Scientific Report of the

KIPAHULU VALLEY EXPEDITION

Sponsored By:
THE NATURE CONSERVANCY

Edited By:
Richard E. Warner, Ph.D.
Expedition Leader

MAUI, HAWAII
2 August-31 August, 1967

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FRONTISPIECE (see following page):

A panoramic view of Kipahulu Valley from the upper rim, elevation 7350 ft. We are looking southwest. Beyond the valley lies the Pacific Ocean. Pictured below are some of the expedition members, photographed in the field.

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SOME OF THE GROUP

1. Win and Paul Banko
2. Hampton Carson
3. Richard Warner
4. The trail cutting crew
5. Nixon Wilson, Bob DeWreede and Garrett Smathers
6. Andrew Berger and Martin Griffin
7. Jack Lind
8. Charles Lamoureux
9. The supply crew

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*Dr. John A. Maciolek, leader of the University of Hawaii Cooperative Fishery Unit, made a separate expedition several weeks after ours. His study is a valuable addition to our report.

CHAPTER 1

GENERAL CONSIDERATIONS, CONCLUSIONS, AND RECOMMENDATIONS

Richard E. Warner

Introduction

This document is the scientific report of the Kipahulu Valley Expedition sponsored by The Nature Conservancy. The field aspects of the project, that is, the expedition itself, encompassed the period from 2 August to 31 August, 1967. Actually, planning for the expedition began in July, 1967; analysis of data and specimens, and writing of reports, has continued until December, 1967. Thus, approximately 40 man months have gone into the project. It is a lasting tribute to those specialists and friends of the expedition who so willingly devoted their energies and resources to this enterprise that the project, which if paid for at the current rate for specialists and logistic support would have cost at least $50,000.00, was accomplished at a fraction of that amount.

The Nature Conservancy is especially thankful for the grant of $5,000.00 to the expedition by the U.S. Department of Interior, National Park Service. This was instrumental in the success of the expedition.

Objectives

The principal goals of the expedition were the following:

1. to gather basic information on the distribution, abundance, and character of the biota of Kipahulu Valley;

2. to integrate these data with information on soils and climate into an ecological overview of the region;

3. to determine the value of Kipahulu Valley in its present natural state to science and to mankind in general; and

4. to prepare a report of findings for the Nature Conservancy and the U.S. Department of Interior, including recommendations for aquisition, use, and longterm conservation of the area.

The time available for the expedition was limited; as a consequence not all objectives were fully achieved. However, the competence of the expedition staff, and the excellence of cooperation and assistance rendered by friends of the expedition were such that this report is submitted with full confidence in the data and conclusions presented, and the recommendations offered.

General Plan of Operations

As can be seen in the accompanying map, the valley itself extends from sea level to an elevation of 2260 meters (7350 feet) in an approximately northwest direction. The valley floor is composed of two roughly parallel surfaces, one about 190 meters (600 feet) above the other, extending the length of the valley. The discontinuity between them is variously referred to as the central ridge, pali, or pali-escarpment. This discontinuity extends the length of the valley, being very precipitous at the lower elevations but gradually becoming less steep as the valley head is reached. The valley itself is bounded on both the northeast and southwest sides by enormous palis or cliffs, at the bases of which are streams. That on the northeast side is called Palikea Stream, that on the southwest Koukouai Stream. The valley floor is transected in many places by streams and stream canyons of various sizes, most of them unmapped and unnamed.

For logistical reasons it was concluded wisest to penetrate the valley from the lower end, gradually extending the trail system and supply line upward into the rainforest, and finally emerging at the edge of Haleakala Crater. While this meant that all supplies had to be packed upward, it also permitted the expedition to utilize the transportation and housing facilities of Kipahulu Cattle Company, located at the base of the valley. The Hana Airport is a 45 minute drive from Kipahulu Cattle Company by a slow but picturesque and all-weather road. We could thus provide logistic support for scientists who could be with the expedition for a limited time only. The proximity of ranch and airport also materially faciliated the transfer of equipment, supplies, specimens and film to and from the research area.

Three successive basecamps were established along the central or ridge trail. Basecamp 1 was at 950 meters (3100 feet), Basecamp 2 at 1270 meters (4100 feet), and Basecamp 3 at 2000 meters (6500 feet). Basecamp 1 was operational from 2 August to 13 August; Basecamp 2 from 8 August to 23 August; and Basecamp 3 from 21 August to 30 August.

Food and scientific supplies were brought in periodically by porter. At higher elevations dried foods were used extensively to reduce the weight and bulk to be packed in. Specimens, film, and mail were sent out by the same means.

Because of the extreme conditions at Basecamp 1, with torrential rains and deep mud owing to poor drainage of the region, the tents were placed on platforms of treefern trunks which had been cut, placed side by side, and covered with a layer of treefern fonds. These platforms proved invaluable, for they raised the living surface well above the mud, and protected equipment and supplies from becoming wet. They also acted as islands during periods of flooding. One night (7 August to 8 August) we experienced an inundation that continued for approximately 12 hours, the rain gauge registering 8.9 inches when it finally subsided, leaving us in a sea of brown water. Physical damage was negligible, although the effects on our nerves was demonstrable.

By extreme good fortune no serious injuries were sustained throughout the expedition, despite the difficult terrain and taxing climatic circumstances. Approximately four man days were lost due to colds; digestive upsets were extremely rare, approximately one man day being lost by this cause. Probably because of the high humidity of the area, cuts and abrasions were very slow to heal, and readily became infected. Above 860 meters (2800 feet) no mosquitoes were encountered. Temperatures were never disagreeably hot or cold, although one perspired freely with exertion because of the uniformly high humidity. Future visitors to the area, especially the lower elevations of the valley, may therefore expect continually wet clothing and muddy hiking conditions to be the principal difficulties.

On 30 August we climbed out of the valley and descended into Haleakala Crater, spending the night at Paliku Cabin (see Figure 52). On 31 August we hiked down Kaupo Gap to the roadhead where vehicles were waiting, and returned to Kipahulu where we brought the expedition to a proper and fitting close with a traditional Hawaiian luau or feast.

Expedition Members

A total of fourteen specialists were involved for varying lengths of time in the field activities. In addition, a supporting crew of trail cutters, porters, and technical assistants raised the total count of participants to approximately 28. Some of the specialists were with the field party for only a few days; others participated throughout, the principal determinants being amount of time each had available for field research and the time required for completion of specific studies.

Expedition members and their affiliations are listed below:

Winston Banko	Research Biologist, Bureau of Sport Fisheries and Wildlife, U.S. Department of Interior, P. O. Box 35, Hawaii National Park, Hawaii.
Paul Banks	Research Assistant to Winston Banko. Address as above.
Dr. Andrew Berger	Professor and Chairman, Department of Zoology, University of Hawaii, Honolulu, Hawaii.
Dr. Hampton Carson	Professor, Department of Entomology, University of Hawaii, Honolulu, Hawaii.

Robert DeWreede	Plant Ecologist, Department of Botany, University of Hawaii, Honolulu, Hawaii.
Dr. Martin Griffin	Physician and Photographer, 313 Goodhill Road, Kentfield, California.
William Hoe	Bryophytologist, Department of Botany, University of Hawaii, Honolulu, Hawaii.
Robert Howell	Research Assistant to Richard Warner. Hana, Maui.
Robert Iwamoto	Entomologist, Department of Entomology, University of Hawaii, Honolulu, Hawaii.
Paul Kaiwi	Trail Crew, Kipahulu Cattle Company, Kipahulu, Maui.
Mike Kambysellis	Entomologist, Department of Entomology, University of Hawaii, Honolulu, Hawaii.
Ken Kaneshiro	Entomologist, Department of Entomology, University of Hawaii, Honolulu, Hawaii.
Dr. Charles Lamoureux	Professor, Department of Botany, University of Hawaii, Honolulu, Hawaii.
Dr. Frederick Landers	Logistics; 47-348 Kamehameha Highway, Honolulu, Hawaii.
Jack Lind	Chief of Trail Crew; Manager, Kipahulu Cattle Company, Kipahulu, Maui.
Jeffery Lind	Trail Crew; Kipahulu Cattle Company, Kipahulu, Maui.
Terry Lind	Trail Crew; Kipahulu Cattle Company, Kipahulu, Maui.
Mike Muraoka	Entomologist, Department of Entomology, University of Hawaii, Honolulu, Hawaii.
Ali Navvab	Entomologist, Department of Entomology, University of Hawaii, Honolulu, Hawaii.
Garrett Smathers	Research Biologist, Hawaii Volcanoes and Haleakala National Parks, Hawaii.

Earl Smith	Trail Crew; Kipahulu Cattle Company, Kipahulu, Maui.
Randy Smith	Chief of Logistics and Supplies; Kipahulu Cattle Company, Kipahulu, Maui.
Jerry Swedberg	Wildlife Biologist, Hawaii Division of Fish and Game, Honolulu, Hawaii.
Dr. Richard Warner	Consultant to The Nature Conservancy as Expedition Leader; Principal Scientist, Foundation of Environmental Biology, Berkeley, California.
Dr. Nixon Wilson	Acarologist, B. P. Bishop Museum, Honolulu, Hawaii.

Note: The porters, which were supplied through the courtesy of Kipahulu Cattle Company, are not listed individually because at different times different ranch personnel were involved. Nevertheless, their contribution to the expedition was an important one, accomplished under exceptionally difficult circumstances.

Participating Organizations

A total of seven institutions or organizations actively participated in the Kipahulu Valley Expedition, providing specialists, supporting personnel, materials and supplies, and other assistance. Without the continued and unfailing support of these organizations the success of the expedition would have been greatly diminished. They are:

The Nature Conservancy

U.S. Department of Interior, National Park Service

U.S. Department of Interior, Bureau of Sport Fisheries and Wildlife

Departments of Botany, Entomology, and Zoology, University of Hawaii.

Kipahulu Cattle Company

Hawaii Division of Fish and Game

Bernice P. Bishop Museum

Foundation of Environmental Biology

Acknowledgements

In addition to the institutions and organizations above which cooperated so admirably in the various aspects of the expedition, several individuals contributed significantly to the endeavor. Mr. Michio Takata, Director of the Hawaii Division of Fish and Game; Dr. Roland Force, Director of the Bernice P. Bishop Museum; Dr. D. Elmo Hardy, Chairman of the Department of Entomology, University of Hawaii; Mr. Hamilton McCaughey, owner of the Kipahulu Cattle Company; Dr. Milton Howell, Head of the Hana Medical Center; Mr. Myron G. Burns, Manager of the Hana Hotel; Dr. John Murphy of the Department of Entomology, University of Hawaii; Mr. Joe Mederios, biologist with the Hawaii Division of Fish and Game; Mr. Huey Johnson, Western Regional Director for The Nature Conservancy; and Mr. Harry Hasegawa, manager of the Hasegawa Store, Hana, Maui; all were individually of great help in overcoming problems and furthering the progress of the expedition.

The Kipahulu Cattle Company, which provided the trail cutting crew, porters, and logistic support for the field activities was of great assistance to the expedition. Without its continued generous support in providing vehicles, housing at the base of the valley, personnel, and other indispensible assistance, the expedition could not have achieved what it did.

Lastly, drawing upon my prerogative as Expedition Leader and Editor of this report, I wish to express my sincere gratitude to the members of the expedition itself. Their unfailing cheerfulness in the face of incredible working conditions, their continued dedication to the task at hand, and their perserverance in following through until reports were completed despite the demands of other responsibilities, have made me extremely proud to be associated with them. To these men, and to the many others who worked so diligently toward bringing the Kipahulu Valley Expedition to a fruitful completion, grateful thanks are tendered.

Conclusions and Recommendations

While the results of the scientific studies are presented in the various chapters to follow, several conclusions are summarized below as they relate to Kipahulu Valley as an Ecological Reserve. The views expressed in the following quotations reflect the position of scientists who have had an opportunity to evaluate the Valley first hand with respect to their own areas of specialization.

1. Dr. Charles Lamoureux (Botany): ". . . We have recorded about 220 species of higher plants in the valley. Of these only 10% (23 species) are species introduced to Hawaii by man. In contrast, 50% of the species now growing in Kipuka Ki and Kipuka Puaulu in Hawaii Volcanoes National Park are introduced species, although these kipukas are justifiably famous as representing outstanding remnants of the original vegetation of Hawaii."

". . . The wide variety of plant communities available in a relatively short distance which could be preserved in Kipahulu would offer unparalleled research opportunities. Within three miles one can find communities ranging from a tropical rain forest to a sub-alpine zone with frequent frosts. Elsewhere in Hawaii today it would be nearly impossible to find this many undisturbed communities in such close proximity. Since most of the Hawaiian species of plants are endemic, these communities are like no others, and Kipahulu in this sense offers an opportunity not available elsewhere on this planet."

2. Robert DeWreede (plant ecology): ". . . it is my opinion that Kipahulu Valley, from a botanical and ecological standpoint is a site that must be preserved. It offers an area where disturbance by exotic plants and animals is still minimal, hence allowing the studying, viewing, and enjoyment of an area preserved much as it was when the Hawaiian people ruled the coastal areas."

3. Garrett Smathers (plant geography): "The entire area could become an outstanding laboratory to test certain hypotheses of pedogenesis. Soil scientists have been looking for areas in Hawaii to study soil genesis under the influence of native vegetation and climate. Rarely is such an area found because most of the native vegetation has been removed and replaced with non-native types."

4. Dr. Nixon Wilson (entomology): "Zimmerman (1948) lists three characteristics of an endemic insect fauna. These are: (1) most endemic insects are confined to native forest plants; (2) most endemic insects are confined to mountain forests; and (3) the majority of endemic species have a restricted geographical range. All of these features apply in one way or another to Kipahulu Valley and are indicative of its uniqueness as an area for native fauna."

5. Winston Banko (ornithology): "The occurrence of four rare birds in Kipahulu Valley, one previously considered extinct, points up the importance of retaining this area in a natural condition if populations of these birds are to be preserved. Elsewhere in Hawaii, many unique birds found nowhere else in the world have become extinct because of land use practices and environmental changes brought about by "civilized" man."

6. Dr. Hampton Carson (Evolutionary Genetics): "The unique opportunity to understand the evolutionary process through genetic study of Hawaiian Drosophila can hardly be overemphasized. Nowhere else in the world does such an opportunity exist. Furthermore, population genetics is not served by dry and dead specimens in museums. The living insect species, with its genetic system, serves as a clue to past evolutionary history. These considerations go beyond the esthetic. Reserves which allow these insects to survive the in-roads of modern development will provide material for understanding--'that mystery of mysteries--the origin of new beings on this earth' as Darwin put it."

Recommendations

The following recommendations are based on a concensus of opinion among the participating scientists.

(1) The Kipahulu Valley Ecological Reserve should definitely encompass the two lakes directly to the north of the valley itself, as well as a substantial portion of the Deschampsia grassland. These areas are of special significance and their inclusion into the Reserve of vital importance.

(2) The system of trails cut by the Kipahulu Valley Expedition should be maintained, and further extended to areas of special interest or beauty. Without an adequate trail system, continuing studies and use of the area are impossible. The trails should be very modest paths, permanently marked, and maintained by periodic cutting and without the use of herbicides.

(3) Immediate steps should be taken to reduce or eliminate the wild pig population within the valley, by any suitable means. Their damage to the vegetation is insidious but serious, and has in addition led to the establishment and spread of exotic plants in the valley.

(4) The feral goat population within and adjacent to the area should be removed immediately. It is a damaging influence both to the Haleakala National Park and to the upper portion of the proposed Reserve. Complete elimination of the feral goats would lead to better preservation of both areas.

(5) Simple, rustic rain shelters should be provided at selected locations, for use by scientists and other visitors to the area. These shelters should have raised floors, be sufficiently large to accommodate several people with their equipment, and be near to water or provide a suitable cistern for water storage. Fires at these sites should be limited to those using fuel brought in by the visitor.

(6) The use of horses or other livestock for travel in any part of the area, including the Deschampsia grassland, should be permanently prohibited and no exceptions made. This will not result in serious inconvenience, and will protect the area from physical damage and the introduction of undesirable exotic plant species.

(7) All human activity in the area, including specimen collecting and other scientific studies, should be under strict control. Any proposed activity that in any way modifies the area, including collecting for scientific purposes, should be rigidly controlled through a system of trespass and use permits, and such activities rejected if (a) they can be done in other areas, or (b) the effects of the activity will in any way diminish the natural values of the Reserve.

(8) There should be absolutely no introduction of new plant or animal species into the valley. Where possible, efforts should be made to remove established exotic plant species by suitable means.

CHAPTER 2

A PRELIMINARY REPORT ON THE ECOLOGICAL CONDITIONS OF KIPAHULU VALLEY, MAUI

by

Robert E. DeWreede

INTRODUCTION

Kipahulu Valley is located on the island of Maui, adjacent to the eastern edge of Haleakala National Park. It lies between 20° 40'00" North and 20° 44'30" North, running in a generally N.W. direction (upslope). A N-S line at 156°05' 00" East would pass through approximately the central area of the valley. (See Figure 57 for map of Kipahulu Valley.)

Kipahulu Valley consists of a valley to the east of the central pali (cliff), and a plateau which extends west of the central pali. This plateau eventually dips down again to form another valley, adjacent to the border of the national park. (Figures 1, 8, and frontispiece.) For this and subsequent figures, see Appendix A. Previous exploration parties came in from the top, and made their way down to the lower areas by way of the valley floor. The Kipahulu Expedition of the Nature Conservancy went from the bottom to the top by way of the central pali. Camps were established consecutively at three altitudes: 3100' (Camp 1), 4100' (Camp 2), and 6450' (Camp 3). A week to ten days was spent at each site.

Thanks to the extensive cooperation of the Kipahulu Ranch, without which the expedition would not have been possible, lateral trails were cut across the valleys at either side of the ridge, thus allowing for their exploration. Plants were collected, and some environmental measurements were made when possible. The difficulty of the terrain and the fact that all equipment had to be carried in on the back severely limited the choice of material. However, measurements of rainfall, temperature, and relative humidity were made, as well as some soil measurements of pH, soil color, and texture. The rainfall, temperature, and relative humidity (RH) measurements are of course by no means representative of the area, but they do at least show the conditions under which the exploration took place.

In general, the valley receives a lot of rain, probably well distributed over the year, though a slightly drier season may occur in the summer months. Yearly rainfall at the lower (to 5000') elevations is probably in the neighborhood of 175"-225". The RH is high, generally in the vicinity of 90%. Average temperatures vary with the altitude.

THE ENVIRONMENT

At all three camps the prevailing wind was the trade wind, coming from the N.E. At the higher altitudes, i.e. above 6000', the physical features of the valley tended to push the wind in the direction of the valley head, hence in a more north to northwesterly direction. One would generally expect a more varied wind pattern above 6000' anyway, since at this level one is above the inversion layer.

Table 1 below shows the average day and evening (0700-1900 and 1900-2300 hrs. respectively) temperatures at the three basecamps.

TABLE 1.

	Day	Evening	Range (in order)
3100', Basecamp 1	19.0°C	17.6°C	16.8° C-22.5° C 16.4° C-19.2° C
4100', Basecamp 2	18.4°C	16.3°C	13.4° C-20.4° C 13.9° C-18.0° C
6450', Basecamp 3	13.2°C	11.6°C	11.4° C-16.4° C 10.8° C-12.5° C

The temperature and humidity readings were taken with a Bendix Psychrometer, battery driven. Besides the limiting factor of time, already mentioned in the introduction, it is important to note that some bias in the temperature and the humidity readings was introduced by the author. During the rare sunny days, the members of the expedition were usually out collecting, hence these days tended to be neglected in terms of RH and temperature measurements; consequently the majority of the measurements were made during the wetter periods. On the other hand, the sunny days were so rare, a total of three or four out of a total of 24 days, that the bias is slight.

Daytime readings are based on 20-27 readings at Basecamps 1 and 2, with fewer readings at Basecamp 3. Evening readings are based on 10 to 14 at Basecamps 1 and 2, fewer at Basecamp 3.

It can be seen that the average temperature decreases as altitude increases, as is expected. Evening temperatures average 1-2° C lower than the daytime temperatures. The indicated ranges show a maximum range of 7° C. Since readings were taken as early at 0600 as well as in the afternoon from 1200-0200 hrs., this range is probably accurate for the time spent at the site. A small temperature range is what one would expect from an oceanic climate, especially in a very humid area.

Table 2 gives the RH readings at each camp. The same limitations as mentioned above apply here, as do the number of readings making up the average.

TABLE 2.

	Day	Evening	Range (in order)
3100', Basecamp 1	89.8%	89.4%	78%-98% 79%-98%
4100', Basecamp 2	90.8%	92.0%	80%-98% 86%-97%
6450', Basecamp 3	95.0%	92.5%	89%-99% 84%-99%

As can be seen, the average RH is very high, with the lower readings occurring on the rare sunny days. The high RH at 6450' is largely due to the presence of clouds, which often seem to form at this level. One hundred to two hundred feet above this level, the transition to the dry zone becomes evident. This high humidity at 6450' helps to keep the area moist, though the actual rainfall is much less here than at the lower camps. However, cloud interception and fog drip undoubtedly play an important part in the moisture regime at this altitude (6450'), and its more immediate surroundings. The porosity of the soil at this altitude is also important in determining the water balance, as the more porous the soil, the faster and more complete is the drainage. At 6450', the soil tends to be much more porous than at the lower elevations.

TABLE 3.

	Rainfall (total)	Day	Period Recorded
3100', Basecamp 1	12.52"	4.28"	Aug. 7, 1600-Aug. 13, 0900
4100', Basecamp 2	5.77"	2.15"	Aug. 13, 1930-Aug. 20, 2230
6450', Basecamp 3	0.193"	----	Aug. 21, 1645-Aug. 24, 1600

Table 3 shows the rainfall at the three basecamps. At 3100' some rainfall occurred during every twenty-four hour period. The total rainfall figure includes a downpour of about 8.9" from 1900 hrs., Aug. 7, to 1200 hrs., Aug. 8. This tremendously heavy rain went mostly into runoff, much of it going over the pali to the valley floor, where it was undoubtedly carried off by the large stream found there. This rain turned the entire area into a quagmire which existed for several hours after the rain ceased, after which the normal muddy character of the area re-emerged.

At 4100', the period from about 1100 hrs. Aug. 17 to about 0100 hrs. Aug. 19 was completely dry. The remainder of the time was typified by drizzles and one heavier rainfall from 1930 Aug. 13 to 0900 Aug. 14, during which time 2.25" fell. Although the recorded rainfall is much lower at 4100' than at 3100', the vegetation leads me to believe that a long term record will show the 4100' level to get more rain than the 3100' altitude.

At 6450' the rain was least, but other factors discussed under the RH section give some reasons why the available moisture may still be quite high.

At 6450' the rain was measured on a ridge with a SW exposure, at 4100' it was nondirectional (exposure) as it was in a sheltered depression, and at 3100' the gauge had a more or less NE exposure. All rain was measured in a wedge shaped standard plastic rain gauge. Such factors as canopy interference, tree-trunks, etc., were ignored by necessity. However, eventhough absolute rainfall may not be accurate in the strictest sense, the measurements are probably quite comparable between the basecamps.

SOILS

Soil measurements were made at 3000' and up, consisting largely of surface measurements, going to a greater depth if possible, of pH, soil color, and texture.

From 3000' to about 6000' the soil appeared to be a hydrohumic latosol (Smathers). The litter layer is minute, probably due to the heavy rainfall and high temperatures. The A horizon varied with the slope, averaging about 8''. The B horizon is often reddish, compared to a dark brown A. The B horizon also tends to be impermeable, probably due to clay accumulation.

In the above mentioned altitudinal range, the soil is quite acid, ranging from pH 4.5 to 5.5. The colors for the A horizon, as measured from the Munsell Colour Chart (wet), are mostly in the area of 7.5 YR 3/2. The texture appears to be that of a clay loam. Many of the soils include heavily weathered ash particles, weathered to the point where they can be crushed between the fingers.

A soil profile at 3050' shows the following properties:

Litter layer of about 1/4''.

A horizon of about 3-4''

Soil colour - 10 YR 3/2; pH 5.0

B horizon of about 4-20'' plus.

Soil colour 7.5 YR 3/2; pH 4.5-5.0

The B horizon contained some 2-4'' diameter rocks, well weathered, but these could not be crushed between the fingers.

In general, from 3000' to 6000' there is much standing water, some apparently persisting throughout the year. The impermeable B horizon plays an important role in keeping these areas wet.

Above 6000', the soil consistency and drainage qualities change quite rapidly as compared to the soils of the lower elevations. At this high altitude the soil becomes much more ashy, and a soil pit shows several ash layers superimposed on each other, with some weathering between the layers. The litter layer increases to a thickness of some two inches or more.

A soil pit at 6450' shows the following properties:

	Litter layer of about 2"	(0-2")
A	Humous layer of about 3"	(2-5")
	Dark leached horizon of about 4"	(5-9")
B	Dark layer of 6", with rooting common	(9-15")
C	Ash layer (red-yellow), few roots, 4-5"	(15-20")
A	Silty-clay, very wet, few roots	(20" plus)

The thicker litter layers at higher altitudes is undoubtedly related in large part to the lower average temperature, and perhaps related to a lower rainfall. The ground fauna, in large part responsible for the removal of the ground litter may also change due to these same or related factors, and hence may be a factor in the litter thickness.

No pH measurements were made at these higher elevations due to a shortage of equipment.

The increasingly ashy nature of the soil at higher altitudes greatly increases the rate of soil drainage, and hence may add to the aridity of the higher slopes. The initially lower temperature and rainfall prevent a more rapid weathering of the ash. The shorter stature of the vegetation at this altitude prevents the extensive "combing-out" of the clouds. All these factors thus tend to re-enforce the aridity of these higher slopes.

As one comes within 1000' of the very top of the central ridge, the ash deposits become very evident. The ash can be seen both in the nature of the soil surface and in the eroded gully walls.

G. Smathers found the soil at 6450' to be a humic latosol, bordering on a brown forest soil.

On the valley floor a deep deposit of alluvium is evident, having a pH of 4.5-5.0, and a dark to black topsoil. Where two layers of soil were evident, the black layer occupied the top 4-6" on the slope, reaching down to a foot or more on the valley floor, underlain by a dark reddish-brown layer of colour 5 YR 3/2 to 5 YR 2/2.

THE VEGETATION

From the base of the central ridge to about 6500', the vegetation reflects the heavy rainfall of the area, though decreasingly so as one approaches the 6500' elevation.

Botannically, the area appears to be relatively undisturbed, especially in the "middle" section, from 2500' to 6300.' Respectively above and below these levels one can find evidence of exotics coming into disturbed areas such as landslides, pig and/or goat trails, or water courses. Pigs are present in the middle section, but disturbance appears to be minimal as yet.

From the edge of the pastures upward to 6500', trees are the dominating vegetation. Around the pasture edges the common guava is plentiful, and unless some care is exercised, birds, people, rats, and the mongoose could move this species into the undisturbed areas of the native forest.

In general, the area from the pastures upwards to about 3000' represents an almost pure Acacia koa stand in terms of the dominant tree story (Figure 1). From 3000' to 4000' one finds the transition zone between A. koa (koa) dominance and the areas dominated by Metrosideros sp. (ohia). Above this altitude, to approximately 6600', a pure ohia zone is found. Above the 6600' level, the ohia becomes scattered, shorter, and begins to branch very close to the ground. Eventually, between 6750'-6850', the ohia becomes very scattered, and is largely replaced by a sclerophyllous shrubby vegetation of Vaccinium sp., Dubautia sp., Styphelia sp., and eventually by the native bunch grass Deschampsia sp. Along the top plateau, the latter is dominant, though along the edge of the pali and the plateau one finds a windrow of the previously mentioned sclerophyllous shrubs again. (Perhaps due to an increased moisture content because of the clouds being pushed over the edge here from below?)

As mentioned, at the 3000' level of the central ridge, the Acacia koa is dominant. Associated with it is the plant Cheirodendron trigynum, hence this entire area could be termed an Acacia koa-Cheirodendron trigynum Association. The koa forms the dominant tree cover, its canopy ranging from 33%-75% in this area. The trees are often covered with epiphytes such as ferns, mosses, and vascular plants. Ferns include Elaphoglossum sp., and in particular the vascular epiphytes consisting largely of Astelia sp. and Freycenetia arborea. Cheirodendron trigynum is the second story cover, its canopy cover ranging about 40% or less. Associated with the Cheirodendron are Pelea clusiaefolia var. cuneata, Broussaisia arguta, and Cibotium spp.

Distinct from the above association both in ground cover and in the second story vegetation are the areas which seem to have standing water on them for a large percentage of the time. I would term this area an Acacia koa-Paspalum conjugatum Assocation (Figure 11). The grass usually forms a pure community, with but a few plants of Eupatorium adenophorum associated with it. The Eupatorium often has insect galls on it, which undoubtedly helps to control its distribution. The koa and cheirodendron are scarce within the P. conjugatum area, and if they are present, they have generally stunted appearance. Initial observation seems to show that the ohia is a bit more common around these wet areas then it is elsewhere at this level; this should be checked out quantitatively, however.

Often associated with the Paspalum conjugatum, around the edges, is the plant Lycopodium cernuum. The lycopodium appears to grow in the slightly drier areas, though it is difficult to tell whether the plant causes an area to be drier by its dense cover, or whether it grows on land already drier than the P. conjungatum areas.

At the 3000' level, the Hawaiian rat, Rattus exulans, and the common rat, Rattus rattus, were found here. The Iiwi, a beautiful orange-red native Hawaiian bird, was also seen several times.

The Acacia-Cheirodendron association is dominant from the 2500' to about 3500'. The koa reaches a height of some 50-60', the cheirodendron 30-40', sometimes higher, more often lower. The ohia can be seen occasionally. Below the cheirodendron, and sometimes up with it, is a scattered collection of Pelea spp., koa regeneration, Cibotium spp., cheirodendron regeneration, Eugenia sp., Broussaisia arguta var. arguta, forma ternata, and Gouldia supp. (For a complete report on the flora, see the report by Dr. C. H. Lamoureux.) A height range of 10-20' would include 80% of these species. From the above observations it appears that the area is quite stable, as regeneration of the dominant vegetation is common.

Cibotium chamissoi appears to be the most common of the tree ferns at this level, by a ratio of about 6:1 as compared to C. splendens. Also found in this area were two of the three native Hawaiian orchids. Found were Liparus hawaiiensis, an epiphyte, and Anoectochilus sandwicensis, a terrestrial plant. Conspicuous by its beautiful pink flowers was Trematalobelia macrostachys, a very common plant at this altitude, especially in wind exposed areas.

The ground cover in the wet areas consisted of Paspalum conjugatum, whereas in the somewhat drier areas the species Rubus rosaefolius and Lycopodium cernuum were present. Also found in scattered areas were the thickets of Dicranopteris linearis and Sticherus owhyhensis.

Fern epiphytes consisted largely of the aforementioned Elaphoglossum spp., Grammitis spp., and a few of the Hymenophyllaceous ferns. Vascular epiphytes consisted largely of Astelia sp., Freycenetia arborea, Peperomia spp., and Korthalsella complanata.

It is of interest to note here that peperomia, which is occasionally a terrestrial plant at this level, becomes solely terrestrial at 6400'. Astelia is never terrestrial at the lower altitudes, while at the elevations above 6300'-6400' it is a terrestrial plant only. All of these factors indicate excessive rain at the lower elevations as far as these two plants are concerned.

Various streams intersect the plateau, and the plants associated with the conditions prevalent along them should be investigated (Figures 12, 22, 24). Plants noted along the streams were Eupatorium adenophorum, Broussaisia arguta, Cibotium chamissoi, Erechtities valerianaefolia, and Cuphea carthagenesis; however, this list is incomplete as to species, abundance, and distribution.

VariouStrips were made to the valley floor, especially on the N.E. side. The valley floor was intersected by two large rivers of apparently intermittant flow, at times stopping altogether (Figures 10, 13, 21, 32).

At 2500' the vegetation was lusher and appeared somewhat taller than on the ridge at 3000'.(Figure 14). Acacia koa was completely dominant in the upper story at this lower elevation, with cheirodendron present in lesser abundance than at 3000'. No ohia was present. Ground cover was dominated by the fern Athyrium sandwichianum with locally dense stands of Dicranopteris linearis, and Drimaria cordata. One spot on the valley floor was particularly noticeable, as it had the densest concentration of Peperomia sp. ever noted by the writer. This stand encompassed several square meters and several large (2 ft. diam.) boulders. Coming down the pali species noted in abundance were Pelea spp., Cibotium spp., Broussaisia arguta, some Perrottetia sandwicensis, and the ferns Dicranopteris linearis and Athyrium sandwichianum.

It would be interesting to compare the valley flora with the same altitude on the ridge, though it is possible that cattle may at one time have come this far into the valley bottom.

The ridge elevation interval from 3000'-4000' represents the transition zone from a relatively pure koa forest to a relatively pure ohia forest. Although koa drops out rather rapidly above 3500', one can still find what amounts to patches of koa at the higher altitudes; for example one such patch was noted at 3725', along the trail. Since koa is known to reproduce vegetatively, it is quite possible that one tree became established and so eventually gave rise by vegetative reproduction to the other trees. It is also possible that this area is somewhat atypical of its surroundings, or the koa stand could be a relic or invader stand. In any case, permanent quadrats in areas such as this may give insights into the dynamics of a forest transition zone.

Styphelia was first noted at 3725' as an epiphyte on ohia, or on fallen logs. This shrub/tree becomes quite common at the higher elevations. P. conjugatum, the common ground cover in the wet areas in the lower elevations, has almost completely dropped out by the 4000' level. It is replaced by the sedge Carex alligata. A rare patch of P. conjugatum can at times be seen at higher altitudes, such as one patch at 4450' along the trail. A study area at such points might also prove interesting. Cibotium spp. is still common at this altitude of 4000' (See Figures 27 and 33).

The Hymenophyllaceous ferns reach their greatest abundance at the 4000' level, thus indicating this to be a wet area, wetter probably than the areas either above or below their persistance level. Trematalobelia macrostachys was very rare or absent at this level. It could appear much more rare than it actually is due to the fact that it may not be flowering, hence only being less visible. One plant was noted at 4400' on a lateral ridge, in fruit.

The second camp site was at about 4100', in a sheltered area immediately to the west of the central pali (Figures 18 and 19). Trips were made from this area to the west pali, into the east valley, and eventually up the ridge to camp 3 at 6450'.

The area here is dominated by Metrosideros polymorpha Gaud., a tree of some 40-50' here. The understory tree is still Cheirodendron trigynum, hence this association may be termed a Metrosideros-Cheirodendron Association. Coprosma spp. are common here, forming a lower layer with some of the smaller Cheirodendrons. Astelia sp. is a common epiphyte, as is Elaphoglossum spp., Peperomia spp., Korthalsella sp., and various mosses and lichens. Freycenetia arborea is less common here than at the 3000' level.

Areas with standing water are also common at this altitude, but as mentioned, the P. conjugatum is replaced by the Carex alligata. In these wetter areas ohia is quite common, unlike the koa at the lower altitudes in similar situations. Also common is the epiphyte Styphelia sp., growing some 4-10' high, with some attaining heights of 25-30'. In one of these wet areas an A. koa was noted growing to a height of about 50'. The average height of ohia is about 35-45', with some reaching 50-60'. In this same area the mongoose was seen, as was some pig sign. Rattus rattus and Rattus exulans were caught here, and the Iiwi was seen many times.

In general, the trees are covered with moss epiphytes, moss also being common on the ground on top of rotting stumps, accounting for some 25% of the ground cover in some areas (Figures 28, 29 and 31). Many of the ohia trees have prop roots, perhaps an adaptation to the wetter ground.

Immediately across from the west pali of the central ridge is the large pali or ridge separating Kipahulu Valley from the Haleakala National Park. This pali is covered by vegetation, some of which could be identified from a distance as Gunnera mauiensis (Figure 23). Other species noted in the area were Eupatorium adenophorum, Vaccinium calycinum, Ilex anomala, and Dubautia sp.

The valley floor at 4000' is here also intersected by the two large rivers as it is below. The vegetation is lush, with a dense undergrowth. A few koas could be seen among the ohias (Figure 34).

In the valley at 4000', ohia makes up the dominant cover, as inferred above. Cheirodendron makes up the understory tree layer, with Rubus hawaiiensis being very common in spots, and growing to a height of some 10-16'. Other common understory plants at this level are Broussaisia, Cibotium, as well as some Perrottetia and Pelea. Dicranopteris linearis mats are common in spots, and along the stream an exotic mint Prunella vulgaris is common. This same species is rather common along the top of the ridge at the head of the valley, ca. 7200-7300', where it was probably brought by the horses coming from Haleakala Crater along the hunting trails. From this trail it probably spread to the valley below by means of the water courses, and at the present time the mint seems to be limited to these areas. This is an excellent example of how man may introduce plants into an area without ever having entered the area himself.

Across the valley to the east, a huge waterfall courses down the pali, and around it are several areas of difficult it not impossible access. Dr. R. Warner and Mr. J. Lind explored a few of these areas, and both felt that these areas may still be completely undisturbed, as it is probably impossible for a pig or goats to enter into these areas (Figures 15, 16, 17, and 25).

The area above Camp 2, above 4100', is rather hilly up to 5300', where a large swamp exists. Above this area a steep grade goes up some 1000', from where it continues up to the rim of the valley.

At 4325' two Cyaneas were found along a stream bed. One was in flower, the other in fruit; they were identified as Cyanea aculeatiflora (Figure 24). In another stream bed at 4425', a third plant of this same species was found, under exactly the same conditions. The third plant was also in flower, and many fruit flies were noted among them.

The swampy area at 5000' is extensive, going on for about a mile, and probably extending over the entire ridge. The ohia trees found here are thin trunked, with fewer branches, and many may be dying, as the ground is littered with fallen trunks. Standing water is of course common, the mud often reaching to over one's knee. It is possible that this area may well be the beginning of a montane bog area.

On the way to Camp 3, two large streams were crossed with bare rocky beds. One of the streams is at about 5100' and had quite a bit of Machaerina spp. present, as was Prunella vulgaris, Broussaisia sp., ohia, Saddleria sp., a small almost round stemmed sedge, and Elaphoglossum spp.

At 5430' ohia has a 50-60% cover, and Cheirodendron forms a canopy with it. The second story is predominantly Broussaisia, Rubus hawaiiensis, and Coprosma sp., with the third level, or ground cover being probably Dryopteris glabra.

At 5750' ohia has about a 50% cover, and forms the canopy by itself. Cheirodendron sp. forms a definite second story, with Styphelia sp., Vaccinium sp., and Coprosma sp. forming a definite third layer, some 8-10 feet tall. The ground cover here is Nertera depressa, Astelia sp.; various ferns, mosses and hepatics are common epiphytes. Styphelia sp. goes to the ground here, thus becoming a terrestrial plant as opposed to its former epiphytic habit.

At 6050' ohia forms the canopy, Cheirodendron forming the second story, and Coprosma sp., Broussaisia sp., and Rubus hawaiiensis form the third story. The fern Dryopteris glabra, Astelia sp., and the mint Stenogyne sp. form the ground cover.

At 6350' ohia has a 60% canopy cover with Cheirodendron forming a second layer some 15' tall. A third layer some 8-12' tall is formed by Vaccinium sp. and Styphelia sp. Below this, young species of Pelea, Cheirodendron, Styphelia, Ohia, and Styphelia form another somewhat irregular layer, and the ground cover is made up of Astelia sp., Ohia seedlings, and various ferns. Metrosideros attains a large D.B.H. here, has flaking bark, and often a light gray colour. Common epiphytes are mosses (for a report on the mosses of Kipahulu Valley, see the report by Bill Hoe), hepatics, lichens, and the fern Elaphoglossum hirtum.

At 6500' Astelia is by far the dominant ground cover, covering as much as 80-90% of the area on the exposed ridges (Figures 35, 36). In a depression off this same ridge, Astelia was practically absent, but a dense fern cover (Dryopteris glabra?) intermixed with Peperomia sp. took its place. Rubus hawaiiensis is quite common here also, growing to 15' tall. At this same height the Hymenophyllaceous ferns are absent though, as mentioned, the mosses are common.

The last Cibotium spp. were noted at 6350', and none were seen above this altitude. At 6500' the Crested Honeycreeper was seen among the ohia trees in flower. The dominant understory at this altitude was composed of Vaccinium sp. and Rubus hawaiiensis.

Above 6500' the vegetation rapidly and radically changes character. At 6550' ohia grows only to some 20-26', with a scattered understory of Cheirodendron (12-15'), Coprosma and Styphelia. Dryopteris has about 70% of the ground cover, with Sadleria claiming a scattered 5-10%. Astelia is present, but quite scattered. Just above this altitude an open forest of Ohia is found, and beyond this point the ridge climbs rather sharply to the rim.

It is noteworthy that at this level a heavy layer of humus is present, a noticeable contrast to the thin or often barren ground found at the lower altitudes. At 6450' Elaphoglossum is present and fairly common, but it is completely lacking at 6550', as are all vascular epiphytes; mosses and lichens are still common at this altitude however. At 6550', the sedge Uncinia uncinata was first noted, as were some small patches of Plantago pachyphyllum.

As one continues up the ridge, Ohia becomes lower and lower, branches closer and closer to the ground, and generally assumes a more globose form (Figure 49). It also becomes more scattered, giving the ridge a more exposed appearance. A species of Coprosma, Coprosma ernodeoides, was first seen at 6560'. C. ernodeoides is a creeping plant much different from the erect species found to be common at the lower altitudes. Due to the changes in the vegetation such as height, growth form, and leaf type, I believe that 6550' altitude is in the transition zone to the dry forest.

At 6580' Ohia is down to 10-15' in height, and is associated with Styphelia tameiameiae of some 4-5', Vaccinium berberidifolium of 1-2' in height, and

Polypodium pellucidum. The vegetation in general has thus become lower and more sclerophyllous, reflecting the more extreme conditions (i.e. more wind, less rain, poorer soil) here prevalent. As one continues up the ridge, the fern Pteridium aquilinum becomes common, Hypochaeris radicata can be seen, as can Lycopodium venustulum and Rumex crispus.

At 6750' ohia is about 10-13' tall, and branches within 3 feet of the ground. Its form here is definitely globose.

As mentioned, it is obvious from the vegetation that conditions change rapidly circa the 6550' altitude, or at least those factors affecting the vegetation become limiting at this height. The vegetation above this height is sclerophyllous and short, as opposed to a wet and tall forest covered with epiphytes below this altitude. Whether the dryness of this upper zone is due to lack of rain, increased exposure, or excessive drainage remains to be determined. The temperature here may also be a determing factor, and through both rain and temperature the soil probably plays a role.

Above the 6800' level, Ohia disappears entirely, and one finds only the shrubs and herbs previously mentioned (Figures 38, 39, 50). At 6900'-7000' one finds a community composed predominantly of Deschampsia nubigena, a native bunchgrass, and an exotic composite, Hypochaeris radicata. This grassland extends up over the ridge top and across the relatively flat area between the pali at Kipahulu Valley to Lake Wai-Anapanapa and beyond (Figure 41).

Along the edges of the pali, and thus surrounded by the grassland, one finds a windrow of low shrubby plants, primarily Vaccinium berberidifolium, associated with Polypodium pellucidum (Figures 38 and frontispiece). As mentioned, its location along these palis may be due to the fact that it is better able to comb out moisture from clouds at such location. There are no trees along this grassland area, though occasional patches of the aforementioned vaccinium are common.

Signs of pigs and goats are very common here, their trails in fact often making walking rather difficult. Both animals open up new areas for invasion, the goat by grazing and the formation of trails, the pig by rooting and trail formation. The goat, if allowed to continue unchecked, could very likely finish off the shrubs now present by eating the seedlings. The pigs, by continually uprooting new areas, allow exotic plants to enter. The combined influence of these two animals could well spell the end of this native Deschampsia grassland. This would indeed be a great misfortune, as extensive areas of this grass are now seldom seen. A study of the dynamics of this area could be initiated by placing some permanent quadrats, fencing some in, and keeping the others exposed. The effect of grazing and rooting could thus be isolated and studied.

In conclusion, it is my opinion that Kipahulu Valley, from a botanical and ecological standpoint is a site that must be preserved. It offers an area where disturbance by exotic plants and animals is still minimal, hence allowing the studying, viewing, and enjoyment of an area preserved much as it was when the Hawaiian people ruled the coastal areas.

It gives to the scientist an area from sea level to 7300' where studies can be done on the ecology of Hawaiian wet montane flora. Within this same area a host of native animals and plants are able to find niches rare elsewhere in the Hawaiian chain of islands, and have these niches well outside of the often deadening hand of man.

The Nature Conservancy has done an enviable job in attempting to attain this area, and at the same time attempt to find out as much as possible by means of the expedition. The valley, if left in its wilderness state, can thus provide a remnant of the native Hawaiian flora and fauna both for study and pure enjoyment.

CHAPTER 3

THE VASCULAR PLANTS OF KIPAHULU VALLEY, MAUI

by

Charles H. Lamoureux

THE VASCULAR PLANTS OF KIPAHULU VALLEY, MAUI

Until the Kipahulu Valley expedition of the Nature Conservancy in August 1967, the botanical exploration of the valley was quite limited. C. N. Forbes, then Botanist at the Bernice P. Bishop Museum spent November 13 to December 5, 1919 in Kipahulu. Examination of his field notebook indicates that he established a base camp at 1625 feet altitude, near Palikea Stream in the eastern part of the valley. From this camp he made one-day trips in various directions. It is not possible to determine exactly how far up the valley he explored, but it is doubtful that he got above 3500-4000 feet, except perhaps along the top of the ridge east of the valley. Since Forbes' collections are the earliest known from the valley and may be of significance in interpreting changes in the valley in the past 48 years, and since a complete record of his collections exists, Forbes' itinerary, as I have abstracted it from his field notebook, is attached to this report as Appendix I.

Harold St. John, then Professor of Botany at the University of Hawaii, made at least two trips into the Kipahulu area. On December 28, 1936, in company with R. J. Catto, he made collctions along the summit of the west ridge of "Kaukaua Gulch" up to at least 2700 feet altitude. I have not yet obtained complete records of this collection. "Kaukaua Gulch" is probably that gulch which is shown on recent maps, (1961 printing) as Koukouai. The 1933 printing of the Maui topographic map spells this as Kaukauai. This is the ridge, then, which is just west of Kipahulu Valley, as Koukouai Stream is that stream which runs along the base of the pali marking the western boundary of the valley. On August 22, 1945 St. John, with A. L. Mitchell, entered the valley from the top, near Wai Anapanapa, and descended to 5800 feet, where he made collections of Gunnera mauiensis. It is not known if he made additional collections at this time.

During August 1967 members of the Kipahulu Valley Expedition of the Nature Conservance explored the valley throughout its length, and made extensive plant collections. Details of places and dates of these collections are given in Appendix 2, this chapter.

This checklist includes those species found from about 1500 feet altitude (roughly from the makai base of Puu Palikea) to the top of the valley. It is based primarily on the collections cited. Sight records are included only when, in my opinion, there is no question about the identity of the plant. For each species the following information is provided:

a) Scientific name.

b) Vernacular name, when one is commonly used, or when a Hawaiian name is known.

c) Status of the species, whether endemic, indigenous, or introduced. The following symbols are used:

E - endemic to the Hawiian Islands
I - indigenous (native) in the Hawaiian Islands but also occurring naturally elsewhere
X - an exotic species of recent introduction to Hawaii
P - a species presumed to be of Polynesian introduction

d) Distribution of the species among the Hawaiian Islands. If no indication of distribution is given, it is assumed that the species occurs in similar areas on all the major Hawaiian Islands. If the distribution is more limited, islands are abbreviated as:

K - Kauai
O - Oahu
Mo - Molokai
L - Lanai
Ma - Maui (or E Ma for East Maui, W Ma for West Maui)
H - Hawaii

e) Citation of collections. Collections made by Lamoureux and DeWreede are cited as L & D; collections made by DeWreede alone are cited as D; the names of other collectors are given in full. The Forbes and St. John collections are in the Herbarium of the Bernice P. Bishop Museum (BISH); all other cited specimens are in the Herbarium of the Department of Botany, University of Hawaii (HAW).

f) Distribution of the species within Kipahulu Valley. Approximate distributions are given for those species noted in August 1967. For other species distributional information is taken from herbarium labels.

PTERIODOPHYTA

PSILOTACEAE - Psilotum Family

Psilotum complanatum Sw. "moa"
I
L & D 3984; Forbes 1734-M. Fairly common epiphyte in wetter parts of forest.

Psilotum nudum (L.) Beauv. "moa," "pipi"
I
L & D 4056. Noted only below about 2500 ft.

LYCOPODIACEAE - Club Moss Family

Lycopodium cernuum L. "wawaeiole"
I
L & D 3878, 3973. Common large terrestrial species above about 1500 ft.

Lycopodium phyllanthum Hook. et Arn. "wawaeiole"

E

L & D 4051; Forbes 1673-M. Epiphyte, seen only in lower parts of valley, to about 2500 ft.

Lycopodium polytrichoides Kaulf. "wawaeiole"

E

L & D 3978. Epiphyte, fairly common at 3000-4000 ft.

Lycopodium serratum Thunb. "wawaeiole"

I

L & D 3905; Hoe s.n. Epiphytic at lower elevations, terrestrial at higher elevations. Occasional between 3000 and 6500 feet.

Lycopodium venustulum Gaud. "wawaeiole"

I

L & D 3955. Uncommon large terrestrial species above 3500 ft.

SELAGINELLACEAE - Small Club Moss Family

Selaginella arbuscula (Kaulf.) Spring "lepelepeamoa"

E

L & D 3903, 3925; Forbes 1685-M, 1712-M. Fairly common above 2000 ft.

OPHIOGLOSSACEAE - Adder's Tongue Family

Ophioglossum penudlum ssp. falcatum (Presl) Clausen "puapuamoa"

I

L & D 4062; Forbes 1674-M; St. John & Catto 17,799. Epiphyte found occasionally above 1500 ft.

MARATTIACEAE - Marattia Family

Marattia douglasii (Presl) Baker "pala"

E

L & D 3949. Terrestrial, occasional in wet shaded areas above 2000 ft.

GLEICHENIACEAE - Gleichenia Family

Dicranopteris linearis (Burn.) Underwood "uluhe," "false staghorn fern"

I

L & D 3945. Common in places throughout forest, usually in open or disturbed areas. All plants noted had nearly glabrous leaves, and correspond with var. maxima (Christ) Deg. et Deg.

Hicriopteris pinnata (Kunze) Ching "uluhe," "giant false staghorn fern"

I

L & D 3906, 3962. Fairly common in small patches in the forest.

Sticherus owhyhensis (Hook.) Ching "uluhe"

E

L & D 3963. Less common than the preceding two species.

HYMENOPHYLLACEAE - Filmy Fern Family

Callistopteris baldwinii (Eaton) Copel.

E

L & D 3901, 3932, 3960, 4019; Forbes 1731-M. Relatively common in wet shaded areas above 2500 ft. Degener and Degener (Fl. Haw., Fam. 10, 7/16/62) have recently renamed this *Macroglena toppingli* Deg. et Deg., and reported that *Hymenophyllum baldwinii* Eaton is a synonym for *Sphaerocionium lanceolatum*. If an examination of the type shows this to be the case the Degeners' specific epithet should be adopted. However, the genera of Hymenophyllaceae are so ill-defined, that I would have to accept Copeland's decision on generic disposition of this species. Since this list is no place to publish new combinations, I have used Copeland's combination to avoid making a new one.

Mecodium recurvum (Gaud.) Copel. "ohiaku"

E

L & D 3998, 4033. Epiphyte, abundant above 2000 ft.

Sphaerocionium lanceolatum (Hook. et Arn.) Copel. "palaihinahina"

E

L & D 3974a. Uncommon epiphyte.

Vandenboschia cyrtotheca (Hillebr.) Copel.

E

L & D 3930, 3972, 4000; D 21. Common in wet shaded forests.

Vandenboschia davallioides (Gaud.) Copel. "kilau," "palaihihi"

E

L & D 3926, 3935. Common in wet shaded forests.

Vandenboschia draytoniana (Brack.) Copel.

E

Forbes 1739-M. Labeled only "Kipahulu," but from somewhere in north-east part of valley.

PTERIDACEAE - Bracken Family

Adiantum cuneatum Langsd. et Fischer "maidenhair fern"

X

L & D 4055. On stream banks at about 2000 ft.

Cibotium chamissoi Kaulf. "hapu iii"

E

L & D 4038. Abundant tree fern above 2000 ft.

Cibotium splendens (Gaud.) Krajina "hapuu"

E

L & D 4039. Abundant tree fern above 2000 ft.

Coniogramme pilosa (Brack.) Hieron. "loulu"
E
L & D 3939; D 42. Uncommon from about 2500 ft. to over 4000 ft.

Hypolepis punctata (Thunb.) Mett. in Kuhn "olua"
I
L & D 3974; Forbes 1732-M. Uncommon, found between 3000 and 4000 ft.

Lindsaea macraeana (Hook. et Arn.) Copel. "laukahi"
I
Forbes 1675-M. Ridge, left side of Kipahulu.

Pteridium aquilinum var. decompositum (Gaud.) Tryon "bracken," "kilau"
I (variety is endemic to Hawaiian Islands)
D 81. Common at higher altitudes in drier areas.

Pteris cretica L. "owalii"
I
D 63. Found at 6500 ft.

Pteris excelsa Gaud. "kaimakanui," "iwa"
E
L & D 4010. Uncommon, found at about 4000 ft.

Pteris irregularis Kaulf. "mana"
E
L & D 3941; D 31; Forbes 1700-M. Occasional, from about 2500 to 4000 ft.

Sphenomeris chinensis (L.) Maxon ex Kramer "palaa"
I
L & D 3888, 4009. Common in open areas, along streams, and also scattered in less shaded places in forest.

DAVALLIACEAE - Davallia Family

Nephrolepis cordifolia (L.) Presl "nianiau," "pamoho"
I
L & D 3921, 3954. Uncommon, both epiphytic and terrestrial.

ASPIDIACEAE - Shieldfern Family

Athyrium dilatatum (Blume) Milde ?
I?
Forbes 1635-M. Ridge, left side of Kipahulu. This specimen is labeled Diplazium maximum (Don) C. Chr., which is considered by Copeland (Fern Flora of the Philippines: 402, 1960) to be a synonym of A. dilatatum. Neither Hillebrand nor Robinson mentions this taxon.

Athyrium microphyllum (Sm.) Alston "akolea"
E
L & D 3973, 4005; Forbes 1736-M. Fairly common at 3000-4000 ft.

Athyrium sandwichianum Presl "hoio"

E

L & D 4012, 4032; Forbes 1651-M. Abundant from 2000 to above 4000 ft., often forming continuous cover.

Athyrium sp.

L & D 3914b. A once-pinnate Athyrium, growing on a stream bank at 2500 ft.

Ctenitis latifrons (Brack.) Copel.

E

L & D 4016; Forbes 1661-M. Occasional at 3000-4000 ft.

Ctenitis rubiginosa (Brack.) Copel.

E

L & D 3961. Occasional at 3000-4000 ft.

Cyclosorus cyatheoides (Kaulf.) Farwell "kikaweo"

E

Warner et al 25; Forbes 1737-M; St. John & Catto 17,813. Occasional at 2500-3500 ft.

Cyclosorus goggilodus (Schkuhr) Link

I

Forbes 1743-M. Label reads merely "Kipahulu."

Cyclosorus sandwicensis (Brack.) Copel.

E

L & D 3914a, 3969. Occasional above 2500 ft.

Cyrtomium boydiae (Eaton) W. J. Robinson

E (O, Ma, H)

D 30. Found only on rocks in stream bed at 4000 ft. in northeast part of valley.

Dryopteris glabra (Brack.) Kuntze "kilau"

E

L & D 4022, 4024, 4030. Occasional above 3500 ft. Above 6000 ft. is a very common fern with extremely scaly fronds (D 82, 84) which seem to be a form of this species.

Dryopteris fusco-atra (Hillebr.) W. J. Robinson

E

L & D 3957, 4018; Forbes 1726-M. Occasional from about 3000-4000 ft.

Dryopteris keraudreniana (Gaud.) C. Chr.

E

Forbes 1733-M. Ridge, left side of Kipahulu.

Dryopteris paleacea (Swartz) C. Chr. "laukahi"

I

L & D 4020, 4027. Occasional above 3000 ft.

Dryopteris unidentata (Hook. et Arn.) C. Chr.

E

Forbes 1735-M. Ridge, left side of Kipahulu.

Elaphoglossum alatum Gaud. var. parvisquameum (Skottsb.) Anderson et Crosby
E (This variety on Mo, Ma, L, H) "ekaha"
L & D 3956, 3987; Forbes 1672-M. Both terrestrial and epiphytic, common above 2500 feet.

Elaphoglossum crassifolium (Gaud.) Anderson et Crosby "ekaha"
E
L & D 3923; Forbes 1715-M. Both terrestrial and epiphytic, common above 2000 ft., but probably less common than E. alatum.

Elaphoglossum hirtum var. micans (Mett.) C. Chr. "ekaha"
E (Variety endemic to the Hawaiian Islands)
L & D 3879. Epiphytic, fairly common above 2500 ft.

Elaphoglossum wawrae (Luerss.) C. Chr. "ekoha"
E
L & D 4021; D. 12. Occasional above 3500 ft.

Lastrea globulifera Brack. "palapalai o kaumaapua"
E
D 8. On stream bank at 4600 ft.

BLECHNACEAE - Blechnum Family

Doodia kunthiana Gaud. "okupukupu," "pamoho"
E
L & D 4061; Forbes 1638-M. Occasional from about 1500-2500 ft.

Sadleria cyatheoides Kaulf. "amaumau"
E (Genus is endemic to Hawaiian Islands)
D 67; Forbes 1649-M, 1737a-M. Occasional from 2500 ft. to above 6500 ft.

Sadleria pallida Hook, et Arn. "amau"
E - K, Ma, H
L & D 3885, 3886, 3958, 4017. The most common species of Sadleria in Kipahulu between 2500-4500 ft.

Sadleria souleyetiana (Gaud.) Moore
E
Forbes 1650-M. Kipahulu Valley, above the plantation. Probably below 2000 ft.

Sadleria squarrosa (Gaud.) Mann
E
L & D 3876; Forbes 1681-M. Occasional above 2000 ft.

ASPLENIACEAE - Spleenwort Family

The systematics of Hawaiian Asplenia are not well understood, and the taxonomy and nomenclature are in a state of confusion. The following list is therefore only provisional. The Forbes specimens are merely listed by the names under which they are currently filed in the Bishop Museum Herbarium.

Asplenium acuminatum Hook. et Arn. "lola"
E (K, O, Ma)
L & D 3964, 3986, 4026; Forbes 1670-M, 1687-M, 1699-M, 1738-M. Common from 2000 to above 4000 ft.

Asplenium continguum Kaulf.
E
L & D 3950, 4013, 4023; D 23. Fairly common above 2500 ft.

Asplenium falcatum ssp. *subcaudatum* var. *sectum* (Hillebr.) Skottsb.
E
Forbes 1671-M. Ridge, left side of Kipahulu.
Forbes 1698-M. Ridge, right side of Kipahulu. Another sheet bearing this number has been identified as *A. lobulatum*.

Asplenium horridum Kaulf. "alae"
I
Forbes 1719-M. Ridge, left side of Kipahulu.

Asplenium kaulfussii Schlecht. " kuau"
E
Forbes 1677-M. Ridge, left side of Kipahulu.

Asplenium lobulatum Mett. "piipiilau manamana"
I
Forbes 1698-M. Ridge, right side of Kipahulu. Another sheet bearing this number has been identified as *A. falcatum* var. *sectum*.

Asplenium macraei Hook. et Grev.
E
Forbes 1741-M. Label reads merely "Kipahulu."

Asplenium normale Don
I
Forbes 1720-M. Ridge, left side of Kipahulu.

Asplenium unilaterale Lam. "pamoho"
I
L & D 3931; D 22. Fairly common on steep shaded banks from about 2000 to 4000 feet. Noted but not collected by Forbes.

Asplenium sp.
L & D 4011. A small species with deeply dissected fronds, collected at 3500 ft.

POLYPODIACEAE - Polypody Family

Pleopeltis thunbergiana Kaulf. "ekaha akolea"
I
L & D 4029; D 20, 70. Fairly common epiphyte from 1500 to above 6000 ft.

Polypodium pellucidum Kaulf. "ae"
E
L & D 3988, 4007; D 18, 77. Both terrestrial and epiphytic, common from 2000 to above 6500 ft.

GRAMMITIDACEAE - Grammitis Family

Adenophorus hymenophylloides (Kaulf.) Hook. et Grev. "pai"

E (Genus endemic to Hawaii)

L & D 3898, 3996. Common epiphyte on undersides of horizontal branches in wetter parts of forest.

Adenophorus sarmentosus (Brack.) K. A. Wilson

E

L & D 3928, 3946; Forbes 1710-M. Common on trees and rocks above 2000 ft.

Adenophorus tamariscinus Hook. et Grev. "wahine noho mauna"

E

L & D 3902, 3934, 3944, 4014; D 7; Warner et al 23. Very common epiphyte above 2000 ft.

Adenophorus tripinnatifidus Gaud.

E

L & D 3999. Uncommon, at about 4000 ft., on bases of trees.

Grammitis hookeri (Brack.) Copel.

E

L & D 3953; D 19. Occasional above 2500 ft.

Grammitis tenella Kaulf. "kolokolo"

E

L & D 3970; D 13; Warner et al 16. Abundant epiphyte from 2000 to above 4000 ft.

Xiphopteris saffordii (Maxon) Copel. "kihi"

E

L & D 3904, 3959. Fairly common epiphyte at 3000-4000 ft.

VITTARIACEAE - Vittaria Family

Vittaria rigida Kaulf. "oheohe"

I

Forbes 1702-M. Ridge, right side of Kipahulu.

MONOCOTYLEDONEAE

PANDANCAEAE - Screw-Pine Family

Freycinetia arborea Gaud. "ie ie"

E

L & D 4034. Common vine above 1500 ft. Noted but not collected by Forbes.

GRAMINEAE - Grass Family

Deschampsia nubigena Hillebr.
E - K, Mo, Ma, H
L & D 3900, 3912; D 29, 33, 73, 86. Fairly common above 2500 ft., especially on rocks in stream beds. Forming an open meadow at 6500 ft.

Eragrostis grandis Hillebr.
E
Warner et al 26. Uncommon, found at 3600 ft. near Koukouai Stream.

Garnotia sandwicensis Hillebr.
E - Mo, Ma, H
L & D 4052; Forbes 1682-M. Uncommon, found below 2500 ft.

Holcus lanatus L. "velvet grass"
X - high altitudes on Mo, Ma, H
L & D 4041; D 74. Occasional in disturbed areas above 3000 ft., more common around 6500 ft.

Oplismenus hirtellus (L.) Beauv. "honohono kukui," "basket grass"
I
L & D 4060, Common below 2000 ft.

Paspalum conjugatum Berg. "Hilo grass"
X
L & D 3892. Common in disturbed wet areas to above 4000 ft.

Sacciolepis indica (L.) Chase "Glenwood grass"
X
L & D 3874, 3899, 3997. Common in disturbed wet areas to above 4000 ft.

CYPERACEAE - Sedge Family

Carex alligata W. Boott
E - K, Mo, Ma, H
L & D 3893, 4008; D 4, 80. Fairly common in wet openings in forest above 2500 ft.

Cyperus auriculatus Nees et Meyen "kilioopu"
I ?
Forbes 1631-M. Kipahulu Valley, above the plantation, in abandoned tare patches.

Cyperus brevifolius (Rottb.) Hassk. "kaluha," "pipiwai"
X ?
L & D 3967. Occasional in open disturbed areas.

Eleocharis obtusa (Willd.) Schultes "pipiwai"
I
L & D 3894; D 3. Occasional in wet openings in forest from 2500-4000 ft.

Machaerina angustifolia (Gaud.) Koyama
E
L & D 4065. Fairly common in open areas.

Machaerina mariscoides ssp. *meyenii* (Kunth) Koyama
E (subspecies is endemic to Hawaiian Islands)
L & D 4066. Growing with, but less common than, *M. angustifolia*.

Oreobolus furcatus Mann
E - previously reported from K, Mo, W Ma.
D 88. DeWreede gathered one sterile specimen in the upper part of the valley which appears to be *Oreobolus*. This is typically a plant of montane bogs and has not before been reported from East Maui, although it is common at the summits of the West Maui mountains.

Uncinia uncinata (L.) Kükenth.
I
L & D 4001; D 5, 34. Occasional above 3000 ft.

FLAGELLARIACEAE - Flagellaria Family

Joinvillea gaudichaudiana Brongn. et Gris. emend Christophersen
E
L & D 3860; Forbes 1614-M. Rare. We found only one plant, growing in a wet forest at about 3000 ft. Forbes' specimen seems to have been collected between 1700-2000 ft.

JUNCACEAE - Rush Family

Luzula hawaiiensis Buch.
E
D 58. Common on exposed ridges at about 6500 ft.

LILIACEAE - Lily Family

Astelia degeneri Skottsb. "painiu"
E - E Ma, H
L & D 3882. Fairly common epiphyte at middle altitudes.

Astelia forbesii ssp. *pachysperma* Skottsb. "painiu"
E - this subspecies known only from E Ma
L & D 3965; D 64. Fairly common above 2500 ft., epiphytic in lower, wetter areas and terrestrial in higher, less wet areas.

Cordyline fruticosa (L.) Goepp. "ki," "ti," "la-i"
P
Observed only below 2000 ft., not found in undisturbed forest. Not collected.

Smilax sandwicensis Kunth "uhi," "ulehihi," "hoi," "pioi"
E
L & D 4044; D 14. Fairly common above 2000 ft. in forest.

IRIDACEAE - Iris Family

Sisyrinchium acre Mann "mauualili"
E - E Ma, H
D 59, On barren ridge at 6550 ft.

MUSACEAE - Banana Family

Musa sp. "maia," "banana"
P ?
Forbes 1742-M. Label reads merely "Kipahulu Valley."

ORCHIDACEAE - Orchid Family

Anoectochilus sandwicensis Lindl.
E
L & D 3896; Forbes 1630-M. Uncommon. We observed several plants on the banks of Koukouai Stream at 3000 ft., and saw a few others between 3000-4000 ft. Forbes' specimen, however, was apparently collected below 2000 ft.

Liparis hawaiiensis Mann
E
L & D 3895; Forbes 1706-M. Uncommon epiphyte. We observed plants between 3000-4000 ft., but Forbes' collection seems to have been made at a lower altitude.

DICOTYLEDONEAE

PIPERACEAE - Pepper Family

Peperomia cookiana C. DC. var. *cookiana* "alaalawainui"
E - This variety on K, Mo, Ma, H
L & D 3871b, 3913; D 16. Common species to above 4000 ft.

Peperomia cookiana var. *flavinerva* (C. DC.) Yuncker "alaalawainui"
E - This variety on K, Mo, Ma, L
L & D 3871a. This variety is less common than var. *cookiana*.

Peperomia eekana C. DC. "alaalawainui"
E - Ma
L & D 4004, Uncommon, between 3000-4000 ft.

Peperomia erythroclada C. DC. "alaalawainui"
E - Ma, L
L & D 3867, 3869, 3991. Fairly common species between 3000-4000 ft., showing considerable variability in distribution of anthocyanins on abaxial surface of leaf.

Peperomia expallescens C. DC. "alaalawainui"
E - Mo, Ma, H.
D28. On streambank at 4000 ft.

Peperomia globulanthera C. DC. "alaalawainui"

E - Ma

D 6, 66; Warner et al. 15. Fairly common between 3500-6500 ft.

Peperomia hirtipetiola C. DC. "alaalawainui"

E - Ma, L.

L & D 3995; Warner et al, 14; Forbes 1683-M, 1691-M. Large terrestrial species, common above 3000 ft.

Peperomia latifolia Miq. "alaalawainui"

E

L & D 3933; Forbes 1727-M. Occasional, below about 3500 ft.

Peperomia ligustrina var. copuolana Yuncker "alaalawainui"

E - This variety on Mo, Ma.

D 17. Epiphytic on Cheirodendron at 4000 ft. Forbes 1704-M, from along Palikea Stream is cited by Yuncker as var. ligustrina.

Peperomia lilifolia var. nudilimba (C. DC.) Yuncker "alaalawainui"

E - This variety on O, Mo, Ma, H

L & D 3870, 3868. Occasional below 3500 ft.

Peperomia sp.

L & D 3889, 3940. These specimens have not yet been adequately identified.

URTICACEAE - Nettle Family

Pilea peploides (Gaud.) Hook. et Arn.

I

L & D 3927; D 27. On very wet stream banks between 2000-4000 ft.

Pipturus rockii Skottsb. "mamake"

E - Mo, Ma, L

L & D 3910, 3916; D 25; Forbes 1701-M. Fairly common shrub or small tree between 2500-4000 ft.

Touchardia latifolia Gaud. "olona"

E - Genus in monotypic, endemic to Hawaiian Islands.

L & D 3928; Warner et al, 2. Uncommon, between 2000-3500 ft.

Urera sandvicensis Wedd. "opuhe"

E

L & D 3907. Rare. We found only a few small trees at the base of the central pali at 2500 ft.

LORANTHACEAE - Mistletoe Family

Korthalsella complanata (Van Tieghem) Engler "hulumoa," "kaumahana"

I

L & D 3872, 3983, 4048; Forbes 1721-M. Common parasite on Vaccinium, Acacia, Pelea, and other plants.

POLYGONACEAE - Buckwheat Family

Persicaria densiflora (Meisn.) Moldenke "kamole"
I ?
L & D 3918; Forbes 1678-M. Found by us only at base of central pali at 2500 ft., there abundant.

Rumex acetosella L. "sheep sorrel"
X
D 55. Locally abundant at about 6500 ft.

Rumex giganteus Ait. "pawale"
E - H, Ma, Mo, K, Nihoa
D 24. Found only at 4000 ft. near northeast edge of valley. Noted, but not collected, by Forbes on ridge east of valley.

NYCTAGINACEAE - Four-o'clock Family

Pisonia umbellifera (Forst.) Seem. "papala kepau"
I
Forbes 1722-M. Ridge, right side of Kipahulu.

PHYTOLACCACEAE - Pokeberry Family

Phytolacca sandwicensis Endl. "popolo"
E
L & D 3908. Occasional from 2500-3500 ft.

CARYOPHYLLACEAE - Pink Family

Drymaria cordata (L.) Willd. "pipili"
X
L & D 3908. Seen only at base of central pali at 2500 ft., there abundant.

Schiedea diffusa A. Gray
E - Genus endemic to Hawaiian Islands, this species on Mo, Ma, H.
Forbes 1665-M. On top of ridge, right side of Kipahulu.

MENISPERMACEAE - Moonseed Family

Cocculus ferrandianus Gaud. "huehue"
E
L & D 4054. Occasional below 3000 ft.

SAXIFRAGACEAE - Saxifrage Family

Broussaisia arguta var. arguta forma ternata Forbes ex Skottsb.
E - Genus monotypic, endemic to Hawaiian Islands. "puahanui," "kanawau"
L & D 4037; Warner et al, 11. Abundant shrub above 2000 ft.

PITTOSPORACEAE - Pittosporum Family

Pittosporum confertiflorum A. Gray "hoawa"
E - (O, L, Ma, H)
D 61. Small trees in forest at 6500 ft. Specimens are sterile but seem best to match this species.

Pittosporum glabrum var. tinifolium Sherff "hoawa"
E - This variety only from E Ma
L & D 4050. A few trees were seen on the north slopes of Puu Palikea at 2200 ft. alt. This variety was known previously only from the type collection, Forbes 1668-M, from the right-hand ridge of Kipahulu.

Pittosporum insigne Hillebr. "hoawa"
E - Ma, Mo
L & D 3980; D 36, 37. Found occasionally between 3500-4500 ft. Specimens are closest to var. micranthum Sherff from Kanaio and Ulupalakua, East Maui. In the Kipahulu material the leaves and flowers are slightly larger, perhaps because these plants are growing in a region much wetter than the type locality.

ROSACEAE - Rose Family

Fragaria chiloensis Duchesne "ohelo papa," "wild strawberry"
I
J. Lind, 24/VIII/67. 7000 ft., in gully west of Wai Anapanapa. This material corresponds with what Degeners call var. sandwichensis Deg. et Deg.

Rubus hawaiiensis A. Gray "akala"
E - K, Mo, Ma, H
L & D 3924. Relatively common above 2500 ft.

Rubus macraei A. Gray "akala"
E - E Ma, H
D 54. Trailing plants at 6500 ft.

Rubus rosaefolius Smith "thimbleberry"
X
Observed but not collected. Abundant in forest from 1500 ft. to above 4000 ft.

LEGUMINOSAE - Pea Family

Acacia koa A. Gray "koa"
E
L & D 4053. The most common tree below 3500 ft. From 1500 to 3500 ft. this is the dominant forest tree. One of the best stands in Hawaii occurs in Kipahulu.

Sophora chrysophylla var. chrysophylla forma haleakalaensis Chock "mamane"
E - This form only on E Ma.
Hoe s.n. Above 6500 ft.

Strongylodon lucidus (Forst. f.) Seem. "nukuiwi"

I

L & D 4063; Forbes 1684-M. Uncommon, below 2500 ft.

GERANIACEAE - Geranium Family

Geranium arboreum A. Gray

E - E Ma

J. Lind s.n., 28/VIII/67. One tree seen at 6500 ft.

Geranium carolinianum var. *australe* (Benth.) Fosb.

X

Observed by Hoe in *Vaccinium* scrub at 7000 ft.

Geranium multiflorum var. *ovatifolium* (A. Gray) Fosb.

E - This variety only on E Ma

P. Kaiwi, E. Smith, G. Lind s.n., 28/VIII/67. Two trees seen at 6500 ft.

RUTACEAE - Rue Family

Pelea clusiaefolia A. Gray "alani"

E

D 69; Forbes 1714-M. These specimens seem to belong to var. *cookeana* (Rock) St. John et Hume.

L & D 3864, 3979. These specimens seem to belong to var. *cuneata* St. John et Hume.

This species is quite common, especially as understory tree or shrub in koa forest below 3500 ft., but also occurs up to 6500 ft.

Pelea volcanica A. Gray

E

Forbes 1637-M, 1717-M, 1723-M. All from left-hand side of Kipahulu.

Pelea spp.

E

The following collections have not been adequately identified. They represent at least two additional species of *Pelea*;

L & D 3866, 3884, 3936; Warner et al, 1; Forbes 1716-M, 1724-M.

Platydesma spathulatum var. *pallidum* (Hillebr.) B. C. Stone "pilokea"

E - Genus endemic to Hawaiian Islands, this variety on O, Ma, H.

L & D 3993, 4043; Forbes 1642-M. Rare tree found between 2000-4000 ft.

EUPHORBIACEAE - Spurge Family

Aleurites moluccana (L.) Willd. "kukui"

P

Observed only; common below 1500 ft., only occasional above this elevation.

Antidesma platyphyllum Mann "haa," "mehame"

E

L & D 4057; Forbes 1634-M. Scattered trees from 1500 to 2500 ft.

Claoxylon sandwicense var. magnifolium Sherff "poola"

E

L & D 4059. A few plants on the south side of Puu Palikea at about 1800 ft. While this variety is widespread in the islands and has previously been found on West Maui, this seems to be the first record of its occurrence on East Maui.

AQUIFOLIACEAE - Holly Family

Ilex anomala Hook. et Arn. "kawau"

E

L & D 4003, 4058b. Occasional trees between 2000-4000 ft.

CELASTRACEAE - Staff Tree Family

Perrottetia sandwicensis A. Gray "olomea", "waimea"

E

L & D 3881, 3982; D 41; Warner et al, 18. Common understory tree from 2000 to above 4000 ft. Many native birds were observed feeding in trees bearing ripe fruit.

SAPINDACEAE - Soapberry Family

Dodonaea viscosa L. "aalii"

I

L & D 4049. Observed infrequently, only below 2500 ft.

FLACOURTIACEAE - Flacourtia Family

Xylosma hawaiiense Seem. "maua"

E

L & D 4058a. A single tree seen, at 2500 ft.

THYMELAEACEAE - Mezereum Family

Wikstroemia sp. "akia"

E

L & D 3992, 4064; Forbes 1718-M. Uncommon, between 2500-3500 ft. This species is a tree, as much as 5 m. tall. Forbes' specimen is identified in the Bishop Museum Herbarium as W. elongata. Our specimens key out to W. sandwicensis. However, these specimens do not agree with the descriptions of the species, and the specimens are probably referable to one of the species recently described by Skottsberg.

LYTHRACEAE - Loosestrife Family

Cuphea carthagenesis (Jacq.) MacBride "tarweed," "puakamoli"

X

L & D 3890. Common in disturbed areas in forest.

MYRTACEAE - Myrtle Family

Eugenia sandwicensis A. Gray "paihi," "ohia ha"
E
L & D 3862; St. John d Catte 17,806. Common tree above 2000 ft.

Metrosideros polymorpha Gaud. "ohia lehna"
E ?
L & D 3985, 4036; D 52; Forbes 1626-M. Scattered trees from 2000-3500 ft. Between 3500-4000 ft. this species replaces Acacia Koa as the dominant tree, and is the dominant tree to above 6500 ft.

Psidium cattleianum Sabine "strawberry guava"
X
Observed only, up to about 2200 ft.

Psidium guajava L. "guava"
X
Observed only, up to about 2000 ft.

ONAGRACEAE - Evening Primrose Family

Jussiaea suffruticosa var. lingustraefolia (HBK) Griseb. "kamole"
X
L & D 4040. Occasional in very wet disturbed areas.

HALORAGACEAE - Water Milfoil Family

Gunnera mauiensis (Krajina) St. John "ape ape"
E - E Ma
D 89; St. John & Mitchell 21,104. Abundant on steep wet cliffs from 4000-6000 ft. St. John & Mitchell's specimen came from "Kipahulu Valley, northerly side gulch near head of Oheo Stream, wet thicket, 5800 ft. alt."

ARALIACEAE - Aralia Family

Cheirodendron trigynum var. confertiflorum Sherff "olapa"
E - Ma for this variety.
L & D 3951, 4035; Forbes 1667-M. Common understory tree in Acacia and Metrosideros forests from 2500 to over 6000 ft.

Tetraplasandra meiandra var. mauiensis Sherff "ohe"
E - E Ma for this variety.
L & D 3863; D 43; Forbes 1713-M. Fairly common tree from 2500 to over 4000 ft., often found in slightly wetter places in forest, such as small stream gullies.

UMBELLIFERAE - Carrot Family

Hydrocotyle verticillata Thunb. "pohepohe," "marsh pennywort"
X
L & D 3929, 4042. Here and there in swampy places or on stream banks, to about 3500 ft.

Sanicula sandwicensis A. Gray
E - H, E Ma
D 85. At Wai Anapanapa.

ERICACEAE - Heath Family

Vaccinium berberidifolium Skottsb. "ohelo"
E - E Ma, H
D 65, 76. Common at higher elevations.

Vaccinium calycinum Smith "ohelo kaulaau"
E
L & D 3873; D 11, 39. Fairly common from 2500 to above 4000 ft.

Vaccinium reticulatum Smith "ohelo"
E - Ma, H.
D 79. Found only above 6500 ft.

EPACRIDACEAE - Epacris Family

Styphelia douglasii (A. Gray) F. Muell. "pukeawe"
E - Mo, E Ma, H
L & D 4025. Occasional above 3800 ft.

Styphelia tameiameiae (Cham. et Schlecht.) F. Muell. "pukeawe"
E
D 1, 78. Occasional from 3500 ft., more common at higher altitudes.

MYRSINACEAE - Myrsine Family

Embelia pacifica Hillebr. "kilioe"
E - O, L, Ma, H
L & D 4002; Forbes 1696-M. Rare between 3000-4000 ft.

Myrsine lessertiana A. DC. "kolea"
E
L & D 3861, 3966; Warner et al, 24. Occasional between 2500-4000 ft.

Myrsine sandwicensis var. *mauiensis* Lév.
E - This variety on O, Mo, L, Ma
Warner, et al, 21. Near Palikea Stream at about 3200 ft.

PRIMULACEAE - Primrose Family

Lysimachia hillebrandii Hook. f. "puahekili"
E
D 53. A common shrub at 6500 ft. The specimens do not fit well into any of the varieties listed in Hillebrand's flora.

Lysimachia remyi Hillebr.
E - Mo, Ma
Warner, et al, 4. Near Palikea Stream at 3200 ft.

SAPOTACEAE - Sapote Family

Pouteria sandwicensis (A. Gray) Baehni et Degener "alaa"

E

Forbes 1669-M. Ridge, left side of Kipahulu.

LOGANIACEAE - Logania Family

Labordia glabra var. orientalis Sherff "kamakahala"

E - Genus endemic to Hawaiian Islands, this variety to E Ma.

L & D 3994; Forbes 1644-M. We found a few plants between 3000-4000 ft. which probably belong to this, the East Maui variety of the species. However, the variety is recognizable only on the basis of fruit size, and we did not find ripe fruits.

Laboradia hedyosmifolia var. centralis (Skottsb.) St. John "kamakahala"

E - This variety on Ma, Mo, L

Warner, et al, 17; Forbes 1688-M. Warner's specimen was from 3200 ft. along Palikea Stream; Forbes' was from the east ridge of Kipahulu.

APOCYNACEAE - Dogbane Family

Alyxia olivaeformis Gaud. "maile"

E

L & D 4006. Fairly common from 2000-4000 ft.

LABIATAE - Mint Family

Phyllostegia macrophylla var. remyi Sherff "ulihi"

E - This variety on Maui

L & D 4015; Forbes 1653-M. We noted a few plants on the central ridge at 3200 ft., near Base Camp 1. Forbes' specimen was from the east ridge.

Prunella vulgaris L. "self-heal"

X

D 26. On stream banks above 4000 ft.

Stenogyne kamehamehae Wawra

E - Genus endemic to Hawaiian Islands, this species to Mo, Ma.

L & D 3948, 3975, 3989, 4028. Very common creeping vine between 2500-4000 ft. There are two varieties of this species which are distinguished on the basis of flower color. All plants we observed were either sterile or in fruit.

Stenogyne rotundifolia A. Gray

E - E Ma

D 60. At 6500 ft., under Metrosideros and Cheirodendron.

SOLANACEAE - Nightshade Family

Nothocestrum sp. "aiea"

E - Genus endemic to Hawaiian Islands.

Forbes 1640-M, Ridge, left side of Kipahulu; Forbes 1663-M, Ridge right side of Kipahulu. Both collections seem to represent the same taxon, which is perhaps a variety of N. latifolium.

Solanum incompletum var. mauiense Hillebr. "popolo"

E

Forbes 1664-M, 1697-M. Ridge, right side of Kipahulu.

Solanum nigrum L. "popolo"

P

L & D 3909. Occasional below 3000 ft., especially in disturbed areas.

GESNERIACEAE - Gesneria Family

The systematic botany of Hawaiian Cyrtandra is exceedingly complex, with many species on each island. St. John's recent monograph of the species from Oahu, while elucidating this complex situation for Oahu, has demonstrated the futility of trying to apply names to species from other islands until similar monographs have been prepared. A few specimens do agree fairly closely with descriptions of C. lysiosepala and are so cited below. The other specimens have not been named, but probably represent at least three additional species.

Cyrtandra lysiosepala (A. Gray) C. B. Clarke

E - Mo, Ma, H

L & D 3942; Forbes 1646-M, 1662-M, 1693-M, 1740-M.

Cyrtandra spp.

L & D 3919; D 40; Warner, et al 6, 8, 13; Forbes 1629-M, 1655-M, 1656-M, 1658-M, 1686-M, 1692-M.

PLANTAGINACEAE - Plantain Family

Plantago pachyphylla A. Gray

E - K, Mo, Ma, H

D 83. Found above 6500 ft.

RUBIACEAE - Coffee Family

Bobea sp. "ahakea"

E - Genus endemic to Hawaiian Islands.

Forbes 1666-M. Ridge, right side of Kipahulu.

Coprosma ernodeoides var. mauiensis St. John in Oliver "kukainene," "leponene"

E - This variety on Ma, H

D 72. Found above 6500 ft.

Coprosma pubens A. Gray Var. pubens "pilo"

E - This variety on Ma, H

L & D 3915. A few plants on the central pali at about 2600 ft.

Coprosma stephanocarpa Hillebr. "pilo"

E - Mo, Ma

L & D 3981; D 9, 68; Forbes 1639-M, 1648-M. Scattered plants from 2500 to above 6500 ft.

Gardenia remyi Mann "nanu", "na'u"

E - K, Mo, Ma, H

Forbes 1705-M. Kipahulu Stream near intake, only one tree seen.

Gouldia hillebrandii Forsberg var. *hillebrandii* "manono"
E - Genus is endemic to Hawaiian Islands, this var. to Ma.
L & D 3976. Fairly common tree from 2500-4000 ft.

Forsberg (Bishop Mus. Bull. 147, 1937) cited two Forbes collections, 1628-M, Kipahulu, above the plantation, and 1694-M, Ridge, right side of Kipahulu as: *Gouldia terminalis* var. *ovata* forma *makawaoensis* X *G. hillebrandii* var. *hillebrandii*

Gouldia terminalis (Hook. et Arn.) Hillebr. "manono"
E
L & D 3875, 3887, 3911; D 35, 38, 71; Warner, et al 22. Fairly common from 2000 to at least 6500 ft. At least two varieties and several forms seem to be represented in these collections, but final determinations have not yet been made. L & D 3875, 3887 seem to be var. *ovata*; D 35, 38, 71 seem to be var. *cordata*.

Hedyotis acuminata forma *obovata* Fosb.
E - Form only from East Maui.
Forbes 1645-M. Ridge, left side of Kipahulu Valley. This is the type and only collection of this taxon.

Hedyotis acuminata forma *forbesii* Fosb.
E - Form only from East Maui
Forbes 1690-M. Ridge, right side of Kipahulu Valley. This is the type and only collection of this taxon.

Hedyotis centranthoides var. *centranthoides* forma *vestita* Fosb.
E - This form on Mo, Ma, L, H.
L & D 3937; D 57; Warner, et al 5. Occasional plants from 2500-6500 ft.

Nertera depressa Banks et Sol. in Gaertn. "makole"
I
L & D 3891, 3897; D 2; Forbes 1676-M. Occasional above 3000 ft.

Psychotria spp. "kopiko"
E
L & D 3877, 3883, 3887, 3943, 4045; D 32; Warner, et al. 19; Forbes 1632-M, 1647-M. Trees are fairly common from 2000 to above 4000 ft. There seem to be at least two taxa represented in these collections.

CUCURBITACEAE - Squash Family

Sicyos sp.
Forbes 1709-M. Kipahulu Stream (=Palikea Stream).

CAMPANULACEAE, subfamily LOBELIOIDEAE - Lobelia Subfamily

Clermontia arborescens (Mann) Hillebr. "haha"
E - Genus endemic to Hawaiian Islands, this species on K, Mo, Ma
L & D 4046; Forbes 1689-M. Abundant above 2000 ft., both terrestrial and epiphytic.

Clermontia kakeana Meyen "haha"

E - O, Mo, Ma

L & D 4047; Forbes 1625-M. Fairly common from 2000-3500 ft.

Clermontia reticulata St. John

E - E Ma

Forbes 1711-M. Kipahulu Stream (=Palikea Stream). In the most recent monograph, Wimmer cites this specimen as belonging to C. grandiflora var. vulgata, and C. reticulata is reduced to synonymy with this variety.

Cyanea aculeatiflora Rock

E - Genus endemic to Hawaiian Islands, this species to E Ma

D 15; Forbes 1679-M, 1725-M. Occasional between 2500-4000 ft.

Cyanea angustifolia (Cham.) Hillebr.

E - O, Mo, L, Ma

Forbes 1660-M. Ridge, right side of Kipahulu. This specimen has been filed in the Bishop Museum Herbarium as var. lanaiensis, which presumably occurs only on Lanai.

Cyanea grimesiana var. ?

E - O, Mo, L, Ma, H

Forbes 1636-M, 1680a-M. Ridge, left side of Kipahulu.

Cyanea hamatiflora Rock

E - E Ma

Forbes 1654-M. Ridge, right side of Kipahulu.

Cyanea holophylla var. obovata Rock

E - Ma

Forbes 1707-M. Kipahulu Stream (=Palikea Stream).

Cyanea horrida (Rock) Degener et Hosaka

E - E Ma

Hoe s.n. 27/VIII/67. Wai Anapanapa, about a dozen plants on a small muddy pali above the second lake, 7000 ft.

Cyanea macrostegia Hillebr.

E - Ma

L & D 3880; Warner, et al 3; Forbes 1652-M. Occasional on stream banks at about 3000-3500 ft.

Cyanea multispicata Lév.

E - K, Ma, H

L & D 3917, Warner, et al 12; Forbes 1680-M; 1708-M. On stream banks between about 2500-3200 ft. there is a yellow-flowered species of Cyanea which belongs to section Pilosae of Rock, or to section Delissoideae as defined by Wimmer. Wimmer has cited Forbes 1780-M as C. multisplicata (although he misspelled Kipahulu as Kapulehua). Rock, according to notes in the Bishop Museum Herbarium, felt that C. multispicata was confined to Kauai, and identified the Maui plants as C. copelandii Rock, a species originally described from Hawaii. Later Rock seems to have changed his mind and considered the Maui material to be specifically distinct, and drew up a description, complete with manuscript name, which was never published. Until the matter can be studied more carefully, it seems best to follow Wimmer's treatment.

Cyanea scabra var. variabilis Rock forma variabilis
E - Ma
Forbes 1657-M. Ridge, right side of Kipahulu.

Cyanea scabra var. variabilis forma sinuata (Rock) E. Wimm.
E - Ma
Forbes 1728-M, 1729-M. Ridge, left side of Kipahulu.

Cyanea spp.
E
Warner et al 20; Forbes 1730-M. These specimens have not yet been satisfactorily identified.

Lobelia grayana E. Wimm.
E - K, Ma
D 62; Warner, et al 9a; Forbes 1659-M, 1695-M. Occasional from 3000 to above 6500 ft. Degener and Degener have recently transferred this to the genus Neowimmeria as N. grayana (E. Wimm.) Deg. et Deg.

Lobelia hypoleuca Hillebr.
E
Warner, et al 9b. Near Palikea Stream, 3200 ft. For those who wish, it can also be called Neowimmeria hypoleuca (Hillebr.) Deg. et Deg.

Trematolobelia macrostachys (Hook. et Arn.) A. Zahlb.
E - O, Mo, W Ma, E Ma, H.
L & D 3859. Common from about 2700-4000 ft, especially in places more exposed to wind.

GOODENIACEAE - Goodenia Family

Scaevola chamissoniana Gaud. "naupaka"
E - Mo, Ma, L, H
L & D 3947. Common from 2000-4000 ft. This collection probably represents var. chamissoniana. Skottsberg cites as var. bracteosa: Forbes 1633-M. This was collected in Kipahulu, above the plantation, probably at about 1500 ft.

COMPOSITAE - Composite Family

Argyroxiphium virescens Hillebr. "greensword"
E - E Ma
Observed by Hoe at 7000 ft., above the second lake at Wai Anapanapa.

Bidens sp. "kokoolau"
E
Warner et al 10. Along Palikea Stream at 3200 ft.

Dubautia demissifolia (Sherff) Keck
E - Genus is endemic to Hawaiian Islands, this species to E Ma.
J. Lind s.n., 28/VIII/67. At 6500 ft.

Dubautia montana var. robustior (Sherff) Keck

E - Variety on E Ma

D 87. At Wai Anapanapa.

Dubautia plantaginea var. platyphylla Hillebr. "naenae"

E - Variety on E Ma

L & D 3976; Warner, et al 7. Occasional from 2500 to above 4000 ft.

Dubautia thyrsiflora (Sherff) Keck

E - E Ma

D 56. Common at 6500 ft.

Erechtites valerianaefolia (Wolf) DC "hino hana"

X

L & D 3952. Fairly common in open disturbed areas, at least to 4000 ft.

Eupatorium adenophorum Spreng. "Maui pamakani"

X

L & D 3968; D 10. Fairly common, at least to 4500 ft., although most plants show insect-induced galls.

Hypochaeris radicata L. "gosmore"

X

D 75. Common in open grassy areas above 6500 ft.

Youngia japonica (L.) DC.

X

L & D 3920, 3990. Occasional in moist places to about 4000 ft.

APPENDIX I

Collecting localities of C. N. Forbes in Kipahulu Valley, Nov. 13-Dec. 5, 1919.

The following information was extracted from Forbes' field notebook. I have expanded on it where possible to indicate exactly where his collections were made.

Nov. 13, 1919: Forbes entered Kipahulu Valley and established his camp in the lower rain forest "above the plantation" at 1625 ft. This was probably along the base of the east pali near Palikea Stream, near the spot marked on current maps as "Gaging Station." Collections were labeled "Kipahulu Valley, above the Plantation," and were probably made below 1700 ft. alt. Collections were numbered 1625-M to 1634-M.

Nov. 15, 1919: Forbes went up ridge to left of "camp valley" to about the 2000 ft. level. I think he climbed up the central pali, probably near Puu Palikea. Collections were labeled "Ridge, left side of Kipahulu." Collections were numbered 1635-M to 1648-M.

Nov. 16, 1919: Collections were made around the camp, and labeled "Kipahulu Valley, above the Plantation." Collections were numbered 1649-M to 1651-M.

Nov. 17, 1919: Forbes went up the ridge to the right of his camp, just mauka of the intake. He climbed up the ridge and worked along the top. This ridge is probably the east pali of the valley, and he seems to have reached its top and proceeded toward Puu Kaumakani. Collections were labeled "Ridge, right side of Kipahulu." Collections were numbered 1652-M to 1668-M.

Nov. 18, 1919: Forbes went up the valley above his camp to the large waterfall on the left-hand side, and climbed the valley above it for some distance. It is hard to tell exactly where Forbes went. The most conspicuous waterfall in the valley is on Palikea Stream at about 3000 ft. However, this is on the right-hand side of the valley. Therefore, I suspect Forbes followed the stream which runs along the base of the central pali, but do not know where the waterfall is or the maximum elevation he reached. Labels read "Ridge at left side of Kipahulu" and some have the further notation "Above the Waterfall." Collections were numbered 1669-M to 1685-M.

Nov. 20, 1919: Forbes went up the ridge above the intake and further up than on the 17th. This is again the east ridge of Kipahulu, leading up to Puu Kaumakani at 4576 ft. Forbes did not mention how far up the ridge he got. Labels read "Ridge, right side of Kipahulu." Collections were numbered 1686-M to 1703-M.

Nov. 22, 1919: Forbes went "up the main stream, keeping to the left, for a long distance." Labels read "Kipahulu Stream," but Forbes must have been following Palikea Stream. Collections were numbered 1704-M to 1712-M.

Nov. 26, 1919: Forbes went up the ridge on the left-hand side of the valley above the waterfall. This probably refers to the central pali, and the waterfall mentioned is the same one he visited on Nov. 18. Labels read "Ridge, left side of Kipahulu," and some have the additional notation, "Above the waterfall." Collections were numbered 1713-M to 1722-M.

Nov. 27, 1919: Forbes went up "ridge left of camp and way over to the left and up." Apparently he climbed the central pali and crossed the western part of the valley, working toward Koukouai Stream. Labels read "Ridge, left hand side of Kipahulu." Collections were numbered 1723-M to 1736-M.

Nov. 28, 1919: Collections were made around Forbes' camp at 1600-1700 ft. Labels read "Kipahulu." Collections were numbered 1737-M and 1737a-M.

Dec. 1, 1919: Forbes went "far up valley to wild cattle country where the going was easier." There is no way to determine the maximum altitude he reached, although his mention of wild cattle in the valley is of interest. He probably was in the eastern part of the valley, and none of the plants he collected is characteristic of higher altitudes, so he probably did not reach more than 3500-4000 ft. Labels read "Kipahulu." Collections were numbered 1738-M to 1743-M.

APPENDIX 2

Collecting localities of the Kipahulu Expedition of The Nature Conservancy.

L & D 3859 to L & D 3906: Collected by Lamoureux and DeWreede along the trail which runs from Base Camp 1, on the central ridge at 3120 ft. across the western part of the valley at about the 3000 ft. level to Koukouai Stream at the foot of the western pali. Aug. 6, 1967.

L & D 3907 to L & D 3952: Collected by Lamoureux and DeWreede along the trail from Base Camp 1 down the central pali to the unnamed stream at the base of the pali at 2500 ft. Aug. 7, 1967.

L & D 3953 to L & D 4040: Collected by Lamoureux and DeWreede along the trail following the central ridge between Base Camp 1 at 3120 ft. and Base Camp 2 at 4100 ft. Aug. 9, 1967.

L & D 4041 to L & D 4066: Collected by Lamoureux along the trail which follows the central ridge from Base Camp 1 to the makai base of Puu Palikea at 1500 ft. Aug. 10, 1967.

D 1 to D 10: Collected by DeWreede along the trail running from Base Camp 2 at 4100 ft. across the western part of the valley to the base of the western pali near Koukouai Stream at 4600 ft. Aug. 16, 1967.

D 11 to D 23: Collected by DeWreede near Camp 2 and on trail up central ridge between 4100 and 4350 ft. Aug. 1967.

D 24, 25, 89: Collected by DeWreede in small valley at base of central pali at 4075 ft. Aug. 1967.

D 26 to D 51: Collected by DeWreede along trail running up central ridge from Camp 2 to 4575 ft., and then along lateral trail down central pali to its base at 4020 ft. Aug. 1967.

D 52 to D 64: Collected by DeWreede along ridge leading from Kipahulu Valley to central Paliku ridge, between 6450-6600 ft. Aug. 24, 1967.

D 65 to D 71: Collected by DeWreede on central ridge of Kipahulu Valley leading up to Base Camp 3, between 6000-6500 ft. Aug. 22, 1967.

D 72 to D 79: Collected by DeWreede on ridge between Base Camp 3 and top of Kipahulu Valley, between 6500-7350 ft. Aug. 22, 1967.

D 80 to D 88: Collected by DeWreede near Wai Anapanapa at about 7000 ft. Aug. 22, 1967.

Warner, et al 1 to Warner, et al 25: Collected by R. E. Warner, J. Lind, W. Banko and others above the large waterfall on Palikea Stream, in a small steep-sided valley at about 3200 ft. This valley was so small and steep-sided that it was probably inaccessible to pigs.

SUMMARY TABLE

Vascular Plants of Kipahulu Valley

	Native Species	Introduced Species	Total
Pteridophytes	75	1	76
Angiosperms	132	21	153
TOTAL	207	22	229

AUTHOR'S NOTE:

Since this report was submitted to The Nature Conservancy, Dr. Harold St. John has returned to Honolulu and made available to me his collections from Kipahulu. These included collections made with R. J. Catto on December 28, 1936, and collections made with A. L. Mitchell between August 13 and August 30, 1945. These collections contained 28 species not included in the present report (see previous page), of which 27 were from the area at the head of Kipahulu Valley and near Wai Anapanapa. With the inclusion of the St. John collections, which will be reported in detail elsewhere, the data in the SUMMARY TABLE should be changed to:

	Native Species	Introduced Species	Total
Pteridophytes	79	1	80
Angiosperms	150	27	177
TOTAL	229	28	257

BOTANICAL POTENTIAL OF KIPAHULU VALLEY: SUMMARY STATEMENT

The lower part of the valley, below 1500 ft., contains very few native plants, although the area around the Sacred Pools does have an interesting vegetation of the sort one usually associates with a "tropical paradise." These plants are, for the most part, species introduced by the Polynesians or haoles (white men). Consequently, no time was spent on a botanical survey of this area.

The botanical survey concentrated on areas above 1500 ft., and the comments below apply only to this area.

We have recorded about 220 species of higher plants in the valley. Of these only 10% (23 species) are species introduced to Hawaii by man. In contrast, 50% of the species now growing in Kipuka Ki and Kipuka Puaulu in Hawaii Volcanoes National Park are introduced species, although these kipukas are justifiably famous as representing outstanding remnants of the original vegetation of Hawaii. In those parts of Kipahulu Valley between 2000 and 6500 ft. only about a dozen introduced species were found. These composed only a minor part of the vegetation, and were most common only in places disturbed by the rooting of pigs. Below 2000 ft. introduced species were more common, and have probably spread upward from the pasturelands below. Above 6500 ft. introduced species were more frequent. These have probably spread down into the valley from along the mule trail between Haleakala Crater and Wai Anapanapa which runs along the ridge at the top of the valley.

The central part of the valley is a happy hunting groundfor the botanist and ecologist. It is one of the least disturbed areas remaining in Hawaii today, and would provide an unequaled opportunity to preserve an entire, unique, ecosystem almost undisturbed by man and his activities.

Among the most interesting botanical features of Kipahulu are: There are at least 75 species of ferns and related plants, all but one of which is native to Hawaii. More extensive exploration would probably reveal another 40 species of ferns here.

There are at least a dozen species of woody lobelias, all of which are unique to Hawaii. These plants are famous among botanists the world over. Many of the 130-odd species known from Hawaii have become extinct in recent years, and others are very rare. One of the high points of the expedition for me was watching a scarlet Iiwi with its long curved pink bill feeding among the long, curved pink flowers of Trematolobelia macrostachys, which is perhaps the most beautiful of all our native lobelias.

Between 2000 and 3500 ft. is one of the best stands of koa trees in the islands. While magnificent koa forest occurred on most of the Hawaiian Islands in ancient times they have been decimated in recent years. This stand is the finest I have seen. Between 3500 and 4000 ft. there is a zone of transition from koa to ohia lehua forest, and above 4000 ft. ohia lehua becomes the dominant tree. The gnarled, tangled trunks, thickly covered with epiphytes, and the abundant undergrowth make travel slow and difficult toward the upper parts of this zone, where the ohia trees are smaller than at lower elevations.

At still higher elevations the ohia forest is replaced by a low scrub zone, which gives way eventually to a meadow of native grasses. The wide variety of plant communities available in a relatively short distance which could be preserved in Kipahulu would offer unparalleled research opportunities. Within three miles one can find communities ranging from a tropical rain forest to a sub-alpine zone with frequent frosts. Elsewhere in Hawaii today it would be nearly impossible to find this many undisturbed communities in such close proximity. Since most of the Hawaiian species of plants are endemic, these communities are like no others, and Kipahulu in this sense offers an opportunity not available elsewhere on this planet.

CHAPTER 4

A PRELIMINARY SURVEY OF THE PHYTOGEOGRAPHY OF KIPAHULU VALLEY

by

Garrett A. Smathers

INTRODUCTION

Basic information contained in this report was obtained by field reconnaissance of the Kipahulu Valley area from August 17, 1967, through August 25, 1967. Only general observations were made because of limited time in the field, and the inability of transporting scientific equipment with personal gear.

The phytogeographical survey was primarily directed toward the distribution and composition of the vegetation cover and only minor attention was given to local productivity. The four main ecological factors of climate, physiography, soils (edaphics), and living organisms (biotics) were evaluated for each vegetation or natural aggregation of plants. Climatic data for the area were practically non-existent, and only a general soil survey was made in 1955.

A topographic vegetation profile was constructed to depict the correlation of major environmental factors (climate, physiography, soils) with particular vegetation types on the central pali-escarpment. However, care should be exercised in interpreting by characterizations since much of the data is subject to further evaluation.

DISTRIBUTION AND COMPOSITION OF THE VEGETATION

The Kipahulu Valley region is located on the southeast slope of Mt. Haleakala within the heavy, windward rainfall area of East Maui. The valley feature extends from a broad alluvial fan near sea level to a steep-sided broad to narrow pali rim which connects in part to Haleakala Crater. Pohaku Palaha at 8,105 feet is the highest point on the valley-head rim. Generally, the area referred to as Kipahulu Valley consists of two valleys, or broad expanses with moderate slope, each bounded by a steep sidewall and separated from one another by a central pali-escarpment.

The valley lies approximately along a northwest-southeast axis, placing it at a right angle to the prevailing trade wind. This geographic position, relative to the trade wind orographic general climate and variable physiography, produces some well recognized microclimates. The long interaction of climate and vegetation has produced several well developed soils, but in some areas factors of slope and parent materials may be the major determinants of a specific pedogenesis. Climate and soil observations will be treated separately in this report.

The vegetation cover is quite diverse as a result of prevailing ecological factors and man's activities. From sea level to approximately 1,200 feet, the native forest cover has been removed for agricultural purposes. Most of the area was first planted with sugar cane, but in later years it was converted to pasture land. Many non-native trees and shrubs grow in scattered to closed colonies throughout the grassland. However, now and then a relict, such as kukui tree, can be found in gulches and similar depressions--spots unfavorable for grazing.

From 1,200 feet to about 2,200 feet a mixed forest of native and non-native trees and understory plants dominate. While several guava and eucalyptus are found in the lower limits, the original dominant component, Acacia koa, still characterize the historic community. The forest floor is under constant disturbance by feral pigs. Several varieties of woody and herbaceous plants readily invade pig-scarified sites.

Beginning at 2,300 feet and extending to approximately 3,400 feet an open to closed koa forest with some ohia (Metrosiduis sp.) and olapa (Cheirodendron triggnum) trees make up the vegetation cover. Except for pig disturbed areas, this forest seems to have escaped man-made changes, and it has practically the same species composition as before western man appeared. Certainly, its physiognomy and structure have not been altered.

As elevation increases, the koa forest eventually gives way to an ohia type, just above 3,500 feet. Above 4,100 feet, koa disappears from the ohia forest, and olapa becomes an association dominant with ohia. This union of native trees and lower story vegetation has not been affected directly by man. Few people have ever penetrated the area. Pigs are still present, but their spreading or engendering of non-native plants appear to have inflicted only minor damage.

At 4,500 feet the ohia forest becomes a scrubby, somewhat closed formation situated upon a marshy to mucky soil. Many large trees are dead, and in some places, many are lying on the ground. There is little disturbance from pigs. The marshy substrate is thought to be ultimately determined by prevailing physiographic and edaphic factors.

A somewhat abrupt change is manifest at 5,400 feet where the scrubby ohia forest joins a large-crowned, vigorously growing ohia forest type. Here, in places, the slope approaches 100%. The large crowns in this formation tend to provide a somewhat homogeneous pattern to the upper valley physiography. This forest type extends to about 6,600 feet, where the ohia becomes shorter and takes on a globose form.

Above 6,600 feet the low globous ohia becomes quite scattered in a thick heathland-like ground cover, which consists of several native woody and herbaceous vascular plants. The growth forms present are somewhat characteristic of those of the sub-alpine zone as defined and described by some plant geographers. Feral goats which inhabit the high ridges above 6,600 feet have caused deeply eroded gullies in the ridge tops.

At 7,350 feet, on the valleyhead rim, there is an abrupt transition from the low globous ohia with heath-like matrix into a native grassland. This native bunch grass--Deschampsia nubigena--covers an extensive area from the valleyhead over a broad table-like expanse which connects to Haleakala crater and adjacent ridges. Although pigs and goats are active in the area, the grassland still retains its original dominant character and composition. A few forbs have successfully invaded pockets of disturbed soil.

METHOD OF VEGETATION ANALYSIS, CLASSIFICATION, AND MAPPING

Analysis - The vegetation cover was examined on the ground along a transect extending from sea level to the valleyhead rim. This transect followed the course of the main expedition trail, starting near sea level and continuing along the central pali-escarpment to the valley head.

Plot analysis was made at approximately every 250 feet gain in elevation along the described transect. At these intervals, the species composition and vegetational structure was recorded in 10 x 10 meter plots. Because there was a limited time for this survey, the plot dimensions were estimated rather than being laid off by tape. Dominant or characteristic species, presence, and cover were determined for each stratum. Special attention was given to ecological factors which were manifested and which possibly determined the vegetation's distribution and composition. Changes in species or forest structure were noted between elevation intervals on the expedition trail transect.

Side trails, leading from the base camps into the east and west valleys, were used as belt transects for vegetation sampling. Various members of the expedition collected and observed plants along these paths, their data providing indispensable information for preparing the vegetation maps.

Since I had only nine days for field work, information supplied by other expedition participants was broadly relied upon. The difficult terrain and thick plant cover were formidable obstacles which prevented a thorough investigation of the east and west valley interiors and walls. Under these circumstances aerial photos supplied basic information on general cover type or dominant tree species.

Classification - Vegetation types were the smallest units of classification used. These were determined by homogeneity in species composition and their contiguous distribution. All vegetation types are defined by either physiognomic, floristic, or physiographic criteria or a combination of these. For mapping purposes a system of symbols were developed to represent the vegetation type classification. The symbols and corresponding vegetation types are listed on page 70. Also the symbol system will be discussed further under the section on mapping.

Mapping - Aerial photographs of 27" x 27" dimension were used for locating the vegetation unit boundaries. Vegetation types of the central pali-escarpment transect (determined by plot analysis) were located on the aerial photos, and their pattern boundaries drawn in accordingly. Wherever a "similar pattern" was located on the Kipahulu Valley photographs, its boundaries were drawn in and given the same vegetation unit classification. As many as possible of these "similar patterns" were field checked to corroborate the classification.

Several patterns appeared on the photos that were not found on the central pali-escarpment transect. In most instances the dominant cover species could be identified by growth form, etc. Several were determined from high vantage points with the use of field glasses. Often other expedition members, or employees of the Kipahulu Cattle Company who had been in the areas of question, could give information as to dominant cover species. Had time permitted and more help been available, all patterns could have been checked. Regardless of the obstacles, 19 definite vegetation patterns were identified on the aerial photos with approximately 50% of these corroborated by field check. Those that were not field checked are listed on page 70.

Very small colonies or consociations of some species such as Gunnera mauiensis, Cyanea sp. and fern were too minute in pattern to place on the vegetation map. The same situation occurred with stream and gulch communities.

The system of symbols and vegetation type classification are adapted from that used by Dieter Mueller-Dombois (1966) in mapping the vegetation of Hawaii Volcanoes National Park. In doing so, the symbols used were derived from the names of genera, or other predominant surface cover or feature.

It will be noted that the symbols are usually in two parts, the first or front symbol denotes the most dominant stand or surface feature. An attribute symbol follows in parenthesis after the front one, thus showing a variation within the cover type. This variation is commonly recognized by a change in the subdominant species or structure modification (Doty, Mueller-Dombois 1966).

Example: MC-(Ac-ad) represents: Metrosideros - Cheirodendron Forest with scattered Acacia koa and admixture of Lower Story Arborescent Shrubs.

Symbols denoting other vegetation and surface features have similar simple abbreviations which are in lower case letters.

Only three aerial photos were provided to give complete coverage of the Kipahulu Valley area. A small section is missing in the northwest quadrant, but through field check it was found to possess no new patterns. By not having photos for adjacent flight lines, it was impossible to get accurate coverage for all the proposed Kipahulu Valley area. Greater accuracy could have been accomplished in mapping if selection of polygonal areas had been made from the aerial photographs.

The linear scale determined for each photo is considered to be most accurate for the central area (+). However, in sections of great topographic relief, the scale may vary considerably. Also, it should be noted that a high degree of distortion occurs at the photo edges.

Boundary lines were drawn around all the vegetation patterns present on each aerial photo. Later, these were traced from the photos for preparing the vegetation map.

Aerial photographs used may be ordered from:

U. S. Geological Survey
345 Middle Field Road
Menlo Park, California

Each photo is ordered by roll number, photo number, and flight. For example: photo EKN-3CC-30, 3-31-65.

Roll number = 3CC
Photo number = 30
Flight = EKN 3-31-65

This information is on each vegetation map.

TOPOGRAPHIC VEGETATION PROFILE

Figure 58 is a topographic vegetation profile of Kipahulu Valley. This profile was constructed from ecological information obtained along the central pali-escarpment expedition trail, therefore representing the various ecosystems found from sea level to the valley head. Ecological factors of climate, topography, and soils can be determined for each vegetation unit, thus giving a cross section of the biotic and abiotic material interrelationships. Although sufficient data were not available on soils and climate, enough reliable material was obtained to construct the profile within acceptable confidence limits.

The profile method was adapted from that used by Dieter Mueller-Dombois (1966) in preparing a vegetation map of Hawaii Volcanoes National Park. Numbers assigned to segments of the profile indicate the different vegetation types which are located along the central pali-escarpment. These segments, much like boundaries on the vegetation map, give a more abstract presentation of the plant communities. For example: profile segment No. 6, Large Crown *Metrosideros* - *Cheirodendron* Forest with Native Shrubs, actually includes four recognized sub-types with some differences in stratification and species composition. However, in each sub-type the Large Crown physiognomy and *Metrosideros* - *Cheirodendron* association is manifested.

Description of Profile Segments:

Segment #1, Pasture Grassland - Widespread Trees and Shrubs; Pg-(ts); aerial photo, EKN-ICC-148, 1-21-65.

This man-managed vegetation extends from near sea level to approximately 1,200 feet. The cover is dominated by Digitaria decumbens and Pennisetum clandestinum grasses and several associated forbes and grasses. Throughout the grassland, and being widespread, are patches of trees and shrubs. Sometimes a tree or shrub may be found singly.

At the lower elevations these patches of phanerophytes are classified as Mixed Lowland Forest Patches; mx-lf-ps. Here Eugenia cuminii, Mangifera indica, Psidium guajava, and Aleurites moluccana dominate.

At higher elevations the patch cover consists of Psidium - Interspersed Aleurites tree and Lantana shrub; P-(AL).

Aleurites moluccana is found throughout the grassland type; however, it is mostly confined to the gulches and similar land forms. In these places Aleurites still maintains its historic distribution. In some respects it represents a relict of the original lowland native forest that was removed for agricultural land.

The grassland covers the most productive soil in the Kipahulu Valley area. However, under present recommended agricultural practices this soil type is not considered best for pasture land, because it is readily invaded by the guava - Psidium (Cline 1955).

Segment #2, Mixed Acacia Koa Forest; mx-Ac; aerial photo, EKN-ICC-148, 1-21-65.

Again, partly because of man's influence, the vegetation type is exhibited by two sub-types which differ somewhat in their structure and composition, but not enough to justify separation on physiognomic or floristic criteria. Acacia koa dominates throughout, and it tends to become larger and more vigorous at the upper limits of the boundary. Also, the latter condition is manifested on well drained slopes and the valley floors. In the lower half of the community the forest possesses a two-story stratification. Upper story association dominants are Acacia koa, Aleurites moluccana, Cheirodendron trigynum and Eucalyptus sp., while the lower layer is mainly Psidium guajava, P. cattleianum, Gouldia sp., and Cibotium sp. Clermontia sp. and Alphitonia ponderosa occur now and then in the lower story.

Ground cover consists of Gleichenia sp., Stachytarpheta jamaicensis, and a few Hedychium sp.

Epiphytes are present in all strata.

In the upper limits of this vegetation segment, the two-story forest continues with Metrosideros collina var. polymorpha and Cheirodendron trigynum appearing as sub-dominants in the top layer. In the lower level Psidium guajava, P. cattleianum, Pisonia sp., and Cibotium sp. dominate the association, although Psidium guajava begins to diminish in number. An interesting woody vine, Freycinetia arborea begins to appear as a climber in the lower stratum, forming somewhat a synusia with the lower trees and shrubs.

Ground cover consists mainly of Rubus rosaefolius, Stachytarpheta jamaicensis, Paspalum conjugatum, Athyrium sp., and Adiantum sp. In some areas the non-native grass, Paspalum conjugatum, forms thick patches on pig scarified sites, although it may be found in places under geodynamic processes; i.e., eroded places on steep slopes, gulches, etc. It has been reported that some native forests have become extinct because Paspalum conjungatum tends to smother slower-growing plants (Neal, 1965).

Several epiphytes are found throughout including Psilotum nudum which occurs now and then. In gulches up to 1,500 feet pure stands of the Aleurites Community, A, can be found.

Segment #3, Acacia koa - Cibotium Forest with Freycinetia liane and scattered Metrosideros - Cheirodendron; AcCbFy(MC); aerial photo, EKN-ICC-154, 1-21-65.

Here, apparently, Acacia koa is within or approaching optimum conditions for growth and reproduction in Kipahulu Valley. This is a reasonable assumption since koa is the dominant species of the community relative to cover, density, and frequency. Self replacement is evidenced by successful reproduction, and also, being the dominant competitor in its vertical growth through the various strata. It was not ascertained whether seeding or suckering, or a combination of both attributed to the juvenile trees.

The community is characterized by Acacia koa controlling the upper story with Cheirondendron trigynum and Metrosideros collina var. polymorpha having a tendency to occupy the same stratum, and both becoming more numerous as elevation increases. At the upper limits, Metrosideros - Cheirondendron become the association dominants while Acacia koa assumes a sub-dominant position. Here Cibotium sp., forms a union or synusia at the lower level with Tetraplasandra sp., Scaevola chamissoniana, and Broussaisia arguta.

The forest floor is mostly covered with Alyxia olivaeformis, Athyrium sp., and Paspalum conjugatum. By 3,200 feet Paspalum conjugatum tends to disappear from the forest floor.

A most interesting feature of the forest structure is the Freycinetia liane of the lower and mid-layers. Every so often this woody climber is associated with a similar life form--Stenogyne sp.

Wherever the slope decreases to such extent that the ground becomes nearly level, rain water will stand on the surface. In doing so, it produces a marshy to swampy condition. This feature of the substrate is apparently brought about by soil characteristics. While no soil pit was dug on the marshy sites to provide a profile description or analysis, several deeply eroded channels revealed the A and B horizons. These were observed and evaluated by general inspection, and the information obtained is covered in the section on soils.

Segment #4, Metrosideros - Cheirodendron Forest with scattered Acacia koa and Admixture of Lower Story Arborescent Shrubs; MC-(Ac-ad); aerial photo, EKN-ICC-154; 1-21-65.

Approaching 4,000 feet, Metrosideros collina var. polymorpha and Cheirodendron trigynum association becomes the dominant cover of the forest. Acacia koa decreases in density and frequency. By 4,100 feet only a few scattered koa are found. At Basecamp 2 (4,100') the koa status was determined by several observations. Near camp, a ring or clone of young koa trees, extending from the base of a large dead one, indicates propogation by vegetative means rather than by seed. This dead koa measured 4 feet in diameter. Certainly, the tree and others observed indicate that Acacia koa held a dominant position in the past formation. A few Metrosideros were found with diameters up to 4 feet.

Cheirodendron may become an epiphyte on Metrosideros. It was not determined why Cheirodendron in one instance would be anchored in the ground, and in another on a Metrosideros tree. This same situation was observed for Styphelia sp., Astelia sp., and some ferns at the community's upper limits. It is very possible that the highly hygric soil conditions could be detrimental for original ground establishment, while more benign edaphics would occur on steeper, better drained slopes. The epiphyte relationship is usually the opposite; i.e., the tree or support may provide more mesic conditions than the ground. Since there seems to be no great difference in light intensity where plants were epiphytes or on the ground, the light requirement hypothesis could not be applied.

The vegetation type is further characterized by an admixture of lower story shrubs consisting mostly of Pelea sp., Broussaisia arguta, and Scaevola chamissoniana. Ground cover is mostly ferns, namely: Athyrium sp., Gleichenia sp., Hicriopteris pinnata; some woody members such as Rubus rosaefolius and Alyxia olivaeformis are colonizers of open spots.

Most common epiphytes included mosses and Astelia sp. By 4,000 feet the Freycinetia arborea liane was practically non-existent.

There are several streams that pass through the forest in both the east and west valleys. Along their banks the forest structure changes to Metrosideros and Acacia koa which occupy the top stratum and are of the same height--40 to 50 feet. Their diameters are less than those trees growing on better drained soils. Cheirodendron makes up the second story, while the third level is occupied by Broussaisia arguta, Perrottetia sandwicensis, Pelea sp., and Cibotium sp. The banks are usually covered with numerous ferns, namely: Athyrium sp., Polystichum Hillebrandii, Asplenium sp., Microlepia sp., Hicriopteris pinnata. Other bank inhabitants are Rubus hawaiiensis and Eupatorium riparium. Common to most stream banks is a mint from Eurasia, Prunella vulgaris. Probably, this plant has been introduced by water carrying the seeds from horse and hunter trails which are on the valleyhead rim.

Segment #5, Closed, Scrubby Metrosideros Forest with Scattered Dead Trees; cs-M-(dM); aerial photo, EKN-3CC-30, 3-31-65.

This forest is primarily distributed upon marshy to mucky soils which have developed on the gentle sloping floors of the east and west valleys. It is believed that a highly impermeable B horizon attributes to the marshy substrate--much like that discussed in Segment #3. This feature is discussed further in the section on soils.

The community is characterized by thick to partially opened stands of small Metrosideros collina var. polymorpha, which form the top story and cover up to 80% of the area. In most places, Metrosideros forms the only story. Acacia koa has disappeared. Dead trees are scattered throughout and possibly are the result of hygric soil conditions. Another feature is numerous fallen trees on the ground. These make travel throughout the marshy area a difficult task.

At times a second story may be found consisting of Cheirodendron trigynum and Broussaisia arguta.

Only those plants possessing a hygrophytic habit can become successfully established on the extremely wet ground. Carex sp. is the dominant form with Athyrium sp. being present where water is not standing.

Styphelia sp. and Astelia sp. are epiphytes, possible because of the extremely wet ground.

By referring to the vegetation map, it is readily seen that this vegetation type is subjected to a high water runoff from the valleyhead watershed.

Thus, gentle topography, soil characteristics, and a high water supply are all interrelated in helping to determine the distribution, composition, and physiognomy of this vegetation unit.

Segment #6, Large Crown Metrosideros - Cheirondendron Forest with Native Shrubs; lc-MC-(ns); aerial photo, EKN-3CC-30, 3-31-65.

The degree of abstraction has been increased in mapping this vegetation type. While the overall physiognomy of the community is homogeneous, there do exist differences in some structural features and in sub-dominant species composition. When considering the criteria for microhabitat classification, relative to the biotope concept, this vegetational pattern offers many opportunities for applying the term. Sections of the major habitat change considerably over the entire area, as manifested by the shrub story and ground cover structure and composition. However, throughout the range, the large crown Metrosideros controls the physiognomy and represents the climax species. Also, at the upper limits of this distributional pattern, the greatest growth form change takes place in Metrosideros.

The lower limits of the vegetation development starts at approximately 5,400 feet (transition from Scrubby Metrosideros - Cheirodendron Forest), where the physiography changes drastically (steep slopes, high ridges, deep gulches, etc.). The physiographic factor of topography (slope and elevation) becomes a major control of edaphic and climatic features. The controlling presence of these ecological factors are evidenced in certain plant cover composition and distribution. Also, the geodynamic process of erosion is manifested on some very steep slopes, and in this instance it may be the controlling factor.

At lower limits the forest is two layered with Metrosideros - Cheirodendron in the upper one, and the lower level consisting of a synusia of Coprosma montana, Broussaisia arguta, and Rubus hawaiiensis. Most common epiphytes are mosses and ferns (Elaphoglossum sp., Asplenium sp.).

At approximately 5,750 feet, where the slope may be 100% or more, the forest becomes thrice stratified with only Metrosideros occupying the upper story and accounting for 50% cover. Cheirodendron forms the second layer and has a crown cover of near 40%. Coprosma montana, Styphelia sp., and Cibotium sp., are co-dominants of the third layer. Nertera depressa, Astelia sp., and Polystichum hillebrandii are major vascular species represented on the forest floor. Moss epiphytes are numerous.

At 6,050 feet Cibotium has practically disappeared from the forest, while Coprosma montana and Styphelia appear in greater number and frequency.

At 6,350 feet, forest stratification changes to a recognizable four level stage with some change in species composition. Here, the large crown Metrosideros continues to solely occupy the first stratum, and Cheirodendron the next below. The third layer is dominanted by Styphelia sp. and a new addition, Vaccinium sp. A fourth layer which is easily delineated consists of young Cheirodendron trigynum, Pelea sp., and Broussaisia arguta. Ground cover is mostly Astelia sp., Athyrium sp., and Polystichum hillebrandii. Lichens begin to appear in greater numbers with mosses and the fern Elaphoglossum sp. forming the epiphyte community.

The forest about Basecamp 3 (6,450..) is a good representative of the overall formation relative to the physiognomic and floristic criteria used for classification. This area offered an excellent opportunity for examining simultaneously the physiographic factors and vegetation development.

The saddle and knoll features of the central pali-escarpment tend to have differences in sub-dominant species and forest structure--even where these features are in close proximity. The following data were obtained from 10 x 10 meter ground plots.

Knoll at 6,500 feet:

1st stratum - Metrosideros, 40-50 feet high, 50% cover.

2nd stratum - Cheirodendron, 20-30 feet high, 25% cover.
Illex anomala, scattered and of low vigor - many dying, though

still possessing live lateral buds which give rise to a few branches, 5% cover.

3rd stratum - Coprosma montana, up to 15 feet high, 25% cover.
Styphelia sp., up to 7 feet tall, 10% cover.
Myrsine lessertiana, up to 7 feet, 10% cover.

Ground cover - Astelia sp., 95% cover.
Polystichum hillebrandii and Lycopodium sp., 5% cover.

Epiphytes - Most common are mosses, Elaphoglossum fern and Nertera depressa.

Remarks: Several dead or dying Metrosideros trees are present. These vary between 20-30 feet tall and are inclined to die terminally. As terminal necrosis begins the trunk tends to develop many buds which give rise to lateral branches.

A few trees have been uprooted by strong Kona winds. Some of these trees continue to live because part of the root system is still below ground surface.

Saddle (location of Basecamp 3) 6,450 feet:

1st stratum - Metrosideros, up to 50 feet tall, 80% cover. Most trees have short, thick trunks and a roundish crown canopy (orchard appearance). A few old trees have diameters between 3 and 4 feet.

2nd stratum - Cheirodendron, 20-30 feet tall, 25% cover.
Myrsine, 15-20 feet high, 10% cover.

3rd stratum - Coprosma montana, up to 15 feet, 75% cover.
Rubus hawaiiensis, 6-10 feet high, 5% cover.

Ground Cover - (Up to 4 feet) - Athyrium 75%, Polystichum 20%, Vaccinium 3%, Carex 2%.

Epiphytes - Numerous mosses, Elaphoglossum, and Peperomia sp.

Remarks: The soil pit profile shows ash parent material, and continued wet through the reddish B horizon.

Western Slope of Central Ridge Near Basecamp 3, (6,450')

On this and other steep ridges the trees lose their short, stout trunk form and their crowns become smaller. An interesting aspect is manifested where the trees grow perpendicular to the steep slope--apparently a function of wind pressure.

Several landslides have removed enough solum to show zonal soil development upon ash material. On one avalanche scar, a dark A zone was observed overlying a reddish one.

Beginning of transition zone between the Large Crown *Metrosideros* - *Cheirodendron* Forest with Native Shrubs and the Scattered, Low Globous *Metrosideros* with Heathland-like Matrix, 6,550 feet:

Here, on a knoll of the central ridge escarpment, *Metrosideros* forms thick stands, with diameters of a few inches up to 1 foot.

1st stratum - *Metrosideros* with globose crown, 30-35 feet high, 100% cover.

2nd stratum - *Coprosma*, up to 20 feet tall, 20% cover.

3rd stratum - *Cheirodendron*, up to 12 feet tall, 5% cover.

Ground Cover - *Polystichium*, 80% cover.
Athyrium, 10% cover.
Sadleria sp., 5% cover.
Elaphoglossum sp., 2% cover.
Astelia sp., 3% cover.

Epiphytes - Folious lichens and mosses are common on trees.

Remarks: Outside the plot, and approaching the Scattered, Low Globous *Metrosideros* with Heathland-like Matrix vegetation type, are small colonies of *Deschampsia nubigena*. Along with *Deschampsia*, *Carex sp.* and *Rubus hawaiiensis* may be present.

Segment #7, Scattered, Low Globous *Metrosideros* with Heathland-like Matrix: hm-(lgM); aerial photo EKN-3CC-30, 3-31-65.

This vegetation pattern affords one of the most interesting in physiognomy and life form composition. Within 600 feet of increase in elevation, *Metrosideros* decreases in height from an average of 25 feet to one of 5 feet.

Some treatments of the Kipahulu Valley phytogeography would probably separate this distribution into two vegetation types. It is possible to place the lower limits into a classification representing the dominant low globous *Metrosideros*. The upper limit becomes densely covered with a variety of heath-like life forms while *Metrosideros* becomes a widely scattered shrub. Here, another classification is justified. However, it is reasoned by observing apparent prevailing ecological factors, that this major distribution represents an ecotone (transition) between the forest below and grassland above. It appears that this peculiar "growth form" or "life form" (low globous shrub) is determined by the prevailing climate. Although edaphics of these steep slopes are not well understood, it doesn't seem to manifest a major control over this particular vegetation type. However, the soil factor must not be ruled out--especially where physiography changes rapidly. This is best seen where fingers of the large crown Metrosideros forest extend up gulches and ravines, well into the Low, Globous Metrosideros with Heathland-like Matrix vegetation unit.

The climate hypothesis is given support by extrapolated isohyets and isotherms. These parameters indicate a zone of lower rainfall and temperatures. The mean minimum temperature falls within a range where large phanerophytes tend to become shrubby but still retain a definite upright stem. Possibly, the upper limit of this vegetation type extends into the beginning of the sub-alpine zone. This elevation is comparable to that at which other investigators have placed the sub-alpine zone on high Hawaiian volcanoes (Robyns and Lamb, 1939; Fosberg, 1959; Hartland Neal, 1940).

Relative to other factors of climate, these higher elevations are subjected to a higher rate and degree of insolation (radiant energy). This and other climatic conditions will be discussed further under the section on climate.

The overall growth form in vegetation cover reminds one of the heath balds of the high southern Appalachian mountains, where ericaceous shrubs of Rhododendron, Kalmia, and Vaccinium form mountaintop communities.

The vegetation development is characterized at the lower limit by globous Metrosideros ranging from 20-30 feet tall and covering about 50% of the area. There are two interesting forms of Metrosideros collina var. polymorpha occurring here. One has a darker, hairy leaf while the other has a lighter, smooth leaf. From field inspection these appear to be respectively: Metrosideros collina subsp. polymorpha var. incana and Metrosideros collina subsp. polymorpha var. glaberrima, though the taxonomy could not be verified (Rock, 1917). One might begin to suspect ecotypes in situations such as this. A few other tree species begin to take on a shrubby form at the lower limits, namely, Cheirodendron, Myrsine, and Coprosma.

All the tree branches become encrusted with a thick layer of folious lichen, while the ground becomes covered with a thick matted matrix of heath-like growth forms. Most common representatives of the mat matrix are: Vaccinium berberidifolium, Railliardia sp., Lysimachia hillebrandia, Lycopodium sp., Styphelia sp., Coprosma ernodeoides, Sadleria sp., Polypodium sp., and Athyrium sp. Rubus hawaiiensis is found scattered throughout. Sadleria sp. and Vaccinium berberidifolium are highest in cover percentage.

As elevation increases Metrosideros becomes widely scattered and less in number and size. By 7,000 feet the heath-like matrix dominates the cover, and is practically free of Metrosideros.

At 7,350 feet there is an abrupt transition to the Deschampsia Grassland vegetation type. Such a sharp change in vegetation is most unusual and cannot factually be explained at this time. While climate may still be in control, edaphics and physiography appear to exert a sharp influence on the apparent grassland climax.

The heathland-like matrix becomes dominated with Vaccinium berberidifolium which accounts for up to 70% of cover, while 3-7 feet tall Metrosideros accounts for less than 10%. The remaining percentage cover is about evenly divided with Hypochaeris radicata, Styphelia sp., Lysimachia hillebrandia, Pteridium aquilinum, Coprosma ernodeoides, Polypodium sp., Lycopodium sp., fruticose lichen, and a few bunches of Trisetum glomeratum scattered throughout.

Segment #8, Deschampsia Grassland; De; aerial photo, EKN-3CC-30, 3-31-65.

The native bunch grass Deschampsia nubigena forms a dense cover on the upper rim and adjacent pali tops and plateau-like features. It is the grass dominant, manifesting one of the finest examples of a native Hawaiian grassland. To this writer it is not unlike early scenes of the Palouse grassland of eastern Washington and Oregon, both in physiognomy and life form characteristics. Also, the quick transition from the phanerophyte dominated vegetation type is similar to the grassy balds and forest boundaries of the high southern Appalachians.

As previously pointed out, it is difficult to say positively that climate is controlling the climax--especially when such a sharp line exists between two entirely different vegetation types. Also, in some depressions or ditch-like features woody plants are present; though they seem not to encroach on the grassland. They do not appear to be successful invaders of pig or goat disturbed ground. Apparently, there is more soil moisture present here than in the main grassland soil.

It is well to point out that should pig and goat activity continue or increase, there is a good chance that the woody plants will become more numerous in the grassland formation--possibly destroying it.

Although the bunch grass habit leaves openings between adjacent tussocks, only a few plants have been able to fill the gaps. The non-native Holcus lanatus grass may appear along animal trails in damp depression or similar habitat. The non-native forb, Hypochaeris radicata, holds a subdominant position as indicated by its density and frequency. It is probably engendered by goats and pigs.

VEGETATION MAP UNITS

Symbol	Vegetation Type
cs-M-(dM)	Closed, Scrubby Metrosideros Forest with Scattered Dead Trees*
MC-(Ac-ad)	Metrosideros - Cheirodendron Forest with Scattered Acacia koa and Admixture of Lower Story Arborescent Shrubs*
O-MC-(Ac-g-F)	Open Metrosideros - Cheirodendron Forest with Scattered Acacia koa and Ground Fern*
AcCbFy(MC)	Acacia koa - Cibotium Forest with Freycinetia Liane and Scattered Metrosideros - Cheirodendron*
o-AcMC(Fy)	Open Acacia koa - Metrosideros - Cheirodendron Forest with Freycinetia Liane
mx-Ac	Mixed Acacia koa Forest*
ps-MC-(g-F)	Pali, Scrub Metrosideros - Cheirodendron and Ground Fern
pF	Pali Fern Cover
p-MCAc	Pali Metrosideros - Cheirodendron Acacia koa Forest
De	Deschampsia Grassland*
hm-(lgM)	Scattered, Low Globous Metrosideros with Heathland-like Matrix*
lc-MC-(ns)	Large Crown Metrosideros - Cheirodendron Forest with Native Shrubs*
Fg-(ts)	Fern - Grassland with Scattered Trees and Shrubs
Fg-(ts-gl)	Fern - Grassland with Tree-Shrub Gulches
A	Aleurites Community*
P-(AL)	Psidium - Interspersed Aleurites and Lantana
mx-if-ps	Mixed lowland Forest patches (Mangifera, Eugenia, Aleurites, Psidium)*
B-(mx-f)	Bamboo Forest with Scattered Components of Mixed Lowland Forest
Pg-(ts)	Pasture Grassland-Widespread Trees and Shrubs (Digitaria Pennisetum)*

*Corroborated by field checks.

SOILS

The 1955 Soil Survey of the Territory of Hawaii included the island of Maui and five other neighboring islands (Cline, 1955). Although the survey is primarily directed toward the conservation and resources management of Hawaiian soils, it also provides an excellent folio of soil maps and profile modal descriptions. Another important contribution is an introduction to the interrelationships of climate, vegetation, geology, and topography in determining Hawaiian soil genesis.

The Kipahulu Valley soils are among the most diverse found on the island of Maui. Their differences have been determined by a variety of soil-forming factors. Within the proposed boundary all three soil orders (Azonal, Intrazonal, and Zonal) are recognized, and are dominated by the laterization process of soil formation (Latosol-suborder). There are six soil families and these are represented by ten mapped units. The following elaboration on these mapped units and the classification system are taken in part from Cline's 1955 Soil Survey of the Territory of Hawaii.

To understand the soil classification used in the Hawaii survey, the following explanation should be helpful. In a manner it is somewhat similar to taxonomic systems of some biological disciplines. Periodic reference to Tables 1, 2, and 3 (pages 75-79) will help clarify the descriptions given.

The first unit of classification is the order. In Hawaii, soil scientists recognize the orders of Azonal, Intrazonal, and Zonal soils. Each of these is determined by the factors of soil development which influence the soil profile. Azonal soils are those of recent origin, and which weathering processes have not prevailed long enough for horizon development. Intrazonal soils are usually those of steep slopes and poorly drained areas, thus reflecting that topography or edaphic conditions are influencing soil formation. Zonal soils are those with well defined horizons, which reflect the major control of climate and vegetation in the soil forming process.

Next, the suborder represents the controlling process of soil formation. In the Kipahulu soils the laterization process has dominated. Accordingly, all soils with diagnostic profiles are placed in the Latosol suborder. They are characterized by having a depletion of silica and bases, weak textured profiles, and with a low silica-sesquioxide ratio.

For the Latosol suborder, three Great Groups were determined from the soil mapped units (See Soils Map, page 80). These were determined on the basis of genetic horizons in the soil profile, relative to their position and kind.

From the Great Groups represented, six Families of soils were determined (see Table 2, page 76). These families were recognized by what degree the genetic horizons modal is manifested for a particular group. As Cline (1955) points out, the family classification unit helps to better comprehend the relationships of the Great Group above with that of the soil series below. Family names are taken from the soil series. The name used (Hawaiian) represents geographically where the soil was first described.

The soil family is divided into series; series into types; types into phases. The series is determined from parent material and minor profile differences, while types reveal the texture of the soil surface. Phases are concerned with soil depth, slope, degree of erosion, and similar condition important to land use and management.

Only those soils found along the central pali-escarpment were field checked by the expedition group. However, these checks were quite general in degree and scope.

Soil augar samples were taken at several intervals, and soil pits were dug at Camps #2 and #3. Along the way numerous, deeply eroded gullies had exposed soil profiles. In some places the eroded cuts reached to the bare lava rock. Practically all observations made on the central pali-escarpment did not agree with the survey maps. However, it must be considered that the mapping reliability data must be reviewed and interpreted accordingly.

Cline (1955) notes that most of the lower elevations of Kipahulu Valley fall into a zone where mapping was done on reconnaissance survey. Traverses were made at 1 to 10 mile intervals. All of the mid and higher elevations were mapped from published maps, reports, or books from oral accounts of foresters, ranchers, and others, and from similar sources other than traverses by trained soil surveyors.

It is noted that by referring to the soil map on page 80, that the central pali-escarpment is completely mapped as a Lithosol (Rp), and also, the east and west valley walls are given the same classification. Thus, these areas were placed in the Azonal order indicating a lack of developed soil horizons.

Through field checks it was found that the edge of the central pali-escarpment had relatively deep zonal soils, and except for a few cliff faces, the side also had horizons in the profile. This soil was very similar to the adjacent mapped units (Aa) of Hydrol Humic Latosols in the valley floors.

The east and west valley walls were not checked, but the vegetation type there which is similar to that of the central pali-escarpment side, suggests that at least an intrazonal soil is present. But it must be admitted that after seeing a goodly portion of the valley walls and gulches, there are some places best mapped as lithosols.

By comparing soil pit and deeply eroded gulley profiles with modal profile descriptions, the soil from approximately 1,200 feet to 5,400 feet has very common characteristics of the Akaka soil family. This family is a representative of the great group of Hydrol Humic Latosols. Relative to series, type, and phase classification, it seems they could best fit the Akaka silty-clay-rough broken land complex (Ad) (see Table 2 and Soils Map). The valley floors appeared to be accurately mapped (Aa). However, an interesting feature of this soil was observed from about 3,000 feet to 5,400 feet. Rain water would stand on the ground surface, and because of this situation, places of level to gentle slope became marshy or swampy. Profile checks in these areas indicate that the yellowish-red B horizon was not permitting expedient percolation of water through the solum. The impermeability of this horizon was manifested on some pig scarified sites. Here, the A horizon was readily removed by runoff, leaving the erosive resistant B horizon exposed. Only on the steepest slopes was the B cut through by water runoff.

On the poorly drained sites the vegetation became stunted and tended to exhibit low vigor, while on well drained slopes, the trees were bigger and healthier.

Soils of the Scrubby Metrosideros Forest with Scattered Dead Trees were not examined, but it is suspected that the Amalu soil (Ar) may be present.

From 5,400 feet to 7,500 feet the deep and irregular layers of pyroclastic materials (pumice and cinders) made it difficult to determine the genetic horizon modal. Near 5,400 feet and to approximately 6,600 feet there appear on some knolls and saddles well defined horizons. However, because of the steepness of the slope and other environmental factors, it seems reasonable to place this soil in the Intrazonal classification. There is good reason to believe that this soil is the same or is intermediate to the soil family on the valleyhead rim. The rim soil of the Deschampsia Grassland vegetation type is mapped as Puu Oo loam and silt loam, slopes undifferentiated (P2v). Thus another great group is recognized--the Latosolic Brown Forest Soils. At this time it must be pointed out that recently the Latosolic Brown Forest Soil is considered Zonal rather than Intrazonal (Swindale and Sherman, 1964).

The soils of Kipahulu Valley are quite significant in their genesis and morphology. Their large variety is an indication of soil formation under several factors (climate, vegetation, topography, geology). There is evidence that one or more of these factors are directing a specific soil genesis. This latter feature becomes more evidenced where the valleyhead joins to the Haleakala crater rim and vicinity.

The entire area could become an outstanding outdoor laboratory to test certain hypotheses of pedogenesis. Soil scientists have been looking for areas in Hawaii to study soil genesis under the influence of native vegetation and climate. Rarely is such an area found because most of the native vegetation has been removed and replaced with non-native types.

Because most of Kipahulu Valley contains a large percentage of relatively undisturbed vegetation, and its contiguous association with the relatively raw volcanic substrates of Haleakala Crater, the area becomes one of the last remaining places in Hawaii where scientists can gain more knowledge of Hawaiian soil genesis. The *Deschampsia* Grassland vegetation type, with its associated edaphic and climatic factors, is a good example for future study. These significant features will make the Kipahulu area an important site for future IBP study (International Biological Program).

However, two very important problems remain. One is that the area has some potential agriculture land--especially the highly productive native *Deschampsia* Grassland would support livestock. This type of land is actively sought after by ranchers. Secondly, there are many feral pigs and goats in the area. Large numbers of these animals have begun to inflict irreparable damage to the high pali and forest interior soils. Their activity has increased or directly caused erosion and the spread of several non-native plants. The longer these animals are permitted to increase without control or elimination, the less significant the area becomes.

SOIL CLASSIFICATION SYSTEM

Table #1 from Cline (1955)

Order	Sub-Order	Great Group	Family	Map Symbol	Series, Type, Phase
Azonal	Lithosol			Rp	Rockland, very steep
				Rs	Rough broken land, residual material.
Intra-zonal	Latosol	Latosolic Brown Forest Soils	Puu Oo	P2v	Puu Oo loam and silt loam, slopes undifferentiated
Zonal	Latosol	Humic Latosol	Niulii	Nn	Niulii silty clay, moderately steep shallow phase
				No	Niulii silty clay, sloping and moderately steep phases
			Tantalus	Ta	Tantalus silty clay loam cinder cone phase
		Hydrol Humic	Akaka	Aa	Akaka family, very shallow phases
				Ad	Akaka silty clay--rough broken land complex
			Amalu	Ar	Amalu clay--rough broken land complex.
			Hilo	H2h	Hilo family, very shallow phases

SOIL FAMILY DESCRIPTION

Table #2 from Cline (1955)

Family		Modal Profile
Akaka	A1	Strongly developed; 5-6 inches thick; dark gray to dark grayish-brown weakly granular smeary silty clay loam pH 4.0 to 5.0.
	B	Yellowish-red very smeary crumb-structured silty clay loam, commonly weakly mottled with gray in the lower part, pH 4.0 to 5.5.
	C	Highly weathered, mottled, clayey volcanic ash at depths near 30 inches.
Amalu	AO	3-6 inches of brown, soft, mushy mat of decaying vegetable matter that partly retains original vegetative form; extremely acid, filled with roots.
	A1	0-7 inches, very dark-brown silt loam; weak coarse crumb structure; hard when dry, strongly smeary when wet; pH 4.0 to 4.5; roots very numerous.
	B	7-27 inches, yellowish-brown clay mottled with gray and rusty brown; structureless but porous; hard when dry, strongly smeary when wet; pH 4.0 to 4.5; at the contact with weathered rock, may contain discontinuous horizontal sheets of ironstone a fraction of an inch thick.
	C	27 + inches, gray, yellow, and brown soft weathered rock, commonly with thin sheets of ironstone in cracks or around rock cores; this soft material grades through a zone in which solid rock cores become increasingly numerous with depth to solid bedrock, which is usually below 20 feet.
Hilo	A1	Strongly developed; 8-10 inches thick; dark brown to dark reddish-brown weakly smeary moderately granular silty clay loam; pH 5.0 to 5.7.
	B	Red to yellowish-red smeary crumb-structured silty clay loam; pH 5.2 to 5.8.
	C	Weathered volcanic ash, usually at depths of 2-4 feet.

Family		Modal Profile
Niulii	A	0-9 inches, dark reddish-brown silty clay; strong medium granular structure; friable when moist or wet; pH 4.5 to 5.5; roots very numerous.
	B	9-24 inches, yellowish-red or reddish-brown silty clay; weak to moderate fine or medium blocky structure; friable when moist but slightly sticky when wet; pH 4.0 to 5.5; roots numerous in the upper part but decrease in number with depth.
	C1	24-32 inches, yellowish-red gritty silty clay similar to that of horizon B but including small amounts of soft, weathered rock fragments that retain the original structure; few roots.
	C2	32 + inches, yellow, red, brown, and gray soft weathered basalt that retains original rock structure; solid bedrock occurs at varying depths ranging to more than 6 feet in the deeper soils of the series; few or no roots; in the shallow phase, solid bedrock occurs at depths ranging from 12-30 inches, and it may replace the C1, C2, and lower part of the B horizon.
Puu Oo	A1	5-6 inches of very dark-brown to black friable granular silt loam or silty clay loam; pH 5.0 to 6.0.
	B	12 to 15 inches of dark reddish-brown friable but smeary weakly blocky silt loam or silty clay loam; pH 5.5 to 6.5.
	C	Brown or reddish-brown moderately weathered volcanic ash.
Tantalus	A	0-9 inches, dark-reddish brown silty clay loam; strong medium granular structure; very friable when moist or wet; pH 5.5 to 6.5; roots very numerous.
	B	9-27 inches, reddish-brown silty clay loam; weak fine blocky to crumb structure; very friable when moist, friable to weakly smeary when wet; pH 5.5 to 6.0; roots numerous.
	C1	27-45 inches, reddish-brown or brown soft weathered volcanic cinders that retain their original structure, mixed with black, hard, relatively unweathered cinders.
	C2	45 inches +, black and brown unweathered volcanic cinders; bedrock generally at depths of several feet.

MAPPED UNIT

Table #3 from Cline (1955)

Map Symbol	Series, Type, Phase	Land Use Potential
Ar	Amalu clay-rough broken land complex	This is best suited for forestry and as a water reserve. Extremely valuable as a source of water for human consumption and for irrigation of the dry lands at lower elevation. Forests are more vigorous on rough broken land parts of the complex than those on the Amalu clay. This better growth seems to be associated with drainage.
Aa	Akaka family very shallow phases	Soils mostly 4-12 inches deep, only occasional outcrops, many loose stones are on the surface and in soil mass. Most of best used for forest and as a water reserve.
Ad	Akaka silty clay-rough broken land complex	Consists of long, narrow to moderately broad areas of deep soil on ridges that slope step-wise toward the ocean; or steep land along streams that flow out of wet regions. Along the streams little true soil exists, but there is either an adequate mantle of volcanic ash or enough weathered rock itself, to provide a foothold for the growth of plants. Best used for water reserve and forest.
H2h	Hilo family, very shallow phases	Once used for sugarcane, but is now in pasture. Makes poor pasture land because guava readily gets started in numerous bedrock outcrops.
Nn	Niulii silty clay, moderately steep shallow phase	Moderate amounts of rock fragments occur on surface; best used for pasture, but when idle it readily becomes covered with guava (Psidium).

Map Symbol	Series, Type, Phase	Land Use Potential
No	Niulii silty clay, sloping and moderate steep phases	Used for sugarcane in the past, but now used for pasture land. Well adapted for supporting _Pennisetum clandestinum_ grass.
P2v	Puu Oo loam and silt loam, slopes undifferentiated	Good pasture land soil.
Rp	Rockland, very steep	This is the material of steep sides of mountains and precipitous cliffs along steep gorges; consists of almost continuous outcrop of older lavas that are practically bare of soil material. In wetter regions, even on slopes of more than 100%, trees, ferns, and vines are established in cracks and crevices, and may form a continuous covering.
Rs	Rough broken land, residual material	Poor for agricultural purposes; mostly covered with thick stands of guava (_Psidium_).
Ta	Tantalus silty clay loam, cinder cone phase	Best used for forest; locally it may be used for grazing.

SOILS MAP

From Cline (1955)

---- Proposed Boundary

xxxx Extension of Proposed Boundary to include Deschampsia Grassland

CLIMATOLOGY

Climatological data on Kipahulu Valley area are practically non-existent. Only uncertain extrapolations for parameters of mean temperature and precipitation have been made. In practically every instance, interpolations have been made from weather stations quite distant from Kipahulu Valley. The only active rain gauge in the area, which has extensive data, is located at Kipahulu (See Table #4 page 83).

The authorities for the weather information used in this report and the Topographic Vegetation Profile are Rainfall of the Hawaiian Islands by William J. Taliaferro, and Climates of the States, Hawaii by David Bluemstock, (1961). Taliaferro (1959) states that isolines are drawn through points of approximately equal value, and that caution should be used in interpolating on the weather maps, particularly in mountainous areas.

Kipahulu Valley lies just within the windward climate of Mount Haleakala, though its northwest extremity is transitory, at least physiographically, to the leeward aspect. The lower two-thirds of the area is subjected to high precipitation, but this may vary considerably across the valley in a west to southwest direction. It is evident that the general climatic pattern cannot be fully applied to this specific area.

The Hawaiian orographic climate is generally well understood, but certain anomalies in local climate reduce the validity of low range statistical application. Normally, the leeward and windward climates can be described within reliable limits relative to the manifested topographic relief. As the warm, moist trade wind moves up the mountain side, it becomes cooled and drops the greater part of its water. Little moisture is left for the leeward side, though some areas of lower elevation may receive considerable precipitation through sea breeze convection. However, in most every instance, rainfall is less for the same elevation on the leeward side than that for the windward side. Also, there is a greater temperature fluctuation. On some leeward sides, clouds are nearly as common as they are for the windward area (Blumenstock, 1961).

The windward rainfall distributional pattern is not the same for all islands. On east Maui the greatest rainfall of the windward region (300") occurs between 2,000-4,000 feet. For the island of Hawaii the 300-inch isohyetal falls below 3,000 feet.

The Hawaiian climate is characterized by rainy winters and drier summers. This distribution is revealed in the Kipahulu rain gauge data (see Table 4, page 83). However, this contrast may not be the same at higher elevations in the valley. For example, on the island of Hawaii at 2,000 feet on the mountain slope above Hilo, high rainfall remains constant all year long (Blumenstock, 1961).

Unlike precipitation, the temperature parameter can be extrapolated within limits of confidence even when local data are limited. Blumenstock (1961) states that the average decrease in mean monthly temperature upslope is about 30° F per 1,000 feet. However, at about 5,000 feet the rate is expected to approach 1° C/1,000 feet because of a temperature inversion that is carried in the trade wind air (Mr. Saul Price, unpublished data, U.S. Weather Bureau, Honolulu).

The 3° F/1,000 feet factor was found to vary about 0.5° C less than the factor used for extrapolating the temperature--elevation gradient for the topographic vegetation profile.* Data from the following Maui weather stations were used to obtain the 2° C/1,000 feet factor:

*See Figure 58 for Topographic Vegetation Profile.

Mean temperatures are from Blumenstock (1961), station location and elevation are from Taliaferro (1959).

	Mean Temperature (° C)	Elevation (feet)	Factor
Kula	17.8	3,005	*2.07° C/1,000 ft.
Wailuku	23.6	200	
	5.8	2,805	
Kula	17.8	3,005	*1.98° C/1,000 ft.
Pauwela	22.8	485	
	5.0	2,520	
Kula	17.8	3,005	*2.02° C/1,000 ft.
Hana	23.6	135	
	5.8	2,870	Average 2.0° C/1,000 ft.

*These values compare favorably with rate of temperature change per 1,000 feet rise in elevation for the island of Hawaii (Doty and Mueller-Dombois, 1966).

Above 5,000 feet, the 1° C/1,000 feet factor was applied to the Topographic Vegetation Profile.

The plotted mean isotherms seem quite applicable to conditions encountered by the expedition. There was a decided decrease in air temperature as elevation increased. Above 6,000 feet the nights were quite cool, especially when the sky was clear.

Rainfall was heavy at times, and the lush vegetation up to 6,600 feet indicated a zone of high precipitation. Thus, field observations did not agree with the precipitation--elevation gradient as depicted on the Topographic Vegetation Profile. It seems reasonable to assume that these figures should be increased by 50-75%. Estimates of 250-300 inches made by some expedition members seem most unreasonable, though after living in the area for a few days one begins to believe this.

Observations above 6,600 feet indicated quite definitely a sharp change in the climate. Here, clouds were less numerous, insolation was high though air mean temperature was getting lower ($10 \pm 2°$ C). Precipitation decreased and windy conditions became more common. The stunted growth of trees and shrubs and the appearance of grassland are all correlated with this climatic change.

TABLE #4

Kipahulu Valley Weather Data
(Rainfall)

Rainfall of the Hawaiian Islands, William J. Taliaferro, 1959. Hawaii Water Authority, Honolulu.

Rain gauge No. 258 - Kipahulu - is the only weather recording device in the immediate area. It is located at 350 feet elevation and has been in operation for 57 years.

Annual Median:	86.6	Upper quartile	107.8
Maximum:	187.4	Lower quartile	77.9
Minimum:	24.8		

Monthly Rainfall Data in Inches

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Max.	23.5	31.1	43.9	23.0	24.1	15.2	23.1	19.1	18.5	20.6	24.6	34.3
Med.	8.4	5.4	7.3	6.2	5.7	5.4	6.6	6.7	6.1	6.3	6.8	9.0
Min.	0.6	0.3	0.5	(1.5)	0.8	0.9	2.2	1.4	1.4	1.5	0.6	0.3

SOME OBSERVATIONS OF THE BIOTIC FACTOR

These observations represent those directly associated with studies of the vegetation and soils. They were often included in field notes as incidental or pertinent information. Their entry here is in essentially the same form as initially recorded.

Goats

Goats were observed and found to be most active on the high ridges and palis of the Low, Globous Metrosideros heathland-like Matrix and periphery of the Deschampsia Grassland vegetation types. Their disturbance of the ridge top substrate has produced deeply eroded gullies. Some gullies up to 2 meters deep have been cut through the pumice layer to the lava rock beneath. Goat activity is progressively destroying the soil and vegetation of this area. The forb Hypochaeris radicata is a common colonizer of goat disturbed soils, and it appears to be engendered by goat activity.

Pigs

Feral pig activity was observed throughout the Kipahulu Valley region. From observations made along the central pali-escarpment, their major activity seems to be concentrated from the upper limits of the Pasture Grassland (1,200') to the lower limits of the Closed, Scrubby Metrosideros Forest with Scattered Dead Trees (4,500'). However, in the Deschampsia Grassland (7,500'), they have scarified large areas of the native bunch grass. This activity is permitting the successful invasion of the native grassland with Hypochaeris radicata, and possibly, woody plants in the future.

Rats

Numerous rat burrows were found in the Deschampsia Grassland (7,500'+). Apparently this animal and vegetation type association is well established. Although the grassland community provides the rodent population sufficient cover and food, their presence (burrows) aids in spread of non-native plants. Apparently, the pigs may be seeking out some of these rat burrows for food as well as other materials in the grassland.

Owls

Two owl pellets were found by an expedition member where the Low, Globous Metrosideros Heathland-like Matrix joins the Deschampsia Grassland. These were found to contain bird and small mammal bones (rats?). The high rat population (if numbers of burrows is an indicator) of the open Deschampsia Grassland must afford suitable preying habitat for the owl. The bird bones could not be identified as to species. This would have been most desirable since some of the rare birds occupy the vegetation types just below the grassland.

Birds

The rare Crested Honeycreeper's call was heard several times in the Low, Globous *Metrosideros* Heathland-like Matrix. The bird was seen many times foraging among the Ohia tree tops of the Large Crown *Metrosideros* - *Cheirodendron* Forest with Native Shrubs.

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CHAPTER 5

GENETICS AND EVOLUTION OF HAWAIIAN DROSOPHILIDAE

Preliminary Report of Collections Made in Kipahulu Valley, Maui,
Cooperatively with the Kipahulu Valley Expedition,
August 1967

by

Hampton L. Carson

I. Scope and Purpose of the Hawaiian Drosophila Project

Flies belonging to the genus Drosophila have provided material of major importance for the understanding of the genetic changes on which evolution is based. Not only can new methods of microscopial and molecular analysis be applied to their chromosomes and genes, but the evolutionary roles of behavior and ecology can be easily studied. (See Figure 46.)

Oceanic islands have had a key role in evolutionary studies ever since Charles Darwin visited Galapagos as a young man. The discovery that the Hawaiian Islands harbored an isolated and highly endemic Drosophila fauna of over 400 species led to a proposal that the genetics and evolution of these species, fast disappearing with the destruction of the native forests, be studied. Modern methods, which have added so much to knowledge of evolution on the continental land masses, are accordingly being applied by a group of biologists whose work is strongly supported by the National Science Foundation and the National Institutes of Health. The work is under the leadership of Professor D. Elmo Hardy of the Department of Entomology, University of Hawaii, and Professor Wilson S. Stone, the Genetics Foundation, University of Texas. Over the past five years, more than twelve senior geneticists and evolutionists from laboratories on the Mainland United States, Scotland and Japan have participated in the work.

II. Obtaining Specimens

Essential for our work is the capture of gravid females in the wild, the return of these to the laboratory and the establishment of permanent laboratory cultures of these flies so that genetic studies can be made. At an early time it was discovered that not only are these flies endemic to the Hawaiian Islands, but they are frequently confined to single islands or even, in some instances, to very restricted areas within an island. Most of the species occur only at altitudes above 1500 feet; this is due in part to adaptation to cool environments but also in very large measure it reflects their close dependence, like the endemic birds, on breeding sites in the native forests.

III. Destruction of Natural Habitats in Hawaii

Collecting crews from our project have been working continually on all the major islands for the past four years. Almost everywhere, it appears that only the most precipitous and unscalable mountain peaks have escaped the cutting and removal of the extraordinary associations of Hawaiian plants. When native forests are logged and removed, non-native vegetation crowds into the available space. The frustration of our group has been very great because we frequently face the fact that we are able to collect only ten or twenty specimens or even none at all in areas which obviously once supported large populations.

IV. Collections in Kipahulu Valley, Maui, by the Genetics-Evolution of Drosophila Group, 1967.

The following excursions have been made; all but the first in connection with the Kipahulu Expedition.

1. Ridge West of Kipahulu Valley (2150'). Th. Dobzhansky, D. E. Hardy, K. Y. Kaneshiro, M. Muraoka. (Guided by J. Lind), June 21.

2. Basecamp 1 (3100'); Basecamp 2 (4000'); Valley floor (2500'); Contour trail from Basecamp 1 (2900'). H. L. Carson, August 2-6.

3. Basecamp 1. K. Kaneshiro, August 7-10.

4. Basecamp 1; Basecamp 2; Trail to Basecamp 3 (4600'); Valley floor (2500'); R. Iwamoto and M. Muraoka, August 16-20.

5. Trail to Basecamp 1 (2000'); Basecamp 1, Basecamp 2. M. Kambysellis, August 20-25.

6. Basecamp 3 (6600'); Valley floor (5300'); "Wai Kipahulu" (6600'); H. L. Carson, August 27-30.

7. Trail to Basecamp 1 (2000'). J. Murphy, M. Muraoka, M. S. Carson, August 31.

Accordingly, it can be seen that our group spent a total of about 36 man days collecting in the valley. Although collections at 2000 feet or below were generally sparse, efforts at higher altitudes have resulted in the collection of several thousand specimens belonging to 60 species. At the time of writing, it is not possible to state how many new species have been found, but it is certain that there are at least six (see appended list). Of particular interest, moreover, is the rather large number of giant-sized Drosophila present in this valley. This includes _D. parkinsi_, which is probably the largest Drosophila species in the world, with a wingspread of 22 millimeters. Seventeen specimens of this spectacular species, with its curiously modified wings and head in the male were captured. Among the other large species with extra wing veins or strikingly spotted wings or both are _D. obscuripes_ and _D. picta_ from the higher elevations, _D. truncipenna_, _D. melanocephala_ and _D. clavisetae_ from the intermediate altitudes. (See Figures 47, 48.)

The vicinity of Basecamp 1 at the 3100 foot level is undoubtedly one of the best Drosophila collecting spots in the Islands. The forest of giant koa trees, completely uncut and unspoiled, shelters the delicate and complex native plants which in turn support the fly population. That such an area still remains intact at this relatively low altitude is to my knowledge unmatched anywhere else in the Islands and is a biotic resourse of tremendous value.

V. Conclusion

The unique opportunity to understand the evolutionary process through genetic study of Hawaiian Drosophila can hardly be overemphasized. Nowhere else in the world does such an opportunity exist. Furthermore, population genetics is not served by dry and dead specimens in museums. The living insect species, with its genetic system, serves as a clue to past evolutionary history. These considerations go beyond the esthetic. Reserves which allow these insects to survive the in-roads of modern development will provide material for understanding -- "that mystery of mysteries -- the origin of new beings on this earth" as Darwin put it. Findings in this area, especially the characteristics of small populations, not only serve this fundamental end, but also may be expected to lead to a more mature understanding and control of man-directed evolution, namely the experimental breeding of animals and plants. Indeed, man himself arose in small isolated populations and it is not unlikely that principles uncovered in this work may contribute to the understanding of human evolution, as well as that of the rest of the biotic world.

LIST OF DROSOPHILIDAE COLLECTED IN KIPAHULU VALLEY
AUGUST 1967

Prepared by K. Kaneshiro, September 8, 1967

	Below #1	#1	Between 1 & 2	#2	Between 2 & 3	#3	Above #3
Drosophila							
adiastola		x		x	x		
araiotrichia						x	
balioptera	x			x			
brunneisetae		x					
canipolita	x						
comatifemora	x	x	x	x	x		
cracens						x	
crassifemur		x				x	
discreta	x	x	x	x			
disjuncta	x	x	x	x			
disticha				x	x	x	
fasciculisetae						x	
fundita		x					
grimshawi	x	x					
immigrans		x					
inciliata				x			
latigena				x			
lemniscata						x	
limitata	x	x					
nasalis					x	x	x
nasuta		x		x			
orphnopeza		x					
orthofascia	x	x					
recticilia	x	x					
seclusa						x	
setipalpus						x	
spectabilis					x		
torula						x	
truncipenna				x	x		
variabilis				x	x		
velutinifrons				x			
venusta		x		x			
(Sophophora) kikkawai	x	x					
(Trichotobregma) petalopeza						x	x
Antopocerus							
aduncus		x		x		x	x
diamphidiopodus		x		x			
entrichocnemus		x					
Idiomyia (Synonym of Drosophila HLC)							
clavisetae		x			x		
melanocephala		x		x	x		
perkinsi				x	x	x	x
picta				x	x	x	x
obscuripes				x		x	x
Titanochaeta chauliodon						x	

Scaptomyza at least 10 species

Drosophila at least 6 new species

Sceptomyza at least 2 new species

CHAPTER 6

DROSOPHILA ECOLOGY REPORT NO. 1

Kipahulu Valley Expedition

by

Robert N. Iwamoto

Drosophila, at the minimum, spend at least two weeks of their life cycles as egg, larva and pupa within the matrices of various parts of the plant body. During this 2 week span, they are invulnerable to any of the sophisticated techniques yet developed to capture adults. Thus, surveys of Drosophila populations in the past have been incomplete. With the advent of the substrate-rearing technique, developed by Dr. William B. Heed of the University of Arizona, more complete data on the number of species inhabiting any one specific area has been made possible. (Unpublished research material, W. B. Heed).

This substrate-rearing technique was used to sample the Drosophila population in Kipahulu Valley. The first step of this technique involves the selecting of substrates. The substrates may be almost any decaying part of a plant and are usually recognized by a distinctive sweet-sour odor of fermentation. Then, the specimens collected are examined for either eggs or larvae--eggs are usually visible to the naked eye and larvae can be observed by exposing the inner matrix of the substrate. After the substrates have been selected, they are put in plastic bags, appropriately labeled, and brought back to the laboratory in Honolulu in ice chests containing cold packs commercially sold as "Magic Ice." There, the substrates are "set" in one-gallon tin cans which contain approximately three to four inches of loosened, damp, sterile sand. The substrates should not be tightly packed, in order to prevent the death of larvae due to the heat of fermentation. It is also important that the substrates be moistened to simulate the high humidity of the rain forest. To provide proper air circulation, three holes along the rim of the can are punched and plugged with cotton. The cans are then covered individually with Saran Wrap. After allowing two to three weeks for the larvae to pupate in the sand, the sand is then "washed." This process involves the removal of the substrates from the gallon can and the depositing of the sand into another container, preferably a cake pan. Enough water is then added to cover the sand by approximately an inch. If any pupae are present, they will float to the surface of the water. Then, the pupae are extracted from the water with a camel's hair brush. The sand is agitated several times to insure the floating of all pupae to the surface. These pupae are then deposited in a glass vial which contains more damp sand. These vials are checked daily and if any flies emerge, they are removed with an aspirator and transferred to another vial containing blotter paper saturated with a sugar-ager solution. These vials provide the newly emerged flies with sufficient food and also allows them to complete their final development, i.e., hardening of the wings and development of coloration. Three to four days later, the flies are killed with ether and are identified.

The following list indicates the results obtained by the substrate-rearing technique.

List of Drosophilidae Collected by Substrate-Rearing
Kipahulu Valley Ecology Report 1
October 19, 1967

Drosophila	Base-camp 1	Between 1 & 2	Base-camp 2	Between 2 & 3	Base-camp 3
adiastola	X (Reared ex: *Clermontia sp.* branches)				
disticha	X[4] (Reared ex: *Cheirodendron gaud.* leaves)				
expansa	X[3] (Reared ex: *Cheirodendron gaud.* leaves)				
fundita	X[1] (Reared ex: *Tetraplasandra sp.* leaves)				
grimshawi	X[1] (Reared ex: *Clermontia sp.* branches)				
mimiconformis	X[3] (Reared ex: *Ilex sp.* leaves)				
nigella	X[2,3] (Reared ex: Brachet Fungus)				
seclusa	X (Reared ex: *Cheirodendron gaud.* leaves)				
setipalpus				X[1] (Reared ex: *Pelea sp.* leaves)	
torula	X[2,4] (Reared ex: *Ilex sp.* leaves)				
(Trichotobregma) petalopeza					X (Reared ex: *Cheirodendron gaud.* leaves)
new species	X (Reared ex: Bracket fungus)				
new species (mimiconformis-like)				X (Reared ex: *Pelea sp.* leaves)	
new species (modified mouth-parts)		X (Reared ex: *Freycinetia sp.* stems and leaves)			
Antopocerus					
aduncus					X (Reared ex: *Cheirodendron gaud.* leaves)
diamphidiopodus	X (Reared ex: *Cheirodendron gaud.* leaves)			X (Reared ex: *Cheirodendron gaud.* leaves)	

	Base-camp 1	Between 1 & 2	Base-camp 2	Between 2 & 3	Base-camp 3
Antopocerus (continued)					
entrichocnemus	X[2]				
	(Reared ex: Ilex sp. leaves)				
Idiomyia					
clavisetae			X[4]		
			(Reared ex; Clermontia sp. branches)		
Scaptomyza					
(2 species)	X		X		
	(Reared ex: Clermontia sp. fruit)		(Reared ex: Clermontia sp. fruit)		

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[1] Reared from new substrate - 3 species

[2] Substrate Reared for First Time - 3 species

[3] Not collected by baiting and sweeping - 3 species

[4] Not collected by baiting and sweeping - 3 species

CHAPTER 7

PRELIMINARY REPORT ON THE ENTOMOLOGY OF KIPAHULU VALLEY, MAUI

by

Nixon Wilson

INTRODUCTION

A preliminary evaluation of the insects and mites of Kipahulu Valley indicates 62 and 65 percent, respectively, of the species collected are endemic. If only those species collected in the native forest or from native animals are considered, then the percentages are considerably higher.

Zimmerman (1948) lists three characteristics of an endemic insect fauna. These are: (1) most endemic insects are confined to native forest plants; (2) most endemic insects are confined to mountain forests; and (3) the majority of endemic species have a restricted geographical range. All of these features apply in one way or another to Kipahulu Valley and are indicative of its uniqueness as an area for native fauna.

ANOPLURA

Four species were collected from three host species. *Hoplopleura* and *Polyplax* were found on *Rattus rattus* and *R. exulans*; *Haematopinus* from *Sus scrofa*; and *Linognathus* from *Capra hircus*. All species are cosmopolitan.

1. Haematopinidae
   - *Haematopinus suis*
2. Hoplopleuridae
   - *Hoplopleura pacifica*
   - *Polyplax spinulosa*
3. Linognathidae
   - *Linognathus stenopsis*

COLEOPTERA

Coleoptera were the second most abundant group collected in respect to number of species. Two-thirds of the species are considered endemic. Larva and adult hydrophilids were abundant in the valley streams. Carabids, elaterids and nitidulids were commonly found in the leaf whorls of Freycinetia.

1. Carabidae
   - 3 species (endemic)
2. Cerambycidae
   - *Ceresium simplex*
   - *Megopis* (*Aegosoma*) *reflexa* (endemic)
   - *Neoclytarlus* (near *pennatus*) (endemic)
   - *Neoclytarlus* (near *raillardiae*) (endemic)
3. Curculionidae
   - *Syagrius fulvitarsis*
   - *Acalles* species (endemic)
   - *Nesotocus* species (endemic)
   - *Oodemas* species (endemic)
4. Dytiscidae
   - *Rhantus pacificus* (endemic)

5. Elateridae
   Eopenthes caeruleus (endemic)
   Eopenthes divisus (endemic)
   3 species
6. Hydrophilidae
   Limnoxenus semicylindricus (endemic)
7. Nitidulidae
   Gonioryctus species (endemic)
   Goniothorax species (endemic)
   2 other species (endemic)
8. Proterhinidae
   2 Proterinus species (endemic)
9. Scarabeidae
   Adoretus sinicus
   Aphodius lividus
   Copris incertus prociduus
10. Scolytidae
   2 Xyleborus species (endemic)
11. Staphylinidae
   1 species (endemic)
12. Undetermined family
   1 species

DIPTERA

Diptera were the most abundant order of insects, both in numbers and variety. Sixteen families and approximately 31 species were collected. Some of these are species new to science and several are endemic to Hawaii, although it is impossible at this time to state which ones. The Drosophilidae were especially rich in numbers and species.

1. Agromyzidae
   1 species
2. Calliphoridae
   2 species
3. Ceratopogonidae
   1 species
4. Chironomidae
   1 species
5. Dolichopodidae
   4 species
6. Drosophilidae
   6 species *
7. Lauxaniidae
   1 species
8. Muscidae
   5 species
9. Phoridae
   1 species
10. Pipunculidae
   1 species
11. Platystomatidae
   1 species
12. Sphaeroceridae
   1 species
13. Stratiomyidae
   Noéxaireta spinigera
14. Syrphidae
   2 species
15. Tephritidae
   1 species
16. Tipulidae
   2 species

* (not including the Carson collection)

HEMIPTERA

Hemiptera were well represented by 10 families and 26 species in the collection. Approximately 16 species are considered endemic. This order was abundant on native vegetation.

1. Anthocoridae
   Lasiochilus species (endemic)
2. Cicadellidae
   1 species (endemic)
3. Cixiidae
   3 species (endemic)
4. Delphacidae
   4 species (3 endemic)
5. Lygaeidae
   5 species (endemic)
6. Miridae
   Hyalopeplus pelucidus (endemic)
   Pseudoclerada species (endemic)
   4 Orthotylus species (3 endemic)
   1 unidentified genus (endemic)
7. Pentatomidae
   Oechalia pacifica (endemic)
8. Reduviidae
   Nesidiolestes (?) species (endemic)
9. Saldidae
   2 Saldula species
10. Veliidae
    Microvelia vagrans

HYMENOPTERA

This order was most abundant at the schoolhouse and above Basecamp 3. Several endemic species, as yet unidentified, were collected above Basecamp 3 from the low herbaceous vegetation and grasses. All species collected in the vicinity of the schoolhouse were introduced.

1. Ampulicidae
   Ampulex compressa
2. Ichneumonidae
   Amblyteles purpuripennis
   Enicospilus species (endemic)
   1 species
3. Sphecidae
   Pelopaeus caementarius
4. Vespidae
   Polistes hebraeus
5. Undetermined families
   8 species (most endemic)

LEPIDOPTERA

This order was the second most abundant in numbers, if not in variety. The microlepidoptera are in the process of being revised for Hawaii and it is impossible at this time to classify them even to family. Most of the species represented in Kipahulu Valley collection should be endemic.

1. Geometridae
   2 species (endemic)
2. Noctuidae
   1 species
3. Pyralidae
   2 species (endemic)
4. Microlepidoptera (several families)
   About 10 species (several endemic)

MALLOPHAGA

Three species of biting lice were collected. Two endemic species were found on Himatione sanguinea and Loxops virens. Another, cosmopolitan species, was found on Capra hircus.

1. Menoponidae
   Machaerilaemus hawaiiensis (endemic)
   Myrsidea cyrtostigma (endemic)
2. Trichodectidae
   Bovicola caprae

NEUROPTERA

Several specimens of Nesomicromus were taken at light; otherwise, this order was not abundant. The species of Anomalochrysa is considered very rare.

1. Chrysopidae
   Anomalochrysa species (endemic)
   1 species (endemic)
2. Hemerobiidae
   Nesomicromus species (endemic)

ODONATA

One species of slender red damselfly was abundant in the forest and around the streams in the valley. Numerous nymphs, presumably of the same species, were collected from the rocky bottoms of the streams in the valley. Two adults were observed mating beneath the surface of a pool of water of one of the streams. At least two other species of Odonata were infrequently observed, but were not collected.

1. Coenagriidae
   Megalagrion species (endemic)

ORTHOPTERA

This order did not appear to be abundant except for crickets which were frequently heard, but seldom seen.

1. Gryllidae
   1 species (endemic)

SIPHONAPTERA

One species of flea was collected rarely from Rattus rattus and R. exulans.

1. Ceratophyllidae
   Nosopsyllus fasciatus

THYSANURA

One species was found frequently under the bark of trees and on the forest floor.

1. Machilidae
   Machiloides heleropus (endemic)

Summary of Families and Species of Insects
Collected in Kipahulu Valley, Maui

Order	Approximate number families represented	Approximate number species represented	Species endemic
1. Anoplura*	3	4	0
2. Coleoptera	12	31	22
3. Diptera	16	31	?
4. Hemiptera	10	26	21
5. Hymenoptera	5	14	7±
6. Lepidoptera	3+	15±	4+
7. Mallophaga	2	2	1
8. Neuroptera	2	3	3
9. Odonata	1	1	1
10. Orthroptera	1	1	1
11. Siphonaptera*	1	1	0
12. Thysanura	1	1	1
Total	57+	130±	61±

*Determinations complete for group, figures final.

Chilopoda

2 species

Diplopoda

2 species

Crustacea

1. Amphopoda
   1 species (endemic)

Mollusca

Several species (most endemic)

Arachnida

1. Araenae
   About 10 species (several endemic)

ASTIGMATA

Feather mites were collected from Leiothrix lutea, Loxops maculata, L. virens and Vestiaria coccinea.

1. 2 undetermined families
   2 species (endemic)
   1 species

CRYPTOSTIGMATA

Oribatids were not as common as expected in the two samples of debris from the forest floor which were Berlesed.

1. 2 undetermined families
   4 species (endemic)

MESOSTIGMATA

Two species of laelapids and one species of haemogamasid were parasitic on Rattus. All are widespread species although the haemogamasid was not recorded from Maui. A new species of rhinonyssid nasal mite was collected from Loxops maculata. Macrochelids were found in forest floor debris, twice on Rattus and on the beetle Copris incertus prociduus. Uropodines were also found on this beetle. Several species of free living mesostigmatic mites were taken from debris which was Berlesed.

1. Haemogamasidae
   Eulaelaps stabularis
2. Laelapidae
   Laelaps echidnina
   Laelaps nuttalli
3. Macrochelidae
   Macrocheles (glaber group) (endemic)
   Macrocheles peniculatus
4. Rhinonyssidae
   Ptilonyssus new species (endemic)

5. Uropodidae
   1 species (endemic)
6. Undetermined families
   About 3 species (endemic)

METASTIGMATA

The cosmopolitan brown dog tick was collected from local dogs used for hunting pigs in the valley.

1. Ixodidae
   Rhipicephalus sanguineus

PROSTIGMATA

One parasitic fur mite was collected several times from *Rattus rattus*. Several free living forms were found on vegetation and beneath the moss on trees.

1. Anystidae
   1 species
2. Myobiidae
   Radfordia ensifera
3. Undetermined families
   2 species (endemic)

Summary of Families and Species of Mites
Collected in Kipahulu Valley, Maui

Order	Approximate number families represented	Approximate number species represented	Species endemic
1. Astigmata	2	3	2
2. Cryptostigmata	2	4	4
3. Mesostigmata	6+	10+	6+
4. Metastigmata	1	1	0
5. Prostigmata	2+	4	2
Total	13+	22+	14+

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Mr. R. Tsuda sorted the greater part of the collection to family and made most of the preliminary determinations. Dr. W. A. Steffan determined the Diptera; Dr. J. L. Gressitt, Cerambycidae; Dr. R. D. Price, avian Mallophaga; and Dr. G. W. Krantz, Macrochelidae. Without their help, this report would be even less complete. The ectoparasites, except those listed above, were determined by myself.

CHAPTER 8

THE MOSSES OF KIPAHULU VALLEY, MAUI

by

William J. Hoe

THE MOSSES OF KIPAHULU VALLEY, MAUI

by

William J. Hoe

Until August, 1967, when the Nature Conservancy sponsored an expedition into the area, Kipahulu Valley was virtually unexplored bryologically. C. N. Forbes, working in the lower portions of the valley in 1919, recorded the collection of a specimen simply labelled "moss." No literature citations refer to Kipahulu Valley, and it therefore seems unlikely that bryologists have been into the area.

The writer spent two weeks in Kipahulu Valley, from August 17 to August 31. Collections were made in the vicinities of Basecamp 2 (at 4100') and Basecamp 3 (at 6375') as well as along lateral trails extending east and west from the campsites. Further collections were made in the vicinity of Wai Anapanapa and its sister, northward-lying unnamed lake. Unfortunately, a late arrival did not allow sufficient time for collections to be made anywhere below 3900' (vicinity of Basecamp 1).

A brief description of the collection trails is included in Appendix A, together with collection numbers from these trails. Appendix B presents the known moss distribution in the valley in a tabular summation.

This checklist, which includes materials collected from 3900' to the top of the valley in addition to a single earlier collection made along the highway and two collections from Kaupo Gap, provides the following information for each species:

1. Scientific name. The Index Muscorum (1959-1967) has been accepted as the authority for nomenclature. Where names differ from those in Bartram's Manual (1933), his nomenclature is provided.

2. Distribution pattern. If the species is known only from Hawaii, it is called "Endemic." If the species is known from other areas as well, its general distribution is given in addition to the distribution pattern listed in the Index Muscorum.

3. General habitat preference. If in quotation marks, this brief statement will have been taken from Bartram; otherwise, the statement is that of the author.

4. Distribution in the Hawaiian Islands, taken largely from Smith (1967).

5. Citation of collections from Kipahulu Valley. The numbers in parentheses refer to the general locality of these collections: (2) referring to collections made in and around Basecamp 2, (3) referring to collections made in and around Basecamp 3. Where such information may be of interest, specific information for single collections is given.

6. Known and probable distribution of the species within Kipahulu Valley together with other comments of interest.

It must be emphasized that the results here presented are based on collections taken over a two-week period from a very limited portion of the valley. Only about 40% of the species known from Maui are represented. As further collections from Kipahulu become available, a better understanding of this valley's bryoflora will emerge.

W. J. Hoe.
December 13, 1967.

FISSIDENTACEAE

Fissidens baldwinii Brotherus
Endemic. "camp stones and bases of trees, in shady places."
Kauai, Oahu, Molokai, Maui.
WJH #1645 (2:ohia forest)

F. mauiensis C. Muller
Endemic. "rocks in ravines."
Kauai, Oahu, Molokai, Maui.
WJH #1806 (3:ravine)

F. sp.
WJH #1738 (2)

Since the species cited are based on single collections, generalizations are impossible. Other species which should have been expected (as *F. hawaiicus* Bartram, *F. oahuensis* Bartram, *F. delicatulus* Angstrom, *F. lancifolius* Bartram) are known from Maui and may simply have been overlooked.

DICRANACEAE

Campylopodium euphorocladum (C. Muller) Bescherelle
Widespread in tropical areas: Asia 2-4; Africa 1-3; Australia 1-2; Oceania.
"on wet rocks in mountains."
Kauai, Oahu, Molokai, Maui, Hawaii
WJH #1791 (3:rocks in large, damp gully)

Campylopus boswelli (C. Muller) Paris
Endemic. "wet turfy banks."
Kauai, Molokai, Maui.
WJH #1644 (2)

C. densifolius Angstrom
Pacific Basin: Australia 1; Oceania. "trees and humus in wooded districts."
Kauai, Oahu, Molokai, Maui, Hawaii.
WJH #1685 (2)

C. introflexus (Hedwig) Bridel
Cosmopolitan. "dry peaty banks and ledges."
Kauai, Oahu, Hawaii.
WJH #1788 (3)
Possibly a new record.

C. purpureo-flavescens (C. Muller) Paris
Endemic. logs and peaty banks in moderately dry areas.
Kauai, Oahu, Molokai, Maui, Hawaii.
WJH #1643, 1684, 1709, 1736 (2)
#1762, 1787, 1809 (3)
Widespread throughout the valley, possibly the most common species to be found.

C. skottsbergii Brotherus
Endemic. "bogs and damp humus."
Kauai, Oahu, Maui, Hawaii.
WJH #1805 (3:ravine)

Dicranodontium falcatum Brotherus
Endemic. "trees and wet peaty banks."
Kauai, Oahu, Maui, Hawaii.
WJH #1713 (2:humus)
#1814 (3:humus)

Dicranum speirophyllum Montagne
Endemic. "damp banks on humus and bases of trees in wet forests, frequent."
Kauai, Oahu, Molokai, Maui, Hawaii.
WJH #1742 (2-3:on wet humus)
#1759, 1771, 1794 (3)

This plant is abundant both an an epiphyte and terrestrial organism at higher elevations. A single small clump was seen at about 5000' but in the vicinity of Basecamp 3, where peat is common, this plant is everywhere.

Holomitrium seticalycinum C. Muller
Endemic. "trunks and branches of trees in rain-forests."
Oahu, Molokai, Maui, Hawaii.
WJH #1660, 1689, 1695, 1728 (2)
#1753, 1793 (3)

An epiphyte frequent at middle and higher elevations, probably is to be found down to the lower limits of the forest as well.

Microdus (spp. sensu Dicranella in Bartram)
M. hawaiica (C. Muller) Paris
Endemic. "damp banks."
Molokai, Maui.
WJH #1789 (3)

M. hillebrandii (C. Muller) Paris
Endemic. "damp banks."
Molokai.
WJH #1786 (3:exposed mud banks near summit)
May represent a new island record.

LEUCOBRYACEAE

Leucobryum gracile Sullivant
Endemic. "bases of trees, logs, damp turfy banks in woods."
Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.
WJH #1661, 1686, 1702 (2)
#1748 (3)

L. solfatare var. hawaiense (Reichardt) Wijk & Margadant
Endemic. "bases of trees and peaty banks in woods."
Kauai, Oahu, Molokai, Maui, Hawaii.
WJH #1662, 1708, 1737 (2)

Neither species seems to be very common above 5000'; both are probably common at lower elevations. L. pachyphyllum C. Muller was expected to have been present at higher elevations.

CALYMPERACEAE

(Calymperes tenerum C. Muller)
Indo-Malaysia to Hawaii: Asia 3, 4; Australia 1; Oceania. "on trees."
Kauai, Oahu, Maui, Hawaii.
WJH #1525 (December 30, 1966--on Mangifera tree trunks along highway.)

Syrrhopodon hawaiicus C. Muller
Endemic. "on trees."
Oahu, Molokai, Maui, Hawaii.
WJH #1652, 1692, 1702, 1739 (2)
#1749, 1799 (3)
A very common plant, even forming small mats, on humified tree trunks. Probably found at lower elevations as well.

POTTIACEAE

Leptodontium brevicaule Bartram
Endemic. on rocks.
Hawaii.
WJH #1778 (3:shaded rocks).
May be a new island record.

Trichostomum mauiense Brotherus
Endemic. "rocks."
Kauai, Oahu, Maui, Hawaii.
WJH #1813 (3)

GRIMMIACEAE

Grimmia haleakalas Reichardt
Endemic. "rock clefts."
Maui, also known from Hawaii.
WJH #1775 (3:on exposed rocks)
Seen once as a single, very small patch about 1 cm. in diameter. Apparently does better at higher, drier elevations as this plant is common in Haleakala and upper Kaupo Gap.

G. sp.
WJH #1790 (3:exposed rock)

Racomitrium (*Rhacomitrium* of most authors)
R. crispulum (Hooker, J. D. and Wilson) Dixon
Tropics and Southern Hemisphere: Asia 4; Africa 4; America 2, 4, 6; Australia 1, 2; Oceania; Antarctica. "rocks at high elevations."
Maui, Hawaii; also collected on Kauai.
WJH #1769 (3)

R. lanuginosum (Hedwig) Bridel var. *sandvicense* (Reichardt (var. *priunosum* in Bartram)
Endemic. "rocks, banks, and bogs."
Kauai, Oahu, Molokai, Maui, Hawaii.
WJH #1744, 1776 (3:exposed banks)
Both species are probably restricted to the higher parts of the valley surrounding Haleakala.

FUNARIACEAE

Funaria subintegra Brotherus
Endemic. "wet banks."
Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.
WJH #1647, 1694 (2:mud banks)
Habitually on mud, this plant is to be expected at lower elevations as well.

SPLACHNACEAE

Tayloria sandwicensis (C. Muller) Brotherus
Endemic. "on ground."
Maui.
WJH #1655 (2:humus)

BRYACEAE

Bryum crassicostatum Brotherus
Endemic. on ground.
Maui, Hawaii
WJH #1740 (2)

Bryum sp.
WJH #1785 (3:exposed mud, Wai Anapanapa)

Bryum sp.
WJH #1792 (3)

Bryum sp.
WJH #1819 (3)

MNIACEAE

Mnium rostratum Schrader
Cosmopolitan. "on ground in shaded ravines."
Kauai, Oahu, Maui, also known from Hawaii.
WJH #1653 (2:wet rocks)
#1811 (3:banks of large gully)

Scantily collected as isolated strands, never forming the large mats as it often does. Probably to be found at lower elevations as well.

RHIZOGONIACEAE

Rhizogonium pungens Sullivant
Endemic. "rotten logs and bases of trees."
Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.
WJH #1666, 1670, 1693 (2)

R. spiniforme (Hedwig) Bruch in Krauss
Widespread in tropical and sub-tropical areas: Asia 2-4; Africa 2-4; America 2-5; Australia 1-2; Oceania.
Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.
WJH #1657, 1681, 1682, 1705, 1741 (2)
#1758 (3)
Both species are common wherever humus accumulates; undoubtedly at lower elevations as well.

HYPNODENDRACEAE

Sciaromium (Limbella in Bartram)
S. tricostatum (Sullivant) Mitten
Endemic. "in flowing streams, locally very abundant."
Kauai, Oahu, Molokai, Maui, Hawaii.

WJH #1668, 1726 (2)
#1784, 1818 (3)

This species is common on stream bed rocks at middle and higher elevations in all normally flowing streams.

BARTRAMIACEAE

(Bartramia baldwinii C. Muller)
Endemic. "rocks"
Maui.
WJH #1821 (August 31, 1967:dry rocks in Kaupo Gap)

This species should also be present in Kipahulu Valley at higher elevations.

Philonotis turneriana (Schwaegrichen) Mitten
Central Asia and Pacific: Asia 2-4; Oceania. "wet ledges, rocks, and banks"
Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.
WJH #1729 (2:rocks)
#1770 (3:rocks)

Although only P. turneriana (Schwaegrichen) Mitten was collected, P. hawaiica (C. Muller) Brotherus and P. falcata (Hooker) Mitten, especially at the middle and lower elevations, were expected. Their scarcity or absence may in part be related to their preference for wet but sunny locations, the forest here being too closed.

ORTHOTRICHACEAE

Macromitrium intricatum C. Muller
Endemic. "trees and logs in the mountains."
Oahu, Maui.
WJH #1669 (2:ohia trunk)
#1743, 1754, 1695 (3:common on exposed ohia trunks)

M. owahiense C. Muller
Pacific: Australia 1; Oceania. "branches of trunks of trees in wetforests."
Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.
WJH #1646, 1688, 1714, 1727 (2)
#1755 (3)

Abundant at middle elevations and undoubtedly as common at lower elevations as well.

M. piliferum Schwaegrichen
Endemic. "trees, logs, and rocks."
Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.
WJH #1648, 1687, 1698, 1720 (2)
#1756 (3)

Abundant at middle and undoubtedly lower elevations.

M. brevisetum Mitten and M. emersulum C. Muller are probably present at lower elevations.

Zygodon reinwardtii (Hornschurch) A. Braun
Tropical Africa and Asia, Tropical and sub-tropical Americas, and Pacific: Africa 2; Asia 3-4; America 1, 2, 4-6; Oceania. "on trunks."
Maui.
WJH #1745, 1782, 1817 (3)

Z. Tetragonostomus A. Braun
Indo-Malasia and Pacific: Asia 3-4; Oceania. peaty banks.
Oahu, Maui, Hawaii.
WJH #1751, 1783, 1800, 1812 (3)

Z. sp.
WJH #1763, 1803 (3)

TRACHYPODACEAE

Trachypodopsis auriculata (Mitten) Fleischer (ornans in Bartram)
Eastern Asia and Hawaii: Asia 2-4; Oceania. "trees and banks in rain forests."
Kauai, Molokai, Maui.
WJH #1649, 1680, 1697, 1718 (2)
#1757, 1772 (3)

A common and very conspicuous moss which was not seen below 3900'. Because of its bright orange-red color it should have been noticed even in the uncollected lower elevations if common there.

At middle elevations, this moss is almost strictly epiphytic; at higher elevations (ca. 6700') it becomes terrestrial.

METEORIACEAE

Aerobryopsis longissima (Dozy & Molkenhoer) Fleischer
Widespread in tropical areas: Asia 2-4; America 2-3; Australia 1; Oceania. "trees and ledges in wet forests."
Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.
WJH #1659, 1671, 1700, 1717 (2)
#1774 (3)

Undoubtedly at lower elevations as well.

Barbella trichophora (Montagne) Fleischer
Endemic. "on bushes or small trees on the windward slopes of the larger islands or in moist open forests."
Kauai, Oahu, Molokai, Hawaii.
WJH #1746, 1796 (3:bases of trees and bushes)

May be new island record.

NECKERACEAE

Baldwiniella (Baldwinella in Bartram)

B. kealeensis (Reichardt) Bartram

Endemic. "damp rocks and wet ledges in shaded ravines."

Kauai, Oahu, Molokai, Maui, Hawaii.

WJH #1676, 1712 (2)

This species which does well on very shaded, wet rocks, is surprisingly poorly represented in the collections made. It is expected, perhaps more abundantly, at lower elevations.

Homaliodendron flabellatum (Smith) Fleischer

East Asia and Pacific: Asia 2-4; Australia 1; Oceania. "tree trunks and rocks in wet, shady forests."

Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.

WJH #1650, 1675, 1703, 1719 (2)

#1752, 1807 (3)

This species, doing well at middle and higher elevations, is expected to be common at lower elevations as well.

HOOKERIACEAE

Daltonia contorta C. Muller

Tropical Asia and Pacific: Asia 3-4; Oceania. "tree trunks."

Kauai, Molokai, Maui, Hawaii. Also collected on Oahu.

WJH #1699, 1723 (2)

#1764, 1801 (3)

By far the most common species of the genus in the valley. In the shrubby Coprosma thicket around Basecamp 3, branches and twigs were "loaded" with this plant--far more abundantly than I had ever seen previously.

D. pseudostenophylla Bartram

Endemic. "branches in wet forest."

Oahu, Maui, Hawaii.

WJH #1767 (3)

D. rufescens Brotherus

Endemic. "trunks."

Oahu, Maui, Hawaii.

WJH #1664, 1715 (2)

Distichephyllum freycinetii (Schwaegrichen) Mitten

Endemic. Frequent on trees and humus in wet forests in all the larger islands.

Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.

WJH #1677, 1734 (2: shaded mud)

#1808 (3)

D. paradonum (Montagne) Hitten
Endemic. "frequent on trees and humus in wet forests in all of the larger islands."
Kauai, Oahu, Molokai, Maui, Hawaii
WJH #1651, 1678, 1701, 1732 (2:shaded mud)

Both species are common wherever mud is found. Undoubtedly at lower elevations as well

Hookaria acutifolia Hooker & Greville
Widespread in tropical and subtropical regions: Asia 2-4; America 1-5; Oceania. "very wet, shaded banks."
Oahu, Maui, Hawaii.
WJH #1721 (2:deeply shaded mud)

Surprisingly rare, represented by a single collection. May be more common at lower elevations but is easily overlooked, since it has a habit of growing under bushes and shrubs.

THUIDIACEAE

Thuidium hawaiiense Reichardt
Endemic. "shaded ledges and banks."
Kauai, Oahu, Molokai, Maui, Hawaii.
WJH #1656, 1690, 1696, 1735 (2)

T. plicatum Mitten
Endemic. "trees, rocks, and banks, in shaded places."
Kauai, Oahu, Molokai, Maui, Hawaii.
WJH #1679, 1724 (2:humus)
#1766, 1779 (3:humus)

Both species are common at middle elevations and probably common at lower elevations as well.

BRACHYTHECIACEAE

Brachythecium rutabulum (Hedwig) Bruch, Schimper, Gimbel
Nearly cosmopolitan: Europe; Asia 1-3; 5; Africa 1; America 1, 2, 4, 6; Australia 1, 2; Oceania. On wet rocks, often along streams.
Maui.
WJH #1673 (2)

Cirriphyllum (sp. in Branhythecium in Bartram)
C. oxyrrhynchium (Dozy & Mokenboer) Fleischer
Malasia-Pacific: Asia 4; Oceania. "damp banks and rocks in the mountains."
Kauai, Oahu, Molokai, Maui, Hawaii.
WJH #1725 (2:shaded rocks)

Palamocladium (Pleuropus in Bartram, 1933)
P. wilkesianum (Sullivant) C. Muller
Endemic. "frequent on ledges, trees, and banks, in moist shady places."
Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.
WJH #1747, 1797, 1810 (3:humusy banks)

The plants are somewhat intermediate between the species and the variety sciuroides (C. Muller) Wijk & Margadant. According to Bartram, the variety is usually in drier situations, which may explain the appearance of the plants collected. The more luxuriant forms of the species should have been present both at middle and lower elevations.

Rhynchostegium vagans Jaeger (sp. in Eurhynchium in Bartram, 1933)
Tropical Asia and Pacific: Asia 2-4; Oceania. "wet rocks and banks."
Kauai, Oahu, Maui.
WJH #1672 (2:stream bank)

This species is represented by a single strand collected at about 4500'. This moss is undoubtedly present, probably abundantly, at lower elevations, with 4500' representing its approximate upper elevational limits.

PLAGIOTHECIACEAE

Plagiothecium draytonii (Sullivant) Bartram
Endemic. "on humus and logs in wet forests."
Kauai, Oahu, Molokai, Maui, Hawaii.
WJH #1731 (2)
#1760, 1798 (3)

Collected only as isolated strands. Expected at lower elevations as well.

SEMATOPHYLLACEAE

Acroporium fusco-flavum (Paris) Brotherus
Endemic. "frequent on trees and stumps in damp forests on all the larger islands."
Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.
WJH #1706, 1716 (2)

This species is common at middle elevations, lacking at higher elevations. Expected to be common at lower elevations.

Aptychella (Aptchella in Bartram, 1933)
A. robusta (Brotherus) Fleischer
Philippines to Hawaii: Asia 4; Oceania. On soil.
Kauai, Maui.
WJH #1802 (3)

Brotherella opaeodon (Sullivant) Brotherus
Endemic. On wet humus.
Kauai, Oahu, Maui, Hawaii.
WJH #1667, 1722 (2)
#1750, 1773 (3)
This plant is abundant at higher elevations, where damp, shaded peaty banks exist in quantity.

Glossadelphus chrysobasilaris Brotherus
Endemic. "mountain ravines"
Maui, perhaps only western part of island.
WJH #1816 (3: bases of ohia trees)

G. zollingeri (C. Muller) Fleischer var. filicaulis (Fleischer) Fleischer
Indo-Malasia to Hawaii: Asia 4; Oceania. Epiphytic in wet forests.
Kauai, Molokai, Maui.
WJH #1665, 1674, 1711 (2)
#1781 (3)

G. sp.
WJH #1765, 1804 (3)
These two collections may represent nothing more than different forms of G. chrysobasilaris)

Sematophyllum hawaiiense (Brotherus) Brotherus
Endemic. "trees, rocks, and stone walls, in shady places."
Kauai, Oahu, Maui, Hawaii.
WJH #1777 (3)
Probably to be found at middle and lower elevations as well.

Taxithelium mundulum (Sullivant) Bartram
Endemic. "bark of living trees, logs, and damp rocks in shaded ravines and forests."
Kauai, Oahu, Lanai, Hawaii.
WJH #1663, 1710, 1733 (2)

Trichosteleum hamatum (Dozy & Molkenboer) Jaeger
Indo-Malasia to Hawaii: Asia 4; Oceania. "Trees and banks, in wet forests."
Kauai, Maui, Hawaii.
WJH #1691 (2)
#1761 (3)

HYPNACEAE

Ctenidium elegantulum Brotherus
Endemic. "Tree trunks in damp, shaded woods."
Oahu, Maui, Hawaii.
WJH #1654 (2)
#1768, 1780, 1815 (3)

Ectropothecium viridifolium Bartram
Endemic. Shaded rocks.
Oahu, Lanai, Maui.
WJH #1704.

POLYTRICHACEAE

Pogonatum baldwinii (C. Muller) Paris
Endemic. "Damp rocks and wet banks."
Kauai, Oahu, Molokai, Maui, Hawaii.
WJH #1730 (2)

This plant is represented in these collections by a single fertile plant. It does best on sunny damp banks, which might explain its apparent scarcity in the heavily forested valley. The exposed soil banks near the top of the valley may well be beyond the upper elevational limits of this plant.

(*Polytrichum piliferum* Schreber ex Hedwig)
Widespread in temperate areas: Europe 1; Asia 1, 2; Africa 1, 2, 4; America 1, 6; Australia 1; Oceania; Antarctica. "Dry rocks and soil." Hawaii.
WJH #1820 (August 31, 1967: Kaupo Gap, on exposed dry rocks).

This species, which may have previously only been known from Hawaii, apparently prefers drier areas than were seen in Kipahulu Valley.

APPENDIX A

August 18, 1967. Southwest lateral from Basecamp 2 at about 4100' in Metrosideros forest.
#1643-1666

August 19, 1967. Trail to about 4500' in Metrosideros forest leading to a branch trail down ridge to valley floor. On the valley floor, the vegetation is a mixed Metrosideros-Acacia forest at about 4100'.
#1667-1692.

August 20, 1967. Collections in the vicinity of Basecamp 2, Metrosideros forest at 4100'.
#1693-1715.

August 21, 1967. Repeat of August 18 to western end of trail, going through many swampy areas. Metrosideros and Carex alligata common.
#1716-1741

August 23, 1967. On way to Basecamp 3; collection made in Metrosideros forest at about 5000'.
#1742

August 24, 1967. From Basecamp 3 (mixed Metrosideros-native trees such as Pelea), through Vaccinium scrub to mixed Deschampsia-Holcus grassland at summit. Elevations between 6375' and 7300'.
#1743-1745

August 26, 1967. Collections in vicinity of Basecamp 3 in mixed Metrosideros forest. Peaty accumulations common. Elevation about 6400'.
#1746-1768

August 27, 1967. From Basecamp 3 to summit, through Deschampsia-Holcus grassland to region of two lakes in Metrosideros forest. Elevations about 6375' to 7100' to 6500'.
#1769-1792

August 28, 1967. Collections in vicinity of Basecamp 3, at about 6375'
#1793-1803

August 29, 1967. Western lateral from Basecamp 3 starting at lower boundary of Vaccinium scrub to a small "pond" through Metrosideros forest and Sadleria-scrubby Vaccinium-Holcus-Deschampsia community. Elevation about 6800'.
#1804-1819

August 31, 1967. Hurried collections on way from Paliku Cabin to Kaupo Village. Polytrichum collected on exposed gravel along main trail; Bartramia collected on rocks along stream bed in remnant native forest. Elevation ca. 4000'.
#1820-1821

APPENDIX B

A listing of the species and the general areas in which they were found. Camp 2 may be taken to represent a moderately well closed Metrosideros forest with some mixture of Acacia; Camp 3 represents predominantly Metrosideros ranging from moderately open to moderately closed; Grass-scrub represents the Vaccinium scrub area up to the Deschampsia-Holcus community near the summit. Most of the species in this zone will be in the Vaccinium scrub as epiphytes or on barren ground; a few of the terrestrial forms will be found on barren ground in the grassland.

GENUS	SPECIES	CAMP 2	CAMP 3	Grass-Scrub
Fissidens	baldwinii	X		
	mauiensis		X	
	sp. 1738	X		
Campylopodium	euphorocladium			X
Campylopus	boswelli	X		
	densifolius	X		
	introflexus			X
	purpureo-flavescens	X	X	
	skottsbergii		X	
Dicranodontium	falcatum	X	X	
Dicranum	speirophyllum		X	
Holomitrium	seticalycinum	X	X	
Microdus	hawaiica			X
	hillebrandii			X
Leucobryum	gracile	X	X	
	solfatare var. haw	X		
Syrrhopodon	hawaiicus	X	X	
Leptodontium	brevicaule			X
Trichostomum	mauiense			X
Grimmia	haleakalae			X
	sp. 1790			X
Racomitrium	crispulum			X
	lanuginosum var. sand			X
Funaria	subintegra	X		
Tayloria	sandwicensis	X		
Bryum	crassicostatum	X		
	sp. 1785		X	
	sp. 1792		X	
	sp. 1819		X	
Mnium	rostratum	X	X	
Rhizogonium	pungens	X		
	spiniforme	X	X	

GENUS	SPECIES	CAMP 2	CAMP 3	Grass-Scrub
Sciaromium	tricostatum	X	X	
Philonotis	turneriana	X	X	
Macromitrium	intricatum	X	X	X
	owahiense	X	X	
	piliferum	X	X	
Zygodon	reinwardtii		X	X
	tetragonostomus		X	X
	sp. 1763, 1803		X	
Trachypodopsis	auriculata	X	X	
Aerobryopsis	longissima	X	X	
Barbella	trichophora		X	
Baldwiniella	kealeensis	X		
Homaliodendron	flabellatum	X	X	
Daltonia	contorta	X	X	
	pseudostenophylla		X	
	rufescens	X		
Disticho-phyllum	freycinetii	X	X	
	paradoxum	X		
Hookeria	acutifolia	X		
Thuidium	hawaiiense	X		
	plicatum	X	X	
Brachythecium	rutabulum	X		
Cirriphyllum	oxyrrhynchium	X		
Palamocladium	wilkesianum		X	
Rhynchostegium	vagans	X		
Plagiothecium	draytonii	X	X	
Acroporium	fusco-flavum	X		
Aptychella	robusta		X	
Brotherella	opaeodon	X	X	
Glossadelphus	chrysobasilaris		X	
	zollingeri var. filicau	X	X	
	sp. 1765, 1804		X	
Sematophyllum	hawaiiense		X	
Taxithelium	mundulum	X		
Trichostelium	hamatum	X	X	
Ctenidium	elegrantulum	X	X	
Ectropothecium	viridifolium	X		
Pogonatum	baldwinii	X		

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CHAPTER 9

A NOTE ON THE LAKES OF EASTERN HALEAKALA, MAUI

By: John A. Maciolek

Two bodies of standing water, locally referred to as "lakes," occur in craters near the upper limit of the rain forest on the Hana slope of Haleakala immediately north of Kipahulu Valley. One of them is identified as Wai Anapanapa on the U. S. Geological Survey topographic map of Maui. The other is unidentified on maps but sometimes called Wai Ele'ele (or Wai Ele) by older residents. Both lakes are within the boundary of the proposed Kipahulu Valley Ecological Reserve.

A preliminary survey has been conducted on both waters which included mapping, sounding and general biological collecting. Data have only been partly studied thus far. They indicate that both waters are very soft (conductivity less than 20 micromhos per cm^2) and slightly acidic (pH 6 to 7). Higher submersed aquatic plants are absent and macrofauna consists of only a few invertebrate species. In other respects, these waters differ considerably.

Wai Anapanapa is a shallow, closed-basin pond occupying the bottom of a small, deep crater atop the northern edge of Kipahulu valley escarpment at about 6,800 feet elevation. It is bordered mainly by sedge and Hawaiian raspberry. The small drainage area and apparent basin permeability result in wide fluctuations of surface area and depth:

Conditions	Date	Surface Area, Acres	Maximum Depth, Feet
High water	Jan., 1967	0.5	6
"Average"	Aug., 1967	0.3	4
Low Water	Oct., 1967	0.2	2

During prolonged drought, it is probable that visible standing water disappears completely. Thus, Wai Anapanapa should be considered a plaustrine habitat. Macroflora consists of mats and clumps of filamentous algae (Chlorophyta) that completely cover the pond bottom. Macrofauna is species-poor but populous. Most abundant are diving beetle larvae and adults (Insecta-Coleoptera), and aquatic earthworms (Oligochaeta). Also collected were damselfly naiads (Insecta-Odonata) and waterfleas (Crustacea-Cladophora).

Wai Ele'ele occupies what appears to be a broad crater of low relief at 6,700 feet elevation about 0.3 mile northeast of Wai Anapanapa. It is an open-basin system, having several small inlets and one outlet. Maximum surface area and depth are limited by the effluent stream. At the time of survey (Sept., 1967) with water being discharged from the outlet, maximum depth was 21 feet. Thermal stratification was observed (19°C. at surface, 14°C. at bottom). It is improbable that this water body disappears, even during a prolonged dry period. These physical features suggest that Wai Ele'ele can be considered a lake or lacustrine environment. Ohia lehua trees and a dense growth of perennial shrubs and ferns surround the lake. It is steep-sided; much of the shore line consists of floating grass mats which are capable of supporting a man's weight. Most of the bottom is covered by a thick layer of filamentos Chlorophyta, underlain by soft, flocculent organic mud. Large clumps of this alga with entangled organic debris float on the surface. Aquatic macrofauna is severely restricted; only dragonfly naiads (Insecta-Odonata) were seen in relative abundance. Also collected were a few damselfly naiads (Odonata), surface-dwelling bugs (Insecta-Hemiptera), and a single midge larva (Insecta-Diptera).

CHAPTER 10

NOTES ON THE MAMMALS OF KIPAHULU VALLEY, MAUI

By: Winston E. Banko and Nixon Wilson

Introduction

All of the mammals found living wild in Kipahulu Valley today are descendents of stocks accidentally or intentionally introduced to Hawaii by man. Neither the Hawaiian bat (*Lasuirus cinereus semotus*) nor Hawaiian monk seal (*Monachus schaninslandi*), the only two indigenous Hawaiian mammals, have been recorded from the Kipahulu Valley area.

The following account is based on information and impressions gathered by the authors who participated in Nature Conservancy's expedition into Kipahulu Valley in August, 1967. Observations and trapping of mammals were accomplished incidentally to attainment of other objectives; conclusions are therefore preliminary and subject to later correction.

Goats, *Capra hireus*. The history of goats on the island of Maui is unknown, but they have been a management problem within Haleakala National Park, bounding Kipahulu Valley, at least since 1950 when 2,309 were destroyed (Yocom, C. F., Ecology of Feral Goats in Haleakala National Park, Maui, Hawaii, Am. Mid. Nat., 77(2):418-451, 1967).

A small herd of goats was observed by some Expedition members along headwall ridges of Kipahulu Valley, and several individuals were collected for their ectoparasites. Well worn trails along rocky ridges and deeply eroded gullies of *Deschampsia* grasslands in the higher elevations of Kipahulu Valley testified to a significant history of goats in the area. There were no indications that a resident herd was established in the Valley nor were any recent signs noted that goats had penetrated the forest zone to any perceptible degree. Goats in Kipahulu Valley apparently confine their activity largely to the rocky headwall ridges above 7,500 feet in elevation where they are a significant, if not the dominant, disturbing ecological factor.

Pigs, *Sus scrofa*. It is not known when Polynesian voyagers first brought pigs to the Hawaiian Islands. Certainly it was a long time ago--long enough for the pigs to become well established in Hawaiian religion and culture before arrival of Caucasian man. It thus seems certain that pigs have inhabited Kipahulu Valley for many centuries.

Pigs are hunted today along the edge of the remnant woodlands and pastures of lower Kipahulu Valley by local residents who value them for food. But contemporary hunters do not commonly penetrate far into the virgin forest of Kipahulu

Valley in quest of pigs because of progressive difficulty in finding and transporting their kill back to their homes in the lowlands.

In mid- and upper-Kipahulu Valley we noticed evidence of wild pigs throughout our range of exploration. On the Valley floor signs of pigs were rather commonly and uniformly observed, and Expedition trail crew members were successful in capturing several suckling pigs during the course of their travels. Evidence of rooting by wild pigs was most noticeable in forest glades and, especially, in grassy meadows above the upper limit of tree growth in the grass-forb-shrub zone. In dense forest, pigs appeared to be fewer and signs were limited largely to those associated with traveling, foraging, and bedding activities. Pig signs were more frequently observed in terrain having little gradient. Steep slopes appeared little used by pigs, probably because of a harder substrate and lessened opportunity to root for food.

Pigs undoubtedly altered the status and distribution of the indigenous biological elements when they were originally introduced to virgin Hawaii centuries ago. But the magnificent koa (*Acacia koa*) and ohia (*Metrosideros collina subsp. polymorpha*) forests of Kipahulu Valley, with their interesting and complex plant community understory, bear witness to the compatability of wild pigs and a wide variety of indigenous plant species. Only in the open forest-edge and grassland communities does the pig appear to be a significant factor in altering the natural succession of the dominant trees.

Rats. According to Hawaii State Division of Fish and Game listing, three species of rats occur on the island of Maui. *Rattus exulans*, the Polynesian rat, wasbrought to Hawaii by ancient colonizers. *Rattus norvegicus*, the Norway rat, and *Rattus rattus*, the black or roof rat, were inadvertently carried to Hawaii by Caucasians.

Trapping of rats in the mid- and upper-elevation forests of Kipahulu Valley was carried out with the goal of learning what we could regarding the status of these animals and their associated ectoparasites in an undisturbed rain forest environment. Coconut and swiss cheese baits were used in ordinary rat snap-traps, with the following results:

Basecamp 1	(3,100 feet)	96 trap nights; 7 *R. rattus*, 5 *R. exulans*
Basecamp 2	(4,100 feet)	190 trap nights; 7 *R. rattus*, 2 *R. exulans*
Basecamp 3	(6,560 feet)	24 trap nights; 3 *R. rattus*
	(7,500 feet)	12 trap nights; no rats caught

While trapping results between stations are not strictly comparable due to unknown reactions of rats to baits used, variability of effort expended, and other unknown imponderables, several factors seem clear. Populations of *R. exulans* appear to be more numerous in mid-Valley habitats than those in higher elevation habitats, if indeed they occur much above 4,000 feet at all. Populations of *R. rattus* appear to be fairly abundant and uniformly distributed through mid- and upper-elevation forests. Two color phases of R. rattus were obtained in approximately equal numbers, the black phase (black back and belly) and white belly (agouti back and white belly), (Tomich and Kami, Journ. Mammalogy, 47(3):423-431, 1966).

Specimens of R. norvegicus were not obtained. Presumably populations of this third species found on Maui occur in the Valley in elevations lower than those trapped; in pastures and around human habitations.

Seven species of ectoparasites, 4 mites, 2 lice, 1 flea, were collected from rats, all being forms commonly reported for rats or domestic animals.

House mice, Mus musulus. House mice occur on Maui according to State Division of Fish and Game listing, but their history of establishment is unknown. The expenditure of 38 trap-nights of effort at Basecamp 2, 12 at Basecamp 3, and 12 at 7,500 feet for house mice resulted in the capture of one mouse at Basecamp 3 and one at 7,500 feet--the approximate upper limit of tree growth. Swiss cheese in mouse snap-traps was used.

House mice are also most certainly found in lower elevations, too, in fields and around human habitations, though no trapping for mice was done below Basecamp 2 (4,100 feet) and confirmation is lacking. It thus appears that house mice found in higher portions of the Valley have originated from populations established in summit grasslands rather than from those which presumably occupy lower elevations. How house mice got to high altitude habitats originally is not known.

Mongoose, Herpestes auropunctatus. Mongooses are found over a wide range on islands where they occur in Hawaii, but the highest population levels seem to occur in lower elevation habitats. Mongooses found on Maui are thought to be descendants of those introduced originally to the island of Hawaii in 1883, but details of their introduction to Maui are not available. The expenditures of 20 trap-nights at Basecamp 2, 9 trap-nights at Basecamp 3, and 12 trap-nights at 7,500 feet for mongooses were made with negative results. Steel traps baited with swiss cheese and fresh meat were used. Local residents say that mongooses are common in lower elevations of Kipahulu Valley, in fields, remnant woodlands, and around human habitations. While the negative trapping results of central and upper Kipahulu Valley should not be considered conclusive, it is apparent that mongooses are not abundant in zones trapped and the question may be raised as to whether they occur there at all. More extensive trapping with a greater variety or more attractive baits is needed before the status of mongooses in the undisturbed portions of Kipahulu Valley can be defined.

CHAPTER 11

RE-DISCOVERY OF MAUI NUKUPUU, HEMIGNATHUS LUCIDUS AFFINIS, AND SIGHTING OF MAUI PARROTBILL, PSUEDO-NESTOR XANTHOPHRYS, KIPAHULU VALLEY, MAUI, HAWAII

By: Winston E. Banko

Kipahulu Valley is a prominent geological feature of the east slope of Haleakala Volcano, rising from sea level to 2,470 meters where it adjoins Haleakala National Park at the rim of the Crater. An expedition sponsored by Nature Conservancy carried out a biological survey of this little-known Valley during August, 1967.

I participated in the Kipahulu Valley Expedition from 17 to 31 August with the principal goal of finding out what I could about several rare species of birds which possibly inhabited the Valley. Other Expedition members with special ornithological interests included Dr. Richard E. Warner, Foundation of Environmental Biology and Expedition Leader; Dr. Andrew J. Berger, Chairman, Zoology Department, University of Hawaii; and Gerlad Swedberg, Hawaii State Division of Game. It is expected that a full account of the avifauna of Kipahulu Valley will be written later in ecological context; meanwhile I wish to make available my observations of two rare species which were not seen by other official members of the expedition.

Scientific nomenclature follows that of Amadon (Bull. Am. Mus. Nat. Hist., 95, 1950) and common names those of Resource Publication 34, Bureau of Sport Fisheries and Wildlife, U. S. Department of Interior, 1966, Rare and Endangered Fish and Wildlife of the United States. Data on observations are furnished from field notes I made immediately after the reported sightings.

Hemignathus lucidus affinus.

Maui Nukupuu. Listed by U. S. Department of Interior (op. cit.) as "extinct" and by Jack Vincent, compiler, International Union for Conservation of Nature (I.U.C.N.), Bulletin 16, 1965, as "known or thought to be extinct."

Not found by Lawrence P. Richards and Paul H. Baldwin in search of Puu Alaea and Wai Anapanapa areas which are adjacent to Kipahulu Valley on the north (Condor, 55, 1953: 222); nor by George C. Nunro who earlier searched the forests of the east side of Haleakala (J. C. Greenway, Jr., Extinct and Vanishing Birds of the World, Am. Comm. for Inter. Wild Life Protection Spl. Pub. No. 13, N. Y., 1958). Greenway (op. cit.) states of the Maui race of Nukupuu ". . . none have been seen since 1896, when Perkins obtained specimens."

The first sighting was made at 1030 hours 24 August at an elevation of 1801 meters while I was descending the Expedition's trail alone on the ridge dividing upper Kipahulu Valley. I was proceding slowly observing every visible bird with 7 x 35 binoculars when a small, dull, yellowish bird with a dark eye stripe and a moderately long, dinstinctly sickle-shaped bill was sighted an estimated 20 to 30 meters away in the crown understory of a large ohia tree (Metrosideros collina, subs. polymorpha). This individual was active, moving about on the branch and hopping frequently to other twigs. This action afforded various views of its unique bill. After about 15 seconds or so it flew into the crown of another, more distant ohia where a distinctly yellow posterior was noted and its peculiar hook-bill was silhouetted against an overcast sky. After a 10 to 20 second period in its new location, where it was somewhat less active, it flew away.

The second individual was seen along the same trail 25 minutes later at about 1,786 meters elevation. This bird possessed much more yellow underparts with the dark eye stripe contrasting markedly with the moderately bright yellow head. It was observed for about 30 seconds at a distance of not more than about 10 meters range as it foraged 3 to 5 meters above the ground in a community of ohia, pilo (Coprosma sp.) and olapa (Cheirodendron trigynum) trees. Several birds of the genus Loxops were also foraging in the immediate vicinity. Neither this nukupuu nor the first one seen were vocal.

The last sighting of this very rare bird was at 1405 hours the same day at about 1740 meters altitude along the identical ridge trail. The plumage of this third individual appeared much duller than either of the preceding nukupuus but the sickle bill was seen clearly as the bird approached to within about 8 meters in response to my "squeaking" before it flew off. Several sharp "shrrp" call notes similar to those of Loxops sp. may have been given by this bird although there were individuals of the latter genera in the immediate vicinity which could have conceivably made these calls. I did not see movement of the sickle-bill that would actually pinpoint the nukupuu as the source of the sound.

This third bird, unquestionably immature or a mature female, was watched for about thirty seconds. The heavy understory vegetation along the trail prevented my following each of the three individuals sighted after they flew away.

On this trip, I had been watching particularly for another hook-billed drepanid, Pseudonestor xanthophrys, the Maui Parrotbill. However, the sickle-bills I saw lacked heavy lower mandibles, a diagnostic field character for Pseudonestor and possessed much longer and more recurved upper bills. I was, therefore, puzzled over the identity of these three birds until my return to camp where illustrations in Amadon (op. cit.) permitted positive identification as Nukupuus. Substantial periods of time were spent 25 and 28 August along the section of trail where these birds were sighted, looking for others, but with negative results.

A few weeks after conclusion of the Expedition, George Morrison reported seeing a Nukupuu in Kipahulu Valley. Mr. Morrison, National Park ranger, was descending the Expedition trail alone 11 September when he made his sighting at about 2048 meters elevation. In a convincing memorandum to the Superintendent, Hawaii-Volcanoes National Park, Mr. Morrison reported seeing the unusual bird several times at distances varying from 8-10 to 12-15 meters. Size, bill shape, and coloration of this individual described to me by Mr. Morrison were similar to those of the Nukupuus I saw. In his letter to the Superintendent, Mr. Morrison described the "tremendously long, curved bill," and the upper mandible being "3-4 times the length of the lower" from seeing it "yawn." Mr. Morrison is interested in Hawaiian birds and familiar with their appearance. I consider his sighting of Nukupuu valid, substantiating my own observations in this area.

Pseudonestor xanthophrys.

Maui Parrotbill. Late in the afternoon on 29 August, the last day of Expedition field work, I was seated at an overlook of the upper Kipahulu Valley at about 2000 meters elevation and set up to photograph any of the various species of honeycreepers that might visit an ohia tree in bloom below. At 1733 hours a smallish, but "big headed" bird was seen to fly into a non-blooming ohia tree, one of a stand below my lookout. Observation through the 7 x 35 binoculars made identification of this bird positive at the first look. It was *Pseudonestor xanthophrys* without a question. It flew toward me and alighted several times, finally perching directly overhead not more than 10 to 20 meters away. Body size and plumage color were not greatly different from the first Nukupuu I saw, but the much shorter, more hooked upper mandible and massive lower bill left no doubt of its identity. This individual was actively moving in a more or less direct line through the ohia mid-story. It was in sight about 30 seconds and did not call. The only other sighting in the present century was that reported by Richards and Baldwin (*op. cit.*).

Sightings of the Maui Nukupuu at from 1,740 to 1,801 meters (and by George Morrison at 2,048 meters), and the Maui Parrotbill at 2,000 meters extend the known altitudinal ranges of these birds considerably above the 1,219 to 1,372 meter levels previously reported for the Maui Nukupuu and the 1,219 to 1,524 meter levels ascribed to the Maui Parrotbill. More significantly, this upward extension of range places both of these rare birds in a forest dominated by ohia rather than koa (*Acacia koa*). Conservation possibilities for both birds are therefore markedly increased since ohia is the dominant plant in the little-disturbed upper elevation forests of Haleakala's northeast slopes.

Another endangered species, the Crested Honeycreeper (*Palmeria dolei*), and the rare Maui Creeper (*Loxops maculata newtoni*), were found in Kipahulu Valley by other members of the Expedition as well as myself. Information concerning these two birds will be given later in a general account of the avifauna.

The occurrence of four rare birds in Kipahulu Valley, one previously considered extinct, points up the importance of retaining this area in a natural condition if populations of these birds are to be preserved. Elsewhere in Hawaii, many unique birds found nowhere else in the world have become extinct because of land use practices and environmental changes brought about by "civilized" man.

CHAPTER 12

SOME OBSERVATIONS ON THE BIRDS OF KIPAHULU VALLEY

By: Richard E. Warner

Introduction

The bird fauna of the Hawaiian Islands is unique. The combined circumstances of remoteness, geological age, incomplete geographical isolation of the several islands of the Hawaiian Archipelago from one another, and the ecological diversity found throughout the islands, have produced an array of adaptively radiated endemic forms that is not matched in any other part of the world. Had Darwin visited the Sandwich Islands instead of the Galapagos with their more modest array of geospizine finches, one cannot help but speculate that some of his caution in presenting his classic thesis of animal speciation might have been abandoned. For the drepaniids, more commonly known as the Hawaiian Honeycreepers, are one of the truly exceptional examples of speciation by adaptive radiation.

Unfortunately, the recent history of the drepaniids has been a tragic one. Following the discovery of the Hawaiian Islands by Captain James Cook in 1778, one after another of the native forms vanished. Destruction of the native forest, introduction of disease-carrying insects, and other still obscure influences all contributed to the decimation and extinction of the native forms. The losses have been summed up by Banko (1967) as follows:

> "At least 25 kinds of birds--40% of the endemic birds known to have inhabited the Islands--have become extinct in the historic period. In fact, Hawaii's loss of 25 species comprises more than 15% of all kinds of birds which have become extinct in the world since 1600!"

Today the remnant populations of Hawaiian Honeycreepers are limited to elevations above 900 meters (3000 feet), principally in the remaining native forests. Most of these remaining forests have been disturbed to one extent or another by the activities of modern man, Kipahulu Valley being probably the most pristine example still available to us.

Thus the interests and expectations of conservationists have been great concerning the possibility that this area might harbour species of great rarity. From a more academic point of view, the ecological relationships of the drepaniids to an intact and undisturbed habitat, such as might be observed in Kipahulu Valley, are of great potential interest. Additionally, it was suspected that further light might be shed on the mechanisms which have led to the extinction of so many native forms. It was therefore with great curiosity and anticipation that we first shouldered our packs at the start of the expedition, and started up the trail into the rainforests of Kipahulu Valley.

History of Bird Study in Kipahulu Valley

Ours was not the first group with ornithological interests to enter Kipahulu Valley. But it was the most completely equipped, and with the most time to devote to bird research of any that have so far been fielded. In September of 1892, Palmer, while collecting for Rothschild, spent several days in Kipahulu Valley. The following extract from his diary gives some indication of what he encountered (Rothschild, 1893-1900):

> "On September 16th the lofty Koa-forest was passing over into Ohia-forest, as the country was rising, the place became extremely wet and swampy. Sometimes we sank so deep into the mud that we could not go on any further.
>
> "When we pitched the tent to-day we had the greatest difficulty to fix the poles, so soft and swampy was the ground, and torrents of water were running down the slopes. We did not succeed in pitching the tent before we had created an island by digging deep ditches and gutters for the water to go off, and we never had so much difficulty in making up our fire. The forest here has a wild and peculiar aspect, dead fallen trees lying everywhere in one's way and others standing lifeless and leafless between the green ones, so that perhaps only half of all of them were alive."

Perkins (1903) visited the mountain forests of Haleakala, but I have not yet been able to determine if he entered Kipahulu Valley.

In February, 1945, G. O. Fagerlund, Chief Ranger and F.A. Hjort, Ranger-in-Charge, Haleakala Section, Hawaii National Park, traversed the valley during a four day period, 19-23 February.

During the period 29 November-11 December, 1945, P. H. Baldwin, Assistant to the Superintendent, Haleakala Section, Hawaii National Park, and F.A. Hjort hiked through the valley. Both of these latter groups began at the top and worked their way down through the rainforest.

In addition to the abundant populations of drepaniids such as the Iiwi (Vestiaria coccinea) (Figure 56), Maui Creeper (Loxops maculata newtoni) (Figure 55), and Apapane (Himatione sanguinea) which were reported by all groups, both Palmer, and Fagerlund and Hjort, reported seeing the Crested Honeycreeper (Palmeria dolei) (Figure 54) at around 1800 meters (6000 feet) elevation. Neither the Maui Nukupuu (Hemignathus lucidus affinus), or the Maui Parrotbill (Pseudonestor xanthophrys) were apparently observed. The historic sightings of these latter two species by Winston Banko, member of the present expedition, are detailed in a separate chapter of this report.

Methods of Study

Our principal technique was that of direct field observation, using binoculars as necessary. In addition, several mist nets with 1 1/2 inch mesh were employed to sample the populations and to provide specimens for ectoparasite and blood samples, and for photography. While it has been suggested that I incorporate the mist-net capture figures, I have not done so for the following reasons. The capture rate for mist nets is determined by many variables, only a few of which are under the control of the worker. The time of day, previous and current weather conditions, season of year, condition of the vegetation, location of nets, local food habits and behavior of the species inhabiting the area, and the behavior of the worker all have a bearing on composition and rate of capture. I have therefore confined myself to presenting conclusions on abundance which are based on combined subjective and objective data, using mist net data only as adjunct to observations.

Distribution and Abundance

Lower Elevations (Forest Reserve Boundary to 980 meters (3200 feet))

From the Forest Reserve Boundary, which is the lower edge of intact forest, until 860 meters (2800 feet) of elevation, no drepaniids what-so-ever were encountered. Several introduced species, namely the Pekin Nightingale (*Leiothrix lutea*) and the White-eye (*Zosterops japonica*) were regularly seen, and the melodious song of *Leiothrix* could be heard both in the lower valley and on the upper plateau.

Another expedition member reported hearing the song of the Chinese Thrush (*Trochalopterum canorum*) on at least one occasion, but I neither heard it with certainty, nor observed it throughout the entire expedition. No specimens of this species were taken in the mist nets, although all nets were placed at ground level. This dearth of Chinese Thrushes is in distinct contrast to the conditions found by Baldwin in December, 1945, of which he commented in his unpublished report:

> "Chinese thrush especially were more numerous than above and were present from the little lake at 3500 feet down."

The cause of this change in abundance is unknown.

At 860 meters (2800 feet) drepaniids began to appear, but in extremely low numbers. From 860 meters to about 1050 meters (3300 feet) of elevation there was a steady increase in the abundance of drepaniids, with no appreciable change in abundance of the introduced species. Apapanes and Amakihis (*Loxops virens wilsoni*) (Figure 53) were the most numerous drepaniids, with smaller numbers of Maui Creepers and decidedly fewer Iiwis.

Baldwin had in 1945 also noted the inexplicable absence of drepaniids below the 860 meter level. His comments, recorded in his unpublished report to the National Park Service, are of significance:

"The forest here was the most magnificent of the whole trip. The Koa trees were not large boled, but they were uncommonly tall and many branched. The forest was open enough that you could see in any direction for quite a ways, making it much more impressive than the dense ohia lehua forest above. A good variety of trees made it botanically rich. Understory plants were striking, such as the Clermontia and Cyanea. Ieie climbed about, its orange flowers and brown fruits conspicuous.

"I couldn't quite reconcile all this with the lack of birds. It was raining, and we were moving fairly fast, but I frequently looked about, whistled, etc., and always without seeing anything except whiteyes and hill robins. Only once did I glimpse a native green bird the size of an amakihi. I followed him up the slope a ways but did not see him again. I heard Iiwi once in a while. The altitude here was around 2600 feet."

The significance in these changes in drepaniid abundance with changing altitude cannot be overestimated. For they corroborate the findings from field and laboratory experiments conducted on Kauai, Oahu, and Hawaii on the role of introduced diseases in the extinction of native Hawaiian birds. These studies are reported in detail elsewhere (Warner, in press). Briefly, the conclusions are as follows:

(1) At the time of discovery of the Hawaiian Islands by Europeans (Capt. James Cook, 1778) the Hawaiian Honeycreepers were distributed from the upper edges of the montane forests to the sea coasts.

(2) This condition persisted for about forty or fifty years after discovery, at which time local lowland populations began to vanish, often with no discernable change in the character of the forest habitat.

(3) In 1826 the night-mosquito, Culex pipiens fatigens, was accidentally introduced at Lahaina, Maui, by the ship Wellington which had brought mosquito wrigglers in its water barrels from the west coast of Mexico.

(4) The night-mosquito rapidly spread to the lowland areas of all the Hawaiian Islands. However, presumably because it is the tropical form of Culex, its distribution was, and is today, limited to elevations below about 860 meters.

(5) Avian malaria and birdpox virus are present today in the domestic fowl, migratory shorebird and waterfowl, and introduced bird populations of all islands. Presumably the pathogens were in these reservoir populations at the time the mosquitoes were introduced. The night-mosquito, being a highly suitable vector for both malaria and birdpox, subsequently spread them among the lowland populations of drepaniids.

(6) Field and laboratory experiments have conclusively shown the remnant populations of drepaniids of today to be still extremely sensitive to avian malaria and birdpox. They have no immunogenetic capacities against these diseases, and will die from either disease if exposed to the lowland environment with its high mosquito populations for as little as three days, and perhaps even less. Where mosquito control is practiced, as the Honolulu environs, the pathogenicity of the lowland environment is reduced.

(7) All known populations of drepaniids are today limited to those regions of forest above approximately 860 meters.

The data on drepaniid distribution in Kipahulu Valley are thus of considerable significance. For Kipahulu Valley is ecologically virtually a pristine region, its native forests and invertebrate populations still nearly intact. This permits us to rule out the variable of forest destruction as a factor in the abruptly attenuated drepaniid populations of the lowland rainforests.

Studies by myself and the expedition entomologists of mosquitoes in the Kipahulu forests definitely established that the distribution of Culex in Kipahulu is the same as in other forested regions throughout the islands: namely, dense mosquito populations from sea level to approximately 770 meters (2500 feet), then a progressive reduction in abundance until by 830 meters (2700 feet) they are virtually absent and by 860 meters (2800 feet) completely absent. The specific reasons for this upper altitudinal limit in Culex distribution are at present unknown, but they are no doubt the consequence of physiological and ecological limitations inherent in this tropical form of mosquito.

These findings--mosquitoes and no drepaniids from the lower forest edge to 860 meters, and drepaniids but no mosquitoes from 860 meters up in a continuously intact and near-virgin Hawaiian rainforest--provide a satisfying corroboration of the theory that introduced diseases and their insect vectors have played a profoundly important role in the extinction and reduction in range of the Hawaiian Honeycreepers.

In the course of the present expedition, blood smears from both introduced and native bird species were taken at progressively higher elevations in Kipahulu Valley. These, when analysed, will shed further light on the dynamics of avian malaria in the Kipahulu Valley bird populations. Unfortunately, at the time of this writing the analyses are not yet completed, so the results cannot be reported.

This study, which required an intact and undisturbed native forest for its successful completion, clearly demonstrates the value of natural areas like Kipahulu for current and future ecological research in the Hawaiian Islands. Without such areas, permanently preserved in their primeval state, many important biological problems will remain unsolved. It is, clearly, one more compelling reason why Kipahulu Valley must be preserved, for ourselves and posterity.

Mid-Elevations (1050 meters (3300 feet)-1540 meters (5000 feet))

In this region the bird populations seemed relatively uniformly abundant. Apapanes were present in greatest numbers, followed by Iiwis, Amakihis and Maui Creepers, with Leiothrix and White-eyes also present but less common. The estimated relative abundance of the bird populations, based on a scale of 0-10 and using the Apapane as baseline, is as follows:

Apapane	10
Iiwi	6
Amakihi	5
Maui Creeper	4
Leiothrix	3
White-eye	1

It must be emphasized that this is essentially a subjective estimate, though derived from extensive field observations and the results of live trapping with mist nets. Truly quantitative estimates of bird populations, at the present stage of refinement of field techniques, are not possible in the environmental circumstances of the tropical rainforest.

Relatively large numbers of immatures of the four drepaniids were noted. These are presumably all birds-of-the-year. In the Iiwi and Apapane they are readily distinguishable by their plumage, which is strikingly different than the adult. Both immatures and adults were molting, the immatures showing various admixtures of the dull juvenile plumage and the bright, colorful adult coloration. Marked differences in feeding behavior were observed between young and adults; these will be discussed in a later section.

On one occasion in the early morning, three finch-like birds were seen perched in the upper branches of a flowering ohia tree near Basecamp 2. Through 10 x 40 binoculars they looked very much like immature House Finches or Linnets (*Carpodacus mexicanus*). The characteristic brown-grey plumage and robust finch bills were clearly seen. However, they departed before one could be collected for positive identification, so the record remains inconclusive.

On several other occasions in this same area finch-like songs were heard, but the birds could not be located in the heavy foliage and precipitous terrain. Since Perkins (Munro, 1944) has reported that the Maui Nukupuu seemed to imitate the song of the imported Linnet, the observations are reported without attempting interpretation.

It became clear after a few days in the rainforest, that because of the density of vegetation, bad light, and behavior of the native birds, impressions of relative abundance were very misleading. The Amakihi and Maui Creeper, being rather sedentary and having colorations similar to the dull green of the understory vegetation, were especially difficult to see. The Apapane and Iiwi, which stayed for the most part in the upper canopy of the ohia forest, and whose red marking were very similar to the ohia flowers, were equally difficult to examine in any quantitative way. Only by sitting quietly in one spot for an extended period of time, watching the general pulse of bird movement through and over the forest, could one begin to appreciate the density of the drepaniid populations.

On rainy days it was as though the drepaniids had deserted the forest altogether, but when the rain stopped and the weather cleared they would reappear, surprisingly abundant, the forest ringing with their songs, the air sometimes vibrant with the musical whistling of their wings.

My overall impression is that the bird density at mid-elevation in Kipahulu Valley was greater than for either temperate deciduous or coniferous forests or tropical rainforests, although, of course, the number of species was vastly reduced. Whether this is due to absence of predators or is a phenomenon associated with simplified ecosystems is impossible to say. Laysan Island, a small sand island about 900 miles northwest of the main Hawaiian group, has but one species of drepaniid, the Laysan Finch (*Psittirostra cantans*). The approximately 900 acres of habitable ground of this island host a population of approximately 15,000 finches, making it one of the greatest resident passerine bird populations so far recorded. Further studies of the population dynamics of drepaniids in Kipahulu Valley should provide important information on this point.

High Elevation (1540 meters (5000 feet)-2260 meters (7350 feet))

It was in this highest portion of the forest that all observations on the rare and endangered bird species were made. The changes in general vegetation and ecology have been well described by DeWreede and Smathers in their respective accounts in this report.

Too few observations were made on either the Nukupuu or the Maui Parrotbill to make any statement about distribution, abundance (except that they are extremely rare) or habitat requirements. The Crested Honeycreeper (*Palmeria dolei*) was observed with some frequency in this region, both in the canopies of flowering ohia trees and in understory vegetation within two meters of the ground. On several occasions Crested Honeycreepers were seen feeding in *Pelea* trees, an endemic genus found in some abundance in the upper forest.

Distribution of Crested Honeycreeper

Based on observations made by members of the expedition and other ornithologists who have visited the upper forests of Mt. Haleakala, the distribution of the Crested Honeycreeper on Maui may be roughly described as the upper forest zone from approximately 1840 meters (6000 feet) and possibly lower to the upper edge of forest, and from Olinda, Maui east and south through Kipahulu Valley and possibly on south until the rainforest terminates near Kaupo Gap.

This species could not be described as even locally abundant, although individuals were regularly seen feeding amongst the flowers of an ohia tree almost directly over the camp site. The appearance of the birds, and the pattern of visitation, suggested that it was the same group seen on a series of occasions. The general average seemed to be between one and two sightings per man day in the field in the area described above. Probably the most descriptive abundance category is "rare."

Relative Abundance Estimates

White-eyes were observed and trapped only infrequently, being nearly absent at the highest elevations. The Peking Nightingale (Leiothrix) was more abundant, two to four being taken in the mist nets each day at Basecamp 3 (elevation 2000 meters (6500 feet)). Amakihis were regularly seen, Maui Creepers seemed less abundant than at Basecamp 2, while the relative number of Iiwis increased and the Apapane possibly diminished somewhat.

The relative abundance, again based on subjective values and patterns of mist net take, was as follows:

Apapane	10
Iiwi	7
Amakihi	7
Maui Creeper	3
Leiothrix	3
White-eye	0.5
Crested Honeycreeper	0.01

It must be remembered that this estimate is not directly comparable to that made for the mid-elevation populations, where all species of birds appeared to be more abundant. In addition, no abundance estimates have been offered for the lower elevations, since the relative numbers changed rapidly with elevation, especially in the vicinity of the mosquito-no mosquito interphase at 860 meters.

Food Habits and Behavior

This subject has been well covered for the drepaniids by several authors (Henshaw, 1902; Perkins, 1903; etc.) and the literature is well summarized by Amadon (1950). I will therefore restrict my comments to what I consider to be new information on this subject.

Broussaisia arguta

There seems no mention in the literature of the use by drepaniids of the plant Broussaisia arguta, called by the Hawaiians "puahanui" or "kanawau." This woody shrub, which is related to the Hydrangia (family Saxifragaceae) grows to a height of 2-3 meters and is one of the commoner plants of the understory from about 620 meters (2000 feet) to treeline. Plants in all stages of flowering, from closed buds to dried seed pods, were seen, many having flowers (see Figure 53). The large flowering heads of the Broussaisia were regularly visited by the Amakihi, Maui Creeper, and juvenile Apapane and Iiwi, and comprised one of the principal food sources for the first two species. One had but to find a Broussaisia plant in blossom, and wait for a few minutes before one of the above species would arrive to work over the flower head for insects and probably nectar. Adult Iiwis and Apapanes were only rarely seen at Broussaisia; most of their time was spent in the canopies of flowering ohia trees.

Observations suggested that in the case of the Iiwi and Apapane the subordinate social position of juvenile birds was one important reason for this dichotomous feeding behavior. Both age classes were seen utilizing the ohia canopy, but there was always much bickering and quarreling in the flowering ohia trees, and juveniles were frequently displaced and pursued by older birds. Thus the Broussaisia formed, for the juveniles of these two species, an important alternate food source to the preferred ohia blossoms.

It should be noted that this disparate feeding behavior between young and adult Iiwis and Apapanes contributed significantly to the disproportionate number of juveniles taken in the mist nets; adult birds with only rare exceptions remained high in the trees and thus out of range of the nets.

In contrast to the Iiwi and Apapane, the Amakihi and Maui Creeper utilized Broussaisia as a principal food source. Both juveniles and adults sought the blossoms with great regularity, and little agonistic behavior was seen. The importance of this plant species to the Kipahulu Valley drepaniids suggests that further studies of drepaniid--Broussaisia relationships might prove of considerable interest.

Iiwi and Trematolobelia

One of the most beautiful sights of the entire expedition was that of the brilliant crimson adult Iiwi feeding amongst the pinkish lavender blossoms of the lobeliad Trematolobelia macrostachys. This endemic plant, which is common from about 830 meters to 1230 meters (4000 feet), grows to a height of about one meter, and has when in flower from 30 to 60 blossoms borne on four horizontal branches or stems. One such plant was in full flower about 30 meters from Basecamp 1, and was visited with great regularity by an adult Iiwi. The sight of the crimson Iiwi, probing the deep, curved, tubular flowers with its deeply decurved orange-red bill (see Figure 56) was a memorable one.

The significance was more than purely aesthetic, for it had been theorized that the once-abundant endemic lobelias, with their curved, tubular flowers, played an important role in the evolution of the tubular tongues and elongate, decurved bills of the nectar-feeding drepaniids. Certainly the Iiwi and the Trematolobelia seemed structurally very well matched.

Wild Pigs and the Lobelias

According to the reports of Jack Lind and other competent amateur botanists familiar with the Kipahulu Valley, in past years several species of lobelias were much more abundant than they are now. I was shown dead trunks of several larger lobeliad species, whose lower bark had been stripped by the wild pigs and the plant thus killed. This, and the peculiar distribution of many of the remaining lobelias--on cliff faces and in canyons inaccessible to wild pigs--strongly suggests that:

(1) the lobelias may in the past have formed a much more significant component of the forest vegetation, and were thus a more important component of the drepaniid food resources; and

(2) the wild pig may be contributing significantly to the alternation of the rainforest vegetation. Because of this I believe it is most important to take immediate steps to reduce or preferably eliminate entirely the pig population in Kipahulu Valley. It would be desirable at the same time to make transect censuses of the principal lobeliad species. These data would, over the years, provide an important indicator of the impact of pigs on the native vegetation.

Pelea and the Crested Honeycreeper

Trees and shrubs of the endemic genus Pelea form a relatively important part of the forest at mid- and high-elevations. On several occasions the Crested Honeycreeper was observed lingering amongst the upper branches of one particular species of Pelea (not yet identified), feeding and apparently resting. The affinity of the Crested Honeycreeper for Pelea was further demonstrated in captive specimens of Palmeria which were being photographed. Their behavior relative to the Pelea is typified by the following incident.

I had picked a branch of Pelea bearing leaves and green fruit (see Figure 54) to use in photographing mist netted specimens of the Crested Honeycreeper. When ready to begin, I thrust the branch into the laces of one of my boots, using it as a base, and turned the birds loose in my tent. They immediately flew to the Pelea branch and settled down in a manner clearly indicating their familiarity and satisfaction with the perch. When dislodged they would return immediately to the leafy branch. Its attraction seemed almost magnetic. The response to two other plant species, ohia and Vaccinium, was similar to that of the other drepaniids: no special interest.

When the photography session was completed, I left the birds perched in the *Pelea* branch for the night, as they were obviously content with the location. The following morning I awoke to find the birds still asleep on the branch. Rather than disturb their repose I crept out of the tent barefoot. It was only considerably later that I was able to retrieve my boot, which still served as a base for the *Pelea* branch; the birds had finally awakened and were chattering amiably in the tent, still perched comfortably on the *Pelea* branch.

This affinity for *Pelea* would have gone unnoticed had *Palmeria* not been the seventh species of Kipahulu bird I had studied close at hand and photographed under the same circumstances. There seems no information in the literature on the use of *Pelea* by the Crested Honeycreeper. The only reference to drepaniids and *Pelea* located to date is a comment by Perkins (1903) regarding the feeding behavior of the Maui Parrotbill, *Pseudonestor xanthophrys*, where he observed:

> "It also visits other trees occasionally, especially some kinds of *Pelea*, whence it obtains the larvae of *Plagithymsus*, leaving remarkable scars on the trees as a token of its visit."

That both captive and wild specimens demonstrate such an affinity to *Pelea* is interesting, and had led me to suspect that the phenomenon may indicate a significant ecological factor in the distribution of the Crested Honeycreeper. However, more research is needed to establish the meaning of this interesting behavior.

The Iiwi and Insectivory

It has long been wondered whether the highly nectarivorous species of drepaniids, such as the Iiwi, are also by nature insectivorous; or whether small insects are only taken incidentally in the course of searching for nectar. The opportunity arose to evaluate this with six captive Iiwis, which had been live-trapped during the expedition for studies on molting patterns, nutritional requirements, and general behavior.

The Iiwis were being maintained in a tightly screened cage of approximately 60 ft^3 volume. They were being fed a standard nectarivorous bird diet of 20% sugar (sucrose) water, hydrolysed protein, and vitamin-mineral supplement. All birds were feeding well and plumage condition was good despite molting in several specimens. The birds have since been successfully kept for an extended period under the same conditions.

Through the courtesy of Dr. Hampton Carson, specialist in evolutionary genetics and one of the expedition members, I obtained stocks of three species of endemic fruit flies, all of which are found occurring naturally in Kipahulu Valley. They ranged in size from very small (*Scaptomyza sp.* (subgenus *Bunostoma*)), to medium (*Drosophila mimica*) and large (*D. grimshawi*), the latter one of the highly attractive "picture-winged" group (see Figure 48).

In the first test, approximately 50 flies of each group were placed in the cage, beginning first with the smallest size, then after 15 minutes introducing the next larger size. As the cage was tightly screened with several layers of cheesecloth, the flies could not escape. The Iiwis were sufficiently accustomed to being observed at close range that they continued to behave normally while I watched their responses to the flies from a distance of less than one meter. In the second experiment, whose results were essentially the same as the first, approximately 50 of each fruit fly species were introduced simultaneously into the cage.

It was immediately apparent that the Iiwis recognized the fruit flies as food, for they avidly pursued the flies about the cage. Using the tips of their long decurved bills as forceps, they would deftly seize the flies in the tip of the bill; then, moving to a perch or branch would carefully work the fly to the middle of the mandibles by rubbing it gently and carefully against the perch. When the fly was properly positioned, they would draw it farther into the bill using the long tubular tongue to manipulate it, masticate it briefly, and swallow it.

This feeding pattern was followed with both the smaller fruit fly species. Their rate of capture for both of the smaller forms was very similar, and they seemed not to prefer one size over the other. However, with the largest species, the situation was markedly different. They attempted less often to capture D. grimshawi, and when they did usually retained it in the bill tip for only a second or two. Then they would usually shake their heads violently, throwing or wiping the fly from the bill, indicating that for some reason it was unacceptable. Close observation suggested that it was the large wings of the flies which disturbed the Iiwis, and the violent rejection occurred when a fly buzzed vigorously while held in the bill. It may also be that they had instinctively determined size limits for insect food, fixed perhaps by the size of the throat.

The net result was that D. grimshawi was relatively immune to predation by the Iiwi. Presumably this same mechanism would be active in nature.

I conclude from this experiment that the Iiwi is an actively insectivorous species, and that a significant portion of the insects in its diet are taken deliberately and not fortuitously with pollen and nectar as had been previously thought.

Concluding Comments

Kipahulu Valley is, without doubt, one of the outstanding areas of the Hawaiian Islands for native birds. The opportunities for research in this unspoiled area are legion. The enigmatic problems of Nukupuu and Maui Parrotbill distribution and ecology are among the most difficult, but simultaneously the most pressing. The relatively wide distribution of the Crested Honeycreeper may render it secure from immediate extinction, but or ignorance of its ecology leaves us powerless at present to take any steps toward improving its meager population numbers.

I do not share the opinion that pigs are of little consequence to the native forest, and feel that control measures with concomitant ecological studies are of great importance, especially the former.

In all likelihood, modification of the present ecology of Kipahulu Valley will very quickly lead to the extinction of at least two exceedingly rare drepaniids: the Nukupuu and Maui Parrotbill. This fact alone is, in my opinion, sufficient justification for permanent preservation of the area.

The opportunity now available to preserve the valley and the adjacent lakes and Deschampsia grassland is unique, one not likely to occur again. Land hunger in Hawaii, as elsewhere, is growing, and areas formerly considered of no value are experiencing increased pressure as new agricultural practices are developed, and the demand for residential and vacation properties grows. If one takes the combined values of Kipahulu Valley--the uniqueness of its vegetation, invertebrate life and birds; its near-pristine character; the ecological and geological diversity; and the extreme beauty of its forests, streams, and waterfalls--the area assumes an importance that justifies our most dedicated and persistent efforts toward its permanent protection.

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APPENDIX A

Photographs and Maps

Maps by Garrett A. Smathers

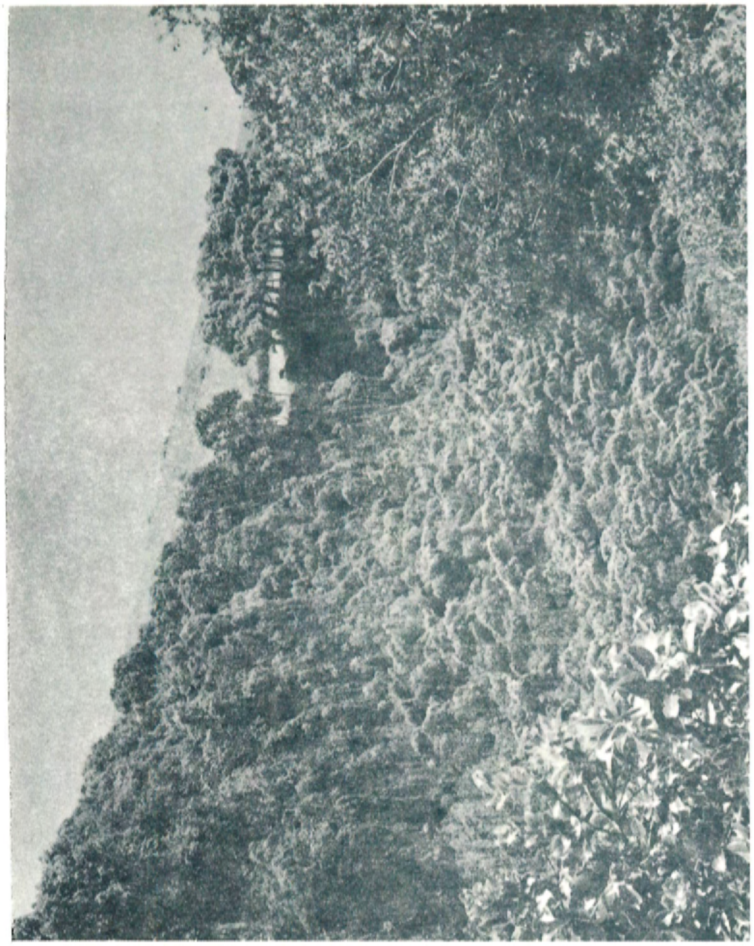
Photographs by Richard E. Warner

Figure 1. Kipahulu Valley as seen from below, looking NW. The koa (<u>Acacia koa</u>) forest begins abruptly at the Forest Reserve line, with but few exotic species at even this low elevation, approximately 1800 feet. In left center can be seen the central ridge marking the edge of the plateau comprising the southern portion of the valley. Basecamp 1 was located on the point of land visible in the photograph.

Figure 2. Looking NE at approximately 1500 feet elevation, across the canyon of Palikea Stream. The profusion of native and exotic species in this area is typical of the uncleared areas in the lower portion of the reserve. A lone cow can be seen grazing in the meadow on the far side of the canyon. No native birds were observed in this area, but several introduced species were abundant.

Figure 3. A view of a portion of the seven sacred pools region, near sea level and below the road. This picturesque area is well suited for recreational development, especially swimming and picnicking. Adjacent areas are suitable for controlled camping, provided that proper planning for modest public facilities is first completed.

Figure 4. One of the seven sacred pools with waterfall, immediately below the bridge. A well used trail to this point already exists. Further development for recreation is probably unnecessary. The leaves in the upper right and the prop roots at lower left belong to the hala, (<u>Pandanus sp.</u>).



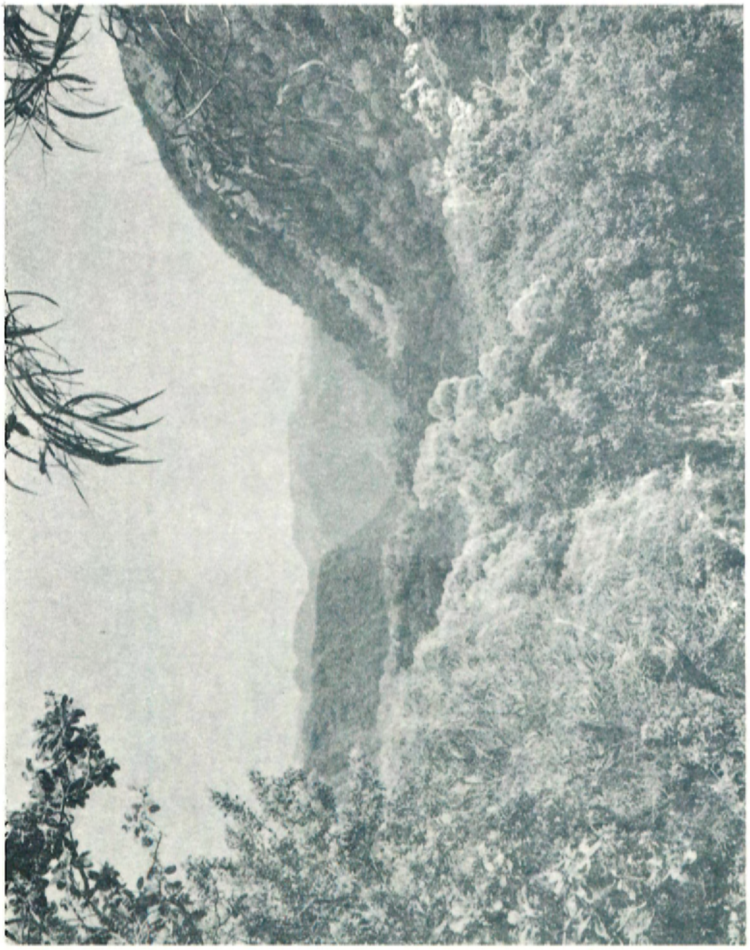



Figure 5. One of a series of deep pools in the lower Palikea Stream area, elevation about 1800 feet. Due to protracted dry weather the stream is very low. With increased rainfall, the rock face is hidden by a large and impressive waterfall dropping into the pool which is visible at the lower right.

Figure 6. Unnamed waterfall on Palikea Stream at approximately 2600 foot elevation, about 200 feet high. This waterfall is not readily visible from the lower canyon or from the trail along the central ridge. Heavy vegetation makes approach now difficult, and obscures waterfall from close view except in one or two places. A spectacular location which would benefit by having a trail cut to it, and a simple shelter built near the top of the fall.

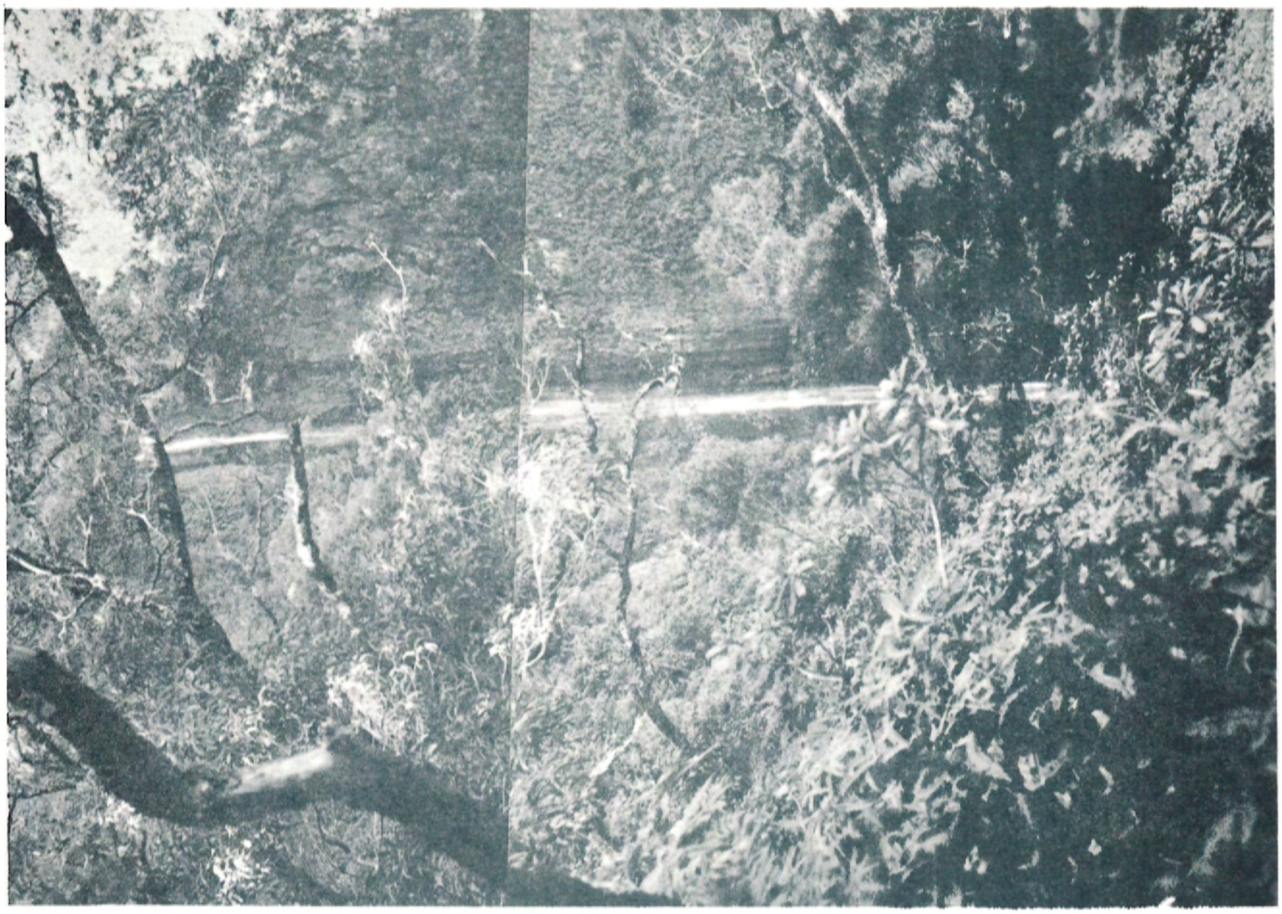


Figure 7. View from the top of unnamed waterfall, Figure 6. A picturesque pool and sand bar lie immediately above this point. Shelter for hikers, if desired, finds suitable location at this spot but approximately 30 feet to the right of photo location. Native birds are present but not commonly seen in this area. Extensive areas of bog are found in the valley to the south of this point.

Figure 8. Lower valley from above Basecamp 1, looking northwest. Second unnamed waterfall may be seen in right background. Trees up to level of second waterfall are mostly koa (Acacia koa); above this elevation the koa is gradually replaced by ohio lehua (Metrosideros polymorpha). Native birds are abundant at this and higher elevations. Photo elevation, approximately 3300 feet.

Figure 9. Dr. Martin Griffin looking over crest of waterfall shown in Figure 6. The trees are Acacia koa.

Figure 10. Pool above first waterfall. Note the luxuriant ferns. This is a very serene and picturesque spot, although requiring a difficult hike to attain.

Figure 11. Dr. Charles Lamoureux enroute to Basecamp 1 on ridge trail. The trees are mostly koa (Acacia koa), the tree ferns are Cibotium sp. and the grasses mainly Hilo grass (Paspalum conjugatum) and Glenwood grass (Sacciolepis indica).

Figure 12. Drs. Lamoureux, Andrew Berger and Nixon Wilson take a break at a rocky pool below Basecamp 1. The ridge trail crosses the stream (unnamed) at this point.

Figure 13. Drs. Wilson and Lamoureux exploring an unmapped stream in the lower valley floor, elevation about 2,500 feet. It is locations such as this, with steep, rocky walls, where many of the rarer native plants are found.

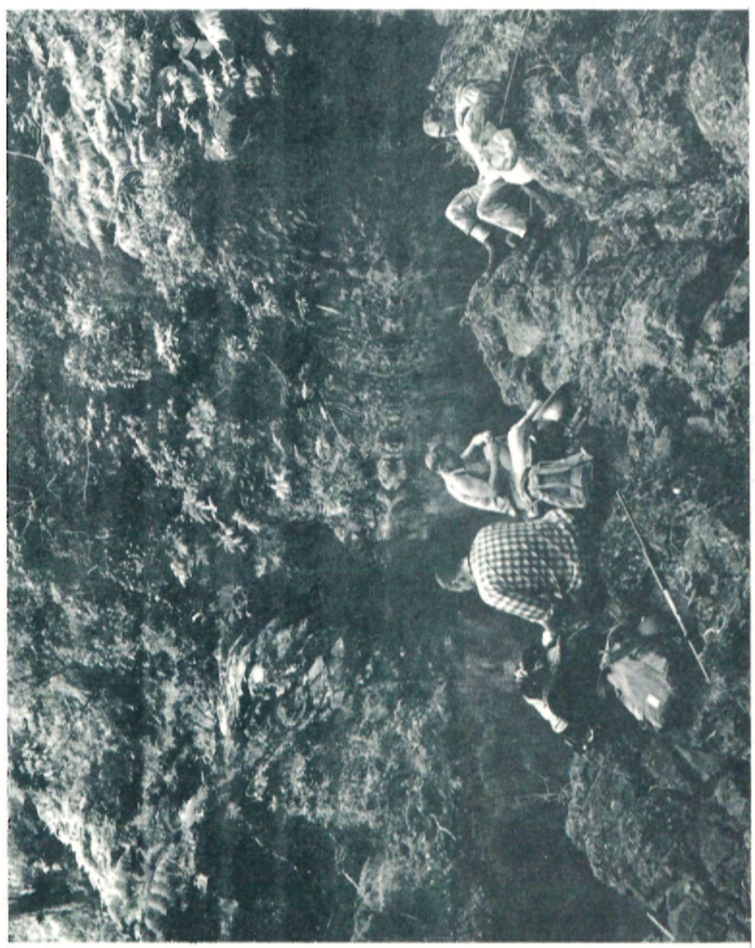


Figure 14. Open koa forest on valley floor below Basecamp 1 at 2,500 feet altitude. The shrubs are kanawau (*Broussaisia arguta*), and the ground cover consists of several ferns, primarily the hoio (*Athyrium sandwichianum*), and the herb *Drymaria cordata*.

Figure 15. Jack Lind working his way upstream above second waterfall, elevation about 3,200 feet. Several rare endemic species of plants were found in the nearly inaccessible canyon above this point. Presumably the area has been protected from the destructive influences of wild pigs, which are reported to find the endemic lobelias very palatable, and which, as a consequence, have grossly altered the distribution patterns of certain native plant species.

Figure 16. Paul Banko seated near rocky pool in Palikea Stream several hundred yards above second waterfall. The stream canyon becomes impassable at this point. Numerous rare native plants may be found on the rocky walls of this canyon.

Figure 17. An extraordinary rock formation immediately above the second waterfall. The picture, badly printed, shows imperfectly the massive, vegetation cloaked, stone arch which spans the stream at this point (upper portion of the photo). Palikea Stream plunges down a 40 foot waterfall into the first of two cavernous grottos before leaping out into space at the second waterfall. The fall itself is estimated to be 300 feet high, and is of great beauty. The grottos, imperfectly explored because of the extreme difficulty of access, contain a variety of interesting plants.

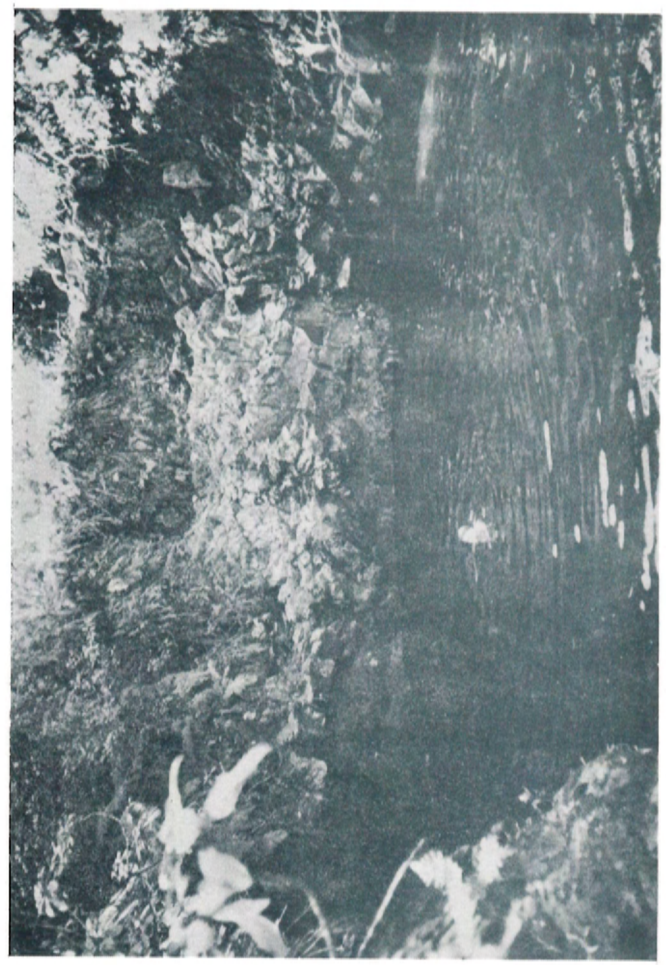



Figure 18. Bob DeWreede, Nixon Wilson, and Jerry Swedberg at Basecamp 2, elevation 4,100 feet. Note the abundance of mosses and other epiphytes in this zone, which has more the character of a cloud- or fog-forest than that of a typical rainforest.

Figure 19. Basecamp 2, general view, showing the dense understory of ferns and the predominately ohia forest. This region abounds in native birds, and many could be heard and seen throughout the day from the camp itself.

Figure 20. Robert Howell and Nixon Wilson examining a baby wild pig for ectoparasites. The color of the piglets, of which nearly a dozen were caught during the expedition, varied from the brown and black stripes shown in this photograph to white with black spots. This variation in color clearly demonstrates the intrusion into the wild stocks of genetic characters derived from feral domestic pigs which from time to time escape from the ranches near the seacoast.

Figure 21. Paul Banko taking a dip in one of the very lovely and deep pools found along an unmapped stream in the lower valley, just north of Basecamp 2. Four such pools were found, and it is believed that further exploration of this stream would produce several more. This portion of the lower valley is especially picturesque; a trail passing through the area, with a shelter at the edge of one of the pools, seems worthy of consideration.



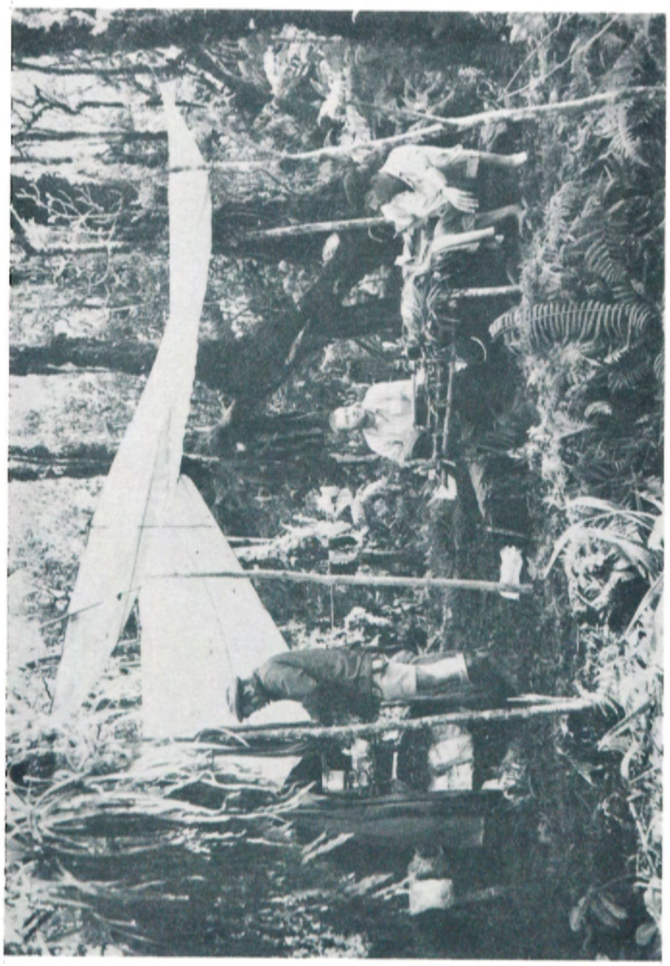
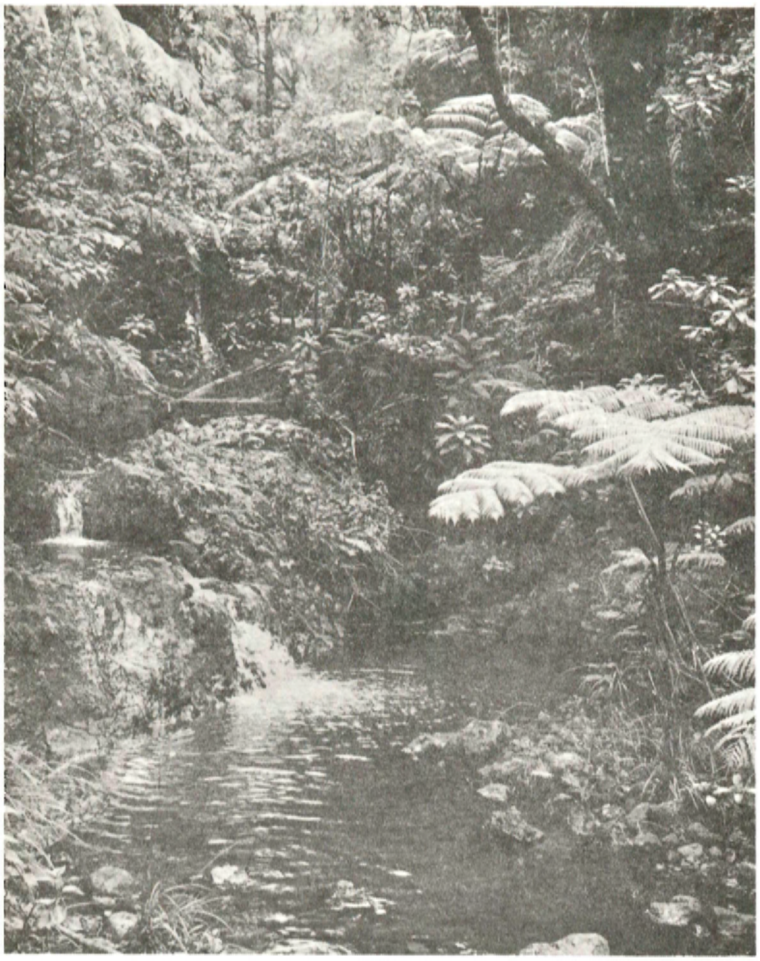


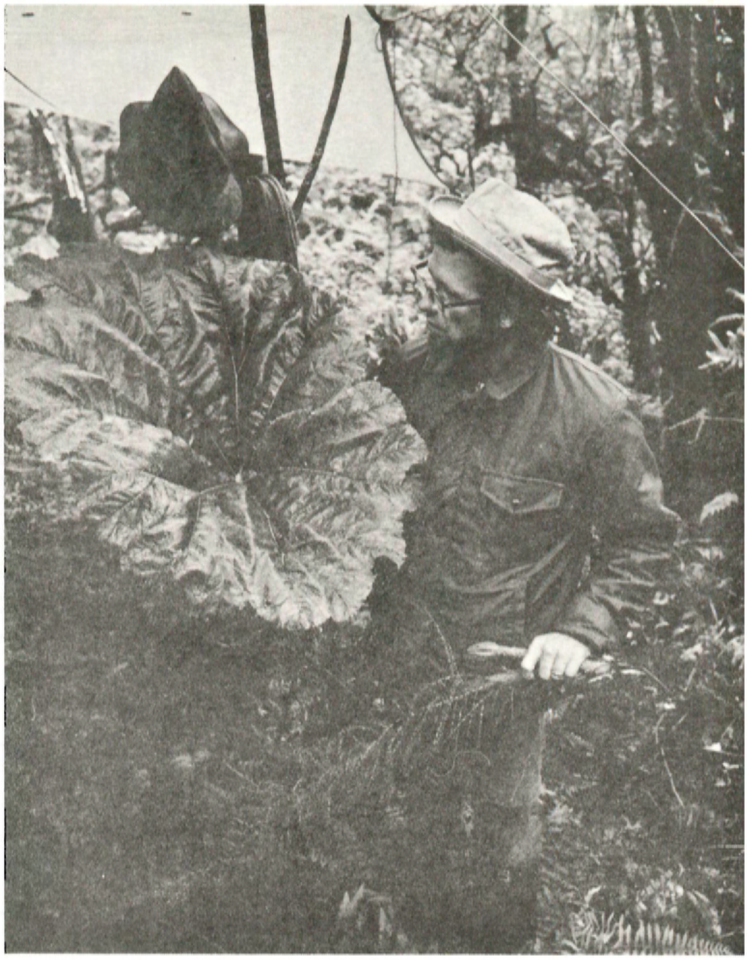
Figure 22. A small, unmapped and very lovely stream on the upper plateau to the south of Basecamp 1, elevation 3200 feet. Tree ferns (Cibotium sp.) and kanawau (Broussaisia arguta) are the most common understory plants. The kanawau is a very important food plant for several species of drepaniid birds, especially the immature of the Iiwi (Vestiaria coccinea), and both young and adult forms of the Maui Creeper (Loxops maculata) and the Amakihi (Loxops virens).

Figure 23. Robert DeWreede holding a specimen of Gunnera mauiensis, the "ape ape." This giant herb grows on steep palis in the wettest areas of the valley at 4000 to 6000 feet altitude.

Figure 24. Paul Banko on stream bank above Basecamp 2. The large plant with a palm-like growth habit is a species of the lobeliad Cyanea. Its long trunk arises from the rocky side of the streambed, a location which pigs would find difficult to reach.

Figure 25. One of several tributary streams contributing to Palikea stream. Height of waterfall about 50 feet. Elevation, 3300 feet, on north side of Kipahulu Valley.





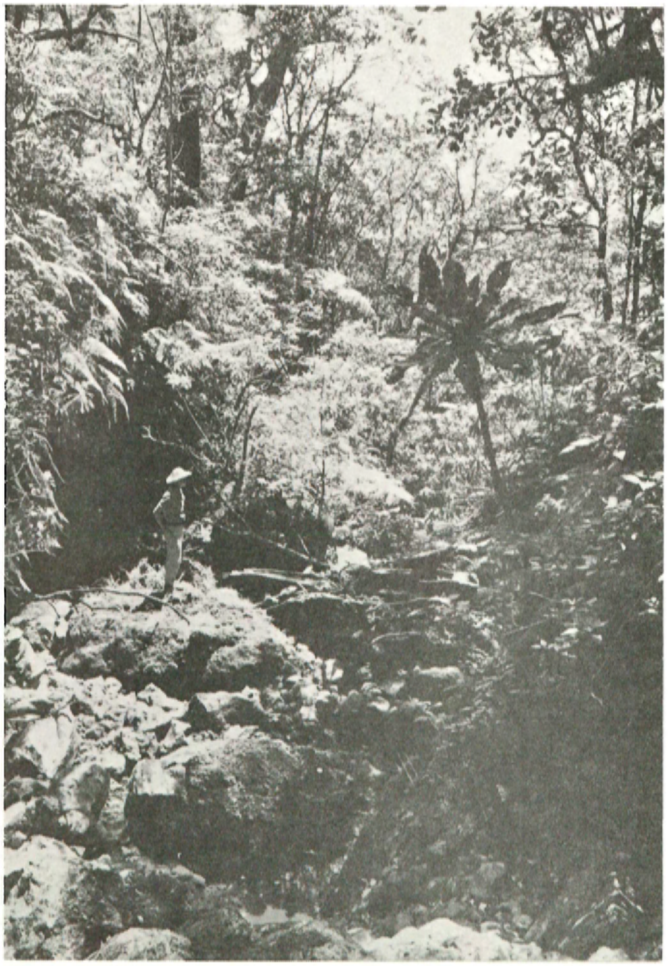


Figure 26. Gulch south of Basecamp 2 at 4300 feet elevation. The plants with the palmlike growth habit are lobeliads (*Cyanea sp.*)

Figure 27. Win and Paul Banko and William Hoe in gulch southwest of Basecamp 2, in dense forest of ohia lehua (*Metrosiderous polymorpha*). Note the abundant ferns, mosses, and other epiphytes on the tree trunks. Elevation 4300 feet.

Figure 28. Epiphytes on 'ohia lehua trees at 4700 feet elevation, along ridge trail.

Figure 29. Dense growth of mosses, liverworts, and other epiphytes in the ohia lehua forest in the cloud zone at 4700 feet elevation. Portion of trail can be seen in the foreground.




Figure 30. The "ieie" vine (*Freycinetia arborea*) on a tree near the trail adjacent to Basecamp 2.

Figure 31. Forest above Basecamp 2. This is a wet forest dominated by trees of ohia lehua (*Metrosideros polymorpha*) which support a dense growth of epiphytes, including here the lily *Astelia*.

Figure 32. Winston Banko examining one of several large poóls in unnamed and unmapped stream below Basecamp 2, elevation about 3600 feet. Win is standing on a sill of harder lava which has resisted weathering and stream erosion, leading to creation of the pool seen here.

Figure 33. Tall tree ferns (*Cibotium* sp.) on ohia lehua forest at 4100 feet elevation near Basecamp 2.

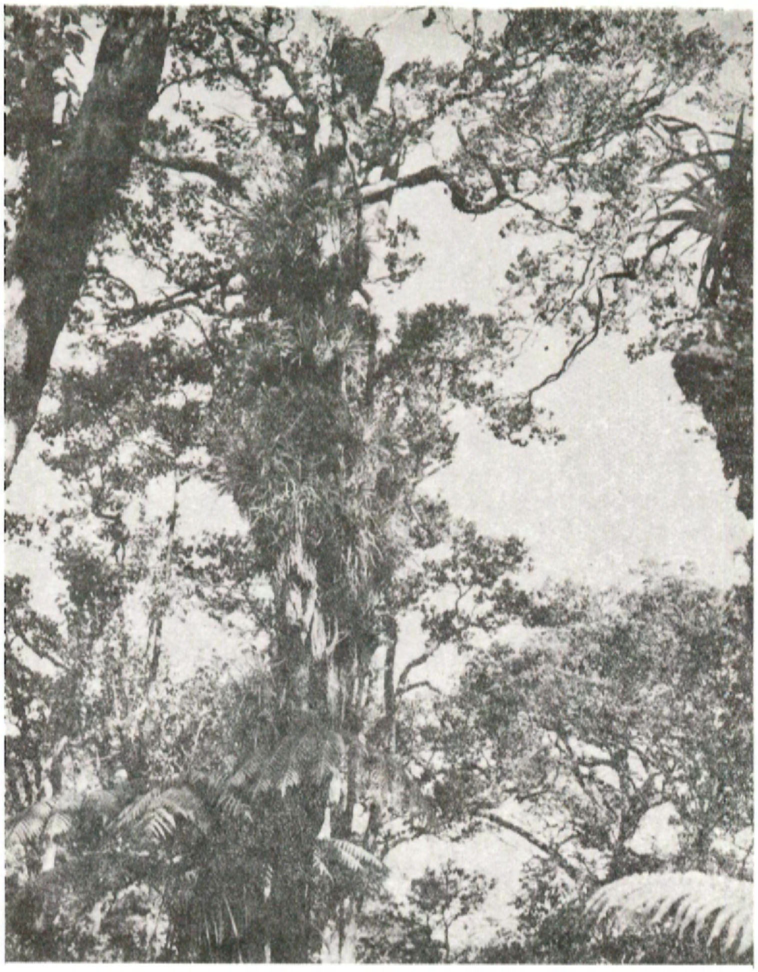
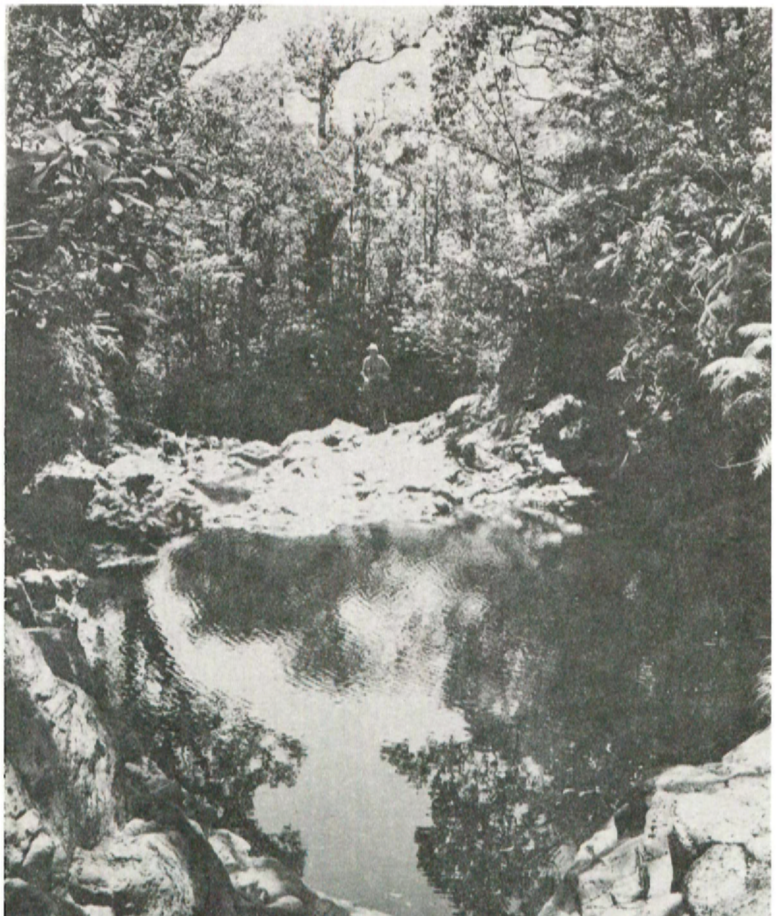





Figure 34. Win and Paul Banko working through dense fern understory in lower valley near Basecamp 2, elevation about 3600 feet. This aspect: slender-trunked ohia lehuas with scattered koas and a rich and luxuriant fern groundcover, is typical of the southern portion of the valley floor at this elevation.

Figure 35. Ridge below Basecamp 3, looking southeast. The groundcover in the foreground is the sedge Carex alligata. Elevation approximately 6500 feet. The trees are ohia lehua. The grey-white appearance of the trunks is typical at this elevation.

Figure 36. Putting up mist nets in the ohia lahua forest 300 feet below Basecamp 3. It was in this area that Winston Banko made his observations on the Maui Parrotbill, Pseudonestor xanthophrys, as it moved through the ohia lehua forest. Had it passed lower through the vegetation, we no doubt would have taken it in the mist net. Banko's extraordinary observations were the result of his dogged persistence; for days he scanned the tangled forest vegetation without result, but was finally rewarded with definite sightings of two extremely rare drepaniids.

Figure 37. An example of the erosion typical in the Kipahulu Valley rainforest. Pounding rains have removed the soil from around a clump of ferns, leaving a pedestal protected by the fibrous root system of the fern plant. Similar pedestals were observed under the sprawling root systems of ohia and koa trees, the adjacent unshielded soil eroded away by the incessant rains.

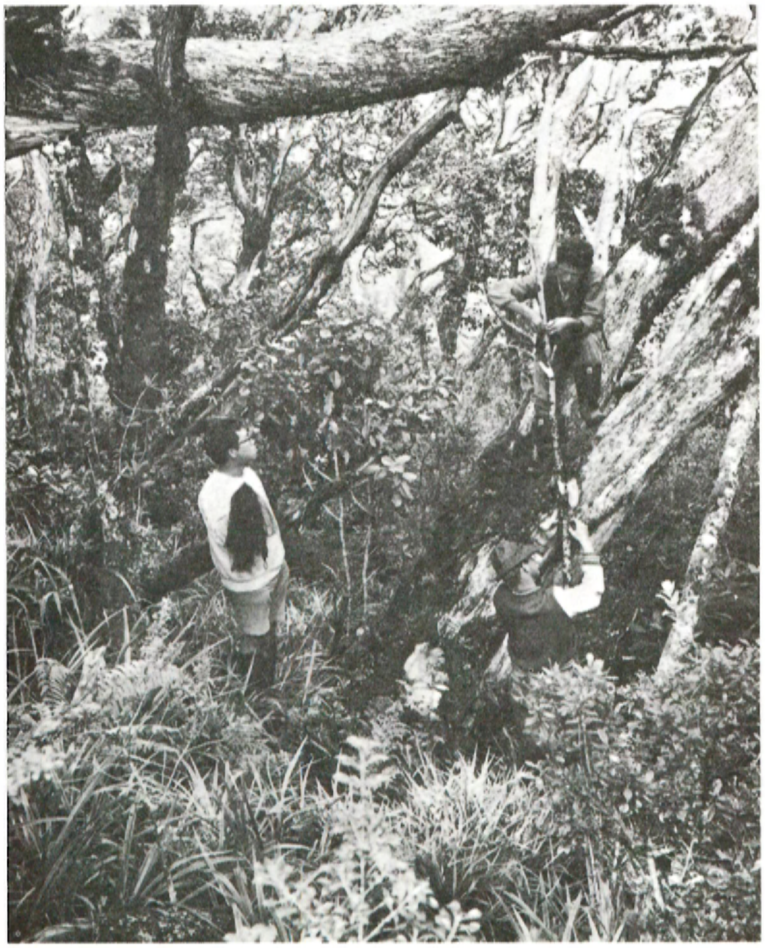


Figure 38. Edge of upper plateau above Basecamp 3. The erosion is due to goat and sheep activity along the plateau edge. Only a further reduction in the number of feral goats in the Haleakala section of the Hawaii National Park will prevent more of this erosion, which, together with pig rooting, threatens the integrity of the high meadows.

Figure 39. Looking up the ridge above Basecamp 3, just above tree line. The upper horizon marks the beginning of the grassy plateau illustrated in Figure 41. This is a region of nearly constant wind, and the native birds tend to avoid it.

Figure 40. A closeup of the eroded area shown in Figure 38. Note the banding of ash layers produced in a series of eruptions. This deep layer of ash, lying over impervious lava, forms the substrate for the high grassland shown in Fig. 41.

Figure 41. Plateau above Basecamp 3. This is a grassland, dominated by the endemic grass Deschampsia nubigena and the composite herb gosmore (Hypochaeris radicata), with occasional plants of the amaumau fern (Sadleria cyatheoides).

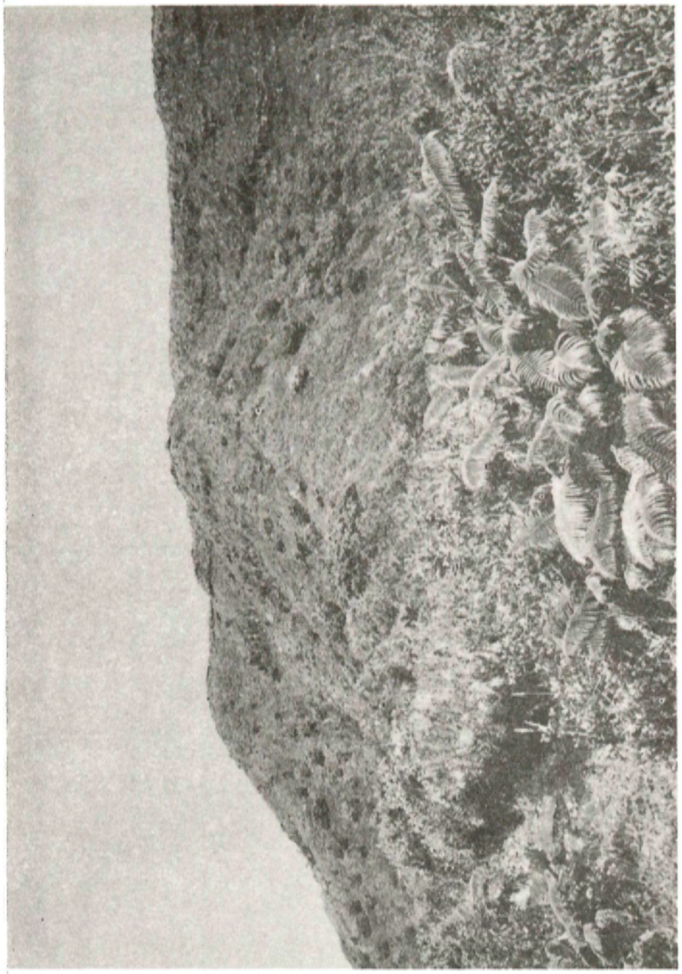
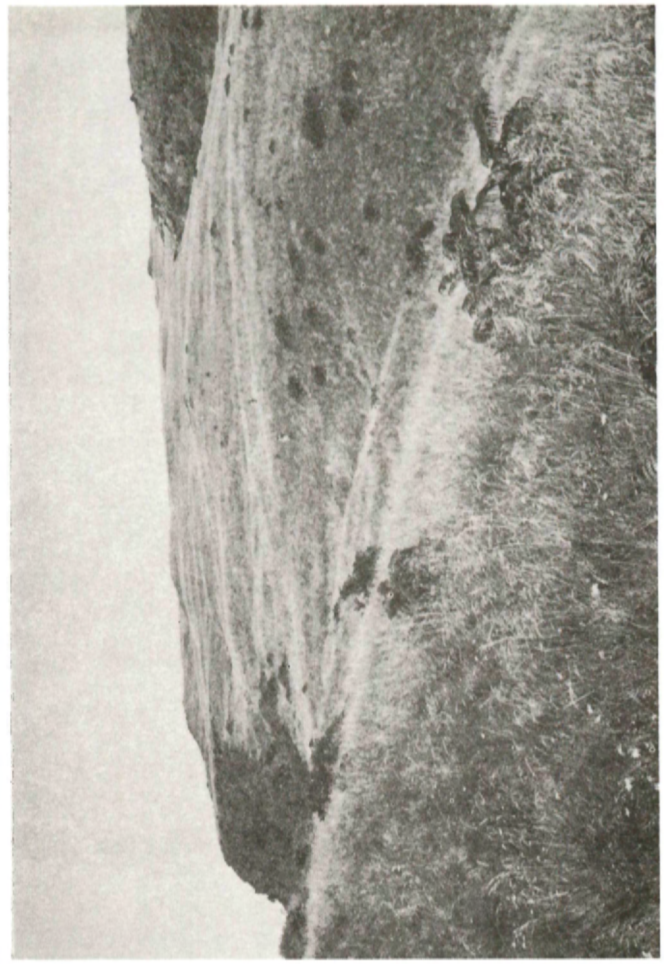
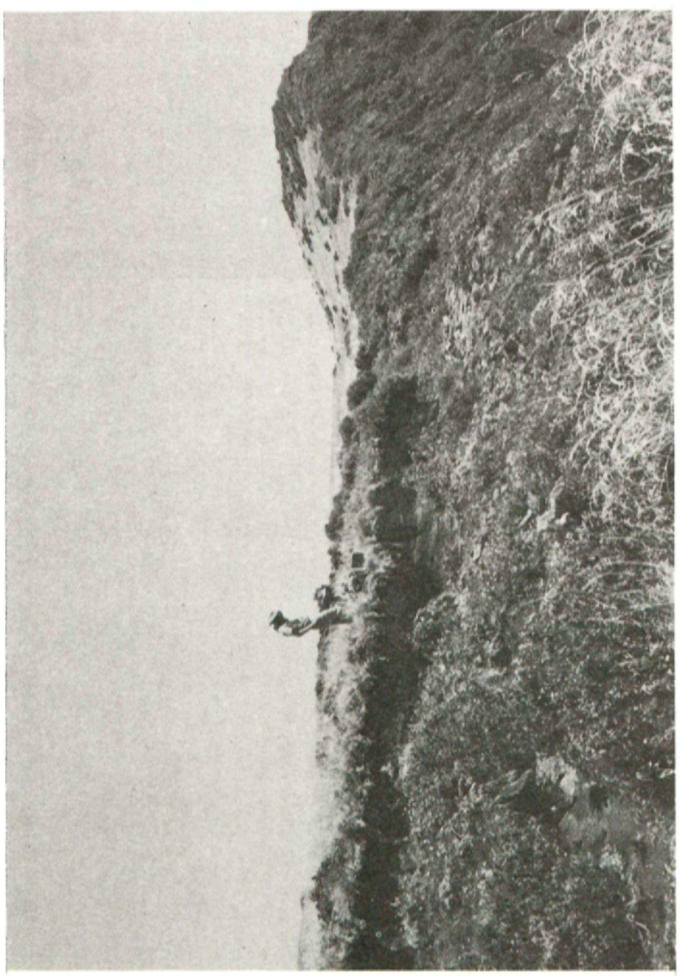
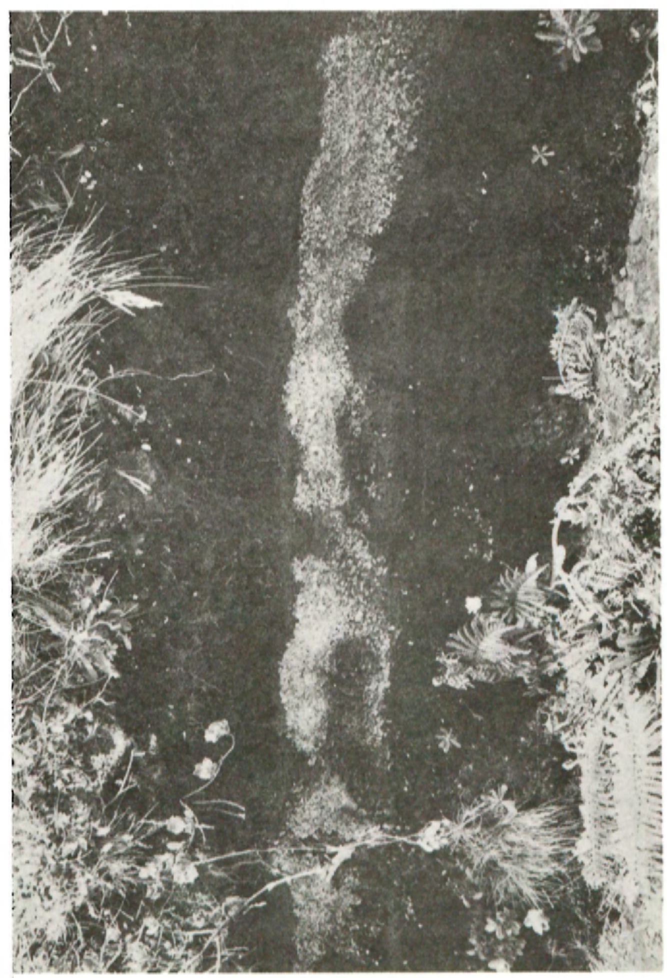





Figure 42. Upper Wai Anapanapa, looking east. Note the lack of an exit stream. John Maciolek reports the depth to vary from 6 to 2 feet, depending upon the season. Elevation about 6800 ft.

Figure 43. A more distant view of Upper Wai Anapanapa. The tree in the foreground, and the most common tree in this area, is the ohia lehua, Metrosideros polymorpha. View is to the east. To the south in the upper right of the photograph can be discerned the edge of Kipahulu Valley.

Figure 44. Lower Wai Anapanapa, or Wai Ele'ele, a close view. Most of the trees are ohia lehua, with one tree of Pelea sp. in the upper right foreground, and a plant of akala, Rubus hawaiiensis in the lower right foreground. Elevation is about 6700 feet.

Figure 45. A more distant view of Lower Wai Anapanapa, or Wai Ele'ele, looking north. A dense ohia lehua forest surrounds the lake. A few meters from the site of this photograph William Hoe found a clump of the extremely rare endemic lobeliad Cyanea horrida.

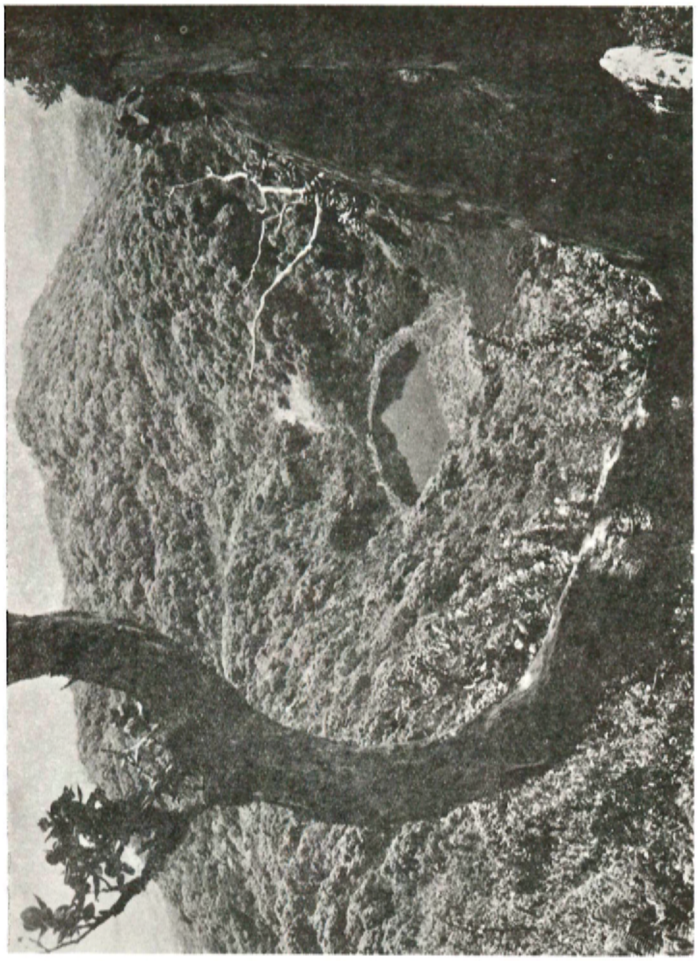
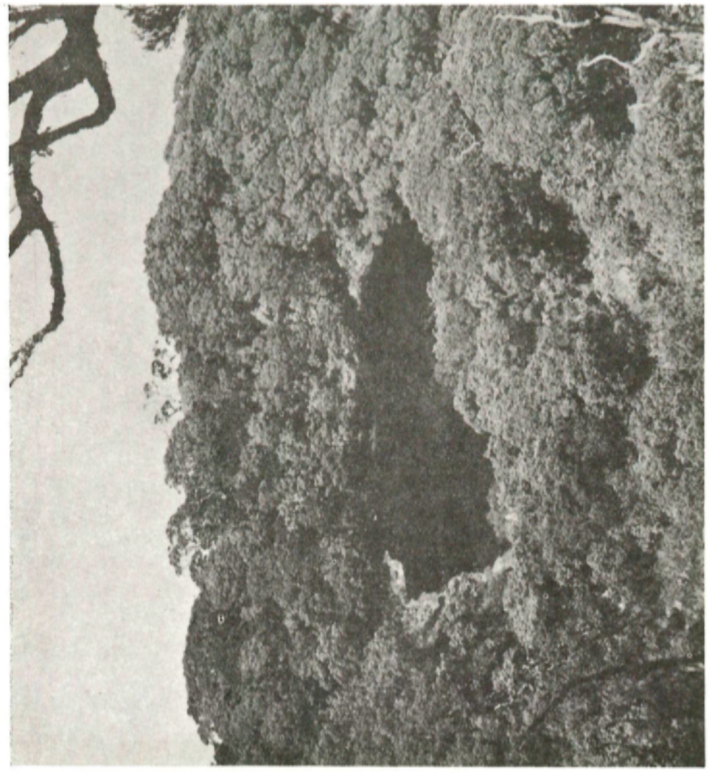
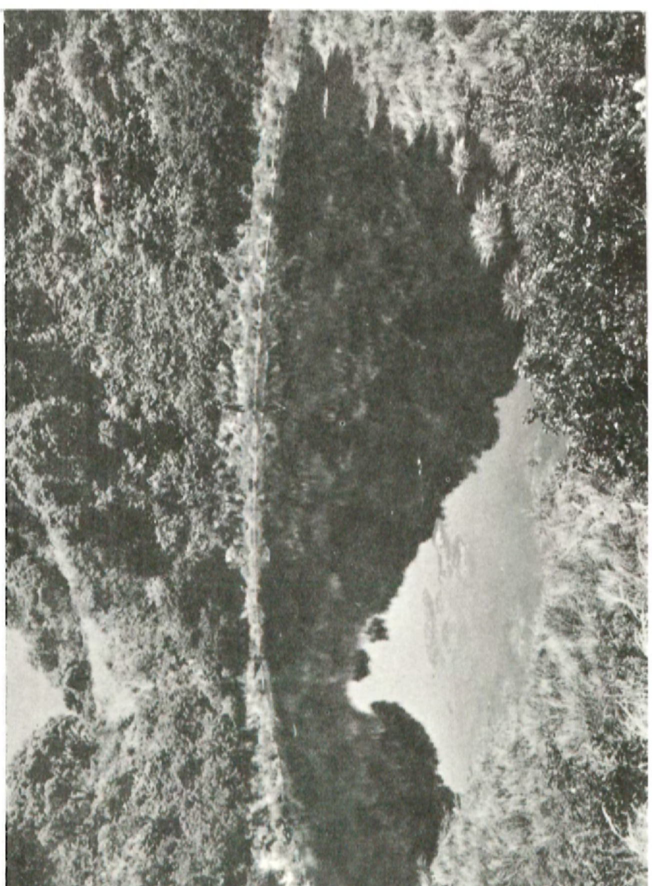





Figure 46. Photomicrograph of a chromosome taken from the salivary gland of a fruit fly. The banding, which is so clearly evident in this excellent photo, represents units or groups of units of hereditary material which some refer to as "genes." Each species of organism has a distinct and specific pattern of chromosome banding. By studying the patterns of chromosome banding, and the changes which take place in banding, both in hybridization and natural speciation, scientists can learn much about the nature of fundamental genetic processes and their role in evolution. Photo by H. D. Stalker, Washington University, St. Louis, Missouri.

Figure 47. A close look at a specimen of Drosophila melanocephala, one of the native "picture-winged" fruit flies of Kipahulu Valley whose genetics and evolution are being studied by Drs. D. Elmo Hardy and Hampton Carson at the University of Hawaii.

Figure 48. Drosophila grimshawi, another "picture-winged" fruit fly found in Kipahulu Valley. Each species has a characteristic pattern of wing markings, some of which are very picturesque. Photos of Figures 47 and 48 by Dr. LaPlant of Washington University, St. Louis, Missouri.

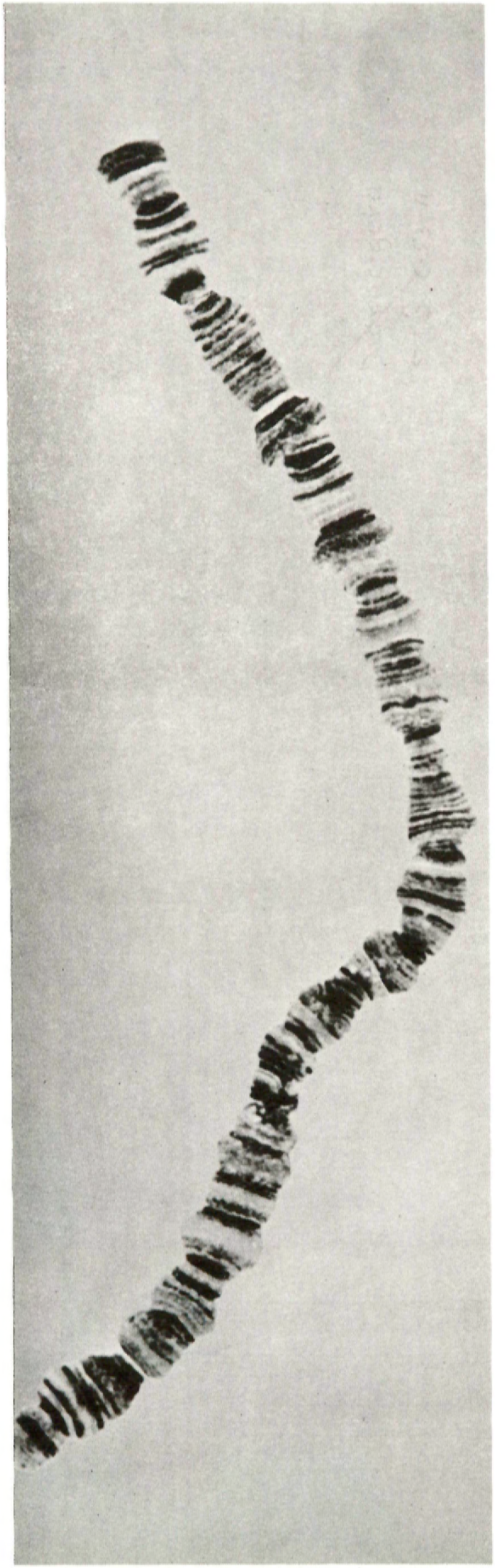
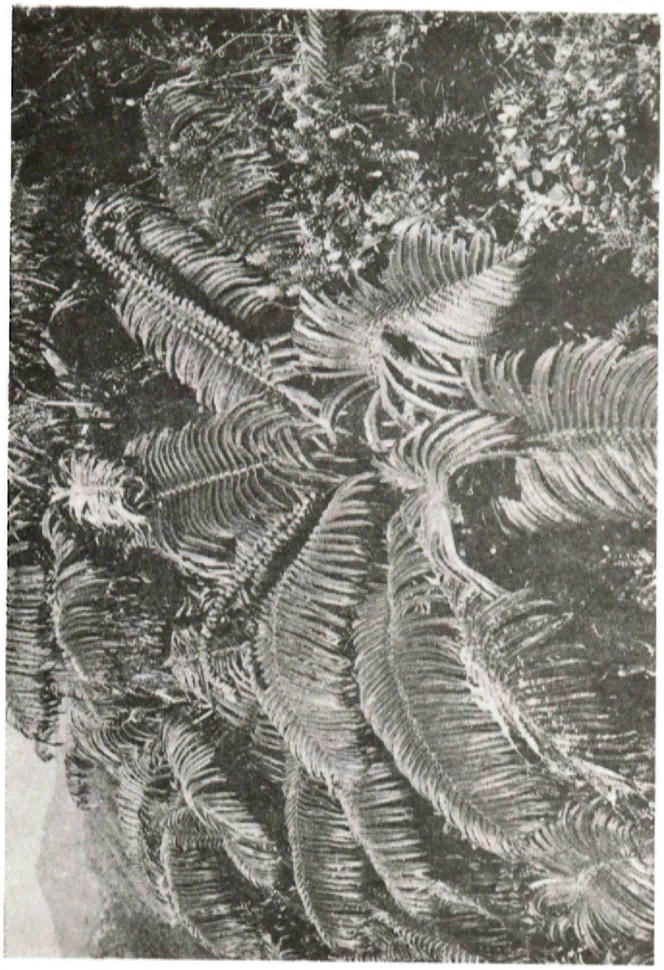


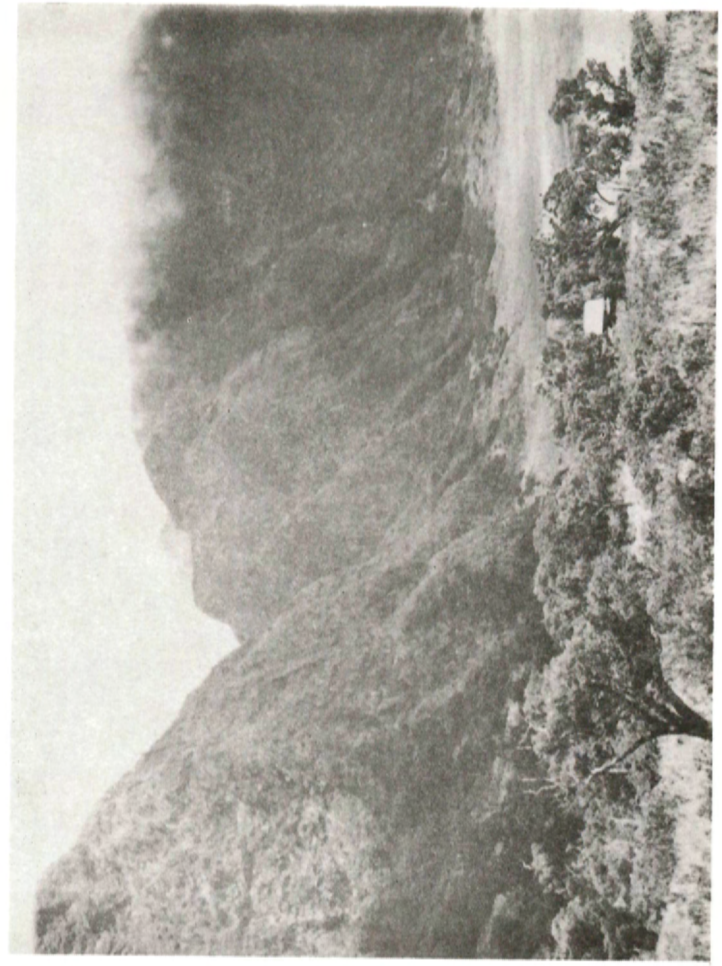
Figure 49. Dr. Hampton Carson looking down into Kipahulu Valley from the ridge above Basecamp 3. The camp itself was located in the saddle visible in the lower right of the photo. Note the shrub-like character of the ohia lehua at this elevation, which is near treeline.

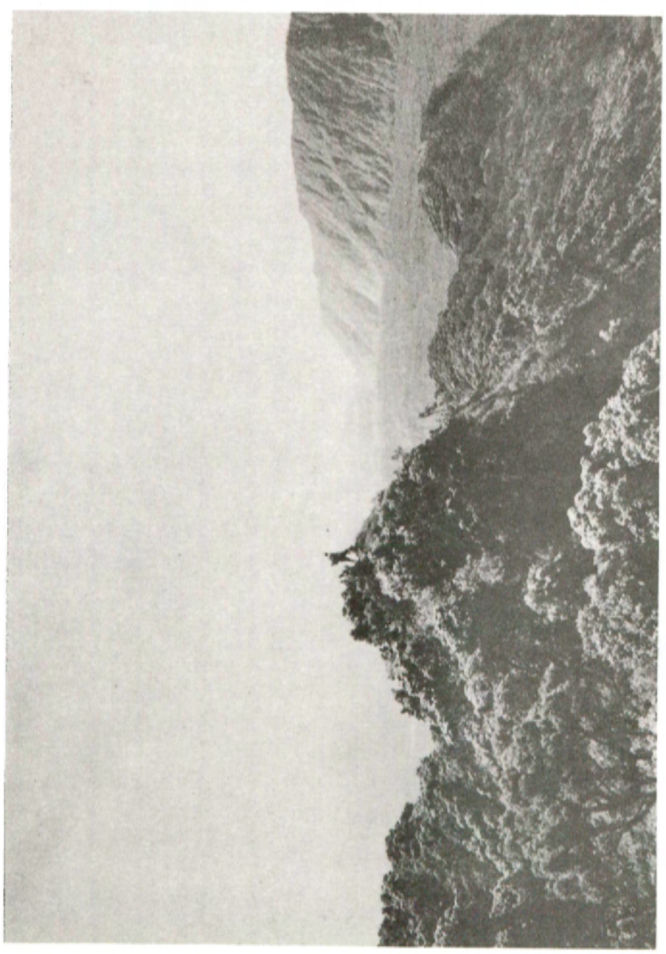
Figure 50. A specimen of the amaumau fern, _Sadleria cyatheoides_ with _Vaccinium sp._ and other ground plants typical of the high slopes between treeline and the high grassland plateau. Elevation about 6800 feet.

Figure 51. Small lake or pond, unnamed and unmapped, in upper Kipahulu Valley about two kilometers southeast of Basecamp 3. This pond is less than one meter deep, and appears to nearly dry up during the drier summer and fall months. Its origin appears to lie with a small cinder cone, as is the case with the other lakes, but its total extent is considerably less. Nevertheless, it is prominently visible from the western ridge separating Kipahulu Valley from Haleakala Crater.

Figure 52. A view to the south from the inside of Haleakala crater. The high ridge at far left is the upper boundary of Kipahulu Valley. Also visible in the photograph is Paliku Cabin, nestled at the base of the cliff forming the eastern boundary of Haleakala crater. From this cabin it is a two and a half hour hike into Kipahulu Valley and Basecamp 3.







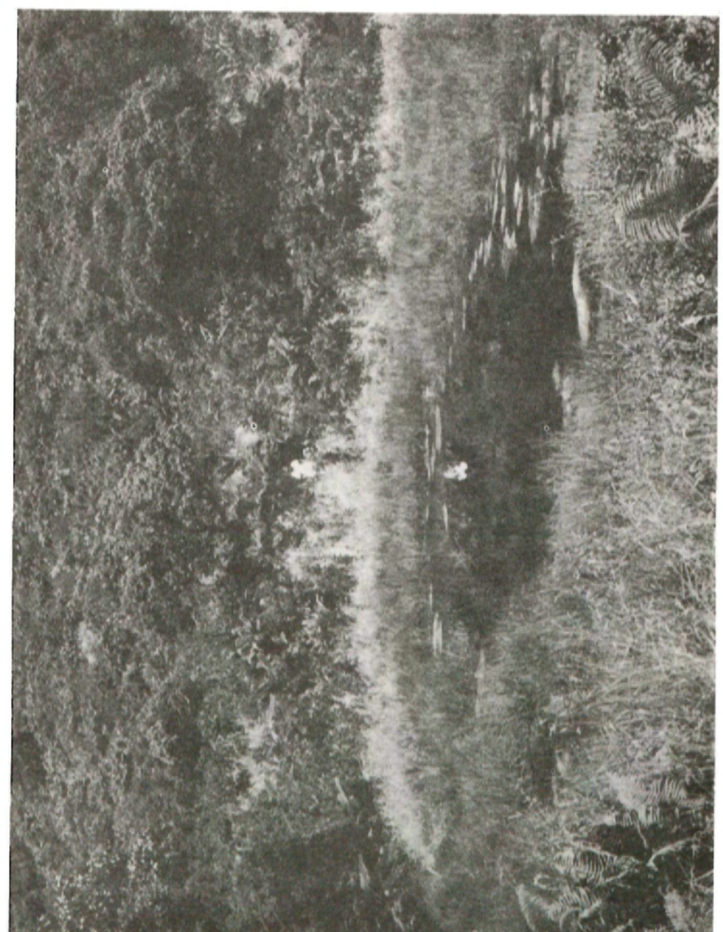
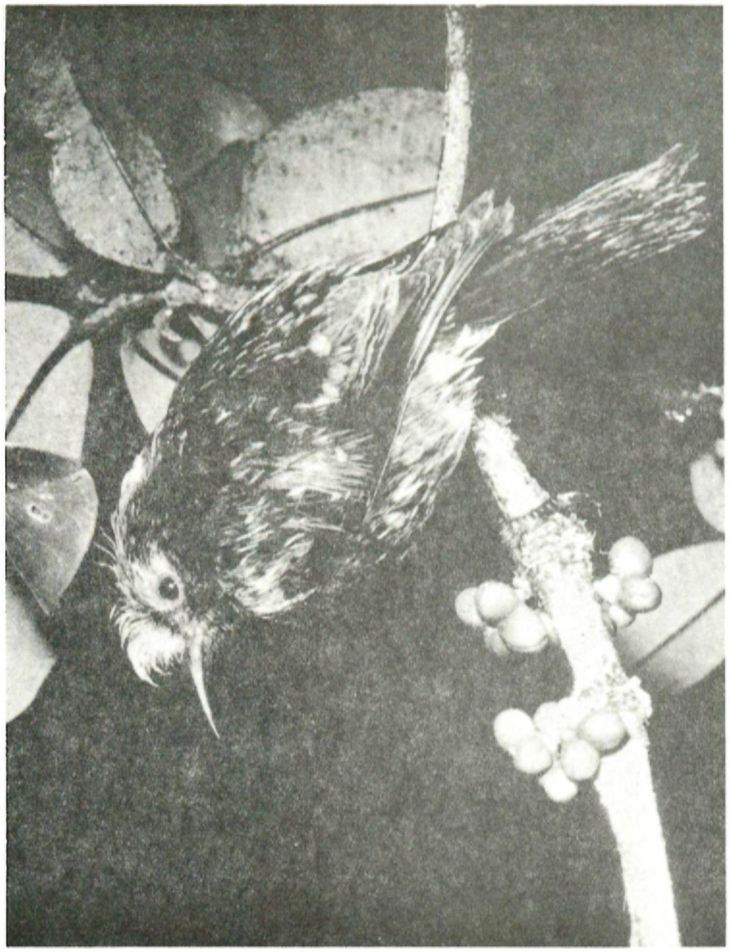


Figure 53. The Amakihi on a flowering head of _Broussaisia arguta_. This relatively abundant plant was regularly visited by the Amakihi and Maui Creeper, as well as juveniles of the Anapane and Iiwi, for which it formed an important food source.

Figure 54. The Crested Honeycreeper, _Palmeria dolei_, perched on a leafy branch of _Pelea_, an endemic tree in Kipahulu Valley. Note the green seed pods attached to the branch. The Crested Honeycreeper demonstrated a strong affinity for this tree, the significance of which is as yet undetermined.

Figure 55. The Maui Creeper, _Loxops maculata newtoni_. This gentle drepanid, relatively abundant throughout the Kipahulu forests, proved the most congenial of all the birds found in the valley. Several had been maintained in a mosquito net cage at Basecamp 2 for study purposes. When ready to break camp we turned the birds loose. One of the Maui Creepers returned instead of flying off like the rest, and hopped about the camp while we continued our packing. In captivity it tamed quickly and showed little fear of man.

Figure 56. The Iiwi, _Vestiaria coccinea_, showing both adult (left) and an immature with lighter colored head. Note the strikingly decurved bill, probably adapted for feeding on certain lobeliad flowers, as well as on blossoms of the ohia tree. The curved bill permitted the bird to forage among the ohia blossoms, which were located high in the crowns of the ohia trees, while remaining below the level of the flowers themselves and thus obscured amongst the leaves and not exposed to avian predators.




MAPS OF KIPAHULU VALLEY

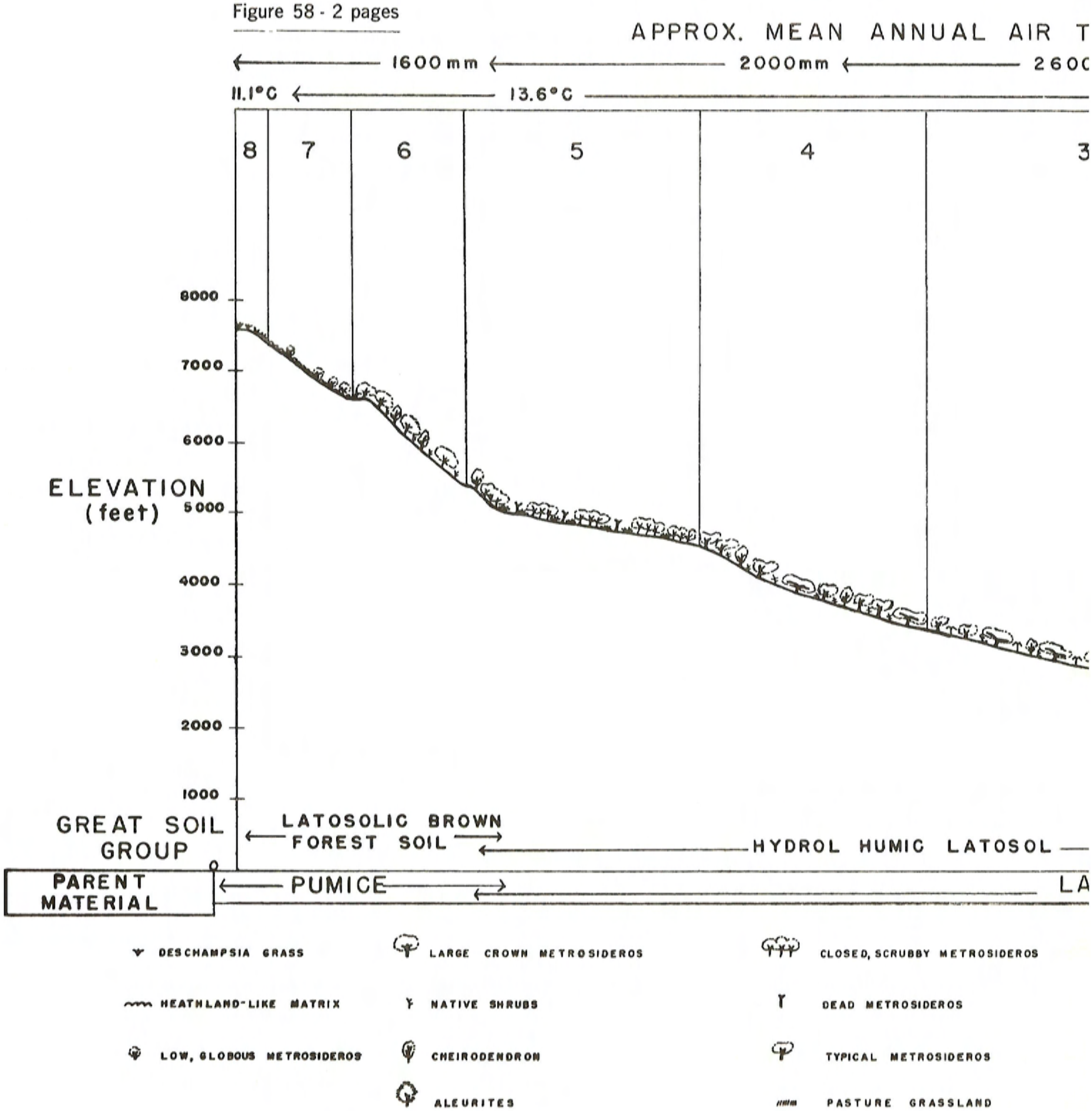
Figure 57. Map of Kipahulu Valley. →


Puu Alaea
Pohaku Palaha
Kaupaiki
Waikekeehia
Kuiki
KIPAHULU VALLEY
Waihoi Valley
Puu Kaukanu
Puu Hoolewa
Puu Mahoe
Puu Hoolio
Kaumakani
KAUPO TRAIL
GAP
Puu Ahulili
Nuanualoa
Kaleps Gulch
Kukuiula Gulch
Kaukauai
Ninaio Pali
Palikea
Kahalawe Gulch
Oheo Gulch
Ohai Pt
Kuloa
Kipahulu
Puhilele Pt
Ahole Rock
Kalepa Pt
Kaupo
Makaakini
Kamanawa
Kue
DAM
KIPAHULU VALLEY
Maui, Hawaii
Proposed Boundary
Extension of Proposed Boundary to include Deschampsia Grassland
Expedition Trails
Basecamps (number in triangle)

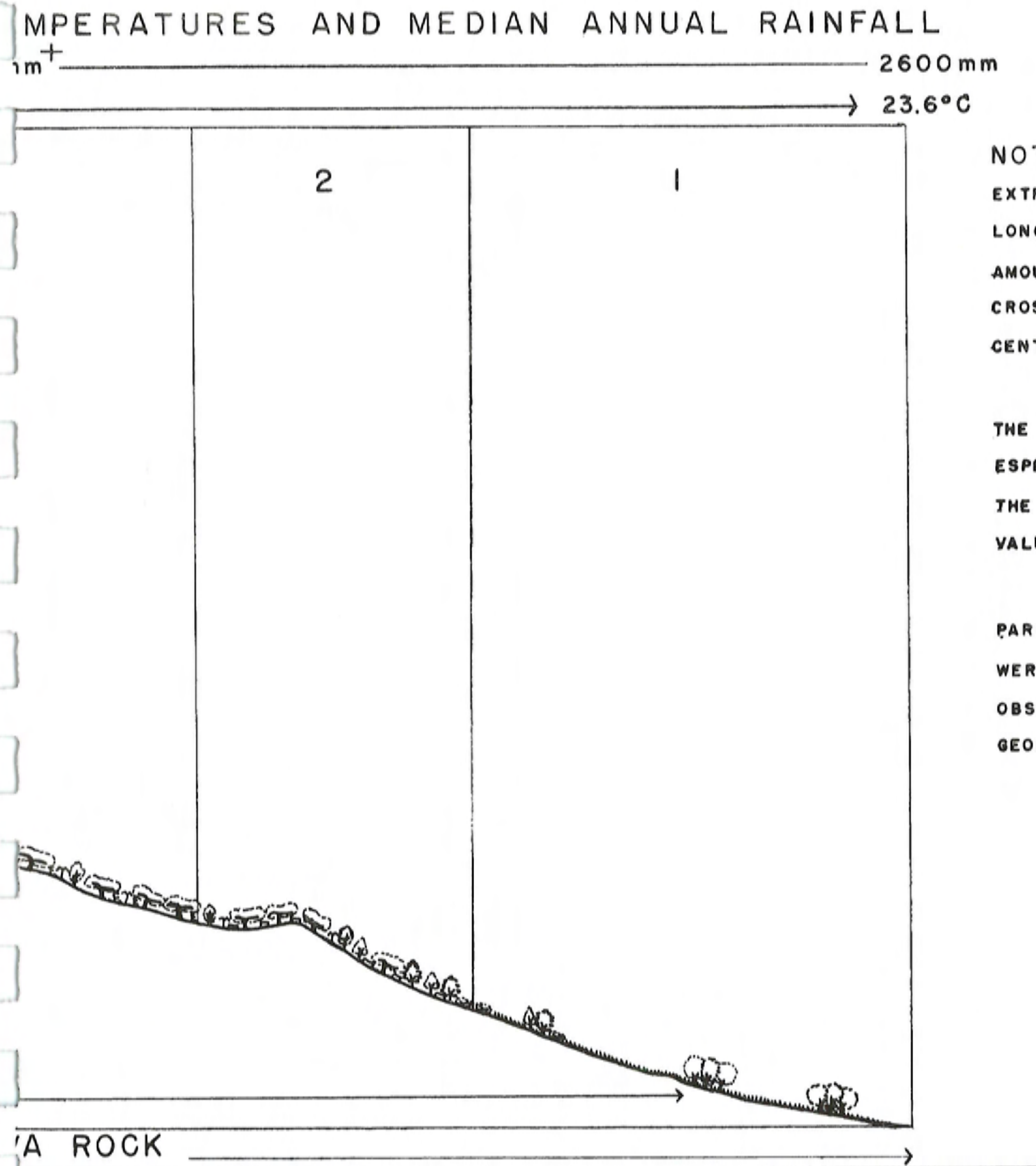
TOPOGRAPHIC VE

KIPAHULU
CENTRAL PA

Figure 58 - 2 pages



;ETATION PROFILE
)F
VALLEY
LI-ESCARPMENT



NOTE- TEMPERATURES ARE BASED ON EXTRAPOLATIONS FROM NEAREST AND LONGEST ESTABLISHED STATIONS. RAINFALL AMOUNTS ARE PLOTTED WHERE ISOHYETS CROSS SPECIFIC ELEVATIONS OF THE CENTRAL PALI-ESCARPMENT.

THE LACK OF LOCAL WEATHER DATA, ESPECIALLY OF HIGH ELEVATIONS, INTRODUCE THE ELEMENT OF ERROR IN EXTRAPOLATE VALUES USED.

PARENT MATERIALS AND SOIL TYPES WERE DETERMINED BY GENERAL FIELD OBSERVATIONS, REFERENCE TO LOCAL GEOLOGY AND SOIL MAPS.

ACACIA KOA

FALSE STAGHORN FERN

LANTANA

FREYCINETIA LIANE

PSIDIUM

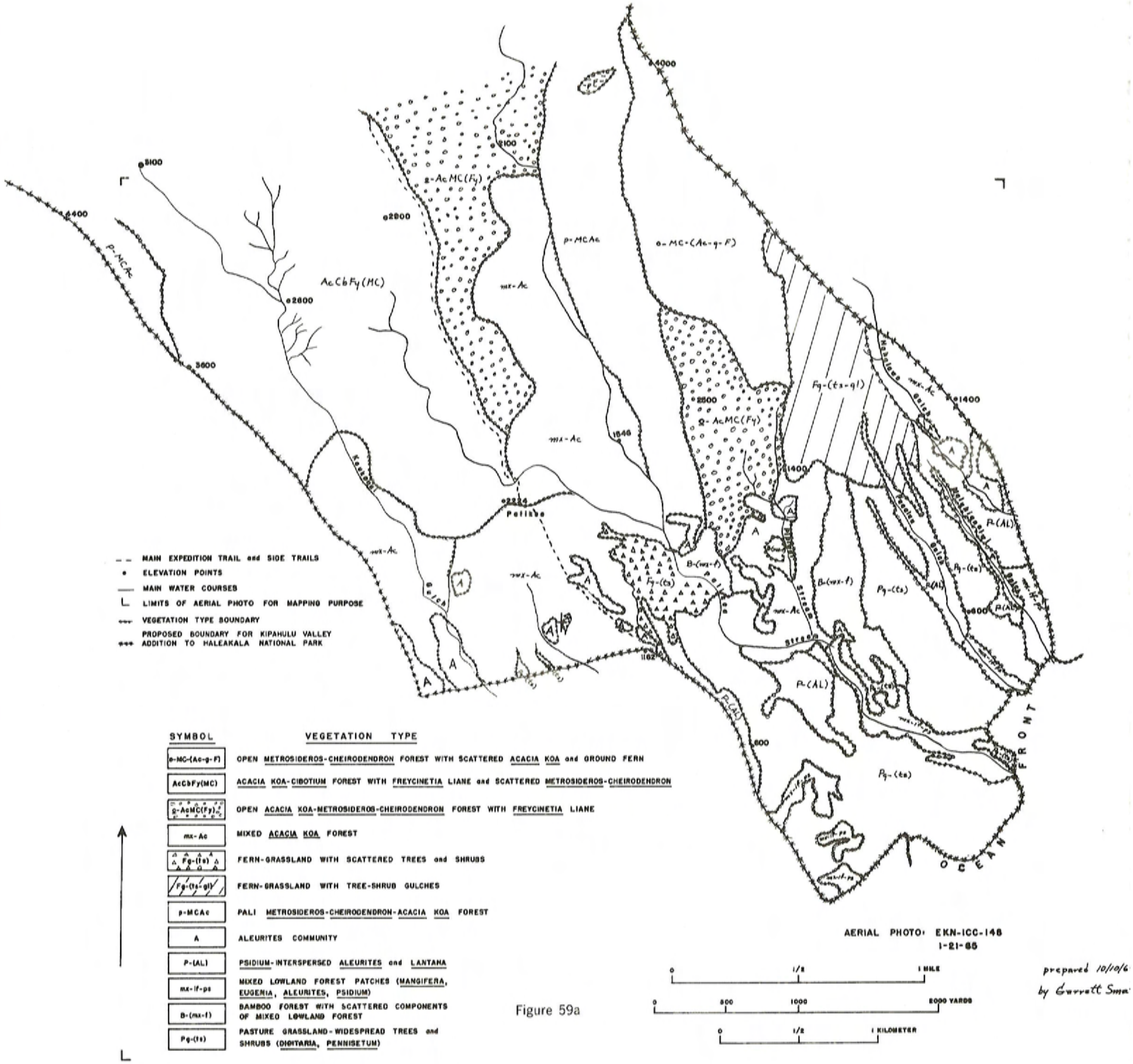
MANGIFERA, EUGENIA, ALEURITES,PSIDIUM [redacted]

SEDGE

CIBOTIUM

ARBORESCENT SHRUBS

PREPARED and DRAWN BY:
G. SMATHERS



MAIN EXPEDITION TRAIL and SIDE TRAILS
ELEVATION POINTS
MAIN WATER COURSES
LIMITS OF AERIAL PHOTO FOR MAPPING PURPOSE
VEGETATION TYPE BOUNDARY
PROPOSED BOUNDARY FOR KIPAHULU VALLEY ADDITION TO HALEAKALA NATIONAL PARK
SYMBOL
VEGETATION TYPE
o-MC-(Ac-g-F)
OPEN METROSIDEROS-CHEIRODENDRON FOREST WITH SCATTERED ACACIA KOA and GROUND FERN
AcCbFy(MC)
ACACIA KOA-CIBOTIUM FOREST WITH FREYCINETIA LIANE and SCATTERED METROSIDEROS-CHEIRODENDRON
o-AcMC(Fy)
OPEN ACACIA KOA-METROSIDEROS-CHEIRODENDRON FOREST WITH FREYCINETIA LIANE
mx-Ac
MIXED ACACIA KOA FOREST
Fg-(ts)
FERN-GRASSLAND WITH SCATTERED TREES and SHRUBS
Fg-(ts-gl)
FERN-GRASSLAND WITH TREE-SHRUB GULCHES
p-MCAc
PALI METROSIDEROS-CHEIRODENDRON-ACACIA KOA FOREST
A
ALEURITES COMMUNITY
P-(AL)
PSIDIUM-INTERSPERSED ALEURITES and LANTANA
mx-lf-ps
MIXED LOWLAND FOREST PATCHES (MANGIFERA, EUGENIA, ALEURITES, PSIDIUM)
B-(mx-f)
BAMBOO FOREST WITH SCATTERED COMPONENTS OF MIXED LOWLAND FOREST
Pg-(ts)
PASTURE GRASSLAND-WIDESPREAD TREES and SHRUBS (DIGITARIA, PENNISETUM)
AERIAL PHOTO: EKN-ICC-148
1-21-65
0
1/2
1 MILE
0
500
1000
2000 YARDS
0
1/2
1 KILOMETER
OCEAN
FRONT
4000
5100
4400
2800
2800
3600
2600
1400
1400
2234
600
1162
Palikea
p-MCAc
AcCbFy(MC)
o-AcMC(Fy)
p-MCAc
o-MC-(Ac-g-F)
mx-Ac
Fg-(ts-gl)
B-(mx-f)
P-(AL)
Pg-(ts)

Figure 59a

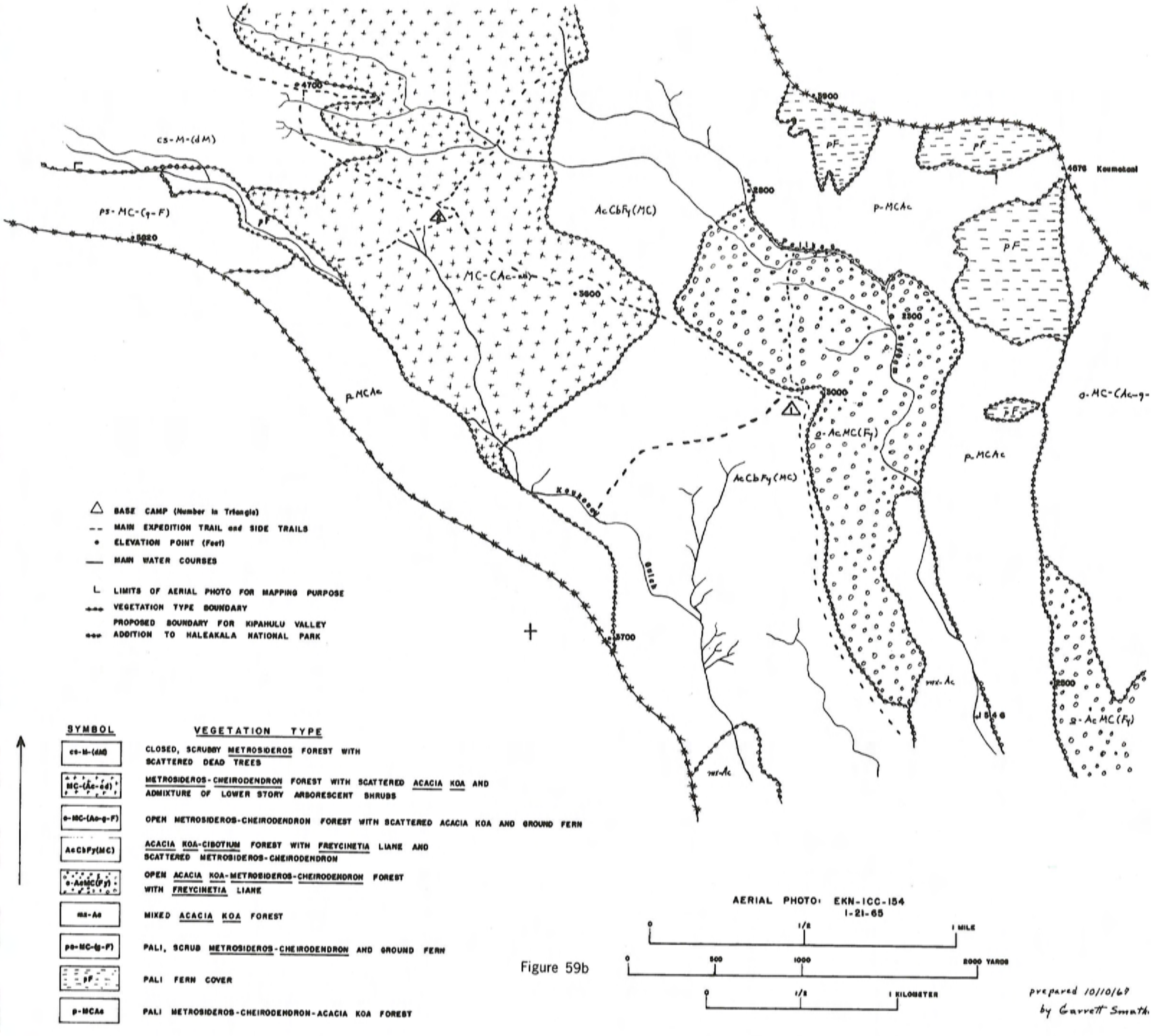
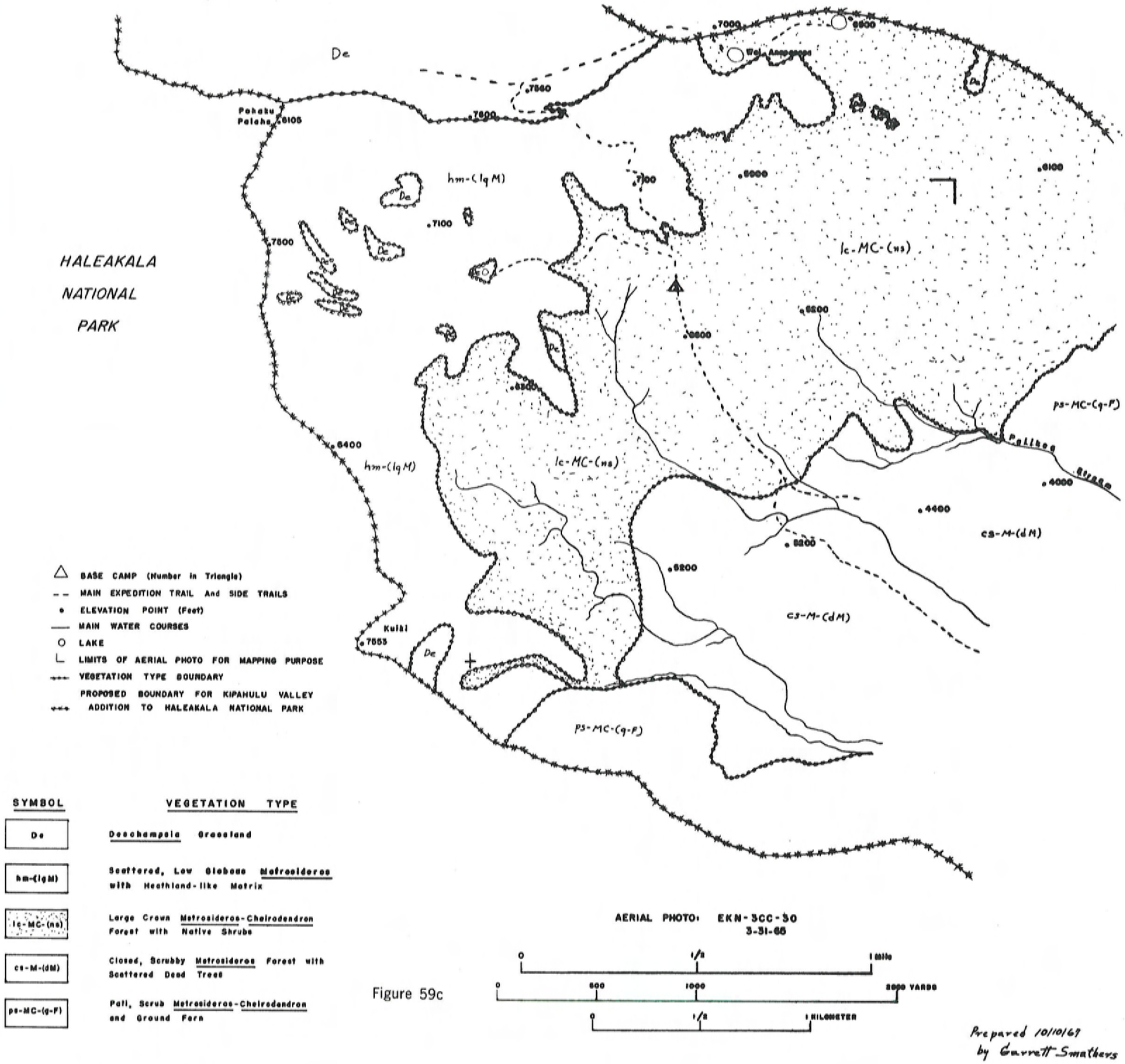

cs-M-(dM)
ps-MC-(g-F)
pF
5020
4700
MC-(Ac-ad)
3600
AcCbFy(MC)
2800
p-MCAc
pF
4676 Koumoku
o-MC-(Ac-g-
3000
o-AcMC(Fy)
p-MCAc
AcCbFy(MC)
Koukouai
Gulch
3700
mx-Ac
1546
2600
o-AcMC(Fy)
BASE CAMP (Number in Triangle)
MAIN EXPEDITION TRAIL and SIDE TRAILS
ELEVATION POINT (Feet)
MAIN WATER COURSES
LIMITS OF AERIAL PHOTO FOR MAPPING PURPOSE
VEGETATION TYPE BOUNDARY
PROPOSED BOUNDARY FOR KIPAHULU VALLEY ADDITION TO HALEAKALA NATIONAL PARK
SYMBOL
VEGETATION TYPE
cs-M-(dM) CLOSED, SCRUBBY METROSIDEROS FOREST WITH SCATTERED DEAD TREES
MC-(Ac-ad) METROSIDEROS-CHEIRODENDRON FOREST WITH SCATTERED ACACIA KOA AND ADMIXTURE OF LOWER STORY ARBORESCENT SHRUBS
o-MC-(Ac-g-F) OPEN METROSIDEROS-CHEIRODENDRON FOREST WITH SCATTERED ACACIA KOA AND GROUND FERN
AcCbFy(MC) ACACIA KOA-CIBOTIUM FOREST WITH FREYCINETIA LIANE AND SCATTERED METROSIDEROS-CHEIRODENDRON
o-AcMC(Fy) OPEN ACACIA KOA-METROSIDEROS-CHEIRODENDRON FOREST WITH FREYCINETIA LIANE
mx-Ac MIXED ACACIA KOA FOREST
ps-MC-(g-F) PALI, SCRUB METROSIDEROS-CHEIRODENDRON AND GROUND FERN
pF PALI FERN COVER
p-MCAc PALI METROSIDEROS-CHEIRODENDRON-ACACIA KOA FOREST
AERIAL PHOTO: EKN-ICC-154
1-21-65
0
1/2
1 MILE
0
500
1000
2000 YARDS
0
1/2
1 KILOMETER
prepared 10/10/67
by Garrett Smith

Figure 59b



De
Pohaku Palaha 8105
7600
7560
7000
6500
Wai Anapanapa
HALEAKALA
NATIONAL
PARK
hm-(lgM)
7100
7100
6000
6100
7500
lc-MC-(ns)
6200
5600
6300
ps-MC-(g-F)
Palikea Stream
6400
hm-(lgM)
lc-MC-(ns)
4000
4400
cs-M-(dM)
5200
5200
cs-M-(dM)
Kuiki 7553
ps-MC-(g-F)
BASE CAMP (Number in Triangle)
MAIN EXPEDITION TRAIL And SIDE TRAILS
ELEVATION POINT (Feet)
MAIN WATER COURSES
LAKE
LIMITS OF AERIAL PHOTO FOR MAPPING PURPOSE
VEGETATION TYPE BOUNDARY
PROPOSED BOUNDARY FOR KIPAHULU VALLEY ADDITION TO HALEAKALA NATIONAL PARK
SYMBOL
VEGETATION TYPE
De
Deschampsia Grassland
hm-(lgM)
Scattered, Low Globose Metrosideros with Heathland-like Matrix
lc-MC-(ns)
Large Crown Metrosideros-Cheirodendron Forest with Native Shrubs
cs-M-(dM)
Closed, Scrubby Metrosideros Forest with Scattered Dead Trees
ps-MC-(g-F)
Pali, Scrub Metrosideros-Cheirodendron and Ground Fern
AERIAL PHOTO: EKN-3CC-30
3-31-65
0
1/2
1 Mile
0
500
1000
2000 YARDS
0
1/2
1 KILOMETER
Prepared 10/10/67
by Garrett Smathers

Figure 59c

CORRECTIONS, ADDITIONS, CHANGES

to the

Scientific Report of the Kipahulu Valley Expedition

The following is a list in numerical sequence of all corrections, additions, and/or changes which have been noted since the printing of the Report. In order that your copy of the report be correct and completely up-to-date, please note all such changes in your copy of the manuscript.

p. 4, William Hoe	Bryophytologist should read Bryologist
p. 15, line 1	Botannically should read Botanically
p. 15, 3rd line from bottom	Reads ...have generally...; should read ... have a generally ...
p. 15, 12th line from bottom	Cheirodendron should be underlined
p. 16, line 9	Acacia-Cheirodendron should be underlined
p. 16, line 14	Delete the comma (,) after var. arguta Gouldia supp. should read Gouldia spp.
p. 16, line 11 from bottom	Reads ... here that peperomia, which is ... Should read ... here that Peperomia, which is ...
p. 17, line 2	intermittant should read intermittent
p. 17, line 6	Reads ... with cheirodendron present in ... Should read ... with Cheirodendron present in ...
p. 17, line 9	Drimaria should read Drymaria
p. 17, line 14 from bottom	Underline Styphelia
p. 17, line 9 from bottom	such points should read such a point
p. 17, 4th line from bottom	Delete their persistance level
p. 18, line 11	Freycenetia should read Freycinetia
p. 18, line 8 from bottom	Underline Cheirodendron
p. 18, line 6 & 5 from bottom	Underline Broussaisia, Cibotium, Perrottetia, Pelea
p. 19, line 14 & 4 from bottom	Underline Cheirodendron
p. 20, line 1	Underline Cheirodendron
p. 20, line 3	Change species to read plants
p. 20, line 3 & 4	Underline Pelea, Cheirodendron, Styphelia
p. 20, line 4	Delete Ohia, and Styphelia; Add: and Metrosideros so that sentence reads... "Styphelia, and Metrosideros form"
p. 20, line 6	Underline Metrosideros
p. 20, line 10 & 12	Underline Astelia
p. 20, lines 22-24	Underline: Cheirodendron, Coprosma, Styphelia, Dryopteris, Sadleria
p. 20, line 23	Change Dryopteris has to Dryopteris forms
p. 20, line 29	Underline Elaphoglossum

p. 20, line 32	Change pachyphyllum to pachyphylla
p. 20, 7th line from bottom	Underline Coprosma
p. 21, line 13	Reads: , or excessive drainage, remains to . . . Should read: excessive drainage, or a combination of these factors, remains to . . .
p. 21, line 21	Delete hyphen (-) in Wai-Anapanapa. 7th line from bottom: Underline Deschampsia
p. 24, line 13 from bottom	Change Conservance to Conservancy
p. 26, line 21	Change penudlum to pendulum
p. 27, line 9	Change toppingli to toppingii
p. 27, line 13	Delete comma (,) after ill-defined
p. 29, line 14	Change seem to seems
p. 33, 8th line from bottom	Change tare to taro
p. 36, line 11	Change copuolana to oopuolana
p. 41, line 3	Change St. John d Catte to St. John & Catto
p. 43, line 12	Change Laboradia to Labordia
p. 45, line 4	Change Forsberg to Fosberg
p. 53, 2nd line from bottom	Change forest to forests
p. 57, line 8	Change characterize to characterizes
p. 57, line 12	Change Metrosiduis to Metrosideros
p. 57, line 13	Change triggnum to trigynum
p. 59, line 14 from bottom	Change Doty, Mueller to Doty & Mueller
p. 61, line 3	Change forbes to forbs
p. 61, line 14	Change original lowland native to pre-European lowland
p. 62, lines 16 & 18 from bottom	Change Cheirondendron to Cheirodendron
p. 63, 3rd line from bottom	Delete Polystichum Hillebrandii ; replace with: Dryopteris sp.
p. 63, line 14 from bottom	Delete Gleichenia sp. ; replace with: Dicranopteris sp.
p. 64, line 20 from bottom	Change possible to possibly
p. 64, line 13 from bottom	Change Cheirondendron to Cheirodendron
p. 65, line 11	Change montana to sp.
p. 65, line 13	Delete or more
p. 65, line 16	Change montana to sp.
p. 65, line 18	Delete Polystichum hillebrandii ; replace with: Dryopteris sp.
p. 65, line 21	Change montana to sp.
p. 65, line 28	Delete Polystichum hillebrandii ; replace with: Dryopteris sp.
p. 65, bottom line	Change Illex to Ilex
p. 66, line 3	Change montana to sp.
p. 66, line 7	Delete Polystichum hillebrandii ; replace with: Dryopteris sp.

p. 66, line 12 from bottom	Change montana to sp.
p. 66, line 10 from bottom	Change Polystichum to Dryopteris
p. 67, line 12	Change Polystichum to Dryopteris
p. 67, line 17	Change Folious to Foliose
p. 67, 2nd line from bottom	Change it doesn't to they don't
p. 68, line 13 from bottom	Change Railliardia to Dubautia; Change hillebrandia to hillebrandii
p. 69, line 5	Change hillebrandia to hillebrandii
p. 69, line 8	Underline Deschampsia
p. 70, line 16	Insert hyphen (-) between: Cheirodendron and Acacia
p. 70, line 17	Underline Deschampsia
p. 70, line 23	Underline Aleurites
p. 70, line 29	Insert comma (,) after Digitaria
p. 72, line 12	Change augar to auger
p. 81, line 10	Change Bluemstock to Blumenstock
p. 82, line 4	Change 30°F to 3°F
p. 86, line 11	Change Forsberg to Fosberg
p. 86, line 15	Change Mitchel to Mitchell
p. 86, line 16	Add at end of line: Unpublished manuscript.
p. 86, line 4 from bottom	Insert comma (,) between by and 1959
p. 95, line 20	Change Brachet to Bracket
p. 107, line 12	Change camp to damp
p. 107, line 19	Underline F. sp.
p. 109, line 12	add (Leucobryum hawaiiense (Reichardt) Bartram, in Bartram)
p. 110, line 6	Change haleakalas to haleakalae
p. 110, line 13	Underline G. sp.
p. 110, line 21	Remove bracket (from: (Reichardt
p. 110, line 21	Change priunosum to pruinosum
p. 112, line 29	Change "branches of trunks" to "branches and trunks. . .
p. 113, line 6	Change Tetragonostomus to tetragonostomus
p. 113, line 10	Underline Z. sp.
p. 113, line 25	Change Molkenhoer to Molkenboer
p. 114, line 36	Change Distichephyllum to Distichophyllum
p. 115, line 1	Change paradonum to paradoxum
p. 115, line 1	Change Hitten to Mitten
p. 115, line 8	Change Hookaria to Hookeria
p. 115, line 34	Change Branhythecium to Brachythecium
p. 121, line 37	Change elegranthulum to elegantulum
p. 122, line 3	Change Van der Wijk, W. D. Margadant and P. A. Florschutz. to read: van der Wijk, R., W. D. Margadant, and P. A. Florschutz.

p. 124, line 6 from bottom	Change filamentos to filamentous
p. 125, line 8	Change schaninslandi to schauinslandi
p. 125, line 15	Change hireus to hircus
p. 127, line 10	Change musulus to musculus
p. 129, lines 17 & 18	Change to read: Gerald Swedberg, Hawaii State Division of Fish and Game
p. 141, line 4	Change Hydrangia to Hydrangea
p. 141, line 4 from bottom	Change four to many
p. 142, line 16 from bottom	Change genus Pelea to genus *Pelea*
p. 162, legend for Fig. 27	Change Metrosiderous to Metrosideros
p. 164, legend for Fig. 33	Change on to in
p. 166, legend for Fig. 36, line 2	Change lahua to lehua
p. 168, legend for Fig. 38, line 2	Change sheep to pig
p. 178, bottom of page	After Figure 57. Map of Kipahulu Valley. Add: Adapted from Cline, 1955