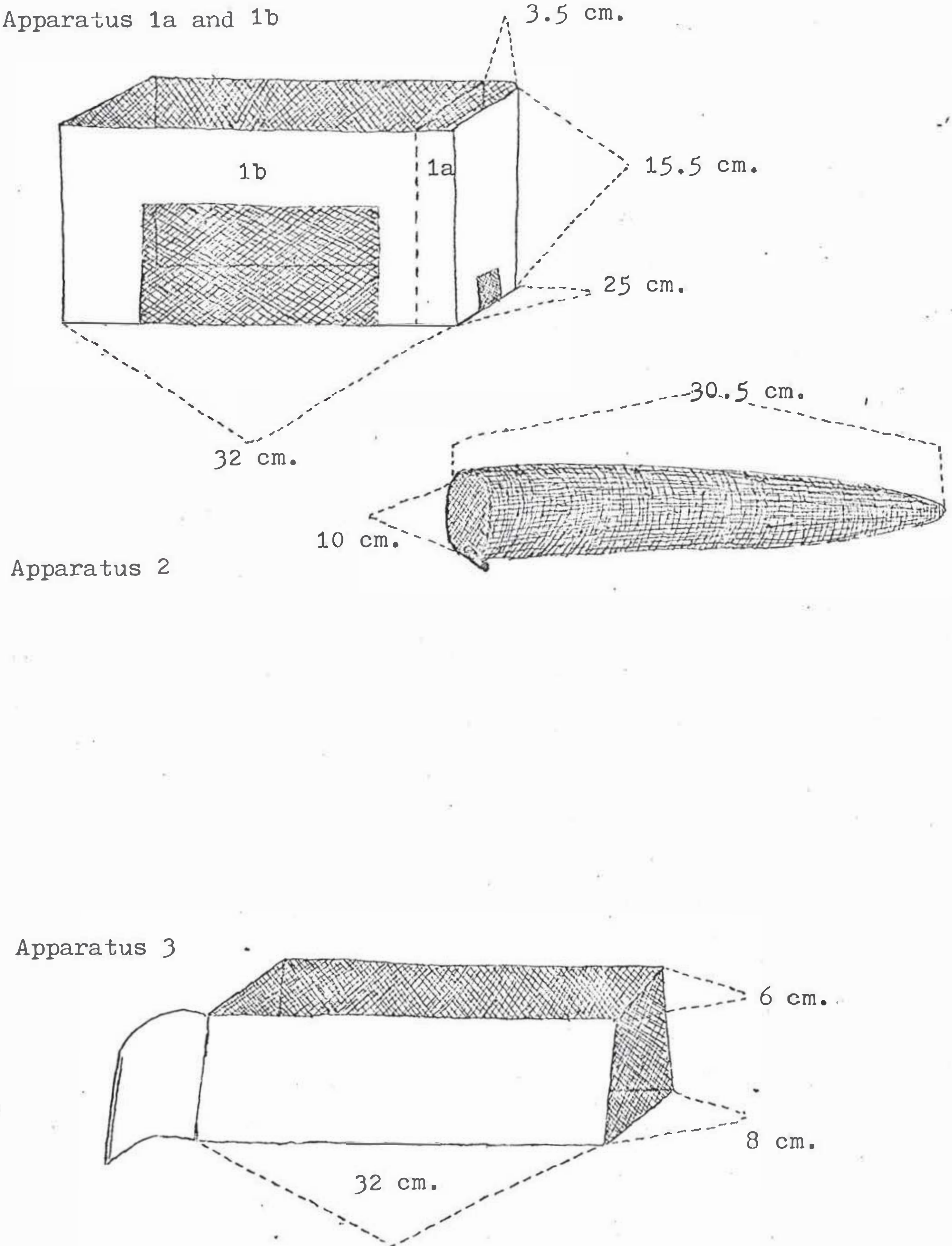

Figure 1. Experimental apparatus.

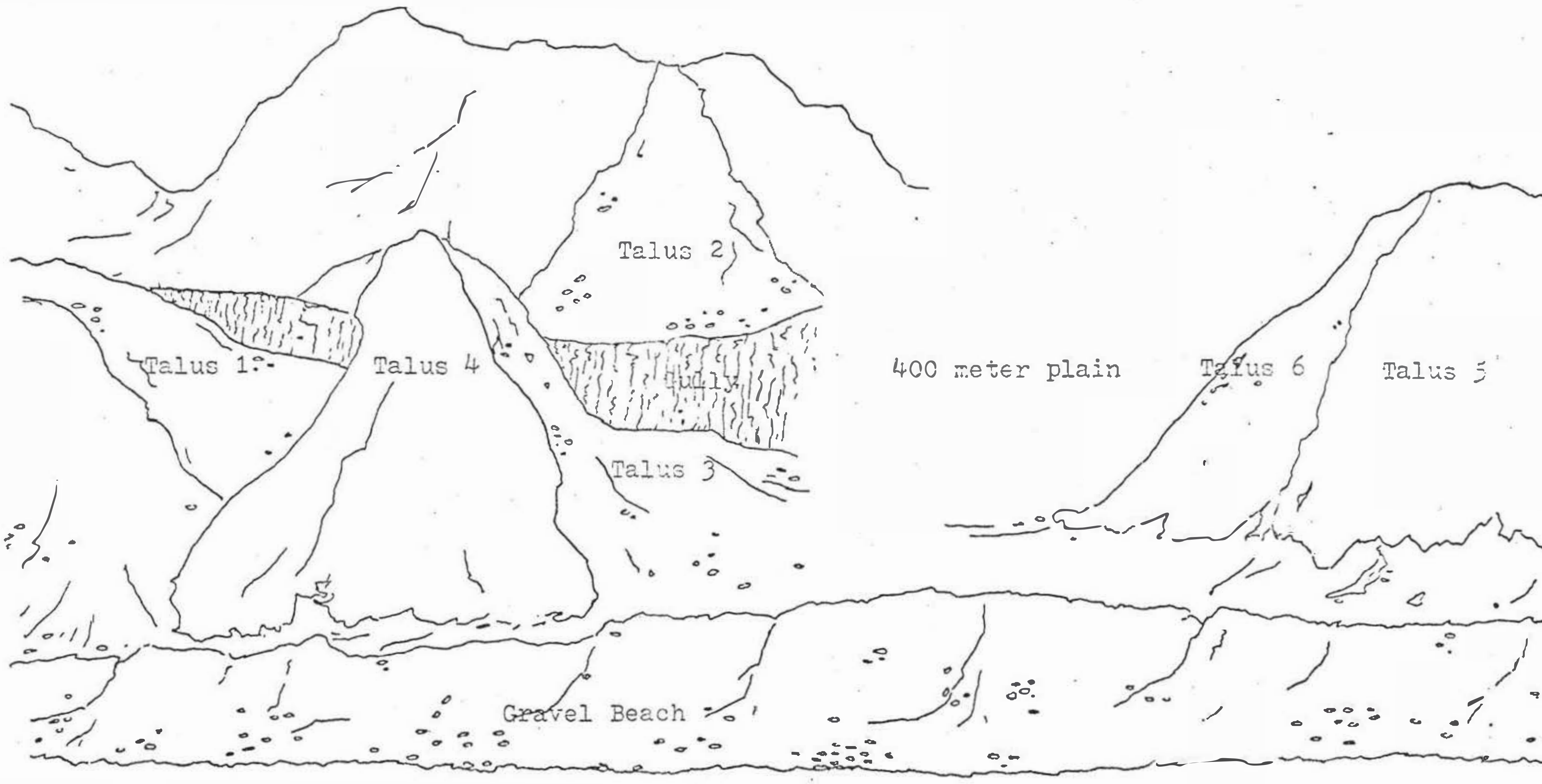

Figure 2. Map of taluses to show relative locations. No dimensions given for talus' area.

LITERATURE CITED

Barabash-Nikiforov, I. I. 1959. Symbiotic relationships in beaver burrows. (in Russian, English summary). Zool. Zhur. 38 (5): 761-767.

Bent, A. C. 1922. Life histories of North American petrels and pelicans. Bull. U. S. Nat. Mus. 121: 123-125; 156-158.

Burt, W. H. 1932. The fish-eating habits of Pizonyx vivesi (Memegaux). J. Mamm. 13: 363-365.

Maya, J. A. 1968. The natural history of the fish-eating bat, Pizonyx vivesi. Ph. D. Thesis. University of Arizona.

McCutcheon, F. H. and A. E. McCutcheon. 1964. Symbiotic behavior among fishes from temperate ocean waters. Science 145 (3635): 948-949.

McLellan, M. E. 1927. Pizonyx vivesi on Isla Partida, Gulf of California. J. Mamm. 8: 243.

Miller, G. S., Jr., and G. M. Allen. 1928. The American bats of the genera Myotis and Pizonyx. Bull. U. S. Nat. Mus. 144: 209-214.

Neuntefol, Adolfo. 1953. Un ejemplo de simbiosis temporal de aves silvestres. Hornero 10 (1): 74-77.

Palmer, R. S. 1962. Handbook of North American birds. vol. 1, Yale University Press. 561pp.

Walker, L. W. 1950. The fish bats of Pescadora. Audubon Mag. 52: 294-299.

Wyman, R. L. and J. A. Ward. 1972. A cleaning symbiosis between the cichlid fishes Etroplus maculatus and Etroplus suratensis. I. Description and possible evolution. Copeia 1972(4): 834-838.