TABLE II. Survival of *Poria weirii* in potted wood cubes.

Treatment	Number of cubes		
	Total	w/zone lines	w/*P. weirii*
NH_4Cl	30	0[1]	0
$NaNO_3$	30	1[2]	1
Check	30	15	14

[1] Five additional cubes had traces of zone lines.
[2] Two additional cubes had traces of zone lines.

Previous observations have led to the hypothesis that *P. weirii* survival is reduced in soil under red alder because of large amounts of NO_3^- in these soils. Nitrate is unavailable to *P. weirii,* a fungus lacking the enzyme nitrate reductase, but usable by many of its competitors in the soil-wood environment (Li *et al.,* 1967).

Apparently, high levels of nitrogen, either as NO_3- or NH_4^+, can decrease survival of *P. weirii.* The additional supply of nitrogen apparently stimulates development of soil micro-organisms which invade the colonized wood cubes and replace *P. weirii.* Another possible but less likely explanation is that the higher levels of nitrogen inhibited formation of zone lines by *P. weirii*—zone lines are suspected of resisting invasion of the *Poria*-colonized substrate. The problem in field application of nitrogen fertilizers might well be getting the nitrogen to the place in the soil where its effect is desired.

Modified field studies are planned to further examine effects on survival of *P. weirii* of nitrogen form and level as well as time and method of application.

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The Distribution of Ground-Dwelling Beetles in Relation to Vegetation, Season, and Topography in the Rattlesnake Hills, Southeastern Washington*

Introduction

The ecological distribution of insects in the semiarid shrub steppe region of south eastern Washington has received little study. This paper reports the results of pitfall-trap survey of four common species of ground-dwelling beetles inhabiting rel tively undisturbed plant communities in the Rattlesnake Hills, Benton County, Was ington during 1966 and 1967.

The major land use of the northeasterly facing slopes of the Rattlesnake Hil prior to 1943 was livestock grazing. After 1943, this area was incorporated int the United States Atomic Energy Commission's Hanford Reservation and since the only occasional grazing has occurred mostly confined to the vicinity of a few widel scattered watering places.

The northeasterly facing slopes of the Rattlesnake Hills have not received dire applications of chemical insecticides or weedicides and probably represent the lea man-modified landscape now available for ecological study within the shrub step region of southeastern Washington.

Description of Study Sites

Eight study sites were established at different elevations ranging between 460 an 3,450 feet. The sites were spread over a straight line distance of about eight mile Site number one is 460 feet above mean sea level located on more or less lev topography. The soil is coarse sand with buried cobbles and boulders. The dominar vegetation is big sagebrush (*Artemisia tridentata*) and bitterbrush (*Purshia tridentata* with a sparse herbaceous understory comprised mostly of Sandberg bluegrass (*Po secunda*) and cheatgrass brome (*Bromus tectorum*). Site number two is at an elevatio of 530 feet. This site is floristically and topographically similar to site number on Site number three is located on a gentle slope at 630 feet in elevation. The vegetatio is dominated by big sagebrush with a few scattered clumps of spiny hopsage (*Gray spinosa*). The understory is comprised mostly of Sandberg bluegrass, cheatgra brome, and a few scattered plants of carey balsamroot (*Balsamorhiza careyana*) The soil profile lacks stones and is less sandy than sites one and two. Site numb four is located on a gentle slope at 925 feet elevation. Big sagebrush is the onl shrub. The understory is dominated by large perennial bunchgrass, especially blu

* This paper is based on work performed under United States Atomic Energy Commissio Contract AT(45-1)-1830.

bunch wheatgrass (*Agropyron spicatum*). Sandberg bluegrass also contributes to herbaceous ground cover, but cheatgrass brome is sparsely represented. The soil profile is essentially free of stones and has about the same texture as site number three. Site number five is located at an elevation of 1,470 feet on a gentle slope. Shrubs are absent from this site as a result of a wildfire in the summer of 1957. The understory vegetation and soil are similar to site number four. Site number six is located at 2,500 feet on a narrow but rounded ridge crest. The only shrub is big sagebrush which is much reduced in stature when compared to that of sites at lower elevations. The understory vegetation is similar to sites four and five, but the soil contains many basaltic stones. Site number seven is located near the head of a shallow valley at 3,100 feet. The soil here is somewhat less stony than site six, but vegetatively, the sites are similar. There is a noticeable tendency for sagebrush plants to be aggregated into clumps at sites seven and eight rather than to be more or less evenly distributed as they are in the stands at the lower elevations. Site number eight is located at 3,450 feet on a gentle slope just below the main crest of the Rattlesnake Hills. The soil and vegetation are similar to site number seven, but the understory grasses cover the ground more completely, and Idaho fescue (*Festuca idahoensis*) also occurs and contributes to ground cover for the first time. Photographs of six of the study sites comprise Figure 1. The amount of canopy cover provided by shrubs on a 20 x 50 meter plot adjacent to each study site is presented in Table I.

Trapping Method

Metal cans four inches in diameter and six inches tall were used as pitfall traps. Five cans were buried to their rims and arranged in a line with approximately three meters spacing between the cans. Small holes were punched into the bottom of each can to allow water from rainy periods to percolate into the underlying soil. All traps were visited weekly throughout 1966 and 1967, except in winter when the cans were closed. At each visit, the trapped beetles were removed, identified and counted. All beetles were killed in 1966, but in 1967, they were released near the sites of capture.

Results and Discussion

Four species comprised most of the trap catch. These were *Eleodes hispilabris, Pelecyphorus densicollis, Stenomorpha puncticollis* (Tenebrionidae), and *Calosoma luxatum* (Carabidae). Other Tenebrionid beetles occurred occasionally in the traps, especially *Coniontis setosa, Eusattus muricatus* and *Eleodes* spp.

The week to week trap catch in 1967 is shown in Figure 2. These data clearly show two seasons of beetle activity, one in spring and one in autumn. The emergence of *Pelecyphorus* and *Stenomorpha* was confined to a ten-week period in September, October, and November. The peak catch of *Calosoma,* 56 beetles, occurred the week ending March 6. *Calosoma* did not appear in the traps in late summer or autumn. *Eleodes hispilabris* was present throughout the year except in winter. It was most often trapped in the period from May 8 to June 5 when 24-26 beetles were caught per week. The catches were smaller during the hot, dry months of July and August.

The total trap catch at the eight sites arranged according to increasing elevation during 1966 and 1967 is shown in Table II. These data show that *Calosoma* was

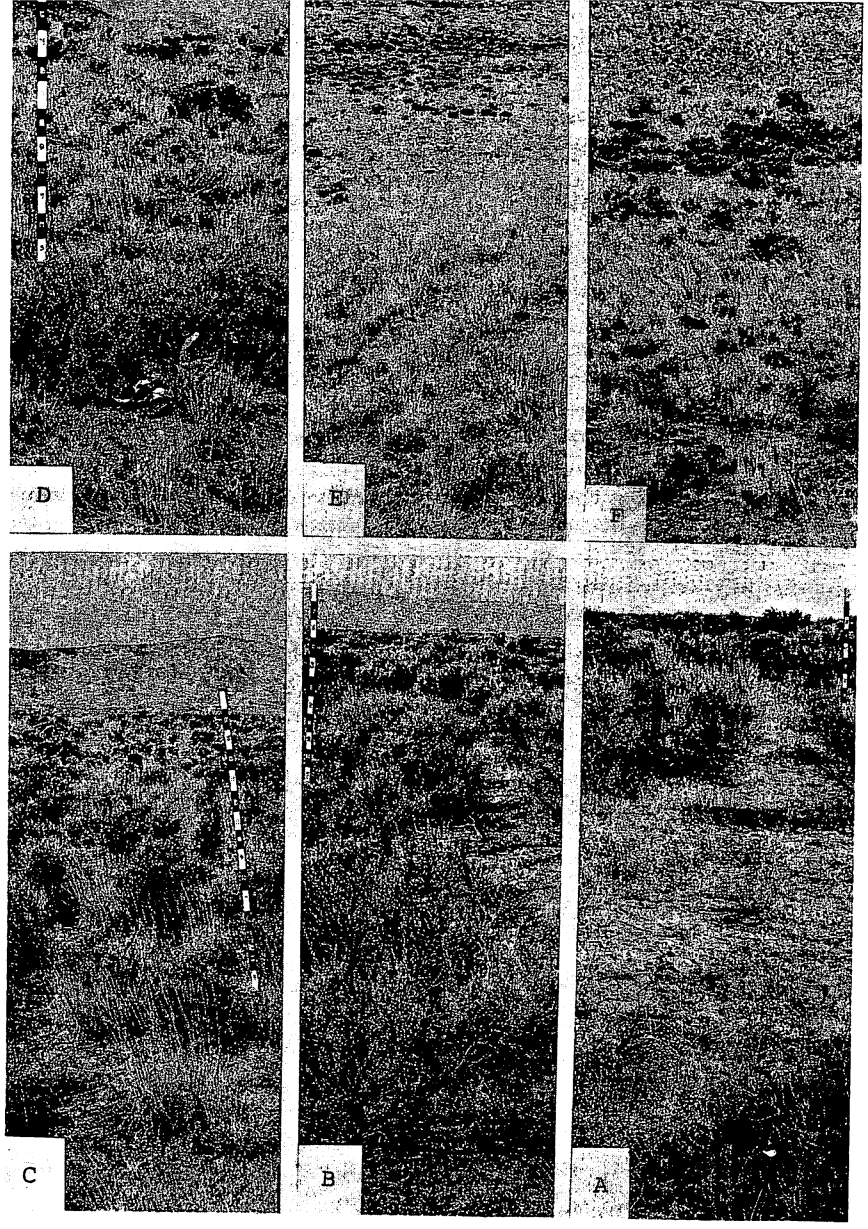

Figure 1. Photographs of six study sites along an elevational transect in the Rattlesnake Hill: A. Site number two located in sagebrush and bitterbrush shrub vegetation with a understory of cheatgrass brome. B. Site number three located in sagebrush vegetatio with an understory consisting mostly of sandberg bluegrass. C. Site number fou located in sagebrush vegetation with an understory of bluebunch wheatgrass. D. Sit number six located in sagebrush vegetation on thin stony soil with an understory c bluebunch wheatgrass. E. Site number seven showing the clumping of sagebrush i a shallow valley. F. Site number eight showing clumped sagebrush. The bunchgrasse are a mixture of bluebunch wheatgrass and Idaho fescue.

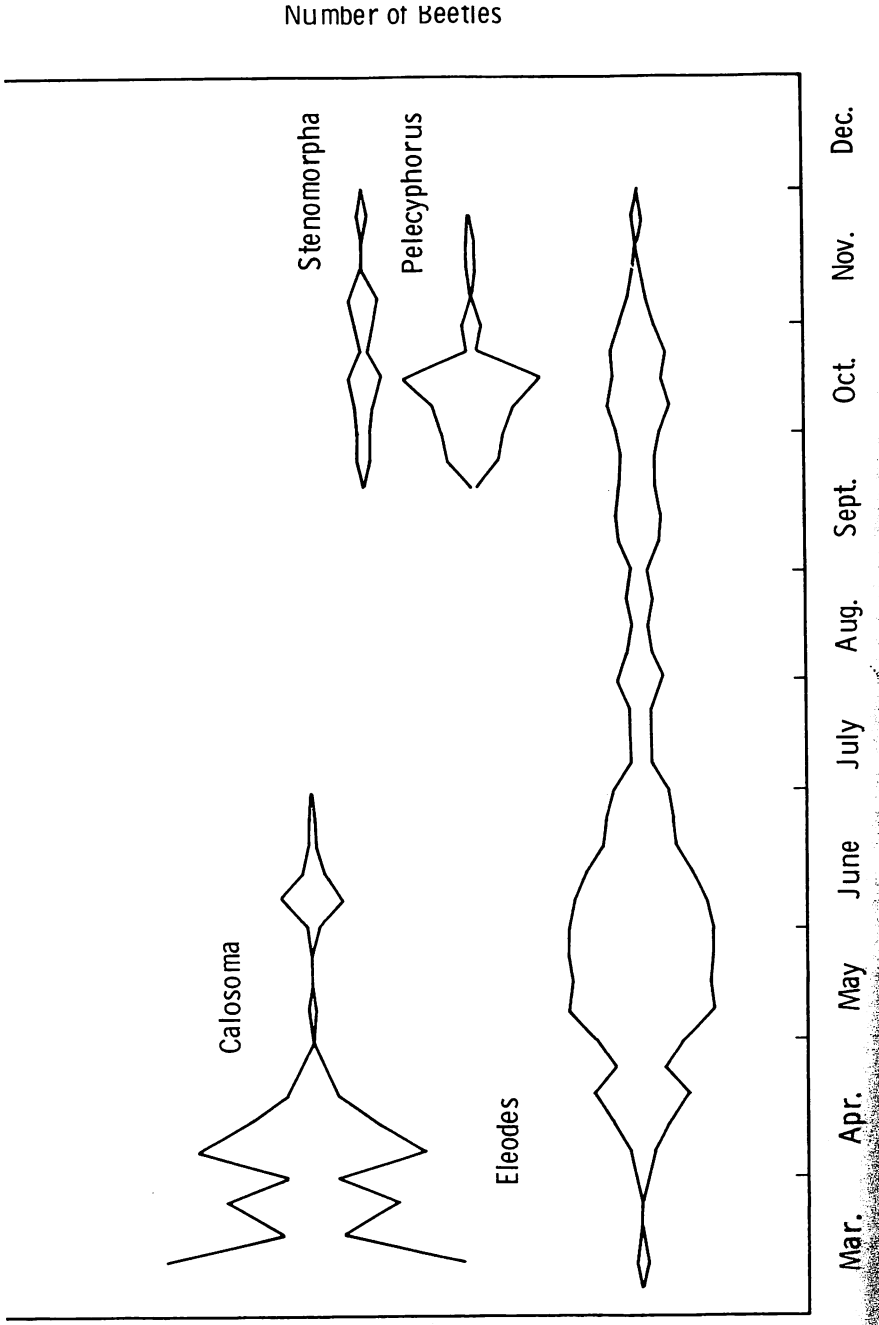

TABLE I. Percent of Ground Cover Contributed by Shrubs at Eight Sites in the Rattlesnake Hills, Benton County, Washington, 1967.

SITES ELEVATION (FT.)	1 460	2 530	3 630	4* 925	5*[1] 1470	6* 2500	7* 3100	8 3450
Big sagebrush *Artemisia tridentata*	5.9	17.7	24.7	10.8		7.1	9.7	10.4
Bitterbrush *Purshia tridentata*	1.8	10.4						
Rabbitbrush *Chrysothamnus* spp	5.5						2.4	4.3
Spiny hopsage *Grayia spinosa*			2.0					
Purple sage *Salvia dorii*	1.2							
Snow Eriogonum *Eriogonum niveum*	—	—	—	—	—	—	—	—
TOTALS	19.6	29.3	26.7	10.8	0.0	7.1	12.1	14.7

[1] Shrubs destroyed by wildfire, 1957.
* Bluebunch wheatgrass dominates the understory in these plots.

TABLE II. Distribution of Trap Catch of Beetles Along an Elevational Transect in the Rattlesnake Hills During 1966 and 1967. Sites are Arranged According to Increasing Elevation.

	SITES									
	1	2	3	4	5*	6	7	8	TOTAL	YEAR
Calosoma	59	39	23	12	0	3	0	1	137	1966
	89	97	17	5	0	0	0	0	208	1967
	148	136	40	17	0	3	0	1	345	
Eleodes	48	75	75	60	33	100	16	14	421	1966
	134	75	58	23	9	37	9	7	342	1967
	182	150	133	83	42	137	25	21	763	
Pelecyphorus	110	5	37	176	235	27	0	1	591	1966
	52	2	6	1	4	2	0	0	67	1967
	162	7	43	177	239	29	0	1	658	
Stenomorpha	0	0	25	10	15	3	13	12	78	1966
	0	0	6	7	4	4	0	2	23	1967
	0	0	31	17	19	7	13	14	101	

* Wildfire disturbance 1957.

most often trapped in the low elevation big sagebrush-bitterbrush vegetation sites Nos. 1 and 2, less often caught at sites 3 and 4, but only occasionally represented in other sites. The catch of *Pelecyphorus* showed an erratic distribution marked by a dramatic reduction in total catch in 1967 as compared to 1966. The high elevation sites 7 and 8 recorded only one *Pelecyphorus* during the two years of study. The catch of *Stenomorpha* was different from other beetles in that it was not caught at all in the two *Artemisia-Purshia* sites. These findings agree with general field observations made in this kind of vegetation. *Eleodes hispilabris* occurred at all sites but the smallest catches were made at the high elevations.

The winter months of December and January are generally too cold for above-ground beetle activity. As warmer temperatures prevail towards the last of February and early March, there is an emergence of *Calosoma* that persists through the spring mostly restricted to the lower elevations.

The hottest and driest months of the year, July and August, are characterized by low beetle catches. Only the nocturnally active *Eleodes hispilabris* consistently appeared in the traps. In September, as temperatures begin to cool, the emergence of adult *Pelecyphorus* and *Stenomorpha* takes place.

The onset of cold winter weather kills adult *Pelecyphorus* and *Stenomorpha. Eleodes,* however, live through the winter as adults by retreating below ground through rodent holes or cracks in the soil (Wakeland, 1926). The fate of adult *Calosoma* is not known.

It is expected that the altitudinal rise of the Rattlesnake Hills with its associated cooler temperatures (Rickard, 1968) would play an important role in determining the distribution of ectothermic beetles. The trap catches of *Calosoma, Pelecyphorus,* and *Eleodes* show that the catch was smaller with increasing elevation. Perhaps the most unexpected finding is the absence of *Stenomorpha* from the two low elevation sites. Such a geographic distribution suggests that an environment characterized by high summer temperatures and/or soil drought, soil texture or combinations of these factors may be limiting for *Stenomorpha.*

The ecological role of the phytophagous beetles is not known. The larvae reside in the soil and have the potential to graze on roots for periods of two years or more. The impact of larvae on plants would be detrimental if the larvae damaged living roots. If, on the other hand, larvae are mostly consumers of dead plant material, especially roots, their role as decomposer organisms would be beneficially linked with making scarce essential minerals, e.g., nitrogen, available for plant uptake.

Phytophagous beetles are not known as agricultural pests in southeastern Washington, but *Eleodes hispilabris* has been described as a serious pest to dryland wheat in southern Idaho (Wakeland, 1926).

Summary

A pitfall trap survey of ground-dwelling beetles was conducted in relatively undisturbed shrub steppe vegetation distributed along the elevational gradient of the Rattlesnake Hills in southeastern Washington during 1966 and 1967.

Four species comprised most of the trap catch. *Eleodes hispilabris* occurred throughout the elevational range but was more abundant at lower elevations. *Calosoma luxatum* was abundant at low elevations but nearly absent at high elevations. *Pelecyphorus densicollis* showed an erratic distribution along the elevational gradient and large differences in total catch between the two years of observation. *Stenomorpha puncticollis* was seldom trapped and was lacking from the low elevations supporting vegetation dominated by big sagebrush and bitterbrush.

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