The Effects of Feral Animals on Soil Mites Recovered from Catalina Ironwood Groves (*Lyonothamnus floribundus*) on Santa Catalina Island, California

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Abstract - Several plant communities on Santa Catalina Island have been altered by trampling and over-grazing from such animals as goats and pigs. The soil beneath selected groves of *Lyonothamnus floribundus floribundus* was sampled in order to determine what impact feral animals may have on populations of soil inhabiting mites. Marked decreases in diversity and abundance of species were noted in heavily disturbed areas. A depauperate soil fauna may result in a decrease in nutrients for plant growth and development. A preliminary checklist of soil mites from Santa Catalina Island is appended.

Introduction

Santa Catalina Island is one of eight southern California Channel Islands and is 34 km long, 13 km wide and encompasses an area of 194 sq. km. It lies approximately 32 km off the coast of California and is parallel to the mainland in a northwest/ southeast direction. The highest elevation is 632 m on Mt. Orizaba and the average annual rainfall is approximately 29 cm (Miller 1985). The human population of the island is approximately 3,000, with the majority residing in the city of Avalon. Eighty six percent of the island is under the protection of the Santa Catalina Island Conservancy as a natural area and includes most of the islands' interior. Astigmate, Prostigmate, Mesostigmate, and Cryptostigmate soil mites were collected once a month from February 1984 to February 1985 at six localities on the island. All specimens were recovered from leaf litter in groves of Catalina ironwood trees (*Lyonothamnus floribundus floribundus*). Ironwood groves are scattered about the island in isolated pockets usually situated on steep north facing slopes where the microclimate tends to be cooler throughout the year (Fig. 1). *Lyonothamnus f. floribundus* is a relict species from the Pleistocene, now extinct on the mainland, and is considered an endemic subspecies of Santa Catalina Island. A related subspecies occurs on some of the other California Islands (Philbrick 1980).

Since the introduction of goats, pigs, deer and bison to Santa Catalina Island, several plant communities have been altered by trampling and over-grazing. Some rare endemic plants have become endangered or have disappeared completely because of the activity of these feral animals (Coblentz 1980). The soil in several ironwood groves has been extensively damaged by goats and pigs and in some cases has eroded away, exposing the hard mineral layer beneath the thick litter and humus layer (Fig. 2). Little is known about the effects of such disturbance on the soil flora and fauna, particularly in the fragile environment of an island. The effects of trampling and over-grazing are obvious when observed on a macroscopic level. Stripped branches, short cropped grasses, turned soil, a lack of seedlings, trails and, in extreme cases, gulley erosion and a complete lack of vegetation are all to apparent. One must ask, however, what happens to the animals inhabiting the soil under these conditions. Soil mites, in particular, are partly responsible for the breakdown of organic matter in the soil (leaf litter, twigs, fungi, bacteria, *etc.*), stimulation of microfloral growth, transport of fungal spores through the soil and mineral recycling (Coleman 1970; Crossley 1977; Engelmann 1961; Mitchell & Parkinson 1976; Wooley 1960). In addition, the predator-prey relationships keep a balance in

Figure 1. Catalina ironwood trees, *Lyonothamnus floribundus floribundus*, in Gallagher's Canyon, Santa Catalina Island.

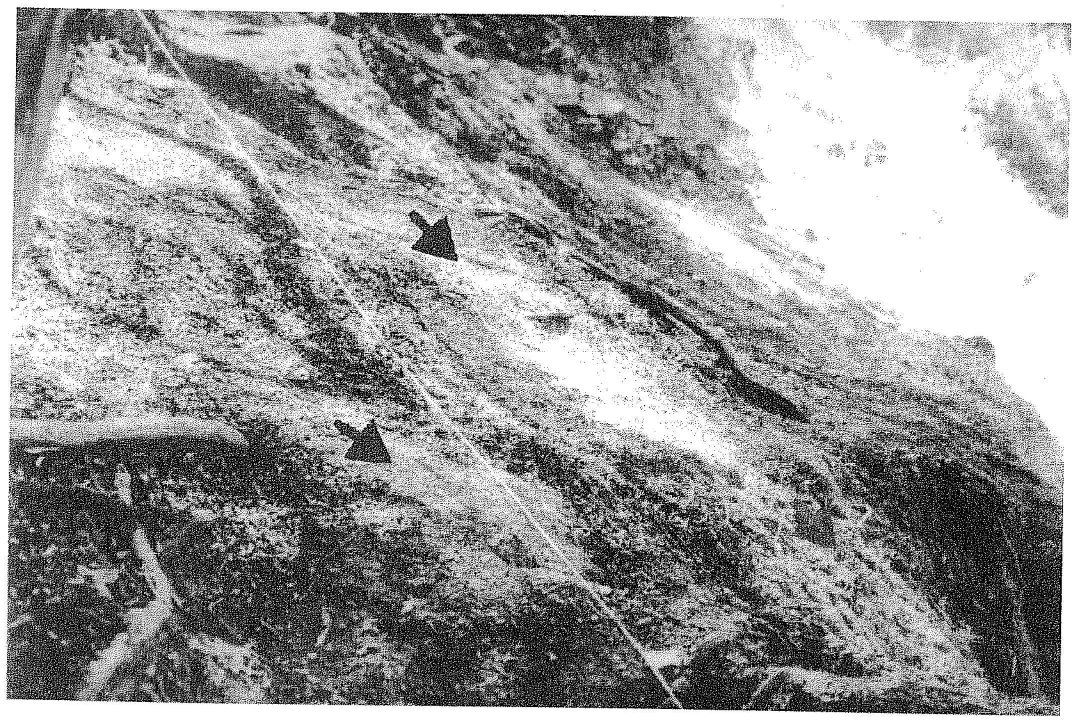

Figure 2. Soil damage by feral goats in *Lyonothamnus floribundus floribundus* grove in Gallagher's Canyon, Santa Catalina Island. Arrows indicate areas where hard mineral layer is exposed.

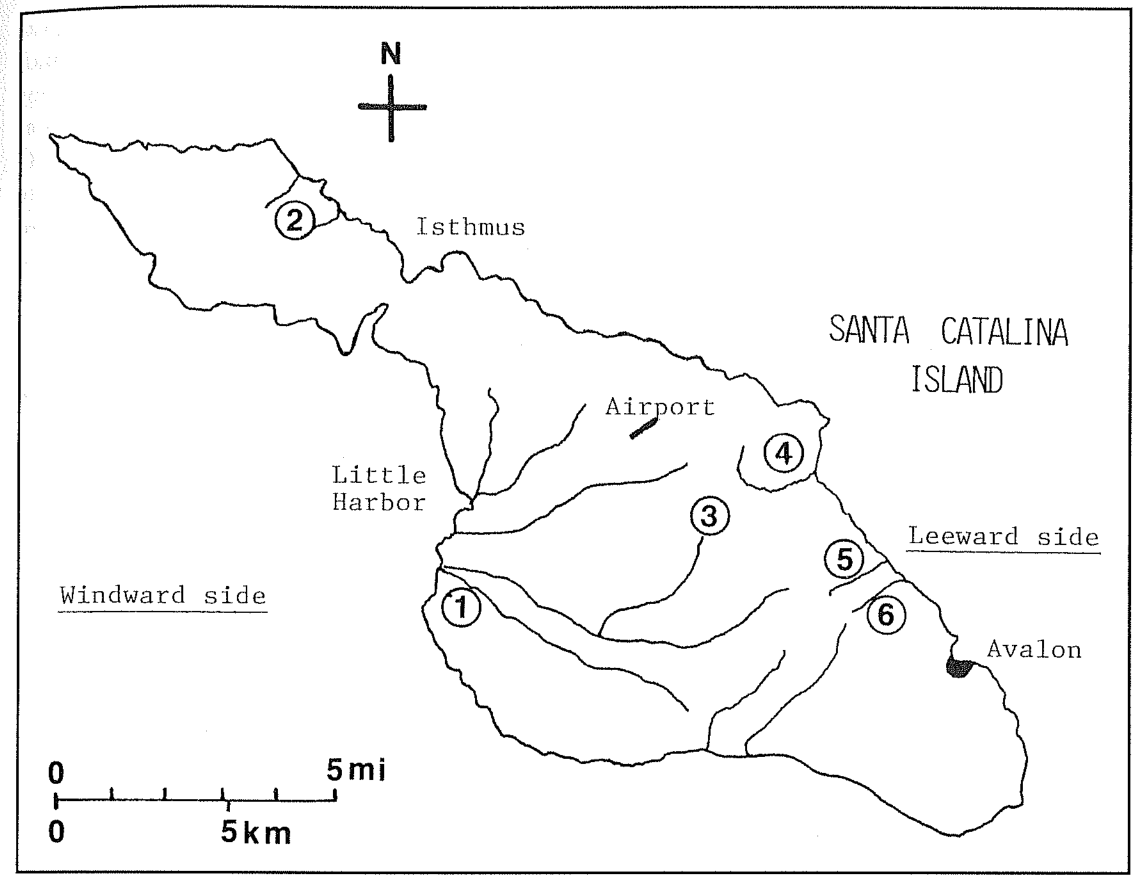

Figure 3. Map of Santa Catalina Island showing six localities of *Lyonothamnus floribundus floribundus* groves sampled for soil mites. 1) Bulrush Canyon; 2) Big Geiger's Cove; 3) Blackjack Mountain; 4) White's Valley; 5) Toyon Canyon; 6) and Gallagher's Canyon. Map modified from Rentz & Weissman (1981).

the arthropod populations and add to the organic matter with their carcasses. The end result is the production of nutrients which ultimately are utilized by plants for growth and development. An imbalance in the soil mite populations may result in an imbalance in nutrient levels.

This study was initiated for four reasons: 1) to inventory the species of mites inhabiting the soil within groves of *Lyonothamnus f. floribundus* during the course of a year; 2) to monitor seasonal changes in the mite populations; 3) compare diversity and abundance of mites from "disturbed" and "undisturbed" soil and 4) determine if soil mites could serve as indicator species for accessing the condition of soil in selected sites on Santa Catalina Island.

Materials and Methods

A total of six groves of *Lyonothamnus f. floribundus* was sampled: 1) Bulrush Canyon; 2) Big Geiger's Cove; 3) Blackjack Mountain; 4) White's Valley (Swain's Canyon; see Menke 1985); 5) Toyon Canyon and 6) Gallagher's Canyon. Survey areas are indicated on the map in Figure 3. Soil samples were collected with a piece of PVC pipe, 7.6 cm in diameter and 5.0 cm deep. This cylinder fit inside a slightly larger piece of pipe that was fashioned with a wooden dowel handle to aid in forcing the pipe into the soil and a plastic plunger for pushing the soil-filled sleeve into a plastic bag. Each sample represented approximatelv 230 cm^3. Two random samples were taken from each grove, usually once a month, along two transect lines; one through the center of the grove and one near the edge. In addition, temperatures at the surface and at 5 cm below were recorded at each sample site every month and the general appearence of the soil was noted prior to sampling. Plastic bags containing the soil samples were kept cool until extraction of the mites with a Tullgren Funnel (Krantz, 1978). Specimens were sorted and counted using a Wild M5 stereomicroscope and representative specimens were mounted on microscope slides in Polyvinyl Alcohol-Lactic Acid (PVA-L) mounting media. Specimens were identified using a Zeiss Phase Contrast microscope at 1,000 x magnification. Classification of mites to the family level follows that of Krantz (1978). Taxonomic keys from Krantz (1978) and McDaniel (1979) also were utilized. The Blackjack Mountain site was used since it had been fenced off for several years, therefore excluding feral animals (except for an occasional deer). The soil in this grove was loose and thick, secondary growth of small trees and shrubs was evident and grasses grew tall and thick. Hypothetically, the soil fauna at Blackjack should represent "undisturbed" conditions in which a "normal" mite population should exist. Abundance and diversity of species found at Blackjack could then be compared to other unfenced sites. The other five ironwood groves were all unfenced.

The White's Valley site had very little damage until January 1985 (Fig. 4) and the soil conditions were very much like those at Blackjack. Groves at Big Geiger's Cove, Toyon, Gallagher's and Bulrush canyons had varying degrees of damage. It should be noted that because of extensive rock outcroppings on the edges of the Bulrush Canyon site, only one transect line was maintained through the center of the grove. Some data are lacking for certain months (September and November) because of an inability to travel to the island. Data for

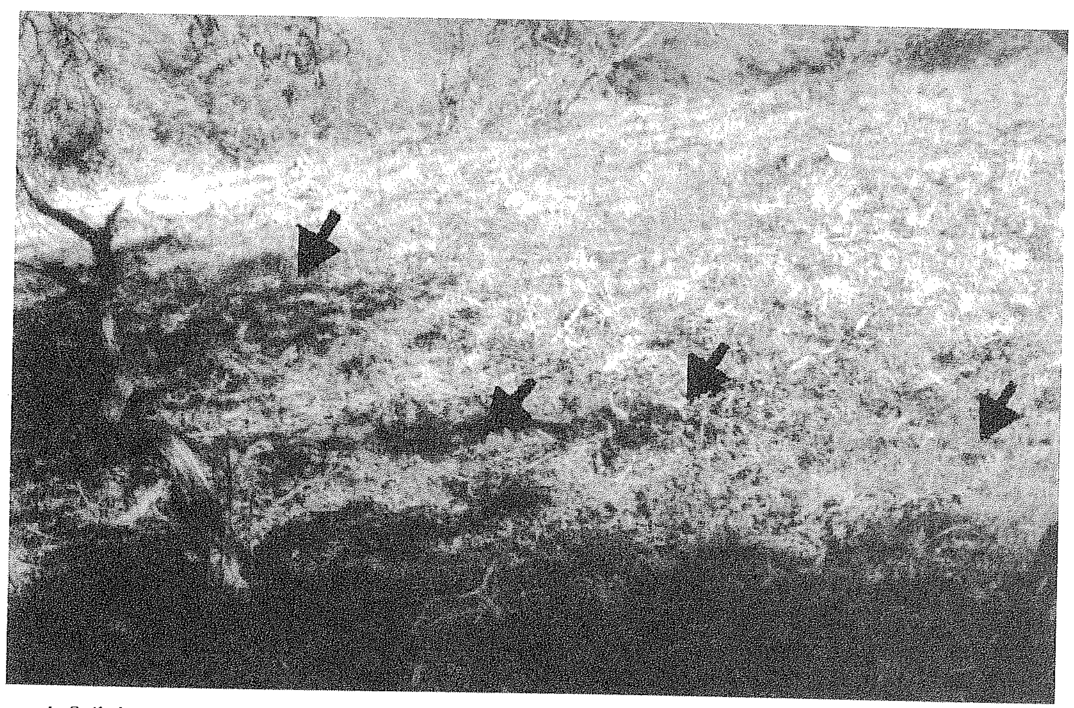

Figure 4. Soil damaged by feral pigs along edge of *Lyonothamnus floribundus floribundus* grove in White's Valley, Santa Catalina Island, in January 1985. Arrows indicate turned up soil along transect line.

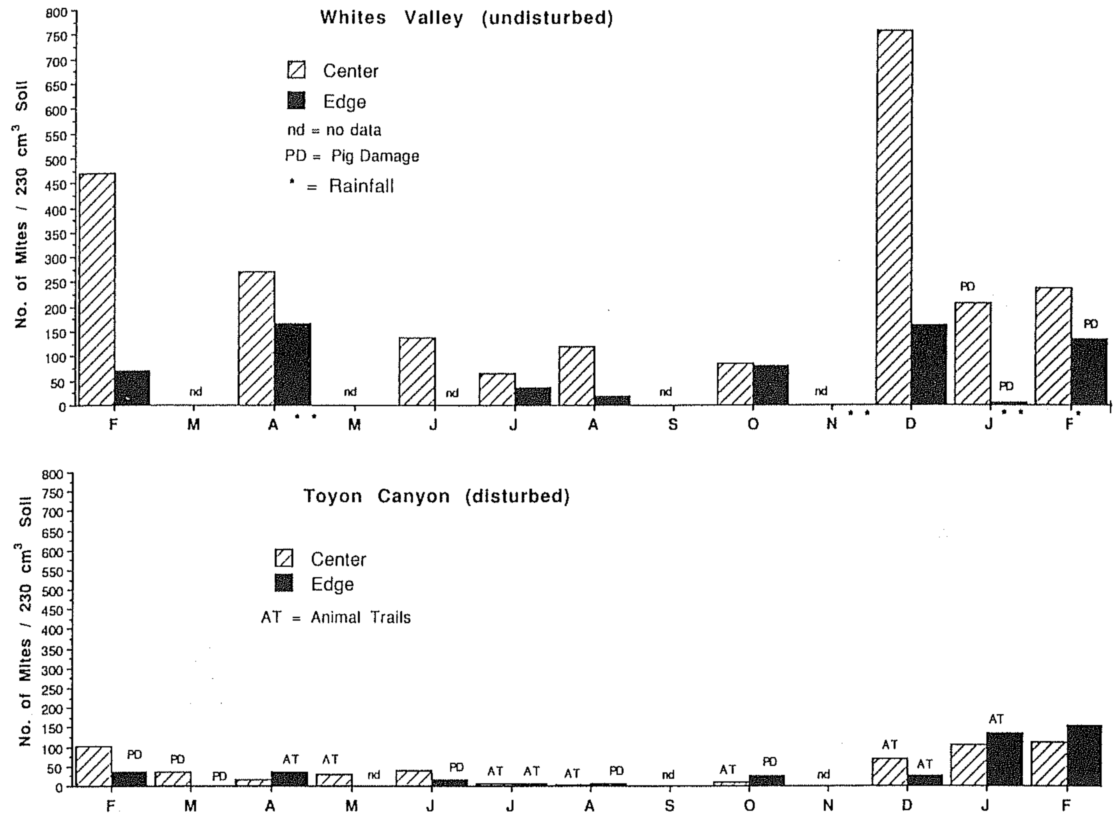

Figure 5. Monthly number of soil mites recovered from White's Valley and Toyon Canyon *Lyonothamnus floribundus floribundus* groves on Santa Catalina Island.

other months are lacking for selected localities as a result of transportation problems on the island, lack of time or loss of specimens to accidental exposure to heat.

Results and Discussion

A total of 9,397 mite specimens was recovered from 90 soil samples collected between February 1984 and February 1985: 3,015 from White's Valley; 1,862 from Blackjack; 1,272 from Gallagher's Canyon; 974 from Toyon Canyon; 1,326 from Big Geiger's Cove and 948 from Bulrush Canyon. The study sites at White's Valley and Blackjack, respectively, had little or no goat and pig damage and had thick litter and humus layers (>15 cm) along most of the transects. Consequently, these two groves yielded the greatest number of individuals. Sites with the fewest individuals were also the most heavily damaged by feral animals (Toyon and Gallagher's canyons and Big Geiger's Cove, respectively.) Although the total for Bulrush Canyon is lower than Toyon Canyon, only one transect was sampled from the center of the grove (two transects in all other groves). Except for February 1985, monthly samples from Bulrush were always greater than Toyon. The Toyon Canyon site was constantly being "rooted" by pigs, particularly along the edges of the grove and had several compacted trails running through the center. The Gallagher's Canyon site was primarily trampled by goats and most of the soil was absent except in the center of the grove where it was compacted. The general trends in the mite populations of

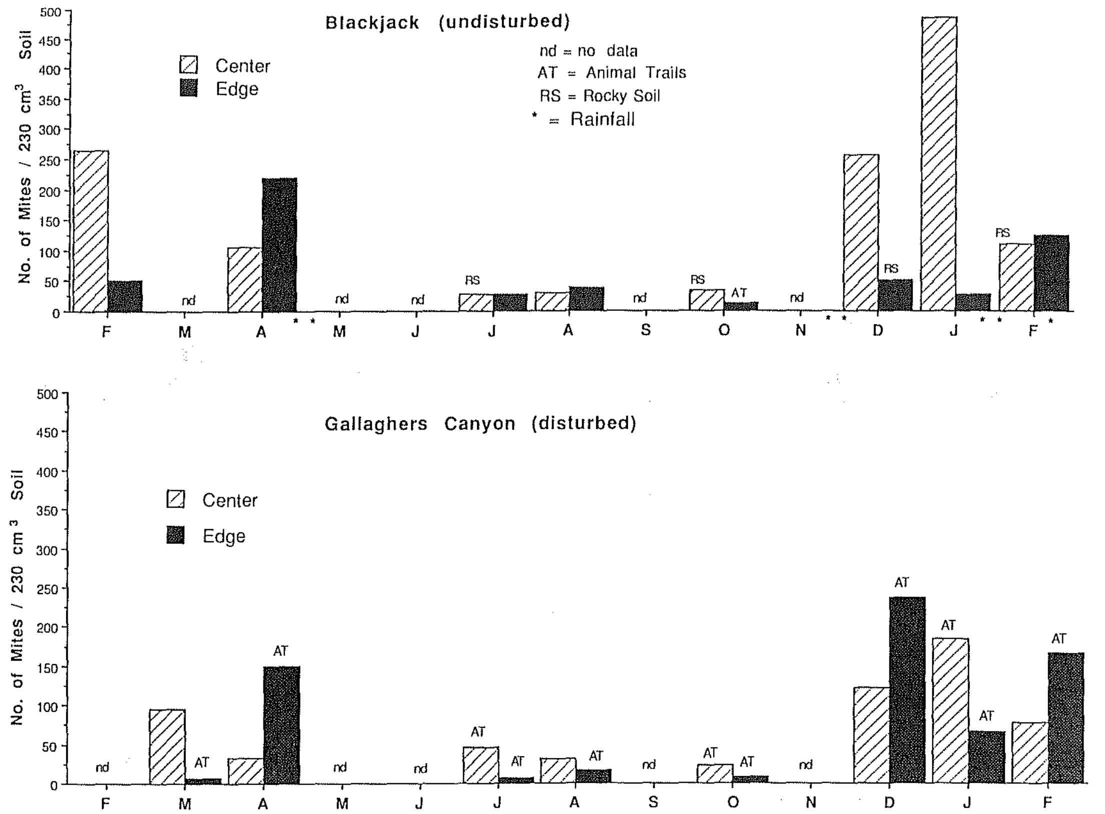

Figure 6. Monthly number of soil mites recovered from Blackjack Mountain and Gallagher's Canyon *Lyonothamnus floribundus floribundus* groves on Santa Catalina Island.

the six study sites during the year are illustrated in Figures 5-7. The greatest numbers of individuals were obtained during the months of December, January, February, and April, corresponding to the rainy season. Evans & co-authors (1961) obtained similar results for soil mites in the British Isles at a depth of 0-6.5 cm and noted a close connection with the reproductive cycles of some of the Cryptostigmata. Samples during these four months were taken within 1-5 days following rainfall with substantial increases in mite numbers occurring in areas without animal trails or pig damage. Notable exceptions are White's Valley in January, Bulrush in February and Blackjack in February (1985). White's Valley is particularly interesting because in the interval between December and January, pigs rooted through the ironwood grove along both transects, turning over most of the soil within the grove. During a month when mite populations would be expected to be high, they were unusually low. The edge of the grove sustained the most damage and the number of mites was lower than any other sample taken in January, including Toyon Canyon. February 1985 samples from White's Valley indicated some recovery of the mite population on the edge of the grove, but little had changed in the center. The February sample from Bulrush Canyon also was lower than expected. The sample was taken along a deer trail where the leaf litter, although thick, had been compressed by the weight of the animals. The fenced grove at Blackjack appeared to be uneffected by feral animals, yet the February sample from the center was lower than expected. This particular sample was taken from relatively rocky soil at

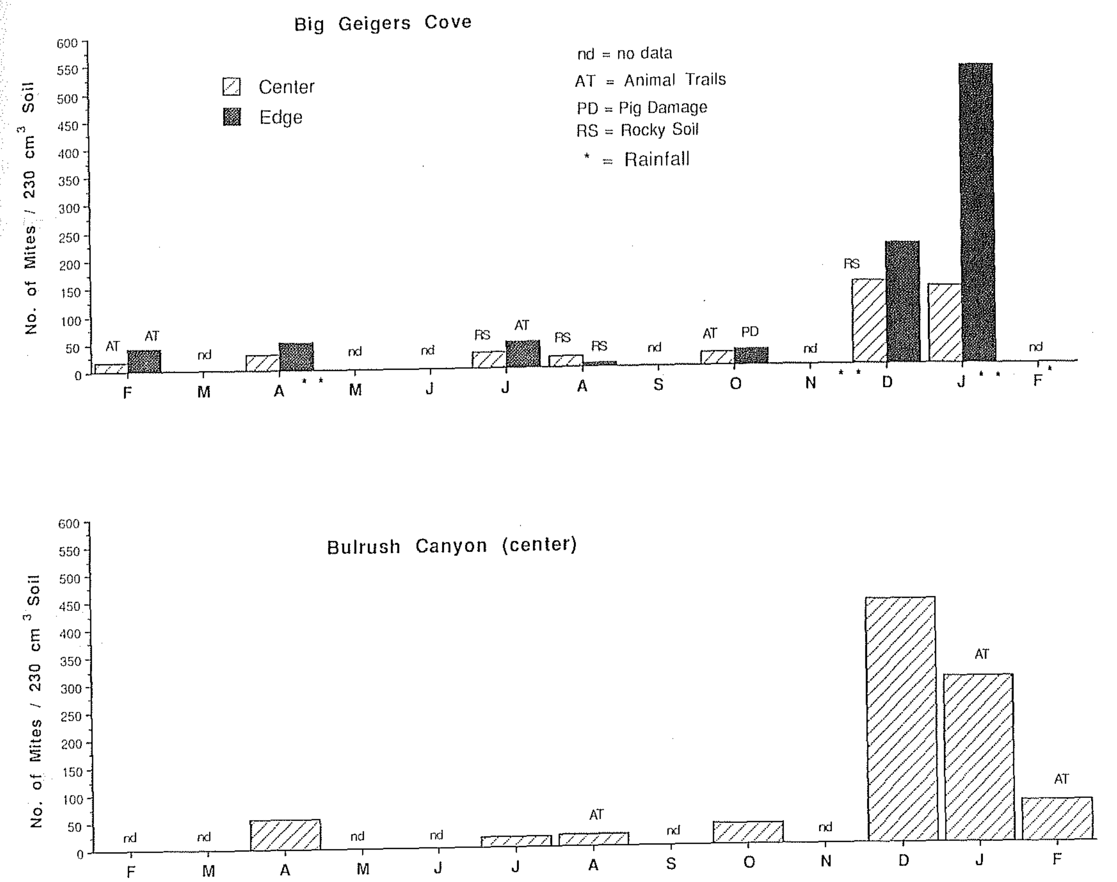

Figure 7. Monthly number of soil mites recovered from Big Geiger's Cove and Bulrush Canyon *Lyonothamnus floribundus floribundus* groves on Santa Catalina Island.

the base of an ironwood tree and probably contributed to the decrease in number of mites. Similar results were obtained from Geiger's Cove in January (Fig. 7). Under these conditions small rocks and gravel were present with the litter and humus in the soil sampler. Decreased humus would mean fewer mites in the sample. As the dry season progressed from May to October, mite populations decreased and at most localities reached their lowest point by mid-summer, particularly the edges of the groves which tended to have fewer mites each month than the centers. The edges of the groves had less leaf litter and humus, less shade because of the lack of canopy cover, and therefore greater exposure to heat, cold, wind and dessication. All these factors could effectively decrease mite populations (at least to the sampling depth of 5 cm). In most instances greater numbers of species and individuals were recovered from the centers of the groves which were insulated from such harsh environmental conditions. When a pig turns up the soil while foraging for food along the edge of an ironwood grove, the existing mite fauna faces exposure to more extreme temperatures, increased evaporation, and decreased shelter within the interstitial spaces between soil particles. In areas such as Toyon Canyon where pigs continuously damage the soil, it seems the mite fauna has little time to recover. The comparison of the disturbed soil at Toyon and the undisturbed at White's Valley is well illustrated in Figure 5. Both groves show the normal seasonal fluctuations, however, the number of mites recovered is considerably lower at Toyon.

Species diversity in both disturbed and

undisturbed groves followed the same seasonal trend, with the greatest diversity occurring during the winter and early spring and the least occurring in the summer and autumn months. Figure 8 summarizes the average number of species recovered from 230 cm³ of soil. Data from all groves are combined into the two catagories, disturbed and undisturbed, in addition to data from center and edge transects. The number of mite species consistantly was higher in undisturbed soil samples. Increases occurred in both soil types after periods of rainfall in the spring and winter, corresponding in most cases to increases in numbers of individuals. Eventual recovery of the soil fauna seems to occur in groves that receive occasional damage from goats and pigs (Figs. 9-10), although recovery of population density may take longer. In groves such as Toyon Canyon where pig damage is constant, mite populations and reproductive potential may be reduced, fewer larval and nymphal mites are present, and certain dominant genera of Cryptostigmata (*Joshuella*, *Opiella*, *Kartoeremaeus*, *Cosmochthonius*, *Eobrachychthonius*), mesostigmate predators (Ascidae, Ologamasidae, Phytoseiidae), and prostigmate predators (Cheyletidae, Cunaxidae) are reduced or absent. A reduction in predation and competition from dominant species may increase the chances of other less common or better adapted species to colonize damaged areas of an ironwood grove. This could increase species richness without dramatically increasing the density. Dindal (1977) demonstrated that in an old field plant community treated with DDT and soil effected by urban street salting, species diversity was greater than at untreated sites. He stated that the potential for colonization by rare species was observed and the ability to colonize by new and different species may be in response to a reduction in competition with the original species on the site as they responded negatively to selection pressures (*i.e.*, DDT and salt). The colonizing species also may be better adapted to the newly formed physical and chemical conditions. Table 1 shows the variation in the numbers of four suborders of mites in the White's Valley and Toyon Canyon ironwood groves. Note the decrease in the Mesostigmata, Prostigmata, and Cryptostigmata at the Toyon site. The majority of the first two groups are predators on other mites, insects, and arthropod eggs. The latter group contains species which feed on fungi, yeast, bacteria, algae, lichens and leaf litter (Krantz 1978; McDaniel 1979). The Astigmata, primarily seed and grain feeders, were not common in any sample (1-2% total) and appeared to be uneffected by soil disturbance. Astigmata from the British Isles were found to be uncommon in forest soils but occurred in large numbers in arable soil and pastureland at a depth of 7.5 cm

Table 1. Comparison of the numbers of four suborders of soil mites recovered from disturbed and undisturbed soil in two groves of *Lyonothamnus floribundus floribundus* on Santa Catalina Island.

Suborder	F	M	A	M	J	J	A	S	O	N	D	J	F	Total
White's Valley (undisturbed soil)														
Astigmata	10		1		2	0	4		1		1	2*	2	23
Prostigmata	174		75		21	65	65		88		34	35*	153	710
Mesostigmata	41		64		30	0	0		0		48	35*	14	232
Cryptostigmata	302		285		64	44	67		70		126	139*	204	1312
Toyon Canyon (undisturbed soil)														
Astigmata	3	1	0	4	7	0	0		2		0	0	4	21
Prostigmata	52	13	28	5	25	7	8		15		12	71	77	313
Mesostigmata	7	3	3	3	0	0	1		1		0	21	15	54
Cryptostigmata	60	19	18	17	22	6	3		17		83	147	171	563

*Pig damage sustained in January 1985 in White's Valley sample.

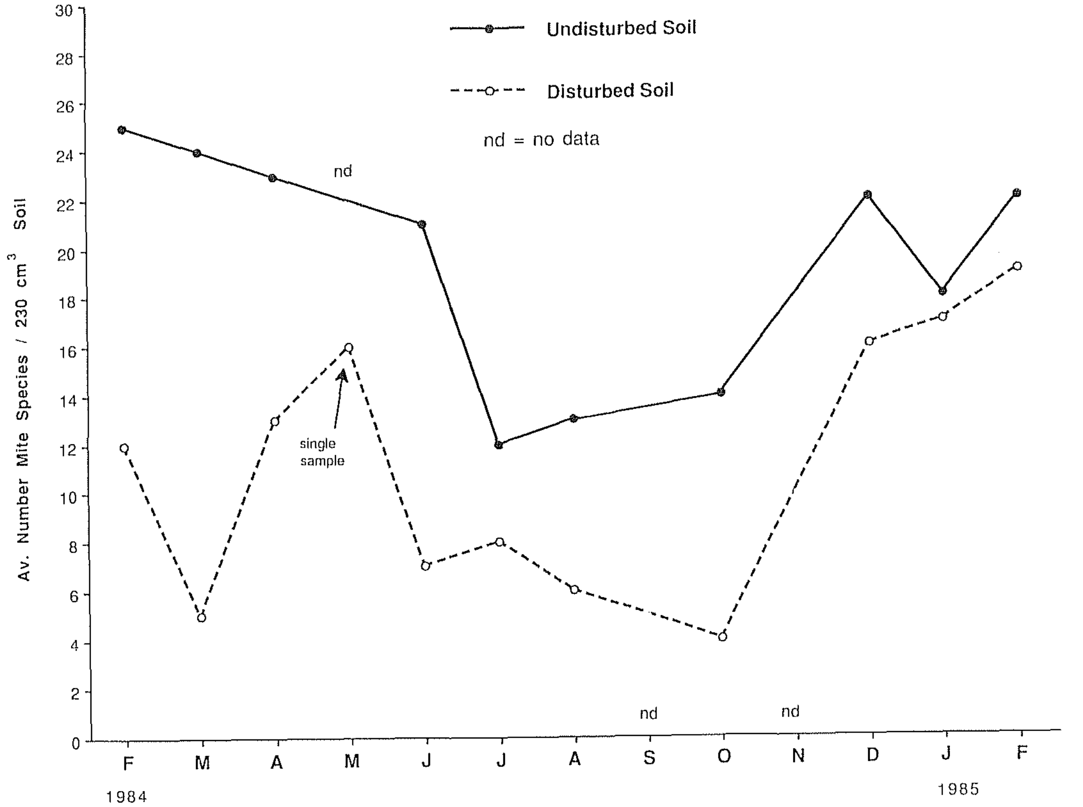

Figure 8. Comparison of species diversity of soil mites recovered from distrubed and undisturbed soil samples in groves of *Lyonothamnus floribundus floribundus* on Santa Catalina Island.

(Evans *et al.* 1961). Most of the Astigmata recovered from ironwood groves were found along the edge transects or in disturbed soil with little or no humus. The oribatid soil mites (Cryptostigmata) comprised 58-59% of the total, the Prostigmata, 31-33% and the Mesostigmata, 7-10% at both localities. However, at the Toyon site the total number of mites from each suborder was, respectively, 57, 56, and 76% less than White's Valley. Cryptostigmate genera that were present in undisturbed samples from White's Valley and Blackjack but not found at Toyon Canyon included *Hermaniella* , *Propelops* and *Camisia*. Prostigmate genera included *Cryptognathus* (Cryptognathidae), *Fessonia* (Smarididae) and *Eucheyletia* (Cheyletidae). Mesostigmate genera included *Chelaseius* (Phytoseiidae), and *Epicriopsis* (Ameroseiidae). Other species that occurred in substantially reduced numbers in disturbed soil samples included *Eobrachychthonius*, *Poecilochthonius*, *Cosmochthonius*, *Joshuella*, *Kartoeremaeus*, *Haplochthonius*, *Sphaerochthonius*, *Opiella* and *Chamobates* (Cryptostigmata); Cunaxidae and Nanorchestidae (Prostigmata); and Ologamasidae, Ascidae and Zerconidae (Mesostigmata). Two cryptostigmate genera, *Aphelacarus* and *Tectocepheus* seemed to be enhanced by soil disturbance, occurring in higher numbers at the Toyon site. *Aphelacarus* apparently favours dry habitats. Wallwork (1972) and Wooley (1960) stated that a species of *Tectocepheus* (*velatus*) was most common in sandy soil, sandy humus or sandy moss and because it was ubiquitous in samples, it could be called an "indicator" species. Lindquist (1979) also mentioned the potential use of oribatid mites as ecological indicators of soil biotopes and of the effects of human activity on agricultural and forest ecosystems. Except for *Sphaerochthonius*

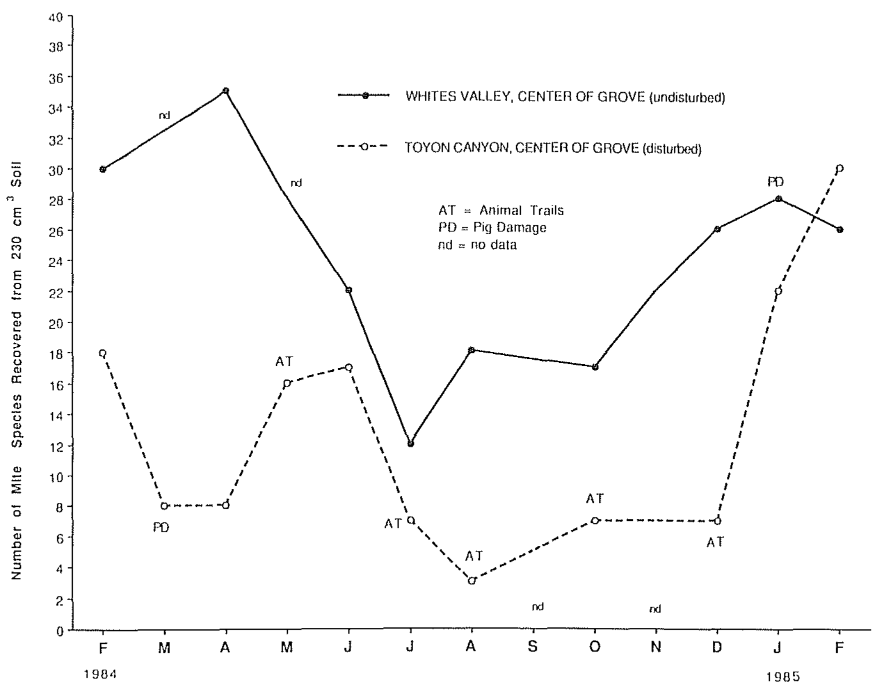

Figure 9. Number of species of mites recovered from disturbed and undisturbed soil in two groves of *Lyonothamnus floribundus floribundus* on Santa Catalina Island (center of grove).

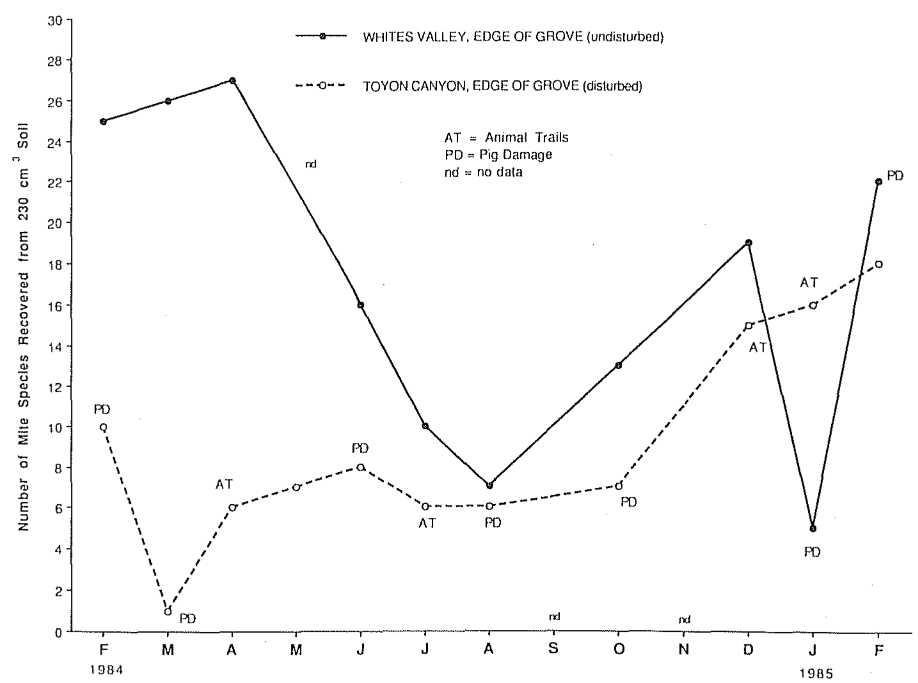

Figure 10. Number of species of mites recovered from disturbed and undisturbed soil in two groves of *Lyonothamnus floribundus floribundus* on Santa Catalina Island (edge of grove).

and *Fessonia*, all of the mites mentioned above were present all year around in undisturbed soil samples and followed the established seasonal trend, reaching their greatest density during December, January and February.

These preliminary findings suggest that certain species of soil mites within the ironwood groves are sensitive to the changes in soil temperature, moisture and density associated with the feeding activities of goats, pigs, and deer. Species that are absent or occur in low numbers under these conditions may be an indication of poor soil quality even if the litter and humus layers superficially appear to be normal. The presence of other genera such as *Aphelacarus* or *Tectocepheus* may serve the same function. These "indicator species" may be useful tools for evaluating the condition of soil prior to the transplantation of seedling trees, for determining which ironwood groves have been effected the most (and the least) by feral animals and for monitoring soil quality after a grove has been fenced off and feral animals excluded. Recovery of a balanced soil fauna could be a good indication of normal decomposition and nutrient production within an ironwood grove. Future studies concerning the recovery of mite populations at the Toyon Canyon site are planned in addition to a more extensive analysis of data regarding "indicator species" from the other five localities mentioned in this paper.

Appendix 1 provides a preliminary inventory of the soil mites from *Lyonothamnus f. floribundus* groves on Santa Catalina Island.

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Appendix 1: Preliminary checklist of soil mites from Santa Catalina Island.

Preliminary studies of the mites recovered from soil in groves of Catalina ironwood trees *(Lyonothamnus floribundus floribundus)* have thus far revealed a total of 62 families, 79 genera and 87 species within 4 orders: Astigmata [2 families, 2 genera, 2 species]; Mesostigmata [10, 16 and 17 respectively]; Prostigmata [23, 29 and 32 respectively]; and Cryptostigmata [27, 32 and 36 respectively] (Table 1). A total of 9,397 specimens were examined. Little is known about the mite fauna of the California Islands and very few records have been published. Powder & Loomis (1962) recorded the trombiculid mites, *Eutrombicula belkini* and *Kayella lacerta*, from East Anacapa Island and Bennett (1987) reported on several species of ectoparasitic mites on vertebrates from Santa Catalina Island which included larvae of *Euschoengastia ambocalis* and *E. numerosa* recovered from soil samples in *L. f. floribundus* groves.

The systematics of some of the groups is poorly known and as a result many of the species listed may represent new taxa. They will be the subjects of other studies as will the mites from other plant communities and soil types. The systematic literature used in compiling this checklist is included at the end of the Appendix.

Order	Superfamily	Family	Genus/species	Source of Identification
Gamasida (Mesostigmata)	Sejoidea	Ichthyostomato-gasteridae	*Asternolaelaps* sp.	Camin (1955)
	Rhodacaroidea	Ologamasidae	*Acugamasus* sp. *Gamasellus* sp.	M. Hennessey (pers. comm.)
		Zerconidae	*Amerozercon* sp. *Microzercon* sp.	Blaszak (1975)
		Ascidae	*Antennoseius* sp. *Gamasellodes* sp. *Iphidozercon* sp. *Zerconopsis* sp.	M. Hennessey (pers. comm.) " "
	Phytoseioidea	Ameroseiidae	*Epicriopsis* (nr. *palustris)*	"
Gamasida (cont.)		Phytoseiidae	*Chelaseius* sp. *C. floridanus*	Schuster (1963) Muma & Denmark (1970)
	Eviphidoidea	Parholaspididae	undet. genus	M. Hennessey (pers. comm.)
	Dermanyssoidea	Laelapidae	*Gymnolaelaps* sp.	Evans & Till (1966)
			undet. genus	M. Hennessey (pers. comm.)
		undet. family		"
	Uropodoidea	Uropodidae		
Actinedida (Prostigmata)	Pachygnathoidea	Pachygnathidae		
		Nanorchestidae	*Nanorchestes* sp.	R. Norton (pers. comm.)
	Adamystoidea	Adamystidae		
	Labidostommatoidea	Labidostommatidae	*Labidostomma* (nr. *plumosum)*	Greenberg (1952)
	Eupodoidea	Eupodidae	*Eupodes* sp.	Strandtmann (1964)
		Rhagidiidae	*Coccorhagidia* sp.	R. Norton (pers. comm.)
	Tydeoidea	Paratydeidae		Baker (1950)
	Bdelloidea	Bdellidae	*Bdella* sp.	Atyeo (1960)
		Cunaxidae	*Cunaxa* sp. *Cunaxoides* sp. *Neocunaxoides* sp.	Smiley (1974) " "
	Pygmephoroidea	Scutacaridae		Delfinado (1976); Mahunka (1964)
	Tarsonemoidea	Tarsonemidae		
	Raphignathoidea	Cryptognathidae	*Cryptognathus* sp.	Summers (1965); Summers & Chaudhri (1966)
		Stigmaeidae	*Ledermuelleria modiola* *L. plumifer* *L. segnis* *L.* (nr. *pectinata)* *Stigmaeus* (nr. *mimus)*	Summers (1962); Summers & Price (1961) " " "
		Caligonellidae	*Caligonella* sp.	Summers & Schlinger (1955)
		Camerobiidae	*Neophyllobius* sp.	Gerson (1972); McGregor (1950)
	Cheyletoidea	Cheyletidae	*Cheyletomorpha* sp. *Eucheyletia* sp. *Neoeucheyla* sp.	Summers & Price (1970) " "
	Tetranychoidea	Tetranychidae	*Bryobia* sp.	Baker & Tuttle (1972)
	Tetranychoidea	Tenuipalpidae		
	Caeculoidea	Caeculidae	*Caeculus* sp.	"
		Anystidae	(nr. *Bachsteinia)*	"
	Erythraeoidea	Smarididae	*Fessonia* sp.	Southcott (1963)
	Trombidioidea	Trombidiidae	(nr. *Parathrombium)*	W. Welbourn (pers. comm.)

Order	Superfamily	Family	Genus/species	Source of Identification
Actinedida (cont.)		Trombiculidae	*Euschoengastia ambocalis* *E. numerosa*	Brennan & Goff(1977); Brennan & Jones (1954); Wrenn & Loomis (1973)
Astigmata	Acaroidea	Acaridae	*Tyrophagus* sp.	Johnson & Bruce (1965)
		Glycyphagidae		
Oribatida (Cryptostigmata)	Ctenacaroidea	Aphelacaridae	*Aphelacarus* sp.	R. Norton (pers. comm.)
		Ctenacaridae	*Beklemoshiva* sp.	"
	Brachychthonoidea	Brachychthonidae	*Eobrachychthonius* sp.	"
			Sellnickochthonius (*zelawaiensis* grp) *Poecilochthonius* sp.	" "
	Cosmochthonoidea	Cosmochthonidae	*Cosmochthonius* sp.	"
		Haplochthonidae	*Haplochthonius variabilis*	"
		Sphaerochthonidae	*Sphaerochthonius* sp.	"
	Protoplophoroidea	Protoplophoridae		"
	Collohmannoidea	Phthiracaridae	*Phthiracarus* sp.	R. Norton (pers. comm.)
	Nothroidea	Camisiidae	*Camisia* (*segnis* grp.)	"
	Hermannioidea	Hermaniellidae	*Hermaniella* sp.	"
	Gymnodamaeoidea	Gymnodamaeidae	*Gymnodamaeus* sp. *Joshuella* (nr. *striata*)	" "
		Licnodamaeidae	*Licnodamaeus* sp.	"
	Belboidea	Damaeidae	*Epidamaeus* (nr. *longiseta*)	"
	Eremaeoidea	Eremaeidae	*Eremaeus stitkos* *Kartoeremaeus* sp.	" "
	Liacaroidea	Liacaridae	*Liacarus* (nr. *bidentatus*)	"
		Xenillidae	*Xenillus* sp.	"
		Metrioppiidae	undet. genus	"
	Carabodoidea	Tectocepheidae	*Tectocepheus* sp.	"
	Oppioidea	Oppiidae	*Oppiella* (2 species)	"
	Oribatelloidea	Tegoribtidae	*Lepidozetes* sp.	"
	Ceratozetoidea	Ceratozetidae	*Ceratozetes* sp. *Ceratozetes* sp. nov.	R. Norton (pers. comm.) V. Behan-Pelletier (pers. comm.)
			undet. genus *Chamobates* sp.	" R. Norton (pers. comm.)
		Mycobatidae	*Zatvatkinobates* sp.	"
	Oribatuloidea	Oribatulidae	*Phaulopia* sp.	"
		Haplozetidae	*Peloribates* sp.	"
		Scheloribatidae	*Scheloribates* sp.	"

Order	Superfamily	Family	Genus/species	Source of Identification
Oribatida (cont.)	Galumnoidea	Phenopelopidae	*Propelops* sp. P. (*canadensis*/ *rossica* grp.)	R. Norton (pers. comm.) "
		Galumnidae	*Galumna* sp.	"

author (date) = literature used for identifications
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Entomological Bibliography of the California Islands: Supplement 2

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Introduction

This bibliography supplements Miller & Miller (1981) and Miller (1985) in compiling references to insects, arachnids and myriapods of the California Islands: the Channel Islands, Los Coronados Islands and the islands in the San Francisco Bay Region. Islands off Baja California, Mexico, are excluded. Papers contributing to any area of knowledge of California Island entomology are included except for those only giving checklist entries.

Since publication of Miller & Menke (1981) and Miller (1985), many papers have been published, and additional older papers have been located. Notable among the new publications is the proceedings of the 1981 symposium on California Islands insects (Menke & Miller 1985). Format follows the earlier bibliographies; papers not included in this list that are cited in cross references may be found in the earlier bibliographies. The abbreviation "TL" means type locality. A subject index is included. Literature search for this supplement was updated to September 1991. Further supplements are planned as sufficient additions accumulate.

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