# HIGH ALTITUDE AEOLIAN ECOSYSTEMS IN THE HAWAIIAN ISLANDS

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## ABSTRACT

Preliminary investigations on the summits of Mauna Kea, Mauna Loa, and Haleakalā indicate that a substantial invertebrate fauna inhabits the barren alpine zones on the islands of Hawai'i and Maui. These animals are predator-scavengers which feed on wind-transported allochthonous (aeolian) insects blown up from the highly productive ecosystems at lower altitudes. Large quantities of alate aphids, psyllids, and other small-bodied insects have been collected on all three summits.

The secondary consumers thus far collected include large *Lycosa* spiders, micropterous Nysine lygaeids, and at least one species of flightless moth. These predator-scavengers reside in barren lava and cinders, and depend almost entirely upon primary consumers transported by wind from distant ecosystems.

Alpine aeolian ecosystems on Hawai'i's major volcanoes may represent some of the most primitive ecosystems on the planet, as well as examples of early terrestrial life systems as they existed on the primordial continents.

Insects and other arthropods at higher altitudes in Hawai'i have been studied in a cursory manner (Bryan 1923, 1926; Swezey & Williams 1932; Usinger 1936; Wentworth, Coulter, & Hartt 1935; Beardsley 1966) but no serious long-term investigations on Hawai'i's summits have yet been conducted. The International Biological Program (IBP) research conducted on Mauna Loa extended only to Pu'u 'Ula'ula (3054 m), although Howarth (1979*a*) studied aeolian ecosystems on new lava flows near Kilauea under IBP. Usinger (1936) speculated that *Geocoris pallens* Stål was predacious on the summit of Mauna Kea, probably feeding on weakened windborne insects. The author has made investigations on the summit of Mauna Kea (1975), Haleakalā (1976), and Mauna Loa (1978, 1979). The recent discovery by Howarth and Montgomery of a predator-scavenger *Nysius* on the summit of Mauna Kea, which was observed feeding on hypsotactic coccinellids, and the discovery of a large subadult *Lycosa* sp. near the 1949 cone on the summit of Mauna Loa in August 1979 by Papp reinforce earlier observations. Indications from these studies are that a substantial invertebrate fauna inhabits high altitudes on Hawai'i and Maui.

## PROCEDURES

### Proposed Biological Surveys

Using established methods for trapping windborne arthropods (Yoshimoto & Gressitt 1961; Papp 1978a, 1978c) the alpine aeolian faunas of Mauna Loa, Mauna Kea, and Hāleakalā will be sampled. Study sites will be established on Mauna Kea and Mauna Loa beginning near the upper limit of vegetation (3000 m) and spaced at approximately 240 m altitude intervals to the summits. On Mauna Loa access trails are maintained only on the N flank (Observatory Trail) and on the NE flank (Mauna Loa Trail via Red Hill). Due to the frequent seismic activity and the possibility of an imminent flank eruption, study sites on Mauna Loa will be limited to locations accessible by trail or road, permitting rapid evacuation if necessary. On Mauna Kea, a dormant volcano, sites will be located along the access road which follows the S flank from Hale Pōhaku Ranger Station to the summit. A number of branches of this road in the summit area will permit establishment of replicate study sites on prominent cinder cones. Haleakalā has a paved access road on the W flank and a good trail system through the crater which exits through Kaupō Gap on the SE. A total of 24 sites--11 on Mauna Loa, 9 on Mauna Kea, and 3 on Haleakalā--will be established.

Three types of traps will be utilized at each study site. A sticky trap consisting of framed hardware cloth sprayed with a resinous adhesive will be anchored to the lava surface in a horizontal plane. A wind sock trap of the type designed by Gressitt, Leech, and O'Brien (1960) for use in the Antarctic, will be fixed on a pole imbedded in the lava. Finally, pitfall traps consisting of 10 x 12 cm glass jars partially filled with ethylene glycol and detergent will be sunk into the lava to trap terricolous predators and scavengers resident in the aeolian zone.

Sites will be conspicuously marked so traps can be initially transported by helicopter and be made operational by a ground crew in one day. Each site will then be visited at monthly intervals to inspect traps and collect the contents. Sticky traps will be removed from frames and replaced by clean traps, with the used traps rolled and inserted in labeled mailing tubes. Wind sock traps will be removed from poles and emptied into labeled ziploc polyethylene bags, then replaced. Pitfall traps will be emptied into labeled aluminum cannisters and refilled with the ethylene glycol-detergent. All trap contents will be transported to Hawaii Volcanoes National Park for preliminary sorting, then shipped to B. P. Bishop Museum, Honolulu, for assignment to systematist-collaborators.

As determinations are received, preliminary models of fallout composition, frequency, and density will be constructed. Predator-scavenger population densities can be concurrently determined using capture-recapture techniques and the Lincoln Index (Southwood 1966) while collateral laboratory studies with live predators at Hawaii Volcanoes National Park can be used to establish prey preferences. The origin(s) of arthropod fallout can be determined by coupling analysis of wind patterns from the Cloud Physics Observatory and the Mauna Loa Observatory (NOAA) with the distribution of plant hosts for trapped insects. This technique has been used successfully by Papp (1978a) to fix the origins of many aeolian components of arthropod fallout in the Sierra Nevada.

Comparison of aeolian fallout density on the three mountains can be achieved using indexes previously developed for community analysis (Sorenson 1948; Pielou 1966; Southwood 1966; Murdoch et al. 1972). The same techniques can be used to compare diversity of predator complexes. This should yield a relative chronology that can be used to establish a time frame for the evolution of Hawaiian high altitude aeolian ecosystems.

## THE AEOLIAN MODEL

Once the components described above are determined, a model can be constructed to integrate each of the following aspects of the aeolian ecosystem: macroclimate (as it applies to the inputs of aeolian fallout); microclimate (as it applies to the distribution and activity of aeolian predators); origins of fallout; taxonomic composition of fallout; diurnal (daily) and seasonal variation in fallout; nutrient biomass; population density of predators; spatial and temporal distribution of predators.

Because of the geological time scale available in Hawai'i, it may be possible to observe both well-established aeolian ecosystems on Haleakala and Mauna Kea and incipient ones on recent lava flows (1950, 1975) on Mauna Loa. The geographical isolation of Hawai'i's mountains from continental land masses also insures that local fallout origins can be determined quite precisely.

## ECOLOGY OF HAWAIIAN MOUNTAINS

Hawai'i's high altitude arthropods have been collected for over 50 years (Bryan 1923, 1926; Swezey & Williams 1932; Wentworth, Coulter, & Hartt 1935; Usinger 1936; Beardsley 1966; Howarth 1979b; Montgomery & Howarth 1980; Papp, unpubl.), but no one has yet studied predation on windborne insects there. The presence of large diurnal lycosid predators on Mauna Loa and Mauna Kea indicates that true aeolian ecosystems are present there. Mull and others have collected many undescribed *Lycosa* spp. from aeolian, alpine, and subalpine sites in Hawai'i. These creatures have been observed also by the author on the NE flank and summit of Mauna Loa, and by personnel at the Mauna Loa Observatory on the N flank at 3350 m elevation. I have recently (August 1979) collected a large subadult male foraging on a pyroclastic cinder cone near the summit of Mauna Loa. Howarth (1979b) has described the larval habitat of Thyrocopa apatela (Wlsm.), a flightless moth which inhabits the aeolian zone on Haleakalā. Birds such as the endemic Hawaiian thrush, Phaeornis obscurus, may utilize aeolian fallout as food (Ziegler, pers. comm. 1978), and may actually breed in the alpine zone on Mauna Loa (Banko, pers. comm. 1980).

## SIGNIFICANCE OF THIS STUDY

Aeolian ecosystems were first recognized only 17 years ago. There is now sufficient evidence to support the contention that nival (snow) aeolian systems are probably present wherever snow is abundant on high mountains with a history of Pleistocene glaciations. However, most of the research to date has been conducted on mountains of relative antiquity (Himalayas, Rocky Mountains, Sierra Nevada) with substantial subalpine and alpine floras. No detailed high altitude aeolian research has yet been conducted on high tropical mountains or high island mountains. Würmli (1974) has studied biocenoses on Mt. Etna and found neo-endemic carabid beetles inhabiting south slopes on the central crater at 3000 to 3200 m altitude. Vegetation on Mauna Kea and Mauna Loa is virtually non-existent above 3000 m. Vast stretches of barren lava, some of it only recently erupted (1975), cover much of the landscape. Atmospheric humidity is low, and available water scarce; atmospheric pressure is less than 75% of that at sea level, and oxygen tension near the summits is only 114 mm Hg. These conditions are among the most rigorous on earth, and yet life survives, perhaps even flourishes there.

The concept of an entire community of predators, adapted to arctic-alpine conditions on the summits of island mountains in the tropical central Pacific, completely dependent on a far distant trophic base, is exciting indeed. The opportunity to study the colonization of vacant aeolian niches (i.e., in recent alpine lava flows on the summit and NE rift zone of Mauna Loa) also may provide valuable insights into the basic requirements for life at high altitudes. Possibilities also exist for studying dispersal and dispersion of terricolous arthropods in alpine aeolian zones. These volcanoes are perfect natural laboratories for ecological studies of a fundamental nature: the processes by which land animals invade and inhabit the more inhospitable regions of the planet earth.

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