FIRST PROGRESS REPORT AND SECOND-YEAR BUDGET

INTERNATIONAL BIOLOGICAL PROGRAM (IBP)

HAWAII TERRESTRIAL BIOLOGY SUBPROGRAM

NSF Grant GB-23230

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Preface

The Hawaii subprogram of the U.S. Contribution to IBP was funded six months ago, in June 1970.

It is one of three subprograms of the "Origin and Structure of Ecosystems Integrated Research Program" under the directorship of W. Frank Blair. Each of the subprograms has passed the IBP and NSF requirements of an integrated research program (IRP).

The subprograms are:

1. Evolutionary and Ecological Diversity Subprogram (C. Nelson, Director)
2. Hawaii Terrestrial Biology Subprogram
3. Structure of Ecosystems Subprogram (O. Solbrig, Director)

Common to these three subprograms is the intent to integrate the study areas of ecology and evolution. Problems of ecosystems structure and development form the underlying theme. Ecologically, questions of species diversity, niche utilization and life form interaction are in the foreground of consideration. Evolutionarily, questions of factors, mechanisms and rates of speciation are pursued.

More specifically, the Hawaii IBP has four general objectives.

The two ecological objectives are:

1. To gain an understanding of selected Hawaiian ecosystems in terms of structural interaction and to assemble these into functional models.
2. To investigate the relative stability of these ecosystems.

The two evolutionary objectives are:

3. To gain an understanding of speciation by comparison of taxa that have highly speciated with others that have not.
4. To investigate their rates of speciation.

These four objectives are further detailed by a number of hypotheses presented in our funded proposal of February 2, 1970.

These hypotheses evolved from previous and ongoing research, and they were scrutinized for their testability.

Endorsements: The budget request for the Second Year (September 1, 1971 to August 31, 1972) as detailed at the end of this report, amounts to $ 458,230 for the core program.

In addition to the core program, separate requests are made for two major subprojects, "Evolution of Hawaiian Drosophilidae" by D. Elmo Hardy and H.L. Carson (code Number A-1) amounting to $100,625, and requesting a starting date of June 1, 1971 and "Evolution and ecology of Hawaiian mollusks" by Albert R. Mead (code number F). The latter subproject will be submitted under separate cover.

Respectfully submitted,

University of Hawaii

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(Mrs.) Eleanor S. Anderson
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INITIATION OF PROGRAM

Funding

Approval and funding of the program was announced in a press release from NSF on June 19, 1970, with official letters of notification to the Co-Directors dated June 18, 1970. The funding was to be retroactive for the period of May 15, 1970 through May 14, 1971, the first year of an anticipated five-year program.

The grant was made to two institutions, $140,200 to the University of Hawaii and $89,500 to the Bishop Museum for the first year.

The University of Hawaii's Research Administration concern about an automatically imposed 35% ceiling limitation on all new NSF grants caused a delay in fund disbursements. This limitation was not imposed and an IBM number was assigned to the University portion of the grant on August 10, 1970. On this date, funds were made available to the IBP participants for the first time.

A letter of the NSF Program Director of Ecosystem Analysis (dated August 5, 1970) urged us to delay the funding date for the second-year budget from May 15, 1971 to September 1, 1971. This request for a delay in the second-year initiation date was reinforced at the National IBP meeting in August, which was attended by Dr. Andrew J. Berger.

A request for a supplement of $10,210 (dated September 22, 1970) was made to NSF for obtaining additional local travel money to enable participants to continue work through the summer of 1971 and for overload for the Scientific Coordinator to accommodate the 3½ months delay till the second year initiation date. This request was approved on December 17, 1970.

Liaison and Facilities

National Park Service and housing. An orientation meeting between officials of the National Park Service and the Co-Directors of the Hawaii IBP was held early July at the Hawaii Volcanoes National Park.

At that time procedures of liaison between the Hawaii IBP and the National Park Service were discussed in detail. A small 3-room house in the Park Headquarters housing area and some desk and storage space was made available in the Research Biology Laboratory of the National Park Service.

As of November 15, 1970 a larger, more adequate (3-bedroom) service quarter was made available on a temporary basis for IBP personnel. We hope that this facility, or a similarly adequate housing space, will be made available on a more permanent basis to sustain our operation for the duration of the five-year project. The National Park Service has expressed great interest in our program, and we have been assured of the greatest possible cooperation. For this, we are very grateful. In turn, we are keeping the National Park Service closely informed of our activities.

This house is used currently by 20 principal investigators and 15 graduate students and co-principal investigators on a rotating basis. In average, each person has been there twice during the fall semester.

Without this facility this would have come to 70 hotel accommodations for 2-3 nights. Should such accomodation be paid from single (i.e. none-IBP) research grants at the going rate of $25 per diem, this would have come to $4,375. Instead, we paid during the same period for the house $280 and $875 in per diem. We allow only $5.00 per diem for anyone using the IBP quarters. This came to an actual expenditure of $1,055 for the fall semester as opposed to $4,375 for the same number of people and time spent on field work, if they were working on independent research grants. This amounts to a saving of 76% in operating cost during the academic year. This saving will be much greater still during the semester breaks, when the investigators will spend more continuous research time in the field.

<u>Local IBP representative and vehicles</u>. Two new vehicles, an 8-seater VW Kombi and a 4-wheel drive 2-door hardtop Toyota were purchased early July from designated IBP funds held by the Bishop Museum.

On the basis of coordination of our research efforts, we were given $7,200 to purchase these two new vehicles. This was based on the following calculation. Minimum car rental on the Island of Hawaii costs $6/day and 10¢ per mile. An average 2-day field trip costs $25-30. At the rate of field work done through the first fall semester, there would have been about 40 car rentals for each 3 to 4 field work days, thus 40 x 50 = $2,000. Therefore, in four months of field operation we would have spent more than half of the purchase price of our 4-wheel drive vehicle. If each principal investigator were to work on an individual research grant, an amount in car rental equivalent to the purchase price of a new 4-wheel drive vehicle (i.e. $4,000) would be spent in about eight months. Moreover, the rental fee for a 4-wheel drive in Hawaii is $20 per day.

A car rental expenditure for 20 principal investigators of $6,000 per year (as extrapolated from the first fall semester) would be an underestimate because in the summer months most people will spend at least one continuous month in the field. If we assume 50% of the principal investigators to spend each 30 days in the field during the summer, the car rental expenditure would go up to 10 (investigators) x 17.50 (mean daily car rental rate) x 30 (days) = $5,250. This comes to a total of $11,250 in travel cost to supply 20 principal investigators with car rental money to do their field work.

Therefore, our capital outlay of $7,200 for the two new vehicles plus $2,000 in operating cost is already less than what the car rental cost would be for the same field work in one year. Over the anticipated project duration of 5 years, we are saving about $39,000 in transportation cost because of the fact that our program is an integrated research project (IRP).

The vehicles are kept on the Island of Hawaii. The Kombi is stationed near the airport at Kitagawa Volkswagen, when not in use. This permits any participant to have immediate transportation when arriving by plane in Hilo.

The Toyota 4-wheel drive is kept at the IBP Quarter in Hawaii Volcanoes National Park (currently Quarter 201).

A local IBP representative (technician and maintenance person) was hired in July. He stays at the IBP Quarter, services our climatic stations, maintains the vehicles and works half-time as assistant on entomological projects for Dr. J.L. Gressitt. He also maintains continuous local liaison between IBP and the Park Service.

Orientation Field Meeting

Following a brief orientation meeting at the University of Hawaii in mid-July, a 2-day field orientation trip on Hawaii was conducted by the Scientific Coordinator on July 21 and 22, 1970.

The purpose of the trip was an introduction of the participants to the Mauna Kea and Mauna Loa transects. These transects are described in some detail in the February Proposal as the first IBP research sites. Further information is found in three publications (Doty and Mueller-Dombois 1966, Mueller-Dombois 1967, and Mueller-Dombois and Krajina 1968). The trip extended on both mountains to the tree line, on Mauna Kea to 9,200 feet and on Mauna Loa to 8,200 feet elevation. It covered the major ecosystems selected for study of the ecological objectives of the program, e.g. lowland and montane rainforest, summer-dry forest, mountain parkland, kipukas, subalpine forest, and scrub. Twenty IBP members participated on the trip.

Climatic Stations

Immediately after the 2-day orientation trip, two climatic stations were established. Both are in the cloud zone in open areas on Mauna Loa at 5,400 feet elevation. One station was set up in a year-round humid climate at the edge of an upper montane rain forest (segment 11, transect 2, p. 87, 412, 418-19 in "Atlas for Bioecology Studies in Hawaii Volcanoes National Park"). The second station was set up in the mountain parkland, which has a summer-dry climate (segment 7, transect 1, p. 87, 139, 405-6 in same reference).

Both stations are equipped with a hygrothermograph (housed in a Stevenson screen), two open-air rain gages and each six rain gages under nearby trees to assess cloud precipitation water. The stations have been in operation since August 1, 1970.

Three additional stations are planned for installation as soon as the equipment arrives. (The two first stations were supplied with equipment obtained from NSF Grant GB 4688 to D. Mueller-Dombois.)

Local announcements

In addition to a few small newspaper announcements, a longer, more explanatory news release on the Hawaii IBP appeared in the Honolulu Star-Bulletin on July 13, 1970 entitled, "Hawaii joins the search for survival." The release was supplied with five large photographs showing some of the ecosystems selected for investigation along the Mauna Kea and Mauna Loa transects.

Another announcement stating the objectives of our program appeared in the October issue of the Newsletter of the Hawaiian Botanical Society.

A second, longer news release about the Hawaii IBP appeared on December 20, 1970 in the Sunday Star-Bulletin and Advertiser of Honolulu under the heading, "Hawaii's ecosystems explored." The article focused attention on the problem of Hawaii's endangered species, which seem to be more dependent on the dominant, structure forming vegetation in Hawaii's native ecosystems than is the case in continental ecosystems that have not evolved in isolated island situations.

The article also served as a prelude to the second symposium on "Hawaii's rare and endangered species" to be held by the Western Society of Naturalists in Honolulu, December 28-30. At this symposium six members of the Hawaii IBP will contribute papers. During the first symposium on "Hawaii's rare and endangered species"held in Washington, D.C. in May 1970, four members of the Hawaii IBP plus the Director of the Bishop Museum contributed papers. Two earlierpapers on the objectives of IBP, one by Tomich and one by Mueller-Dombois, are appended under "Supplemental information."

Governor Burns of Hawaii appointed (December 1970) several members of the Hawaii IBP to the two new State Commissions:

Hawaii Natural Area Reserves Commission: J.L. Gressitt, Chairman; D.E. Hardy, Member; S. Montgomery (Grad. Asst., IBP), Member.

Animal Species Advisory Commission: A. J. Berger, Chairman

PROGRESS AND CURRENT STATUS OF INDIVIDUAL SUBPROJECTS

A secretary was hired end-July to assist the Scientific Coordinator. Additional copies of the February Proposal were collated and sent out to prospective second-year participants, who were listed in the proposal but were not yet actively included in the first-year budget.

Two graduate studentswere hired before September 1st, but most (eight additional) joined the project after September 1st, when several of the participants returned from their summer activities abroad.

Workshop Meetings

Regular IBP workshop meetings are held at the beginning of each second month at the University of Hawaii's Plant Science Building to discuss general IBP news from other areas, current problems, methods and progress. The meetings thus far were organized and chaired by the Scientific Coordinator.

August 4, 1970 Meeting. The meeting was a follow-up of the 2-day orientation field trip of July 21-22. The two transects were reviewed with slides focussing on the more important ecosystems occurring in topographic sequences and on their ecological characteristics in form of a comparative analysis of situations in equivalent climates but on recent (Mauna Loa) as compared to older matured (Mauna Kea) substrates. These differ significantly in soil water relations. Attention was also drawn to different aspects of man and animal influences on otherwise equivalent ecosystems on the two high Hawaiian mountains. The essence of this information is published in Mueller-Dombois and Krajina (1968). This is a continuing project by D. Mueller-Dombois, listed as subproject B-1 in the February Proposal, "Vegetation-environment correlation studies."

The second part of the meeting was devoted to a review of what is known so far about the areas along the two transects.

Cliff Davis (Co-principal investigator with J.L. Gressitt on subproject C-3, "Ecology and evolution of Hawaiian cerambycid-beetles and other wood borers") gave a review of what is known from past records of insect damage and killing of ohia (*Metrosideros collina*) trees in the Hawaii Volcanoes National Park area (Mauna Loa transect) and surroundings. A lot of survey data has been accumulated over the years, but the direct cause and effect relationships of ohia killing remain uncertain. Insect relations varied from place to place and no one epidemic could be pinned as responsible for the various die-back patterns seen in spots or larger patches throughout the area.

Ivan Buddenhagen (U.H. plant pathologist) commented on the pattern of ohia die-back in the rain forest at mid-altitude on Mauna Kea and extending to Mauna Loa. He showed a number of slides (partly infra-red) taken last spring (1970) from a low-flying plane over the area. Healthy tree stands were noted along the main drainage channels of the streams on Mauna Kea, while die-back occurred in contagious patterns between the streams. Other die-back patterns were less clearly related to the geomorphology of the area. Buddenhagen thought the ohia die-back to be primarily a pathological problem. But it seems likely to have an ecological base.

(I. Buddenhagen participated on the 2-day orientation field trip July 21-22, and he was to write a proposal for a plant pathological subproject under IBP for the second year. A joint proposal with the U.S. Forest Service was written instead and directed to the State of Hawaii for funding. This is now under consideration. The tree pathology project will be closely tied-in with the Hawaii IBP if funded by the State.)

D. Elmo Hardy and H.L. Carson (IBP subproject A-1, "Evolution and genetics of Hawaiian Drosophilidae") spoke briefly on some of the evolutionarily significant findings obtained in their long-established and ongoing research. Future plans of sampling Hawaiian Diptera in connection with the Mauna Kea transect were briefly circumscribed (subproject C-1).

Carolyn Corn (B-6, "Genecology of Metrosideros") talked about some morphological variations of Metrosideros (ohia tree) samples collected along the transects.

Thereafter, we briefly discussed sampling plans for a comprehensive ecological survey of the koa-ohia-tree fern forest in the Kilauea Forest Reserve (segment 11 on transect 2, Atlas for bioecology studies, p. 412 and 418-19). This upper montane forest is to become the site for the first detailed within-ecosystem type analysis.

October 5, 1970 Meeting. The purpose of this second IBP group meeting was to discuss the initial steps taken by those who have started with field work and sampling.

A detailed procedure worked out for the plant ecological survey of the koa-ohia-tree fern forest in Kilauea was presented and a write-up was circulated within the IBP group (Subproject B-2, Mueller-Dombois, "Plant-plant interaction and distributional studies"). A copy is attached under "Supplemental information."

A similar procedural write-up was presented and discussed for insect sampling by Wayne Gagné, subproject C-4 "Phytophagous insects, sap- and seed feeders (Heteroptera)." A copy is attached under "Supplemental information."

The two main discussion themes at this meeting were:

1. How the data we obtain can be usefully integrated in space and time.
2. How the data can be made suitable for computer processing and analysis.

A lively discussion developed on the ways of integrating population structural data. M.P. Mi, our computer analyst, made several comments on "destructive" versus "non-destructive" sampling.

IBP members interested in this intensive sampling phase were encouraged to partake and to write similarly detailed sampling procedure.

December 7, 1970 Meeting. The third meeting centered on four themes: New programs, progress reports, future needs, and reorientation of our objectives (including second-year budgets).

The essence will be discussed in the next sections.

All meetings were well attended with more than 90% IBP participants present.

Intermittent communication is maintained by memoranda. A list of running program events is kept at the coordinator's office for perusal by any participant. This refers primarily to logistics.

Strategy and Development

The initial steps taken to accomplish the four general objectives will be briefly outlined below:

Ecological objective No. 1. This aims at gaining a basic understanding of Hawaiian ecosystems by compiling information on at least the most significant ecosystem components and by using this information in the construction of simulation models. The most significant general components are:

- biotic
  - plants
  - animals
    - vertebrates
      - mammals
      - birds
    - invertebrates
      - insects
      - snails
  - microorganisms
- abiotic
  - atmospheric
  - soil

What information?

1) checklists and qualitative assessment
2) population counts = quantitative assessment
3) population structure (size, age classes, mortality)
4) spatial variation of populations within the ecosystem
5) structural position of populations within the ecosystem
6) function of major populations (life cycle studies, physiological ecology).

Through life cycle studies and physiology we expect to learn about interaction

7) understanding of interactions will lead to ecological integration. The ecological integration phase will permit construction of ecosystem simulation models. This will lead to
8) fresh insights for recommendations regarding the handling of our natural resources

Ecological objective No. 2. We hope to answer the question of stability of Hawaiian ecosystems (as further described by hypotheses 2a-e in the February Proposal) by the careful selection of sites.

For intensive study of ecosystems structure and population interaction (as outlined by the 8 points listed under Ecological objective No. 1) we intend to select the following five ecosystems:

A. Montane environments

1) koa-ohia-tree fern forest (at 5400 feet, rainfall high throughout the year, soil moisture augmented by frequent cloud interception, 14°C mean annual air temperature).

2) mountain parkland vegetation (at 5400 feet, same mean temperature, but rainfall seasonal; also in frequent cloud range)

3) kipuka (ki forest) ecosystem, 4200 feet elevation. This represents a much older ecosystem in much the same (i.e. summer-dry) climate as type (2).

B. Lowland environments

4) koa-ohia-tree fern forest (alt. 1800 feet on Mauna Kea, lowland tropical rainforest on old substrate, i.e. hydrol humic latosol, rainfall high throughout the year, mean annual air temperature 20°C).

5) dry lowland forest ecosystem, near 1800 feet on Kilauea slope, Naulu Forest, summer-dry climate.

The comprehensive ecological survey has just begun in ecosystem (1) above. Completion of the outline will keep a number of IBP participants busy throughout the second year. Progress on this intensive sampling phase is further detailed under Level III, intensive phase.

The two ecological objectives will be achieved at <u>different levels of intensity of study</u>. We may distinguish three levels. These will, however, not be approached necessarily in that order. Instead they will receive simultaneous attention..

<u>Level I, extensive phase</u>. Entitation, establishment of strategically placed ecosystem profiles and mapping. So far, we have established the following seven profiles:

Hawaii Volcanoes National Park, five:

1) Mauna Loa east flank (shown in February Proposal)
2) Kilauea Forest Reserve across Kipuka Puaulu, Kau Desert, Hilina Pali to coastal lowland
3) Glenwood (rainforest) across Alae Crater, Ainahou Ranch, Hilina Pali to coastal lowland
4) Napau - Makaopuhi Crater, Naulu Forest, Kalapana Coast
5) Kalapana Coast in dry lowland below Naulu Forest to Kalapana near Black Sands beach.

The location of the five profiles is shown on Fig. 1. They are described in detail in the "Atlas for bioecology studies in Hawaii Volcanoes National Park," Chapt. 8.

On Mauna Kea, one:

6) East flank from summit to sugar cane fields above Hilo (shown in February Proposal)

On Maui, one:

7) Kipahulu Valley (Smathers 1968)

Plan next (subproject B-1 "Vegetation - environment correlation studies")

8) A successional profile or "chronosequence" on different lava flow ages, all in the same climate (utilizing some already established ecosystems;will use Atkinson's (1969) work as a basis).
9) NW flank of Mauna Loa
10) Kauai profile

Level II, semi-intensive phase. This sampling level is designed to contribute first order information to hypotheses 2 a-e as stated in the February Proposal.

Sampling has proceeded along the five Hawaii Volcanoes National Park transects. It is primarily focussed on the Mauna Loa east flank transect and continued down to sea-level through parts of transects 2, 4 and 5 (Fig. 1).

The primary object is to establish the altitudinal ranges and amplitudes through a study of variation between ecosystems.

Contributors to this phase have been so far (in order of subproject code as shown in the February Proposal; an asterisk refers to more detail given under "Supplemental information"):

B-1	Mueller-Dombois (checklist of plants in each ecosystem, established 62 plot locations, general environmental analysis)
*B-3	Lamoureux (General woody plant phenology as related to growth anatomy, established 7 sample stations in 7 of the 62 plots established under B-1)
B-4	Porter (Graduate student under Lamoureux; _Metrosideros_ phenology along Mauna Loa and Naulu-Kalapana transects; same stations as Lamoureux)
*B-6	Corn (collected _Metrosideros_ seeds and vegetative samples from different locations along Mauna Loa transect)
*B-7	Doty (made trappings of airborne algal disseminules along Mauna Loa east flank from 6,600 feet down to 50 feet elevation at transect 5; the results of trappings are cultivated for taxonomic analysis)
*C-2	Steffan (sampled for Sciaridae (Diptera) at 2 places along Mauna Loa transect in Kipuka Puaulu (4000 feet) and in mountain parkland ecosystem at end of strip road, 6600 feet elevation).
*C-3	Gressitt, Davis (cerambycid beetle and wood borer inventory) sampled in same plots as used by Lamoureux, Porter, Nishida and Haramoto, see C-6)
*C-5	Beardsley (_Acacia koa_ sap-sucking insects _Psylla uncatoides_, will continue with _Metrosideros_; sampled at 3 places along

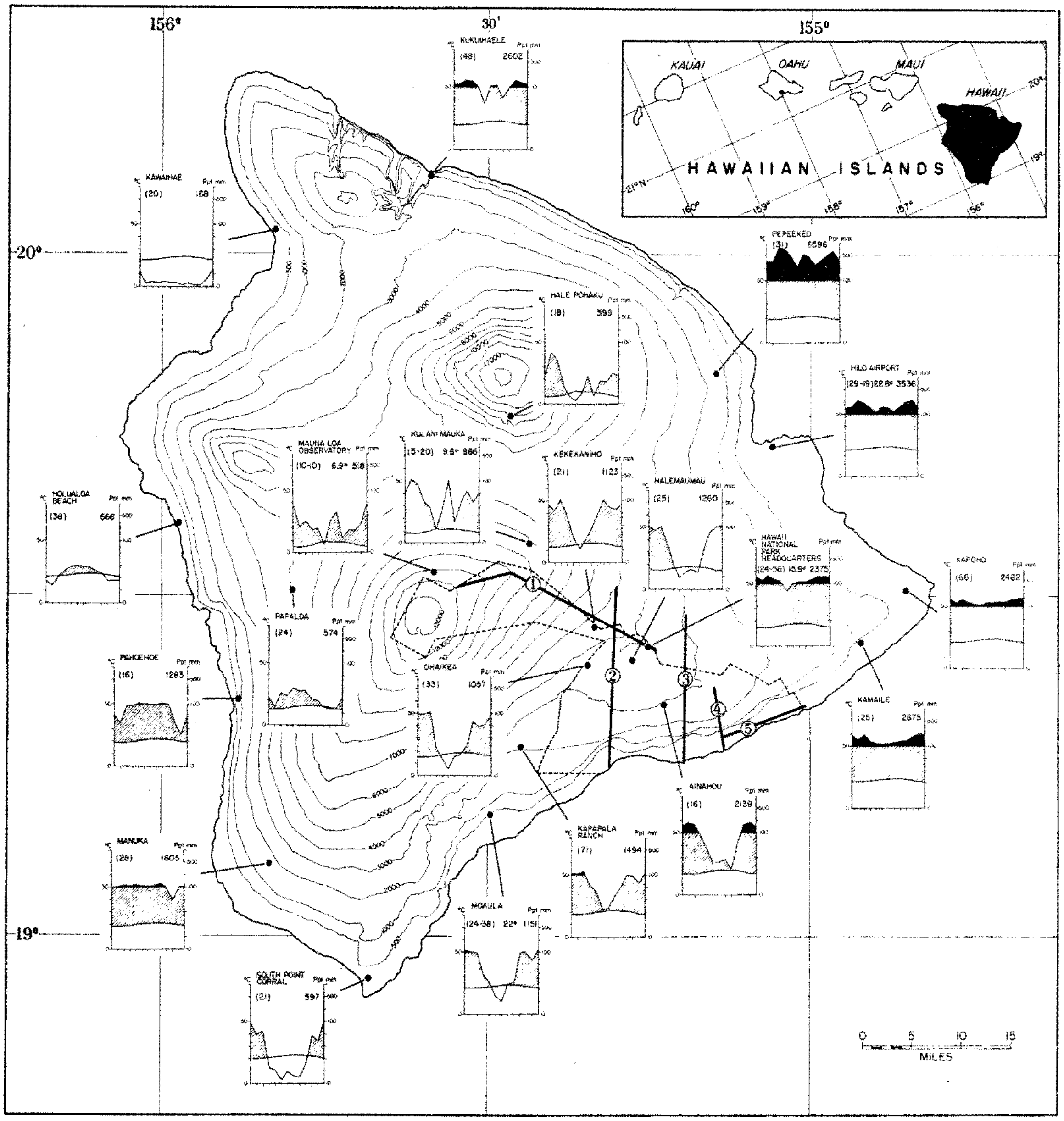

Fig. 1. Orientation map of the Island of Hawaii showing the outline of Hawaii Volcanoes National Park, the 5 transects and 21 climate diagrams, both described in the "Atlas for Bioecology Studies in Hawaii Volcanoes National Park", Chapters 4 and 8.

Mauna Loa transect: Kipuka Ki, 4200 feet, at mountain parkland climatic station, 5200 feet, and at end of strip road, 6600 feet)

*C-6 Nishida, Haramoto (faunal research on Metrosideros, particularly bark-inhabiting arthropods and leaf-feeding insects; sampled in 6 of the 62 plots established under B-1, same locations as Lamoureux and Gressitt, at 600, 1700, 3600, 3800, 4000 and 7000 feet elevation on east flank of Mauna Loa and Kilauea, i.e. transects 1, 2, 4 (Fig. 1).

Level III, intensive phase. This relates to accomplishing initially at least the first 5 items listed under ecological objective No. 1, and the transfer from one intensive study site to the next as listed under ecological objective No. 2. This includes the exploration of hypothesis 3a, and the second order information to hypotheses 2 a-e as outlined in the February Proposal.

Contributors to this phase, now beginning with the 200 acre tract in the koa-ohia-tree fern forest in the Kilauea Forest Reserve, are (an asterisk refers to more detail under "Supplemental information"):

*B-2 Mueller-Dombois (plant ecological sampling procedure written, lined out first transect and plot 1 studied; further work will be carried out by two graduate students, R.G. Cooray and Jean Craine).

*B-8 Baker (fungi of phyllosphere and rhizosphere, succession in relation to leaf senescence and population variation in time and space; graduate student Benny Lee, one exploratory sampling trip).

*C-2 Steffan (set out one large Malaise trap across bulldozer track at entrance to transect 1, plus temporary light traps, initial results in "Supplementary information", for location see Fig. 1 and 2 in B-2 report).

C-3 Samuelson (set out 20 bait logs to attract Plagithmysus beetles, a koa associated species).

*C-3 Gressitt (second Malaise trap installed along transect 1 at plot 1, and 13 sets of attractant logs along transect 1. Each set is comprised of 3 logs: Koa, ohia and naio = Myoporum sandwicense).

*C-4 Gagné (wrote sampling procedure for intensive phase of insect sampling in different plant biomass strata and across the 200 acre tract).

*D-1 Berger (birds; will write detailed sampling procedure; so far has done exploratory work in all stations and found the Kilauea koa-ohia-tree fern forest one of the best sites for the study of birds; a list of 14 native birds sighted in the Kilauea koa-ohia-tree fern forest was contributed by Winston Banko, Biologist, Bureau of Sport Fisheries and Wildlife, U.S. Dept. of Interior, Hawaii Volcano National Park).

*D-2 Tomich (rats; has written a preliminary sampling procedure, which involves quarterly trapping at 18 check points along the 4 transects in the 200 acre block).

G Ekern (microenvironmental analysis; in addition to rainfall, temperature, and relative humidity data taken in a forest opening since August 1, 1970, precipitation under the tree canopy is measured; additional parameters of importance to the comprehensive study of this forest will be worked out in collaboration with Friend and Mueller-Dombois)

Evolutionary objectives:

No. 1. Study of contrasting populations, i.e. those that have highly speciated as opposed to other endemic taxa that have not speciated much, but are of widespread occurrence.

No. 2. Investigate as much as possible about rates of speciation.

Participants that have begun work on these objectives include:

B-5 Lloyd (ferns; established 4 sample sites; only one on IBP site, Kilauea forest, collected fern spores of 9 species)
*B-6 Corn (Metrosideros sampled along Saddle Road between Mauna Loa and Mauna Kea transects, also on Maui and Oahu)
*C-1 Hardy and Delfinado (Diptera; made a preliminary survey for these flies along Wailuku River, which runs along the Mauna Kea transect and along streams in the Kohala Mts., NE Hawaii)
*C-2 Steffan (Sciaridae)
*C-3 Gressitt (cerambycid beetles)
D-1 Berger (birds; graduate student continued work on Kauai; post doctoral student began a study of the anatomy of honeycreepers)

The above participants (with exception of Steffan) worked away from the established IBP transects and study sites in order to follow their evolutionary pursuits. The additional areas visited were:

Lloyd ⟶ new lava flows on Hawaii
Hardy ⟶ Kohala Mts., Hawaii
Corn ⟶ Island of Maui
Berger ⟶ Island of Kauai
Gressitt ⟶ Islands of Maui, Molokai

The development of the program shows that field sampling is evolving at three levels of area-intensity:

1) Intensive sampling of individual ecosystems for the purpose of studying the within-ecosystem population structure and function.

2) Semi-intensive sampling of individual ecosystems along transects to elucidate primarily the between-ecosystem variations along distinct macroenvironmental gradients.

3) Island wide sampling in special habitats for pursuing the evolutionary objectives.

PLANS FOR YEAR 1971-72

First-year funded subprojects

We intend to continue the 18 subprojects that were funded for the first year (May 15, 1970 - May 14, 1971, with renewal date changed to August 31, 1971). A list of these subprojects is shown below.

B-2, 4 Mueller-Dombois (U.H., Botany)
"Plant-plant interactions and distributional dynamics"
"Life history studies of important dominants"

B-3 Lamoureux (U.H., Botany)
"Growth rates and anatomy of woody plants in relation to environment"

B-5 Lloyd (U.H., Botany)
"Life history studies of important ferns"

B-6 Corn and Ashton (U.H., Botany and Genetics)
"Genecology of *Metrosideros*"

B-7 Doty (U.H., Botany)
"Ecological and evolutionary roles of algae"

B-8 Baker (U.H., Botany)
"Ecological roles of fungi"

C-1 Hardy and Delfinado (U.H., Entomology)
"Biosystematics of Hawaiian Diptera"

C-2 Steffan (Bishop Museum)
"Ecology and evolution of Hawaiian Sciaridae"

C-3 Gressitt (Bishop Mus.) Davis (Hawaii State Dept. Agric.), and Samuelson (Bishop Mus.)
"Hawaiian cerambycid beetles and certain other wood-borers"

C-4 Gagné (Bishop Mus.)
"Phytophagous insects - sap and seed feeders (Heteroptera)"

C-5 Beardsley (U.H., Entomology)
"Effects of sap-sucking Homoptera on the stability and fragility of Hawaiian ecosystems"

C-6 Nishida and Haramoto (U.H., Entomology)
"Behavior and population dynamics of endemic insects", subtitle: "Faunal research on *Metrosideros*"

C-7 Beal (Northern Arizona Univ., Flagstaff)
"Litter inhabiting and inquilinous coleopterous scavengers of the Hawaiian Islands"

C-12 Tamashiro (U.H., Entomology)
"Effects of diseases on endemic insects"

D-1 Berger (U.H., Zoology)
"Life history and functional anatomical studies of the Hawaiian honeycreepers"

D-2 Tomich (Hawaii State Dept. Health)
"Study of rodents and ungulates"

D-3 MacMillan (Irvine, California)
"Physiological ecology of terrestrial Hawaiian birds and mammals"

E-1 Ashton and Mi (U.H., Genetics)
"Genetical studies on speciation of Hawaiian plants and animals and computer analysis"

Dr. Lloyd (B-5) is leaving the University of Hawaii summer 1971. Instead, Dr. W.H. Wagner, Jr. (Michigan) will join the Botany Department, U.H., for his sabbatical year 1971-72. Dr. Wagner is a member of the Advisory Committee of the Hawaii IBP. It is expected that he will become actively involved in the fern study relating to our program.

However, continuity in subproject B-5 is currently established through Dr. D.C. Friend, who will carry on the physiological ecology part of the program. This aspect is very important in the life history of community structure-forming dominant plants. Dr. Friend's interests are also closely related to the problems of microenvironment associated with the structure-forming dominants. Therefore, he will fit well into the program, and will work in close collaboration with subprojects B-3 (Lamoureux), B-4 (Mueller-Dombois) and G, Topographic climate analysis (Ekern). The latter is suggested as a new subproject (see below).

Dr. Friend's curriculum vitae is attached under "New Personnel".

First-year included, but not yet funded subprojects

The following subprojects were already fully included in the February Proposal, but they were not yet supported because of funding limitations imposed at that time. We request that they be funded for the second year of our program, except for B-9. Dr. Vaarama (B-9) has asked for postponement of his project initiation date until the third year.

A-1 Hardy and Carson (U.H., Entomology and Genetics)
"Evolution and genetics of Hawaiian Drosophilidae"

B-1 Mueller-Dombois (U.H., Botany)
"Vegetation-environment correlation studies"

B-9 Vaarama (Finland)
"Bryophytes, their distributional dynamics in Hawaiian ecosystems"

C-8 Huddleston (Texas)
"Role of ants in ecosystem structure and function in Hawaii"

C-9 Radovsky and Wallace (Bishop Mus.& Queen's Medical Center, Hi.)
"Parasites of Hawaiian vertebrates and soil arthropods (mites)"

C-10 Chabora and Chabora (Flushing, N.Y.)
"Evolutionary interaction of the Hawaiian Drosophilidae and their hymenopterous parasites"

C-11 Mitchell (U.H., Entomology)
"Biology, ecology and control of insects attacking the Hawaiian silverswords (Argyroxiphium spp.)

Two of the above projects were activated in the first year in spite of lack of funds. These were B-1, which provided for plant checklists and representative study locations along the IBP transects, and C-9 (see "Supplemental information").

The Drosophila project (A-1) is a major evolutionary research program with a very successful history. Since this program is ideally suited for adding significantly to the evolutionary objectives of our program, we ask that it be included in the Hawaii IBP. However, because of its size, we wish to request that this project be considered separately in funding.

The reasons for the large budget are put forward in the following proposal by Drs. Hardy and Carson.

RESEARCH PROPOSAL SUBMITTED FOR INCLUSION IN THE HAWAIIAN IBP

by

University of Hawaii
Departments of Entomology and Genetics
Honolulu, Hawaii 96822

Evolution of Hawaiian Drosophilidae

Principal Investigators

Name:	D. Elmo Hardy	H. L. Carson
Title:	Senior Professor	Professor
Social Security No.:		
Dept. Affiliation:	Entomology	Genetics

Proposed starting date: June 1, 1971

Amount requested for year one : $100,625.

Support requested for five years (1971-1976).

ABSTRACT

The purpose of this research is to gather as much data as possible, by a team approach, on the genetics, behavior, bioecology, nutrition, biochemistry and systematics of Hawaiian Drosophilidae and obtain further knowledge concerning evolutionary processes under insular conditions. Our aim is to determine the factors which have caused the profuse speciation and the associated development of such diverse morphological, behavioral and physiological characters in the Hawaiian fauna.

INTRODUCTION AND BACKGROUND INFORMATION

We now have had fifteen years of experience with the Hawaiian Drosophilidae, including seven years of team research on the evolution and genetics of this remarkable fauna. Up to now, the project has involved approximately twenty senior scientists and over one hundred graduate and undergraduate assistants. The results of the accomplishments to date have been summarized in chapter 15 of the volume "Essays in Evolution and Genetics in Honor of Theodosius Dobzhansky", a supplement to Evolutionary Biology 1970, by H. L. Carson, D. E. Hardy, H. T. Spieth, and W. S. Stone, pages 437-543. Appleton-Century-Crofts, New York.

With this great amount of background work which has been done a number of our collaborators are now making major contributions in the field of evolutionary biology and it is essential that this research be continued. This project will be an important augmentation to the IBP Hawaii Terrestrial Biology Subprogram. For over the thirty years since the pioneer work of Th. Dobzhansky and the late J. T. Patterson and W. S. Stone, Drosophila flies have served as almost ideal material for the study of patterns of evolution in higher organisms. The existence of a rich fauna on an archipelago of oceanic islands, with the attendant simplified ecogeographical conditions, is a circumstance of the greatest good fortune. It should be exploited to the fullest by those best equipped to do so. These flies are ideal for achieving objectives one and four of the Hawaii subprogram and we have made tremendous progress toward these goals.

The dipterous family Drosophilidae is most remarkably developed in Hawaii and represents one of the most striking examples of "explosive" evolution known in the animal kingdom. We have now described approximately 500 species (97% endemic) and estimate that the total fauna may number 700 species. The Hawaiian species are unique among drosophilids in many different ways. They have structural peculiarities and picturesque wing markings which are extraordinarily diverse. They exhibit striking sexual dimorphism and elaborate courtship and mating behavior, including lek behavior in the males. They have radiated into a great variety of habitats and their food and breeding requirements differ from those of species from other areas of the world. The fauna exhibits a high degree of endemicity by islands. It appears probable that 90-95 per cent of the species are restricted to single islands.

The field and laboratory techniques have been perfected so that we know where to find and how to collect most of our species and can now culture over 100 species in the laboratory. Nearly 200 species (approximately 30% of the total fauna) have now been reared from their natural media and have been taken in the following substrates: rotting bark, stems, branches, roots, leaves, fruits, and flowers of native trees (especially Araliaceae, Lobeliaceae, Myrsinaceae and Nyctaginaceae); frass collected in leaf axils; fleshy fungi; fern leaves (miners); morning glory flowers (pollen feeders); spider eggs (parasites); slime fluxes; and plant hairs.

The evidence that these flies have undergone adaptive radiation is striking: (1) there are large numbers of species: (2) the external phenotypes are extremely diverse while the internal morphology shows stability; (3) the majority of metaphase chromosomes are the primitive five rods plus a dot for the drosophiloids or with one or two fusions in the scaptomyzoids; (4) some groups of species of Drosophila show homosequential banding in the salivary chromosomes; and (5) the mating behavior can be grouped into species showing very little complexity (the scaptomyzoids) and species with elaborate patterns (the drosophiloids) and some species which have elements of both types of behavior.

These characteristics suggest a rather recent evolution of many populations issuing from a common ancestor(s) into an area offering little competition.

A number of factors appear to be responsible for the evolution of the extraordinary numbers of species. The major factors would appear to be the spartan nature of the food supply which resulted in the evolution of a low reproductive rate, relatively long-lived adults and consequently small population sizes; the infrequent but repeated migrations from each island to adjacent islands, which resulted in effective isolating barriers; the added effects of volcanic and meteorological action which further isolated small areas such as kipukas; the evolution of lek behavior, and invasion of specialized food sources such as the fresh decaying leaves of a number of plants.

Studies of internal morphology have demonstrated that the internal systems are remarkably stable and are much more reliable for determining relationships than are external characters. The immediate results of this study showed that the two major groups, Drosophila and related genera (drosophiloids) and Scaptomyza and related genera (scaptomyzoids) intergrade in Hawaii and the borderline groups can be differentiated only by internal characters, egg structure and behavior. This leads to the startling implication that the total Hawaiian fauna could have originated from one ancestral species and that the genus Scaptomyza originated in Hawaii. From data presently available concerning world distribution of Scaptomyza, however, definite espousal of the "one-introduction" over the "two-introduction" hypothesis seems premature.

The sequential relationship of the banding patterns in the polytene chromosomes of the picture-winged Drosophila has been studied in detail; a phylogeny has been constructed for nearly 100 species of this complex and their migration routes over the Islands have been charted. These studies (supported with evidence from behavioral and morphological studies) indicate that the major center for adaptive radiation has been the Island of Maui, that the ancestral types migrated from Kauai in several well-documented cases direct to Maui, bypassing Oahu, subsequently, various species groups developed on Maui and dispersed to other islands.

Metaphase chromosomal data has been obtained for nearly 200 species and support the general concept of dichotomy of scaptomyzoids and drosophiloids. The Hawaiian species show remarkable stability in retention of the primitive karotype but many species show altered configurations which may be explained on the basis of added heterochromatin. In a few cases, there has been chromosome fusion with centromere loss.

Courtship and mating-behavior studies have provided valuable phylogenetic data. The pattern of behavior is elaborate and specific for the Drosophila and related groups and primitive for Scaptomyza. The studies indicate that the behavior has served as an important isolating mechanism for speciation in Drosophila and conversely in Scaptomyza the isolating mechanism is a mechanical one resulting from elaborate specific differences in male genitalia. These studies have also clearly demonstrated that most of the unusual structural modifications and elaborate wing markings are directly correlated with courtship and mating.

The mating behaviors of the native Hawaiian Drosophila differ radically from those of species from other parts of the world in that most, if not all, species display true lek behavior. Correlated with this aspect of behavior is extraordinary sexual dimorphism and aggressive defense of a small mating territory, or lek, by the males. To date nearly 100 species, representing all of the major species-complexes of the picture-wings, plus eight laboratory-reared hybrids, have been studied. A phylogeny based upon mating behavior closely corroborates the phylogenetic arrangement of the picture-wings based upon chromosome comparisons, and is also closely supported by comparative studies of male genitalia.

Gel electrophoresis is proving a valuable tool for analysis of inter- and intraspecific variation. Quantitative studies to date have been mainly with Drosophila mimica to determine the stability of enzyme frequences and establish a standard which can be used in interpreting differences between species.

Studies on interspecific hybridization are providing valuable data concerning the degree of reproductive isolation between species. A relatively large number of hybrids have been produced in the laboratory. Of 318 interspecific crosses tried 50 (16%) produced F_1 larvae, pupae or adults. No natural hybrids have yet been found. These studies indicate that ethological isolation is not as great as might be expected from the considerable development of secondary sexual characters commonly displayed by the males. They further show that the relatively great frequency of hybridization parallels the other data in indicating a close biological relationship which is often obscured by the large amount of morphological specializations.

A technique for ovarian transplantation has been perfected and has proved an effective tool for determining degrees of relationships between species.

Taxonomic studies: the major species groups and relationships have been established and approxomately 500 species have been described and figured.

Population movements and dispersal: a new technique has been tried in the Kilauea area using stable isotopes for labeling Drosophila in natural populations. This involved feeding of rare earths such as dysprosium and subsequent detection of the elements by neutron activation analysis. The results of this first experiment are now being analyzed at the University of Texas and are not yet available. The technique allows, for the first time, measurement of dispersal and migration patterns in great detail. This should provide knowledge needed for making estimates of behavior parameters, ecological variables, and time dependent variables of movement and reproduction, while causing a minimal disturbance to the individual behavior patterns, to the population structures, and to ecological systems.

A stock center for Hawaiian Drosophilidae has been established at the University of Texas Genetics Foundation and these stocks are now available for use by all qualified researchers over the world.

OBJECTIVES

A major goal is the determination of the factors responsible for the evolution of the extraordinary number of species found in the Hawaiian Islands. Major emphasis will be upon continuation of the cytogenetic, ecological, nutritional, biochemical and systematic studies. Investigation emphasizing the genetics of populations will be instituted. Pooling the results of the interlocking studies will clearly provide a more complete understanding of evolutionary processes.

We will attempt to determine speciation rates, patterns and mechanisms. Chromosomal and distributional information may give evidence concerning the probable time required for speciation. Further documentation of the founder principle will be sought. These studies will largely involve the picture-winged species upon which we now have considerable knowledge of the ancestral relationships. Emphasis will be concentrated largely on the island of Hawaii where the lava flows of various portions of the island have now been rather accurately dated and where there are many isolated habitats ("Kipukas"--islands of vegetation in the lava).

SPECIFIC AIMS AND PLANS OF THE WORK

A major challenge now remains to work out the nutritional and medium requirements for the large fauna of fermenting leaf-breeding species. In spite of our successes we presently can handle only approximately twenty per cent of the species of Drosophila (ca. 100) in the laboratory and only about 1/7 of the total fauna. One phase of our research will be directed toward obtaining detailed knowledge of the micro-fauna and -flora and the chemistry of the substrates in which the flies breed and will attempt to duplicate their nutritional requirements in the laboratory. It is felt that once we have learned how to culture one of the leaf breeders we will have a major breakthrough and have the information needed to establish the bulk of the fauna in artificial media. Both field and laboratory studies will be conducted toward this aim. Coincident with this study, as successes are attained, cytogenetic studies of the modified mouthpart species will begin, patterned after the work which has been accomplished on the picture-wings. This will provide supportive evolutionary data based upon a large group of species which breed in the substrates which were probably utilized by the progenitor(s) of the Hawaiian fauna.

Since the phenomenon of adaptive radiation is primarily ecological, a great deal of emphasis will be placed upon this phase of the research. Only approximately 30 per cent of the Hawaiian species have been reared so that much remains to be learned concerning biologies and feeding habits. An important aspect of ecological work will be the emphasis upon the effect of isolation of populations in kipukas. These studies should provide valuable data concerning speciation rates and factors influencing evolution.

CYTOLOGICAL STUDIES

Dr. Frances Clayton (1969) has reported the occurrence of a number of peculiarities of heterochromatin both within and between species. The origin of these conditions is not known. Heterochromatin will be compared in metaphase configurations from mitotic and meiotic divisions. Analyses of abnormalities in meiotic figures, the variations in metaphase chromosomes and the alteration of the primitive _Drosophila_ karyotype by added heterochromatin will be investigated further. In conjunction with these studies, details of spermatogenesis will be analyzed by phase contrast microscopy.

The karyotype determinations for species not yet examined will be continued either by larval metaphases or meiotic cells from adult males and the metaphase configurations will be correlated with salivary gland chromosome analysis.

Studies of genetic diversity in homosequential chromosome species will be made by electrophoretic techniques. The homosequentiality of chromosomes is equally as remarkable as the great number of species and the electrophoretic studies will provide valuable supportive data.

THE POLYTENE CHROMOSOME PHYLOGENY

In a recent paper (Carson and Stalker 1969), much data have been advanced which support the theory that all five subgroups of picture-winged flies evolved on Kauai. In several instances, founders from Kauai apparently reached Maui directly, establishing the _adiastola_ and _Planitibia_ subgroups there, but the _D. grimshawi_ subgroup apparently invaded Oahu directly. It had a secondary evolutionary episode there before eventually reaching the Maui Island Complex and Hawaii. More evidence is needed pertaining to this theory. In particular, the rare picture-winged species of Oahu, which are not yet known cytologically, need to be collected before what appears to be inevitable extinction overtakes them. Thus, the phylogenetic arrangement of the large picture-winged species, which now includes 69 (Carson _et al._, 1970) needs to be enhanced by critical new material. Methods of collection and culture of these flies are now fully satisfactory. What is particularly needed now is to find the last remaining populations of the rare species, not only on Oahu but on Kauai and Molokai as well. Carson proposed to continue the construction of the chromosomal phylogeny, with emphasis on the seeking out of the rarer species in key geographical areas.

HYBRIDIZATION OF CERTAIN SPECIES

Considerable hybridization has been done between species of the picture-winged group (Yang and Wheeler, 1969). We plan to make a study of the hybridization capacity of a number of picture-winged species with special reference to the inheritance of so-called "species characters." Theoretical considerations would suggest that, unlike what is found in many cases, the number of genes involved might be expected to be small, expecially between species which have diverged from one another rather recently. Most interesting would be the cross of D. heteroneura (Hawaii) by D. planitibia (Maui) where clear morphological characters can be followed. Preliminary crosses show that the F_1 females are fertile in backcrosses. These two species are homosequential, that is, identical in gene order as revealed by the polytene karyotype. The study of the backcross hybrids between these species by ordinary genetic and electrophoretic methods is highly desirable. From this may come an estimation of the number of gene differences between two species which have diverged from one another only recently in the geological sense.

MATING BEHAVIOR

The mating behaviors of the native Hawaiian Drosophila differ radically from those of species from other parts of the world in that most if not all of the Hawaiian species display true lek behavior. Correlated with this aspect of behavior is extraordinary sexual dimorphism and aggressive defense of a small mating territory or lek by the males.

Studies on the mating behavior of the species have involved both laboratory and field observations. To date 81 species representing all of the major species groups plus eight laboratory reared hybrids have been studied.

Perforce these studies have been descriptive and qualitative in nature. Further, for those species which can as yet not be reared in the laboratory, field-captured specimens have of necessity been utilized.

It is proposed in the future to study additional species, both in the field and in the laboratory. Such studies will further our understanding of the evolution and phylogenies of the various species groups.

Males of many of the species clearly produce pheromones, but the chemical nature of the specific materials have not as yet been identified. These materials appear to serve as primary isolating mechanisms between closely related species that dwell in the same area and thus present an intriguing problem as to their chemical differences.

Quantitative studies on the behavior of hybrids as well as their parent species will it is hoped give insights not only into the inheritance of the courtship elements but also the nature of the specific stimuli involved in the complex mating sequences displayed by the various species.

In sum it is proposed to extend and elaborate future studies on the foundation of findings and principles that have been established to date.

BIOSYSTEMATICS

Systematic studies will provide names and descriptions for new species as they are needed for use in research papers prepared by the various collaborators. These studies will emphasize the setting up of phylogenies and preparation of monographs of species groups. It will involve detailed morphological studies and will incorporate all available knowledge concerning species concepts drawn from the results of all pertinent aspects of the evolution and genetics research.

We plan to tie as many species groups together as possible, and determine the primitive species, or group, from which other groups have arisen. Also, we plan to trace the lines of evolution which the species have taken and obtain basic information concerning *Drosophila* vs. *Scaptomyza*; the intergrading between these major groups, and obtain further data concerning the probable number of ancestral species; the effect upon drosophilid populations and the co-evolution between parasite-predator and host populations.

Studies will be made of the predators and parasites of the native drosophilids.

Continuing research for the homeland of the Hawaiian species. The type species of *Scaptomyza* (*Bunostoma*) Malloch and *S.* (*Rosenwaldia*) Malloch are from the Marquesas Islands. These groups are well represented in the Hawaiian fauna, and search in the Marquesas for the ancestors of Hawaiian species may be fruitful.

STOCK CENTER

The stock center for Hawaiian drosophilids established at the University of Texas Genetics Foundation will be maintained and as techniques are developed for establishing additional species in cultures, these will be added to the Center. International interest is being expressed in these unusual flies and arrangements will be made to provide stocks to qualified researchers. Because of their large size, diversity of characteristics and ease of handling, these flies make excellent laboratory animals and will be most valuable for future research in genetics, physiology, behavior and evolution.

SPACE AND FACILITIES

The project is well established with adequate facilities and most of the items of equipment which we anticipate needing are in the Entomology

Department but facilities also in the Genetics Department will be available. We are presently using two large cold rooms, twenty feet by twenty feet and fifteen feet by fifteen feet. These are essential to this project as the flies must be reared in cool, moist habitats. We have most of the necessary food preparation, sterilization and washing equipment; microscopes, autoclave, balance, thin-layer chromotography outfit and other items needed for this research, including an equipped biochemical laboratory. Additional insect cabinets and replacement of some items of equipment will be necessary.

The following publications have resulted from this study.

Carson, H. L. 1966. Chromosomal Races of _Drosophila crucigera_ from the Islands of Oahu and Kauai, State of Hawaii. _Univ. of Texas Publ._ Studies in Genetics. III. 6615: 405-412.

Carson, H. L. 1968. Parallel Inversion Polymorphisms in Different Species of Hawaiian _Drosophila_. _Proc. XIIth Int. Congr. Genet._, 1: 321.

Carson, H. L. 1969. Parallel Polymorphisms in Different Species of Hawaiian _Drosophila_. _Amer. Nat._ 103(932): 323-329.

Carson, H. L., F. E. Clayton, and H. D. Stalker. 1967. Karyotypic Stability and Speciation in Hawaiian _Drosophila_. _Proc. Nat. Acad. Sci._ 57: 1280-1285.

Carson, H. L. And H. D. Stalker. 1968a. Polytene Chromosome Relationships in Hawaiian Species of _Drosophila_. I. The _D. grimshawi_ subgroup. _Univ. of Texas Publ._ Studies in Genetics. IV. 6818: 335-354.

Carson, H. L. and H. D. Stalker. 1968b. Polytene Chromosome Relationships in Hawaiian Species of _Drosophila_. II. The _D. planitibia_ subgroup. _Univ. of Texas Publ._ Studies in Genetics. IV. 6818: 355-365.

Carson, H. L. and H. D. Stalker. 1968c. Polytene Chromosome Relationships in Hawaiian Species of _Drosophila_. IV. The _D. primaeva_ subgroup. _Univ. of Texas Publ._ Studies in Genetics. V: 85-94.

Carson, H. L. and J. E. Sato. 1969. Microevolution Within Three Species of Hawaiian _Drosophila_. Evolution 23(3): 493-501.

Carson, H. L., D. E. Hardy, H. T. Spieth, and W. S. Stone, 1970. The Evolutionary Biology of the Hawaiian Drosophilidae. In. Essays in Evolution and Genetics in Honor of Theodosius Dobzhansky. A Supplement to Evolutionary Biology, pp. 437-543. Appleton-Century-Crofts, New York.

Carson, H. L. 1970a. Chromosomal Tracers of Founder Events. Biotropica 2(1): 3-6.

Carson, H. L. 1970b. Chromosome Tracers of the Origin of Species. Science 168: 1414-1418.

Carson, H. L. Polytene chromosome relationships in Hawaiian species of _Drosophila_. V. Additions to the chromosomal phylogeny of the picture-winged species. _Univ. Texas Publ._, Studies in Genetics VI. (in Press.)

Clarke, Bryan, 1970. Review, in Science 169(3951): 1192.

Clayton, F. E. 1966. Preliminary Report on the Karyotypes of Hawaiian Droso-Philidae. _Univ. of Texas Publ._ Studies in Genetics. III. 6615: 397-404.

Clayton, F. E. 1968. Metaphase Configurations in Species of the Hawaiian Drosophilidae. Univ. of Texas Publ. Studies in Genetics. IV. 6818: 263-278.

Clayton, F. E. 1969. Variations in Metaphase Chromosomes of Hawaiian Drosophilidae. Univ. of Texas Publ. Studies in Genetics V:95-110.

Clayton, F. E. Additional karyotypes of Hawaiian Drosophilidae. Univ. of Texas Publ. Studies in Genetics VI. (in Press).

Grossfield, J. 1968. Visual Stimuli in the Biology of the Hawaiian Drosophila. Univ. of Texas Publ. Studies in Genetics, IV. 6818: 301-317.

Hardy, D. E. 1966. Descriptions and Notes on Hawaiian Drosophilidae (Diptera). Univ. of Texas Publ. Studies in Genetics. III. 6615: 195-244.

Hardy, D. E. 1969. Notes on Hawaiian "idiomyia" (Drosophila). Univ. of Texas Publ. Studies in Genetics. V: 71-77.

Hardy, D. E. and Kenneth Y. Kaneshiro. 1968. New Picture-winged Drosophila from Hawaii. Univ. of Texas Publ. Studies in Genetics. 6818: 171-262.

Hardy, D. E. and Kenneth Y. Kaneshiro. 1969. Descriptions of New Hawaiian Drosophila. Univ. of Texas Publ. Studies in Genetics. V: 39-54.

Hardy, D. E. and K. Kaneshiro. New species of picture-winged Drosophila. Part Two. Univ. Texas Publ., Studies in Genetics VI. (in Press.)

Heed, Wm. B. 1968. Ecology of the Hawaiian Drosophilidae. Univ. of Texas Publ. Studies in Genetics. IV. 6818: 387-419.

Heed, W. B. Ecology of the Hawaiian Drosophilidae, Part II. Univ.of Texas Publ. Studies in Genetics VI. (in Press).

Kambysellis, M. P. and M. R. Wheeler. "Compatability in Insect Tissue Transplantations. I. Ovarian transplantation between Drosophila Species Endemic to Hawaii." Developmental Biology, (in press).

Kambysellis, M. P. and Wm. B. Heed. "Studies of Oogenesis in Natural Populations of Hawaiian Drosophilidae. II. Uniformity of oogenesis in D. disticha reflected by seasonal uniformity." (in preparation).

Kambysellis, M. P. and Wm. B. Heed. "Studies of Oogenesis in Natural Populations of Hawaiian Drosophilidae. III. Significance of microclimatic changes of oogenesis of D. mimica." (in preparation).

Kaneshiro, Kenneth Y. 1969. A study of the Relationships of Hawaiian Drosophila species based on external male genitalia, Univ. of Texas Publ. Studies in Genetics. V:55-70.

Kaneshiro, Kenneth Y. 1969. The Drosophila crassifemur Group of Species in a new Subgenus. Univ. of Texas Publ. Studies in Genetics. V: 79-94.

Robertson, F. W., M. Shook, G. Takei, and H. D. Gaines. 1968. Observations on the Biology and Nutrition of Drosophila disticha Hardy, an Indigenous Hawaiian Species. Univ. of Texas Publ. Studies in Genetics IV. 6818: 279-299.

Rockwood, S. 1969. Enzyme Variation in Natural Populations of Drosophila mimica. Univ. of Texas Publ. Studies in Genetics. V: 111-132.

Rockwood, S. Enzyme evolution in Hawaiian Drosophila. Univ.of Texas Publ. Studies in Genetics VI. (in Press).

Spieth, H. T. 1966. Courtship Behavior of Endemic Hawaiian Drosophila. Univ. of Texas Publ. Studies in Genetics. III. 6615: 245-313.

Spieth, H. T. 1966. A Method for Transporting Adult Drosophila. Univ. of California. Drosophila Information Service 41: 196.

Spieth, H. T. 1966. Drosophilid Mating Behavior: The Behavior of Decapitated Females. Animal Behavior 14: 226-235.

Spieth, H. T. 1968a. Evolutionary Implications of Sexual Behavior in Drosophilia Evolutionary Biology. II. eds. Th. Dobzhansky, M. K. Hecht, and Wm. C. Steere, Appleton-Century-Crofts, N. Y. Division of Meredith Corporation.

Spieth, H. T. 1968b. Evolutionary Implications of the Mating Behavior of the Species of Antopocerus (Drosophilidae) in Hawaii. Univ. of Texas Publ. Studies in Genetics. IV. 6818: 319-333.

Stalker, H. D. 1968. The Phylogenetic Relationships of Drosophila Species Groups as Determined by the Analysis of Photographic Chromosome Maps. Proc. XIIth Int. Congr. Genet., 1: 194.

Yang, H. and M. R. Wheeler. 1969. Studies on Interspecific Hybridization Within the Picture-wing Group of Endemic Hawaiian Drosophila. Univ. of Texas Publ. Studies in Genetics V. 6918: 133-170.

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Drosophila Project Investigators: D.E. Hardy & H.L. Carson

Project Code & Title: A-1, "Evolution of Hawaiian Drosophilidae"

	NSF Funded Man Months Cal	NSF Funded Man Months Acad	NSF Funded Man Months Sum	UH Funded Man Months Cal	UH Funded Man Months Acad	UH Funded Man Months Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES								
1. Principal Investigator & Fac. Assoc.								
D.E. Hardy, Entomologist (R-5)			1	3			2,493	7,504
H.L. Carson, Prof. (CI-5)			2		5		5,050	10,999
Sub-Total							7,543	18,503
2. Other Personnel								
F.E. Clayton, Res. Assoc.			2				3,000	
W.B. Heed, Res. Assoc.			2				3, 00	
Post Doctorate Res. Assoc.	12						10,800	
3 Graduate Asst.		14	6				16,500	
Clerk Technician	12						6,000	
Student Help							11,520	
Sub-Total							50,820	
Total Salaries and Wages							58,363	18,503
B. FRINGE BENEFITS:							4,751	3,920
Total Salaries, Wages and Fringe Benefits							63,114	22,423
C. PERMANENT EQUIPMENT:								
Cornell type insect cabinets, 3 units at $300 ea. (storage of collections)							900	
Microscope, "Wild" stereoscopic w/trinocular fitting for photography and double illuminators							1,200	
Power supply for electrophoresis studies							100	
Miscellaneous items over $25.00							200	
							2,400	
E. TRAVEL:								
1. Domestic								
Mainland, 6 rd. trips for senior invest.							3,000	
Inter-island travel field expenses, car rental (15-18 trips for ea. 3 people, 4 days ea.)							6,000	
Total Travel							9,000	
F. PUBLICATION COST								

G.	OTHER COSTS:		
	Maintenance and repair		
	Vehicles (two 4-wheel drive Jeeps), upkeep and servicing	1,500	
	Typewriters (two, 1 electric office model, 1 portable SCM)	150	
	Microscopes	200	
	Dictaphones (2 units)	50	
	Laboratory equipment (autoclave, blender, timers, air conditioner, photographic equipment)	300	
	Communications:		
	Postage	100	
	Phone and telegrams	100	
	Freight and delivery	150	
	Total Other Costs	2,550	
H.	TOTAL DIRECT COSTS	77,064	22,423
I.	INDIRECT COSTS		
	1. On-Campus 40.37% of Salaries & Wages ($58,363)	23,561	
J.	TOTAL COSTS	$ 100,625	$ 22,423

New subprojects

Four new subprojects are requested for inclusion in the second year of our program. These are listed below:

B-10 Smith, W.C. (U.H., Botany)
"Lichen communities in Hawaii"

D-4 Whittow (U.H., Medicine)
"Adaptation of some small introduced and immigrant Hawaiian mammals to their environment: A study in physiological ecology"

F Mead (Tucson, Arizona)
"Relationships between endemic Hawaiian and introduced snails and their impact in different ecosystems" (tentative)

G Ekern (U.H., Water Resources)
"The water and radiation budgets along IBP transects"

The above new subprojects fill important gaps in our integrated program. They include two, so far excluded biota, the lichens and the snails, a strenghening of our program on mammals, and an analysis of topographic (local or meso-) climate along the IBP transects. The latter will be important to anyone on the program.

The malacological project was included in the February Proposal, but procedural details were not shown.

The new proposals follow in the same sequence as listed above. The curriculum vitae of the principal investigators are shown in the next section.

New subproject proposal C.W. Smith B-10

Lichen Communities in Hawaii

The problem of the species concept and speciation in the lichens is one of great complexity. Most people nowadays avoid the question by regarding the fungal component as the dominant organism and constructing the taxonomy around the fungal element. Since no one has been able to offer a satisfactory biological definition of the term species in lichens, at the first and fourth objectives of the I.B.P. proposal though conceptually appropriate are for practical reasons outside the scope of this lichen proposal. This proposal is, therefore, aimed to aid in fulfilling the ecological objectives.

Since lichens are almost impossible to manipulate for experimental ecology because they are slow growing, the only approach is extensive fieldwork in an area where climatic conditions differ in a relatively small area. The Hawaii I.B.P. offers an ideal vehicle in which to carry out such studies. Not only is the location ideal but the concurrent studies on other organisms and the continuous accumulation of detailed data on climate are of vital importance. Indeed, without this detailed climatic information, no such study on ecological variation would be possible. The climatic information necessary is relative humidity, temperature, rainfall, mist cover, and light intensity.

Lichen communities tend to be small and are dictated by rigid substratum requirements as well as climatic considerations. Thus an overall survey will be conducted to get some impression of the various lichen communities that exist on rocks, soil, trees and leaves along the two transects. The permanent streams along the Mauna Kea transects will also be studied. It is expected that the lichen community will change radically in the various climatic zones from sea-level to mountain top.

The first sub-problem to be studied is how does the lichen community vary with differing climatic conditions within the s ame general geographic locations? Are there lichens which are substratum specific, e.g., _Metrosideros_ sp. bark, but relatively insensitive to climate variations except where the climate affects the substratum? Put another way, is the substratum more important than climatic factors in the development of lichen community. Many lichens are known to have very high climatic variation tolerances but we have little idea how the variations affect the morphology, fertility or production of lichen substances. For example, in a recent Ph.D. thesis, Jackson noted that the morphology of _Stereocaulon vulcani_ tended toward the juvenile and infertile condition with decreasing rainfall. Unfortunately, no lichen chemistry was carried out. Though not by any means conclusive, only small samples were sent away for verification, morpho-ecological variation has not been studied very thoroughly in lichens.

The obligately foliicolous lichen flora with increasing elevation should be particularly interesting because they are generally confined to tropical and sub-tropical regions. Only one species, _Strigula elegans_, has been found in temperate regions and seems to be cosmopolitan in tropical and sub-tropical regions. It will be interesting to see if S. elegans does occur up into the cooler climatic zones of the mountains. Again, the climatic and biological information from the program is essential for any meaningful analysis. In particular, it will be interesting to have information of fungal communities in the phyllosphere. Present casual observations suggest that mycological communities predominate on leaves which are continuously moist whereas lichen communities are dominant in humid regions in which the leaf is "dry" 50 percent of the time.

However, I must introduce a word of caution here which in part has influenced my choice of the two initial sub-problems. Since there is no decent reference collection of Hawaiian lichens available, a considerable time will be spent on identifications. Much material will have to be sent away for verification and identification which will also take considerable time. For the foliicolous lichens, there is Rolf Santesson's monograph,and the morpho-ecological variations study particular species. Thus the two initial subproblems should be feasible within a short time period.

The lichen communities are an integral part of all ecosystems. Thus it is importhat that we try and gain some idea of their importance in the Hawaiian ecosystems. They can be detrimental to plants on which they grow or partially responsible for the weathering of rocks, for example. In other situations, they are the dominant life form in the ecosystem. However, we have so little information on the lichen communities of Hawaii that the initial long-term objective is to make an inventory of the species in the study area. At the same time, a preliminary quantitative analysis will be conducted to ascertain the frequency of lichens in each of the quadrats.

This approach will contribute not only to a more detailed knowledge of the total ecosystem, it will also aid or be complementary to other studies. The Psocopteran insects apparently derive most of their nutrients from lichens thus it will be interesting to find out whether these insects are specific or general in their choice of lichens. The lichens also act as shelter for many invertebrates particularly annelids. However, we do not know whether or not the worms feed on the lichen thallus. Also, do they contribute in any way to the nutrition of the lichen? Their faeces could be an important source of nitrogen to some lichens. This study could be complementary to the mycological study particularly in the investigation of the loose associations of algae and fungi.

Sampling

This will depend somewhat on the results of the previous studies of the area.

For the broad investigation of lichen communities it is proposed to sample extensively the plots along the transects already established. Small areas will be sampled completely.

For the morpho-ecological variation studies, common and readily identifiable lichens will be chosen e.g. Stereocaulon vulcani and some species of the genus Ramalina which will be collected from any locality but particularly along the transect line. However, as this study progresses it will be necessary to enter other areas which will complement the study. It is hoped that this approach may provide lichen markers for particular ecological conditions.

For the foliicolous lichen study, site surveys will be carried out in every plot along the transect line. It is important in these studies to have accurate identification of the host leaves. Sampling will be conducted in the various strata of the forest with records of temperature, humidity and light intensity. Other information, particularly rainfall pattern, will then be correlated with this information.

Adaptation of some small introduced and immigrant
Hawaiian mammals to their environment:
A study in physiological ecology

It is proposed to study the behavioral and physiological responses of the mongoose (Herpestes auropunctatus auropunctatus), the roof rat (Rattus rattus rattus), and the Norway rat (Rattus norvegicus norvegicus) to different temperatures, humidities, air velocities, and radiant heat loads. The species to be studied are known, suspected, or potential predators of some of the endemic fauna. With this information it should be possible to predict the environmental conditions which the animal prefers, and the limits of the environment within which it is likely to become established. This prediction depends upon the availability of data for the microclimatic conditions in different habitats. Where this information is not forthcoming from other studies, it will have to be procured as an essential part of the present project. The results obtained will permit an assessment to be made of how close a species is to the limits of its capacity for adaptation.

In a second part of the proposed work, samples of the populations of the mongoose and the rats will be obtained from different climatic areas and at various altitudes. The samples will be examined in order to determine if they display physiological and behavioral differences which may be correlated with the different microclimates in their habitats.

A special aspect of both parts of the investigation will be the study of the responses of the animals in relation to their water supply and state of hydration.

It is envisaged that the program of work outlined above will provide valuable clues to the physiological evolution of these species. This phase of the work will be complemented by laboratory studies in which groups of animals will be experimentally adapted to different environmental conditions over long periods of time.

The study will be closely coordinated with that of Dr. Tomich, with regard to the sampling areas, ecological information and species identification, and with that of Dr. Ashton, as far as the genetical composition of the population samples are concerned. The experimental techniques to be ueed will be very similar to those proposed by Dr. MacMillen so that the two projects will be mutually helpful.

New subproject proposal P.C. Ekern G

The water and radiation budgets along IBP transects

The physical environments of the Mauna Loa and Mauna Kea transects (Mueller-Dombois and Krajina, 1968) are under the influence of a marked mesoscale circulation up and down the slope that transcends the strong trade winds inversion (Price and Pales, 1963; Mendonca, 1969; Lavoie, 1967). Measurement of this mesoscale circulation must precede measurement of the detailed microclimate if a rational approach to the climate of the different sites is to be made. The water and radiation budgets dominate the physical environments of these relatively steep transects, and in turn dominate the ecological forms which fill the various niches (Beals, 1969).

Though rainfall is the prime source of water, it is augmented by direct interception of cloud water within portions of the transects (Ekern, 1964). Extreme variations in rainfall along the transects require onsite rainfall measurements (Baer, 1956; Blumenstock and Price, 1967). The net radiation supplies energy for growth (photosynthesis), convective heating of the air, and evapotranspiration.(Ekern, 1965 a,b). Measurements of solar radiation alone specify the radiation budget once the consistent regression of net radiation on solar radiation is established (Ekern, 1965a; Idso et al., 1969; Polavarapu, 1970). Because of the extreme local variations in cloudiness, sunlight too must be measured for each site. The net long-wave balance, important in the overall net radiation, is closely related to the water content of the overlying air mass, hence closely allied to elevation, since the water content varies strikingly across the trade wind inversion at an average elevation of 6,000 ft. The uniformity of the surrounding ocean temperature makes the free air temperature relatively independent of radiation in this marine climate. The radiosonde observations at Hilo provide a convenient upwind monitor for the air temperature profile. The diurnal change in the flow of air along the mountain slope ascertained from the Mauna Loa station (Price & Pales, 1963; Mendonca, 1969), suggests that relative humidity changes provides a reasonable record of flow across the trade wind inversion (Mendonca, 1969; Reber, 1959). However, the measurement of detailed wind structure is beyond the scope of this project (Lavoie, 1967, 1966; Taylor and Fullerton, 1970).

Long term unattended operation requires battery operated or spring powered instrumentation capable of one month recording. Proper interpretation requires daily and often interdiurnal record of the elements.

ESSA weather data and maps will be surveyed for dynamic representation of the macroscale synoptic flow.

Instrumentation:

On the upper Mauna Loa transect is the ESSA Mauna Loa station (11,500') that supplies data for high altitudes well above the trade wind inversion.

A new site well above the inversion, at approximately 8500' elevation, will be installed to record the parameters near the critical lower limits of the freeze line. A station, currently instrumented in part, will be expanded at 7000', just above the mean position of the trades inversion, where relative humidity changes are frequent. The upper rain forest station at 5400' within the cloud zone will be expanded, and the amount of direct cloud interception measured. A similar station will be expanded, near the same elevation in the mountain parkland which receives less rainfall. A final new station will be established near 1800' to monitor the lower portion of the transect.

At each site, a continuous record of rainfall, solar radiation, temperature, and humidity will be made. Net radiation will be recorded at the several sites serially, so that a regression of net radiation on solar radiation for each site can be made. The additional water intercepted in the cloud zone (Kilauea Forest) will be gathered on a standard catcher, to record the augmentation of rainfall. Daily weather maps and satellite photos will be used to generate a continuing summary of the macroscale synoptic circulation during the period of study. The Hilo radiosonde measurements will be compiled for statistical assessment of variations from the normal to the vertical gradients of humidity and temperature. Should the matching grant proposal of Fullerton, C.M., to the Water Resources Research Center be funded, and start 1 July 1971, for the study of the space-time variations in high intensity rains on the windward coast of the island of Hawaii, the results would be immediately pertinent to and will be applied to the IBP study (Taylor and Fullerton, 1970).

References

Baer, L. 1956. Orographic rainfall distribution patterns with application to Hawaii. Trans. Amer. Geophys. Union 37 (5): 546-48.

Beals, E.W. 1969. Vegetational changes along latitudinal gradients. Science 165(3897): 981-85.

Blumenstock, D.I. and S. Price, 1967. Climate of the states, Hawaii. ESSA No. 60-61. 27 pp.

Charnell, R.L. 1967. Long-wave radiation near the Hawaiian Islands. J. Geophys. Res. 72(2): 489-96.

Ekern, P.C. 1964. Direct interception of cloud water on Lanaihale, Hawaii. Soil Sci. Soc. Amer. Proc. 28(3): 419-21.

1965a. The fraction of sunlight retained as net radiation in Hawaii. J. Geophys. Res. 70(4): 785-93.

1965b. Disposition of net radiation by a free water surface in Hawaii. J. Geophys. Res. 70(4): 795-800.

1966. Evaporation from bare Low Humic Latosol in Hawaii. J. Appld. Meteor. 5(4): 431-35.

Idso, S.B., D.G. Baker and B.L. Blad. 1969. Relations of radiant fluxes over natural surfaces. Quart. J. Roy. Meteor. Soc. 95: 244-57.

Lavoie, R.L. 1967. Air motions over the windward coast of the island of Hawaii. Tellus. 19: 354-58.

1966. The warm rain project in Hilo, Hawaii. Summer 1965. Hawaii Inst. Geophys. HIG-66-5. 52 pages.

Mendonca, B.G. 1969. Local wind circulations on the slope of Mauna Loa. J. Appld. Meteor. 8(4): 533-41.

Mueller-Dombois, D. and V.J. Krajina. 1968. Comparison of east-flank vegetations on Mauna Loa and Mauna Kea, Hawaii. Proc. Symp. Recent Adv. Trop. Ecol. 2: 508-20.

Polavarapu, R.J. 1970. A comparative study of global and net radiation measurements, at Gueplh, Ottawa, and Toronto. J. Appld. Meteor. 9(5): 809-14.

Price, S. and J.C. Pales. 1963. Mauna Loa Observatory: the first five years. Mon. Wea. Rev. 91(10-12): 665-80.

Reber, G. 1959. Temperature and humidity atop Haleakala. Aust. Meteor. Mag. No. 24: 73-79.

Taylor, R.C. and C.M. Fullerton. 1970. A new rain intensity recorder. Bull. Amer. Meteor. Soc. 51(3): 286.

New personnel

The curriculum vitae of three new IBP participants follow. The curriculum vitae of Drs. A.R. Mead (F) and G.C. Whittow (D-4) were already included in the February Proposal.

Paul C. EKERN, Jr.

Born: 2 July 1920; Ardmore, Oklahoma.

Marital status: Married, 4 children.

Degrees: A.B., Westminster College, Fulton, Missouri, 1942; Prof. Cert., Meteorology, Univ. Chicago, 1943; Ph.D., Univ. Wisconsin, 1950.

Positions held: Univ. Wisconsin, 1947-55; Pineapple Res. Inst., Honolulu, 1955-63; Univ. Calif., Davis, 1963; Univ. Hawaii, 1964 to date.

Field experience: Pineapple and sugarcane moisture consumption, Hawaii; weather forecast, Oklahoma, 1943-1945; Manila, Philippines, 1945-46; Madison, Wisconsin, 1952-55.

Military service: U.S. Army,Air Force, 1942-46.

Scientific societies: Soil Science Society of America; Amer. Meteor. Soc.; Amer. Geophys. Union; Int. Soc. Bioclimatology; Soil Conservation Soc. Amer.; Amer. Assoc. Adv. Sci.; Sigma Xi.

Selected publications

Ekern, P.C. 1964. Direct interception of cloud water on Lanaihale, Hawaii. Soil Sci. Soc. Amer. Proc. 28(3): 419-21.

1965a. The fraction of sunlight retained as net radiation in Hawaii. J. Geophys. Res. 70(4): 785-93.

1965b. Disposition of net radiation by a free water surface in Hawaii. J. Geophys. Res. 70(4): 795-800.

1965c. Evapotranspiration of pineapple in Hawaii. Plant Physiol. 40(4): 736-39.

1966a. Evapotranspiration of Bermuda grass sod in Hawaii. Agron. J. 58(4): 387-90.

1966b. Evaporation from bare Low Humic Latosal in Hawaii. J. Appld. Meteor. 5(4): 431-35.

1967a. Soil moisture and soil temperature changes with the use of black vapor-barrier mulch and their influence on pineapple growth in Hawaii. Soil Sci. Soc. Am. Proc. 31(2): 270-75.

1967b. Pilot evapotranspiration study: lysimeter design. WRRC Tech. Report. No. 13. 26 pages.

Ekern, P.C., J.S. Robins and W.J. Staple. 1967. Soil and cultural factors affecting evapotranspiration in irrigation of agricultural soils. Amer. Soc. Agron. Monogr. 11: 522-33.

Ekern, P.C. 1970. Consumptive use of water by sugarcane in Hawaii. Water Res. Res. Cntr. Univ. Hawaii Tech. Publ. 37. 193 pages.

Douglas J. C. FRIEND

Born: 16 April 1929; London, England.

Marital status: Married, 2 children.

Degrees: B.Sc. Hons. Bot. Imperial College, London University, England, 1949; Ph.D. Plant Physiology, Imperial College, London University, 1953.

Positions held: Research Officer, Plant Research Institute, Canada Dept. of Agriculture, Ottawa, Canada, 1953-66; Assoc. Prof. Bot., Univ. Hawaii, 1966-69; Prof. Bot., Univ. Hawaii, 1969-date.

Scientific and honorary societies: American Soc. Plant Physiologists; Scandinavian Soc. Plant Physiologists; Canadian Soc. Plant Physiologists (past); Amer. Assoc. Adv. Sci.; Hawaiian Bot. Soc.

Selected publications

Environmental physiology

Friend, D.J.C. 1966. Responses of cereals to temperature and light. In 'The growth of cereals and grasses' Ed. F.L. Milthorpe, J.D. Ivins, Butterworths, London, 181-99.

Photomorphogenesis

Friend, D.J.C. 1961. A simple method of measuring integrated light values in the field. Biology 42: 577-80.

1965. Tillering and leaf production in wheat as affected by temperature and light intensity. Canad. J. Bot. 43: 1063-76.

1965. Ear length and spikelet number of wheat grown at different temperature and light intensities. Canad. J. Bot. 43: 345-53.

1967. Effect of daylength on the growth of wheat. Canad. J. Bot. 45:117-31.

1969. Net assimilation rate of wheat as affected by light intensity and temperature. Canad. J. Bot. 47: 1781-87.

Friend, D.J.C., V.A. Helson, and J.E. Fisher. 1962. The rate of dry weight accumulation in Marquis wheat as affected by temperature and light intensity. Canad. J. Bot. 40: 939-55.

1962. Leaf growth in Marquis wheat, as regulated by temperature, light intensity, and daylength. Canad. J. Bot. 40: 1299-1311.

1965. Changes in the leaf area ratio during growth of Marquia wheat, as affected by temperature and light intensity. Canad. J. Bot. 43:15-

Friend, D.J.C. and M.E. Pomeroy. 1970. Changes in cell size and number associated with the effects of light intensity and temperature on the leaf morphology of wheat. Canad. J. Bot. 48: 85-90.

Clifford W. SMITH

Born: 10 March 1938; Hereford, United Kingdom.

Marital status: Single.

Degrees: B.Sc., Univ. Coll. of N. Wales, 1962; M.Sc., Univ. Manchester, 1963; Ph.D., Univ. Manchester, 1965.

Positions held: Visiting Asst. Prof., Univ. Hawaii, 1966; Res. Assoc., Princeton Univ., 1966-67; Asst. Prof. Bot., Univ. Hawaii, 1967 to date.

Scientific and honorary societies: Botany Society of America; A.I.B.S.; British Lichen Society; American Fern Society.

Selected publications

Smith, C.W. 1967. Growth of excised embryo shoot apices of wheat grown _in Vitro_. Ann. Bot. N.S.W. 31: 593-605.

Smith, C.W. and W.P. Jacobs. 1969. Transport of C^{14} indole acetic acid in developing bean hypocotyls. Amer. J. Bot. 56: 492-97.

Smith, C.W. and L.F. Lew. 1970. Cellular arrangement at the node of various angiosperms. Bot. Gaz. (in press).

SUPPLEMENTAL INFORMATION

Following is a selection of reports of individual participants that give useful detail augmenting the general progress section.

Papers presented

Tomich, P.Q. "The International Biological Program - Hawaii's objective and progress". First Hawaii Wildlife Symposium, May 13, 1970.

Mueller-Dombois, D. "The International Biological Program in Hawaii". Hawaiian Botanical Society, Sept. 22, 1970.

Reports

B-2 Mueller-Dombois. Procedure for sampling the koa-ohia-tree fern forest in Kilauea Forest Reserve, Hawaii. Sept. 28, 1970.

B-3 Lamoureux and Porter. Report on establishment of 7 phenological observation stations. Dec. 7, 1970.

B-5 Lloyd. Report on fern study. Nov. 3, 1970.

B-6 Corn. Genecological studies on Metrosideros. Dec. 1970.

B-7 Doty. First activity report on algae study. Dec. 3, 1970.

B-8 Baker. Progress report on roles of fungi. Dec. 1970.

C-1 Hardy. Progress report on Diptera project. Dec. 7, 1970.

C-2 Steffan. Progress report on Sciaridae project. Dec. 1, 1970.

C-3 Gressitt. Interim report, fieldwork on Big Island. Nov. 25, 1970.

C-3 Davis. Communication letter to Park Superintendent on Acacia psyllid investation, Mauna Loa transect. Sept. 1, 1970

C-4 Gagné. Proposed sampling procedure for IBP transects (Heteroptera). Oct. 1970.

C-5 Beardsley. Progress report on effects of sap-sucking Homoptera on Hawaiian ecosystems. Dec. 1970.

C-6. Nishida, Haramoto and Nakahara. Progress report on faunal research on Metrosideros. Dec. 1970.

C-9 Radovsky. (1) Progress report on soil and duff inhabiting arthropods and vertebrate parasites. (2) Plan of next work. Nov. 12, 1970.

D-1 Berger. Report on IBP field trips to Hawaii. Dec. 5, 1970.

Banko. Preliminary status of native birds, Kilauea koa-ohia-tree fern forest. October 1970.

D-2 Tomich. Sampling plan for the roof rat, Rattus rattus, in the Kilauea koa-ohia-tree fern forest. Dec. 5, 1970.

P A P E R S

FIRST HAWAII WILDLIFE SYMPOSIUM
Hawaii Chapter, The Wildlife Society
Kahului, Maui May 13, 1970

The International Biological Program - Hawaii's Objectives and Progress

By P. Quentin Tomich

The International Biological Program (IBP) was first conceived in 1963 at the 10th meeting of the International Council of Scientific Unions in Vienna (1). The ICSU is a broad organization that deals at the international level in all disciplines of science. The United States participating body is the National Academy of Sciences - National Research Council. Since our interest today is primarily in what is going on in the United States, and especially in Hawaii, I will refer only briefly to the international aspects of the program. A principal aim is that there shall be a world-wide cooperation, and especially of understanding, in approaches to basic biological problems. Actually, each of the 54 participating nations is essentially autonomous in the pursuit of its own endeavors.

The U.S. National Committee for IBP was established in 1965, and this is the body that United States investigators look to for review and approval of their projects. Projects need not be implemented in the United States. For example, a project on the tropical forest biome is planned to take place in Costa Rica, and a study of population genetics of American Indians is in progress in Brazil and Venezuela. A substantial share of funding is the responsibility of the National Science Foundation and the final word of the funding agency is needed even after the National Committee approves of a project. This is where the proposed Hawaii Project stands today. It has gained approval of the Committee, and now we are awaiting funding through NSF.

The objectives of the IBP were well stated in 1967 by Roger Revelle, who was then chairman of the U.S. National Committee (2):

"In our times of unprecedented change, biologists tend to be conservative. They are well aware of the rapidly growing abilities of their fellow human beings to alter the face of the earth through the enormous physical power of technology. But they are equally aware that the physical alterations produced by technology can bring about unknown, far-spreading, and often destructive changes in the web of life that is stretched so thinly over the surface of our planet. Our technology has outpaced our understanding; our cleverness is growing faster than our wisdom.

Our goal should be, not to overcome the natural world, but to live in harmony with it. To attain this goal we must learn how to control not only the external environment but ourselves. Especially we need to learn how to avoid irreversible change if we are going to be able to assure for future generations the opportunity to choose the kind of world in which they want to live. Biologists realize they understand too little about the complex inter-relationships among living things to be able to predict the effects of technical change or to help the technologists in conserving the values and utilizing the abundance of the world of life. They believe greater understanding will make it possible for man to respond to opportunity as well as to react to need. To gain such understanding is the underlying purpose of the International Biological Program.

This program has three related objectives: human welfare, scientific advance, and the development of international scientific cooperation. These three objectives cannot be separated. Biologists can contribute uniquely to human welfare only by advancing scientific understanding, and the basic premise of the International Biological Program is that the growth of understanding will be accelerated by international cooperation among the world's biologists".

One of the major problems in formulating a program for Hawaii was to establish a proper focus for the study. Planning was at first centered at the University of Michigan and was led by Dr. Warren H. Wagner, Jr., who is director of the university arboretum and who has had considerable experience in Hawaii as a specialist in the study of ferns.

A conference held at the Bishop Museum in Honolulu, in March 1967 established guidelines for a proposal for a Hawaii Terrestrial Biology Program (3,4), including the following principles.

a) The project was to be a comprehensive, long-term investigation of endemic and invasive biotas of the Hawaiian Islands, because of the high degree of endemicity and rapid rate of disappearance of species before the pressures of man and the species he has introduced, and because the islands are an outstanding natural laboratory for the study of evolutionary processes.

b) The project was to be limited to the biology of land areas, including those of the Northwestern Hawaiian Islands, with a cutoff point at the shore line. Marine investigations are already well established under other auspices.

c) Priorities for groups or species to be studied were established on the basis of rarity, narrowness of specialization, evolutionary significance, and other features. Hence the Cerambycidae (long-horned beetles), Achatinella (a genus of land snails), the Drepaniidae (honeycreepers), and several groups of plants were suggested as prime examples for research.

d) That exotics such as mites, ants, axis deer, mongoose, pigs, goats and several species of introduced plants, be studied for their effects on native communities of plant and animal life.

3) To consider undisturbed ecosystems such as rain forest, dryland forest, bogs and sand dunes.

f) To prepare species lists, manuals and bibliographies of the Hawaiian biota.

In spite of this substantial outline of needs, immediate progress was slow. After a period of inaction in order to accelerate planning, headquarters of the project was moved to Honolulu from Ann Arbor in July 1968. Dr. Andrew J. Berger, an ornithologist at the University of Hawaii, and Dr. J. Linsley Gressitt, an entomologist at the Bishop Museum, were appointed co-directors.

By October 1968 a first proposal was filed with an advisory board of the U.S. National Committee (5). In a revised and expanded form this detailed document contained 364 pages, and included more than 60 investigators from Hawaii, other states and other nations, reflecting a wide response to the unique problems to be studied in Hawaii (6). A budget of $507,000 was suggested for the first year of a 5-year projected program. The proposal was subjected to further official scrutiny and site visitors made their evaluations (7). These endeavors, unfortunately, consumed most of the year 1969.

Two major factors emerged during this period. There was a shift in the ground rules for IBP projects so that, in effect, studies of systematics could not be incorporated, and emphasis was directed toward the close integration of all phases of any program as a condition of approval. Thus the project was to be known as an Integrated Research Project. A second factor was a newly organized budget for the National Science Foundation that forced a ceiling of $200,000 on any revised proposal that might be offered.

As a result of these restrictions, subsequent revisions have settled on the following objectives:

1) To determine why some organisms have undergone speciation while some of the most successful have not.

2) To determine why some ecosystems in Hawaii are stable, some fragile.

3) To develop fundamental equations relating the variables contributing to stability and diversity of ecosystems in Hawaii.

4) To determine rates of evolution in Hawaii and factors affecting them.

For objective 1 (speciating organisms) and objective 4 (rates of evolution), study sites will be the whole of the Hawaiian Islands. For objectives 2 and 3 (stability and fragility of ecosystems) transects will be chosen on the islands of Hawaii, Maui and Kauai.

The work is planned to begin in Hawaii Volcanoes National Park, initially, and a first permanent field facility will be established there in cooperation with the Park Service. Eighteen sub-projects have been written (8), to be performed by investigators who are already actively working in Hawaii, largely from the Bishop Museum and the University of Hawaii. Topics for study include the soils, climate, soil and litter fauna, vegetation, selected plant groups, phytophagous and pollinator insects, birds, mammals and parasitic forms.

Dr. Dieter Mueller-Dombois is to be scientific coordinator of the project. As a plant ecologist at the University of Hawaii, he has already done extensive research at Hawaii Volcanoes National Park (9) and is an excellent choice for this position.

IBP projects are actively functioning in the continental U.S. and elsewhere, with 14 fully established. Three of these are NSF supported - the grasslands biome with headquarters in Colorado, the eastern deciduous forest biome in the Atlantic States, and the desert biome in the Southwest (10). It is hopeful that the Hawaii Integrated Research Project will be the fourth such study, and that it will expand beyond the modest beginnings now proposed for it.

With IBP I can see a great promise for advancement of our understanding of the importance of Hawaiian ecosystems. It is already well known that some of our ecosystems can make remarkable recoveries when relieved of the disturbances and pressures from exotics and over use. Laysan Island is an outstanding example of rejuvenation following removal of the rabbits. Another is segments of Mauna Kea where the sheep were greatly reduced in number. Other systems are not so flexible and we are still losing birds, plants and perhaps other life forms even under the best of conditions. The people of Hawaii are becoming increasingly interested and knowledgeable and even concerned, about environmental problems, and answers must be forthcoming on many issues. The burden of proof is falling increasingly on foresters, wildlife managers and parks administrators to justify policies now established and presently operative.

In this brief report I have only skimmed the substance of the proposal for an IBP project in Hawaii, but it is obvious that such a project will have important implications for anyone who deals with public recreation, forestry practices and wildlife management in the State. The persons who have formulated the Hawaii proposal are, by and large, practical scientists. They share many common interests with those of you in attendance at this series of meetings. They ask questions about environmental problems, many of which can be answered only by research still in the planning stages. If answers can be obtained, it would seem that this would stimulate the kind of thinking and action that will assure firm and equitable decisions in matters relating to the terrestrial environment and its physical and biological components.

In closing, I would like to pose a number of questions that have occurred to me in my experience as a zoologist in Hawaii, and are pertinent to IBP research interests.

1) Can koa forests be managed on a sustained yield basis without the loss of significant plant and animal life usually associated with this vegetation type?

2) Should the project for replacement of virgin forest with exotic timber species be continued if it means further threats to our rare and endangered species of birds and plants?

3) Can some present range lands that were once covered by forest be reverted to native forest species, koa in particular, in a multiple use concept for cattle and timber?

4) Is clearing of dry-land forest for "habitat improvement" to promote populations of exotic game birds justified when other lands already cleared or in natural grassland could possibly produce game birds more effectively?

5) How will we know when the Hawaiian goose is safely restored as a wild species and is predation by various animal species a major factor in retarding its recovery?

6) A program for the replacement of feral sheep and goats with more desirable game mammals has apparently lagged seriously in recent years. Should this program be renewed, and if so, is it the best program that can be offered to the hunters and at the same time prevent further deterioration of the mamane forest on segments of Mauna Kea, or new kinds of damage to the vegetation elsewhere?

7) Is the National Park Service justified in its continued denial of public hunting of feral goats and pigs in the parks. Should it accept these species as part of the Hawaiian scene and continue to exercise only nominal control over their abundance, or should strong political action be taken to insist that the parks be fenced against exotic or wild game species?

8) If we are to establish a system of reserves for representative ecosystems throughout the islands, what lands should be included, how large should the areas be, and how much interference with natural successional processes can be tolerated within them?

REFERENCES CITED

1. IBP News No. 8, May 1967. IBP Central Office, 7 Marylabone Road, London NW 1, p. 1.

2. Science: 155 (3765): 957. 24 February 1967.

3. U.S. National Committee on the International Biological Program, Hawaiian Terrestrial Biology Project (SB-CE). Report of the Planning Committee. March 20-23, 1967. 8 pp.

4. Report No. 3 of the U.S. National Committee for the International Biological Program, Part 1: 3. September 1967.

5. Memorandum: Meeting of the Ad Hoc Advisory Committee on the Hawaii IRP in Ann Arbor, Michigan. 13 February 1969. 13 pp.

6. Application to National Science Foundation from B.P. Bishop Museum and the University of Hawaii. International Biological Program, Hawaii Terrestrial Biology Subprogram. Submitted 18 April 1969. 364 pp. (revised version of preliminary plan submitted October 1968).

7. Observations and recommendations from a site visit of the "Hawaii Terrestrial Biology Program". W. Frank Blair and George Van Dyne. July 3, 1969. 6 pp.

8. Application to National Science Foundation from B.P. Bishop Museum and the University of Hawaii. International Biological Program, Hawaii Terrestrial Biology Subprogram. Submitted 26 September 1969, revised February 1970.

9. Atlas for bioecology studies in Hawaii Volcanoes National Park. Doty, M.S. & D. Mueller-Dombois. 1966. University of Hawaii Botanical Science Paper No. 2, 507 pp.

10. Panorama, Bioscience 20(7): 431. April 1, 1970.

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The International Biological Program in Hawaii

By D. Mueller-Dombois

This summer, a group of 25 scientists from the University of Hawaii and the Bishop Museum obtained $229,000 in research funds from the National Science Foundation. This is the first installment of a five-year coordinated ecological and evolutionary study of Hawaiian ecosystems and species.

The steering committee is composed of three co-directors, Dr. J. Linsley Gressitt (Entomology, Bishop Museum), Dr. Andrew J. Berger (Zoology, University of Hawaii) and Dr. Dieter Mueller-Dombois (Botany, Univ. of Hawaii). The latter acts also as scientific coordinator.

With the initiation of this project on September 1st of this year, Hawaii has joined the International Biological Program (IBP). So far, 57 nations participate in the IBP, which became effective in 1966. The overall objective of IBP is to search for the biological basis of organic production on a world-wide scale. This includes production of plants and animals and their interactions with man and microorganisms in the quantitative and qualitative sense. The quantitative studies are directed towards the volume, rates and pathways of cycling of organic and inorganic matter in the major natural and cultivated ecosystems of the world.

A major segment of the U.S. contribution to IBP deals with the different important biomes occurring in America; the tundra, the western coniferous forest, the eastern deciduous forest, the grassland (prairie), the desert and the continental tropical forest biome. The six major projects are called "Ecosystem Analysis Studies" and are concerned primarily with the physiological aspects of these broader ecosystems and with quantitative turnover studies. So far, only four of these are underway. Marine and freshwater habitats are included in other segments of IBP.

The qualitative studies aim at studying the underlying reasons of species diversity (number of species) in evolutionarily important ecosystems. The U.S. contribution includes another major segment of this sort which runs under the name "Origin and Structure of Ecosystems Integrated Research Program." This segment consists of three subprograms. The Hawaii IBP is one of these, primarily because of its unique island flora and fauna.

There are two important environmental conditions that form the background for the unique character of the Hawaiian fauna, flora and ecosystems. These are (1) the isolated insular situation and (2) the volcanic environments and their dynamic history.

The Hawaiian Islands are extremely isolated as far as the origin of the native biota is concerned. They are 2,000 miles away from the nearest continental land mass. This extreme isolation and the relatively young geological age (estimated to be 10-20 million years) has had an important influence on the development of the Hawaiian ecosystems.

For example, our native flora is comprised of 1,729 species and varieties of seed plants which belong to 216 genera. There is nothing peculiar in this species number. But it is of significance that this number has developed from only 272 original arrival forms (as estimated from careful comparative studies by F.R. Fosberg). The high number of native species and the low number of original forms implies that the vast majority of native seed plants (about 95%) have evolved on these islands and are therefore endemic, meaning that they do not occur anywhere else in the world.

However, this uniqueness applies only to the species and variety level of differentiation. At the genus level, only few (13%) genera are endemic. Most are represented elsewhere; about 40% in the Indo-Malaysian Tropics, 12% in the Pantropics, 16% in the Australian region and 3% in the north temperate zone. Therefore, on the generic level of differentiation, Hawaii's flora is not so unique. Similar relations apply to the insects and birds.

An important aspect for ecosystem development is that a number of taxa are absent here that are otherwise found in tropical ecosystems. This has the peculiarity - extremely rare in other tropical environments - that our native forests are dominated by only two tall-growing tree taxa. These are, Metrosideros, forming mono-dominant forests on new volcanic substrates and in wet climates, and Acacia koa, forming mono-dominant forests on more weathered soils in summer-dry climates and mixed forests in wet climates.

This disharmonic nature of our native biotic communities may in part be responsible for their fragility. This means that the native communities are easily subject to invasion by exotic newcomers, because all available niches have not been filled or many are only weakly occupied. However, this varies with different ecosystems.

This may also explain in part the easy destruction from introduced grazing animals, such as goats, pigs, cattle and axis deer. The Hawaiian vegetation has evolved in the absence of grazing and browsing pressure from big animals. The plants have no effective mechanisms to either counteract overfeeding or to regrow fast enough.

However, the biota of Hawaii have evolved together with another destructive form, and that is volcanism. There is evidence that the native vegetation is more stable on recent volcanic surfaces than on old. Moreover, on new ash substrates we find that native plants compete often successfully with exotics by replacing them after exotics were initially established.

An outstanding example of adaptation to volcanism is displayed by *Metrosideros*. This tree produces aerial roots after it is covered by a thick ash blanket from volcanic explosion. It, moreover, produces a profusion of branches and foliage providing it with an increased photosynthetic area for accelerated growth.

The Hawaii IBP is aimed at four specific objectives:

1. To determine why some organisms in Hawaii have undergone speciation while some of the most successful have not.

2. To determine why some ecosystems in Hawaii are stable, some fragile.

3. To develop fundamental equations relating the variables contributing to the stability and diversity of ecosystems in Hawaii.

4. To determine the rate of evolution in Hawaii and factors affecting it.

Each objective is further defined by a series of testable working hypotheses.

The field approach is to work along previously defined ecosystem transects. The first transects to be studied are along the east-flanks of Mauna Kea and Mauna Loa. Later, the study will include other transects on Maui and Kauai.

An important cooperating agency is the National Park Service which has provided a house and laboratory space for the IBP researchers at the headquarters of Hawaii Volcanoes National Park.

The eventual aim of these fundamental research programs under IBP is to more substantially upgrade decisions in the day to day handling of our biological and environmental resources. The limitations have become painfully obvious within the last decade. The number of concerned people is growing everywhere who realize that decisions in the handling of our biological and environmental resources cannot be anymore on a hit and miss basis, but instead, must be based on deeper knowledge gained from fundamental ecological research.

R E P O R T S

Procedure for sampling the koa-ohia-tree fern forest in Kilauea Forest Reserve, Hawaii (Upper montane rain forest)

Part 1

Comprehensive plant ecological survey

Dieter Mueller-Dombois

September 28, 1970

Introduction

Mr. Norman K. Carlson, Forester for the Bishop Estate Forests on Hawaii, has offered the Kilauea Forest Reserve for study. His primary interest is the behavior of Acacia koa as commercial timber tree. This includes explanations as to the trends of development in the existing virgin forest and regeneration and development after cutting.

For the Hawaii IBP project this koa forest represents an ideal study site. It is close to our Headquarters in the Park (10 miles away), it lies on one of the transects (Transect 2, segment 11, in 1966 Atlas for bioecology studies in Hawaii Volcanoes National Park), and most important, koa forms currently an important dominant organism in the ecosystem. 200 acres will be contracted out for logging of koa. Here, we have an excellent test case for studying the effect of removal of an important dominant on the rest of the biota of this rain forest ecosystem. We hope to arrive at reasonably sound predictions of the effect on the biota if one or several of the structurally or functionally important biota are eliminated or otherwise aversely affected.

In this particular situation, we can check out what really happens after the important dominant is removed by resurveying the area after cutting of the koa.

The date of koa logging has not yet been fixed, but it is expected to take place during the first half of 1971.

Area

The koa-ohia-tree fern forest is briefly described on pp. 418-19 as segment II, Transect 2 in the "Atlas for bioecology studies in Hawaii Volcanoes

National Park" (1966).

The following two maps define the location of the study site. The overall extent of this forest has been mapped on airphoto 8-0081 that accompanies the Atlas.

Sampling layout

Fig. 1 shows the location of the 200 acre site on the Kulani topographical sheet. Fig. 2 shows the location on the vegetation map=air photo (8-0081). This air photo set with transparent vegetation type overlays is kept in the map cabinet at the Research Biology Laboratory in the Park Headquarters. Fig. 2 can be laid over the airphoto to check the homogeneity of the koa-ohia-tree fern forest selected for sampling. It was found that the homogeneity is rather great for plant ecological purposes so that no further type-stratification was found necessary or advisable. Therefore, the smapling layout was arranged systematically with predetermined sample plot locations.

Both figures also show the position of the IBP climatic station, which is operative since August 1, 1970. The climatic station (the Stevenson screen shelter) forms the NW corner of the 200 acre study site. The exact corner is moved out a little (about 20 m) NW to the middle of the logging road that gives access to the area.

The 800 m base line follows more or less the first part of the road. The exact direction is 55° NE. From this base line 4 transects will be run. These transects are oriented 145° SE. Transect 1 (recognized on the maps by plot-points 1 to 5) starts with plot 01 at 100 m distance from the 800 m long base line. From here a sample plot is planned at every 200 m. Transect 2 (including plot-points 6 to 10) starts 200 m, 55° NE from Transect 1.

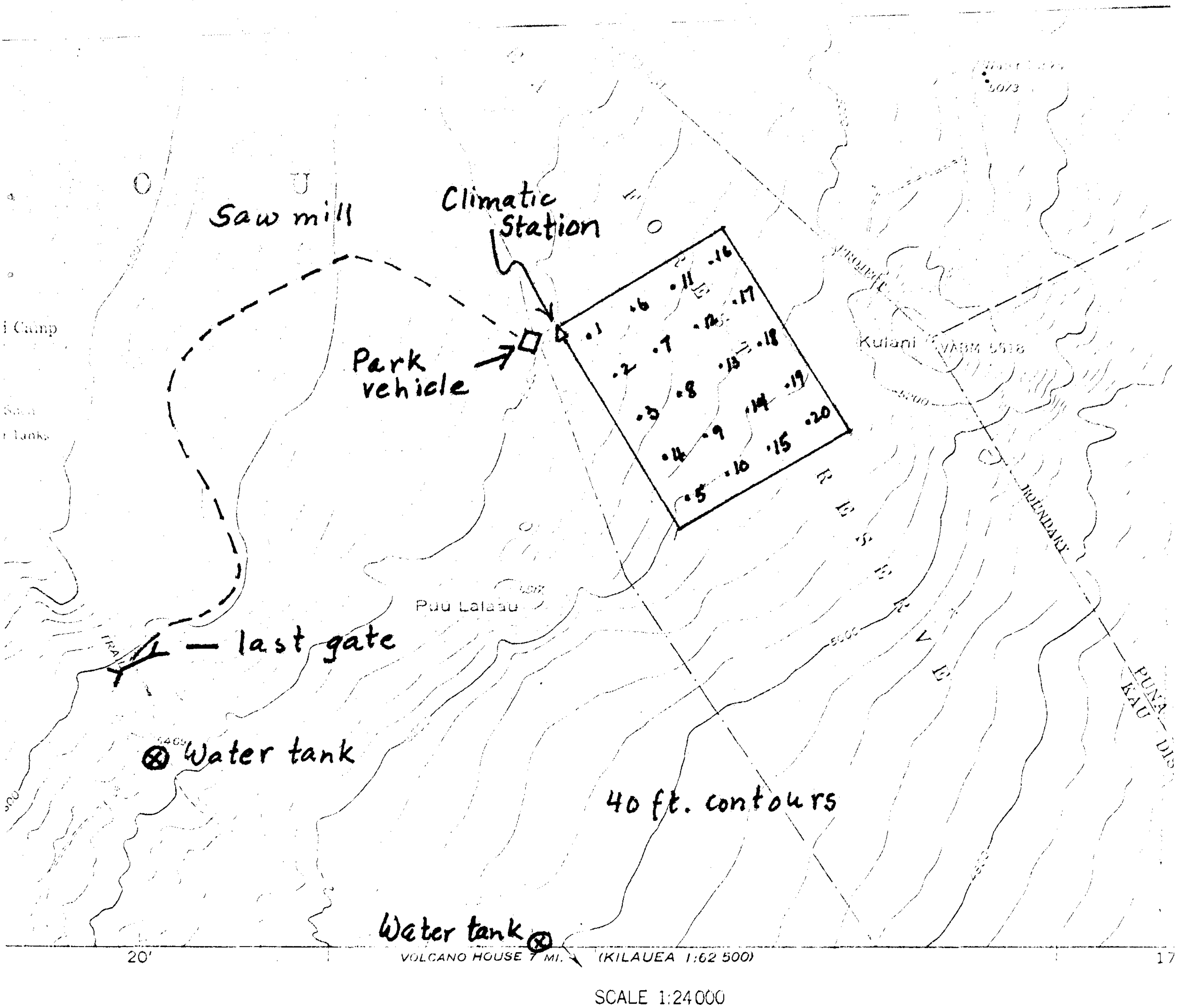


Fig. 1. Map of 200 acre study site (Section of Kulani, Hawaii Topogr. sheet).

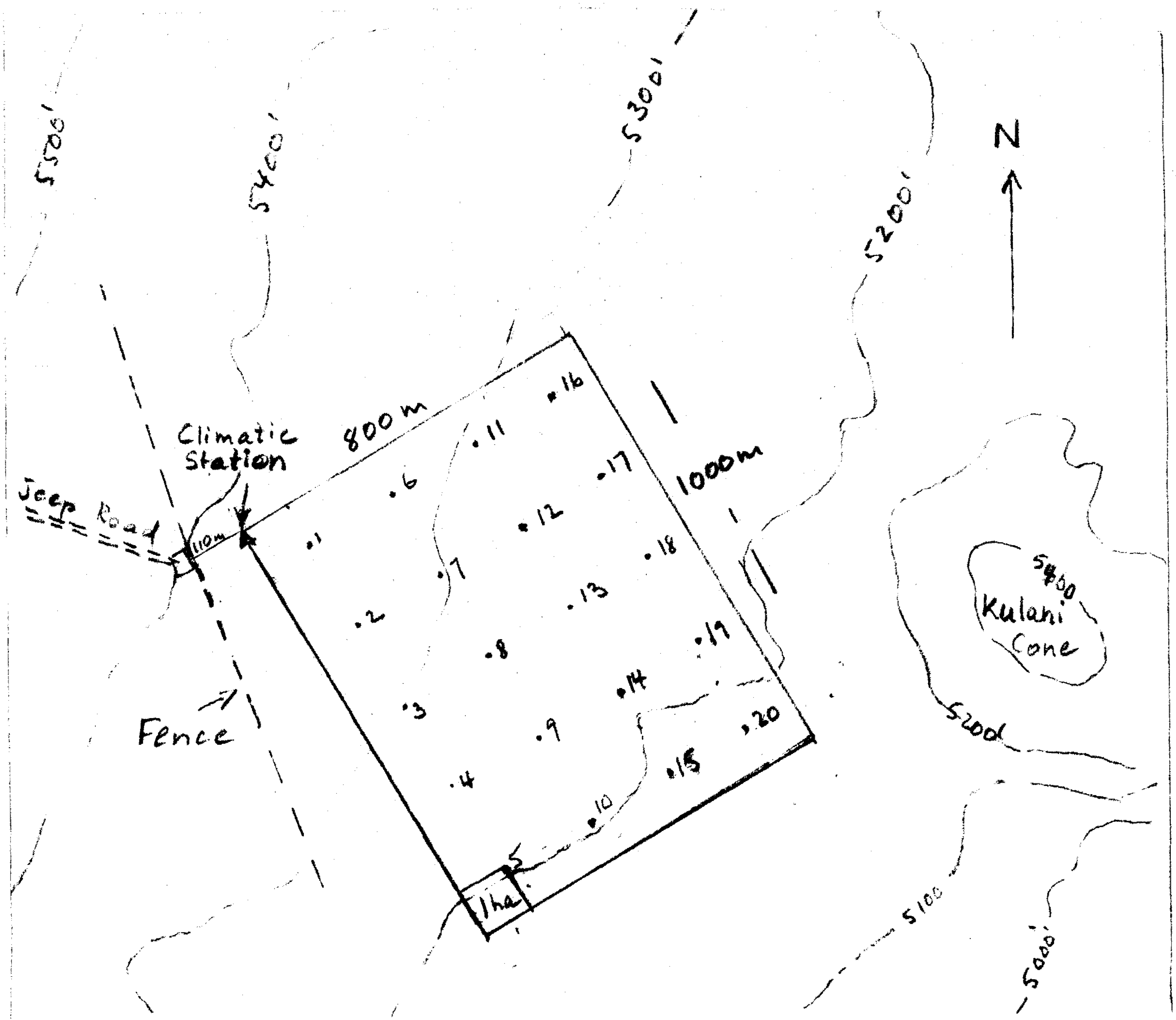


Fig. 2. Map of 200 acre study site (scale 1 : 12,000). Prepared as an overlay on air photo 8-0081 of 1954 series used for 1965 vegetation mapping. For air photo index see "Atlas for bioecology studies in Hawaii Volcanoes National Park", p. 22. (The air photo set is kept in the Research Biology Lab. at Park Headquarters).

So far, Transect 1 has been marked to plot-point 1 and beyond, including the first sample plot. The transect is marked by blue trail-marker tape. An aluminum label, hung on a branch of a tree fern, reading "Start of TR 1" shows the beginning of transect 1 at the 800 m base line. At 100 m from the start of TR 1, red trail-marker tape is hung on a tree fern. Also, two aluminum labels are fastened to this tree fern, one on a branch with copper wire, the other nailed at the base on the tree fern. These aluminum labels read Plot 01 TR 1. The starting points (= plot points) of all other sample plots will be marked in the same way.

Vegetation sampling

From each plot point or starting point the vegetation will be sampled in form of subplots aligned along the 145^{o} transect line. The emergent and co-emergent trees will be sampled additionally by the point-centered quarter method. The cover of koa will be measured on air photographs.

The first subplot is 3 x 5 m in size and lies to the right of the central transect line. The 5 m length starts from the plot point. The second subplot is of the same size and lies to the left of the transect line. Further subplots of the same size (each 3 x 5 m = 15m^2) are added until 10 are sampled at the 25 m point (Fig. 3).

From here on the sample area will normally continue with 6 x 10 m subplots in which only woody plants exceeding 5 m in stem length are enumerated. The overall sample area is variable and depends on the number of enumerations of individuals of trees above 5 m tall. We intend to sample a minimum of 50 in each sample plot. Most plots will be approximately 6 x 200 m = 1200m^2 in overall size. Thus, they cover the entire length from one plot point to the next.

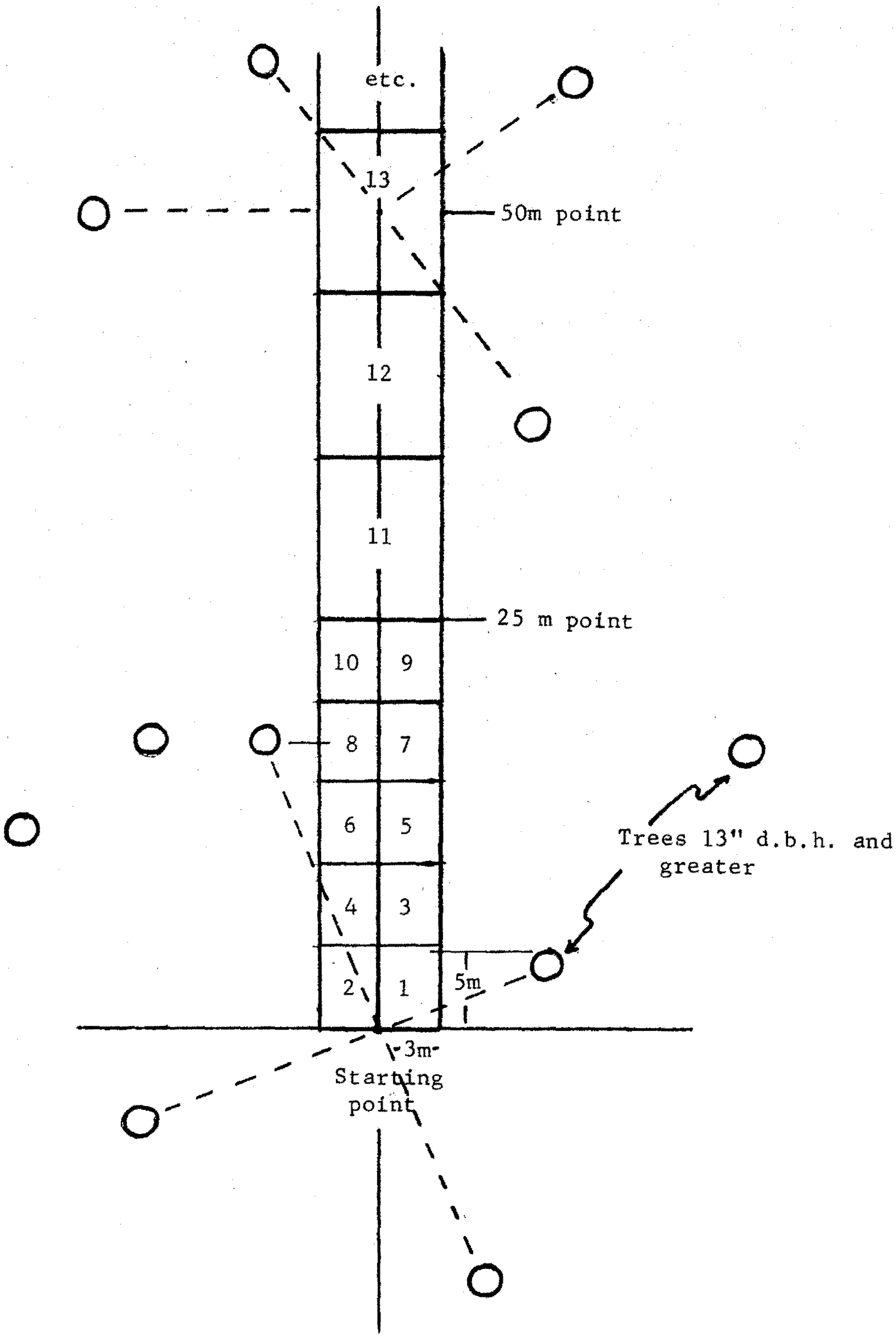


Fig. 3. Sketch of sample transect. At the starting point, 50 m point and 100 m point, measure the distance and diameter of any tree that has a diameter of 13" or greater. (These are considered to be the emergents and co-emergents). Do this for one tree per quarter, i.e. 4 trees per sampling point.

Sample categories

Following is a list of items that will be assessed for each transectal sample stand or relevé.

1. Estimate in % cover separately for each 3 x 5 m subplot of

   (1) bare ground, litter and humus-covered ground

   (2) lying logs and rotting wood

   (3) outcropping rocks

   (4) ground cover by mosses, liverworts and herbaceous plants

2. Mosses and liverworts assessed in the first four 3 x 5 m subplots with Braun-Blanquet rating

   5 = 75% + cover

   4 = 50-75% cover

   3 = 25-50% cover

   2 = 5-25% cover

   1 = 1-5% cover

   + = scattered, up to 1% cover

   r = rare (no significant cover)

3. Epiphytes (only vascular epiphytes) will be checked for presence in 3 height classes, .5-2 m off the ground, 2-5 m off the ground, above 5 m. They will be recorded in 10 subplots of 3 x 5 m resulting in a frequency count out of 10 for each relevé.

4. Ground rooted herbaceous plants (which are primarily ferns in this forest), shrub and tree seedlings (of less than .5 m height) will be assessed in 10 subplots of 3 x 5 m with Braun-Blanquet ratings. This will result in a frequency count of 10 and a mean cover % value for each species for sample areas of $150 m^2$ per relevé.

5. Tree seedlings will be counted in 3 x 5 m subplots to a minimum number of 100 in each relevé; in two classes
   (1) established tree seedlings up to .5m tall
   (2) recent germinants (i.e. not yet considered established, still showing cotyledons and usually less than 10 cm tall). They may be a seasonal phenomenon and thus ephemeral.
6. Count of at least 100 woody plants in 3 x 5 m subplots in 5 stem-length classes up to 5 m.

Class	Range
1	.5 - 1 m
2	1.1 - 2 m
3	2.1 - 3 m
4	3.1 - 4 m
5	4.1 - 5 m

   Stem-length is measured to woody apex. This definition is particularly important for tree ferns. Their fronds extend usually 1.5-2 m beyond their woody apex. Also many are leaning. Height in this group is therefore interpreted as stem length. The expected mean number of woody plants in this site class per subplot is 10. Thus, 100 are usually obtained with 10 subplots on an area of 150m^2.
7. Count of trees above 5 m tall in 2 inch (= 5 cm) diameter classes. Diameter at breast height (d.b.h.) classes for trees exceeding 5 m in height with their woody apex are:

Class range (inches)	Class (inches)	Class (cm)
1 - 2.9	2	5
3 - 4.9	4	10
5 - 6.9	6	15

6 - 8.9	8	20
9 - 10.9	10	25
11 - 12.9	12	30
13 - 14.9	14	35
15-- 16.9	16	40
17 - 18.9	18	45
19 - 20.9	20	50
etc.		

The approximate average expectancy of finding trees above 5 m tall in the 6 m wide sample strip is 10 trees per 50 m in this forest. Thus, for obtaining a minimum number of 40 trees, the sample transect has to usually extend over the entire length of 200 m. But the trees most frequently enumerated will be the smaller diameter classes up to 12 inch (30 cm) d.b.h. classes. Therefore, for obtaining a sufficient sample of the larger diameter classes, which includes particularly the emergent koa trees, an additional, independent tree sample has to be taken for trees of the 14-inch (35 cm) diameter class and greater (i.e. from a lower diameter limit of 13 inches on upwards).

8. Four trees, starting with a lower d.b.h. limit of 13 inches are measured at 3 sampling points in each relevé; at the starting point, the 50 m point and the 100 m point. The 4 trees will be measured, one in each quarter, for their distance from the sampling point and diameter (by 2-inch class). The compass direction of these 4 trees will also be recorded. This increases the tree sample for those exceeding 5 m in length to a minimum of 50 per relevé.

Each tree will be identified as to whether it grows directly on mineral soil (and among rocks) or on fallen logs (and accumulated organic debris). Dead trees (snags) will be recorded separately, but are included in the minimum count of 50 per relevé.

9. Flow diagram. A diagrammatic record of progression will be kept during each relevé analysis.

10. Soil depth (in cm) will be determined by steel probe at every 5 m point.

<u>Summary</u>

Each relevé record will give a total list of plant species (except of epiphytic bryophytes, algae and fungi) in a sample exceeding the "minimal area".

Quantitative records for each species include

(1) frequency for bryophytes out of 4 in each relevé, i.e. out of 80 for the whole area

(2) percent mean cover for bryophytes

(3) frequency for all herbaceous and small woody species (.5m tall), out of 10/relevé or out of 200 for the 200 acre stand

(4) percent mean cover for all herbaceous and small woody species

(5) frequency of vascular epiphytes

(6) count of at least 100 tree seedlings in 2 classes for each relevé, and recorded by substrate type (i.e. mineral soil or rotting wood)

(7) Count of at least 100 woody plants from .5-5 m tall in 5m height or stem-length classes for each relevé

(8) count of an approximate number of 40 trees exceeding 5 m in height in 2-inch d.b.h. classes for each sample transect

(9) 12 distance measures to trees at least 13 inches in diameter from 3 sampling points per relevé. This will include primarily the emergents and co-emergents reaching above the general 10-15 m tall canopy. These trees are mostly koa (reaching up to 25-30 m height).

From these records one can calculate density of all woody plant species per acre (or hectare) and by size classes for an analysis of each species population.

Basal area will be obtained for all tree species exceeding 5 m in height.

Cover will be obtained for the undergrowth species.

Cover of the emergents (koa) will be measured on the 1 : 12,000 air photo.

Cover of the canopy and subcanopy species, mostly tree ferns and ohia (as a group) can be obtained as an approximation by subtracting the cover % of emergents from 100.

The data will be used for

(a) a structural analysis to determine the trends of development of the woody species in the koa-ohia tree fern forest; and,

(b) an analysis of species diversity and stand variation in space.

Example of the 1st relevé follows.

Altitude 5,240 feet

Plot 01 TR 1 Date, Sept. 26/70 Subplot (3 x 5 m)

1. Estimate of ground

	1	2	3	4	5	6	7	8	9	10
rotting logs & wood	45%	25%	20%	20%	5%	80%	2%	2%	1%	1%
humus & mineral soil	54%	74%	79%	80%	80%	19%	73%	73%	98%	96%
rocks	1%	1%	1%	-	15%	1%	25%	25%	1%	3%
herb. & moss cover	40%	24%	20%	21%	5%	60%	7%	25%	1%	.5%

2. Mosses & liverworts (encircle, if not on rotting wood)

	Species	1	2	3	4	
16	Rhizogonium	2	2	2	2	(stopped with 4th subplot)
17	coarse Rhizogonium with capsule	+	+	+	+	
18	Bazzania	1	1	1	1	
19	leafy liverwort	+	+	+	+	
19A	" " (same?)	+	+			
23	blackish fine moss	+	-	?	?	
26	stringy moss	+	+	+	+	
29	fine appressed liverwort	+	+	+	+	
28	fine upright moss (on bare rock)	+	-			
30	Scapania		+	+	+	
31	brown, shiny alga Eurhynchium		+	-	+	
32	blue-green alga				+	

(cont'd.)

	1	2	3	4	5	6	7	8	9	10
3. Epiphytes (check +, for presence)										
Elaphoglossum retic.			+							
Asplenium with dis. lus.			+							
Cheirodendron			+							
Vaccinium calyc.			+							
Rubus hawaiiensis				+	+					
40 Peperomia leptostachya (red lf. underside)					+		+			

(will be done in 3 height-off-ground classes)

4. Ferns and other herbaceous plants and shrub seedlings (up to .5m) (encircle, if not on rotten wood)

Species	1	2	3	4	5	6	7	8	9	10
06 Spine-rachis fern	+	r	-	+	+	+	+	+	-	-
07 Asplenium	r	-	-	-	-	-	-	-	-	-
08 Adenopherus	1	1	+	+	+	+	-	-	+	-
09 Cibotium seedling?	+	+	-	+	-	-	+	+	-	-
11 Small Dryopteris with hairy rhizomes	r	-	-	-	-	+	+	+	-	-
12 hair-rachis fern	r	+	-	-	-	-	-	+	-	-
13 Grammitis hookeri	r	-	+	+	-	+	+	-	-	-
14 Asplenium contiguum	-	-	-	-	-	-	-	-	-	-
20 fern with black sporangia and dark-purple stem	+	+	+	-	-	-	+	+	+	-
22 stout Asplenium	-	-	-	-	-	-	-	-	-	-
24 Asplenium, dissected leaves	-	-	-	-	+	-	+	-	-	-

(concluded)

		1	2	3	4	5	6	7	8	9	10
25	Lycopodium	-	-	-	-	-	-	-	-	-	-
27	filmy Asplenium	r	-	-	-	-	-	-	-	-	-
21	Carex sp.	⊕	+	+	+	⊕	⊕	⊕	⊕	⊕	⊕
	Rubiaceae creeper (with orange berries)	-	+	-	-	-	-	-	-	-	-
03	Vaccinium calyc.	+	+	+	+	+	+	+	+	+	-
04	Rubus hawaiiensis	+	+	+	+	+	+	+	+	+	-
	Broussaisia				+	+	+	-	-	+	-
33	Myrcodium				+	-	-	-	-	-	-
42 or 34	Glabrous grammitis				+	-	-	-	+	-	-
	Pipturus hawaiiensis seedling					+	-	-	-	-	-
	Myrsine lessertiana				+		-	-	-	-	-
	Metrosideros	+	+	+	+	+	+	+	+	+	+
37	Vaccinium calyc.?	+				+	+	+	-	+	-
	Dryopteris paleac.					+	-	+	+	-	-
	Polypodium (v. small)					r	-	-	-	-	-
	Cheirodendron	+	+	+	+	+	+	+	+	-	-
	Pelea					+	+	-	-	-	-
	Acacia koa	-	-	-	r	+	+	+	+	-	-
	Ilex anomala	+	+	+	+		+	+	+	+	-
36	Polypodium pellucidum						+	+	-	-	-
39	Microlepia						⊕	⊕	-	-	-
41	Anaphalis							ⓡ	-	-	-

(continued)

	1	2	3	4	5	6	7	8	9	10
Stenogyne calaminthoides								+	-	-
Cyrtandra lysiosepala								+	-	-
Myoporum seedlings										r
Cibotium splendens	r	-	+							

5. <u>Tree seedlings</u> (up to .5m) <u>Count</u> (encircle if not on rotten wood - note recent germinants extra)

Species	1	2	3	4	5	6	7	8	
05 Metrosideros	15:	⁚⁚	⁚⁚						(dec. to continue counting koa only)
02 Cheirodendron	..	::	⊠						
01 Ilex anomala	::	⁚⁚	⊠:						
15 Acacia koa			.		4	1	1	1	
10 Pelea									
Cibotium	.		..						
Myrsine lessertiana				.					
	22	14	30	1	4	1	1	1	

<u>Tree germinants</u>

	1	2	3	
Metrosideros	19	9	⁚⁚	stopped counting
Cheirodendron			.:.	
Ilex			.:.	
	41	23	41	

(continued)

6. Woody plants and tree ferns from .5m stem-length up in 1m length classes (always to a woody apex).

Count to a minimum of 100 individuals in 5 height or stem-length classes

Height class & species	1	2	3	4	5	6	7	8	9	10
.5-1m.										
Cibotium	::	–..	–..	..	..	.	.	.	.	
Pelea		.					.			
Ilex				.						
Cheirodendron			..		..					
Metrosideros				..	.	∴			..	.
Acacia koa						.				
1-2m										
Cibotium	::	.	..	–..	.	..	.			.
Cheirodendron			.			.			.	
35 Cyrtandra lysiosepala					.		.			
Broussaisia						.				
Myoporum					..		.			
37 Vaccinium					.					
2-3m										
Cibotium	8̄	. 8̄				..	.			
Broussaisia						.				
Vaccinium (new)						.				

(continued)

	1	2	3	4	5	6	7	8	9	10
3-4m										
Cibotium			·· 12	· 11	·	·	9		4	·
4-5m										
Cheirodendron						· 12	9	· 2		3

7. Trees above 5 m height (over first 25 m transect)

Subplot No. and Species*
(note, 3 x 5 m subplots up to 10)

d.b.h.	1	2	3	4	5	6	7	8	9	10
Class	M Ch					M Ch		My	M	
2						·		·	·	
4	··									
6										
8	·					·				
10										
12										
trees/subplot	3					2		1	1	

7 / 150 m^2

(in form leave room for 5 species under each subplot no.; larger diameter classes are also recorded; in form add the classes that come up during the enumeration)

---

* abbreviated by symbols

M = Metrosideros polymorpha
Ch = Cheirodendron trigynum
My = Myoporum sandwicense

I = Ilex anomala
k = Acacia koa

(continued)

7. (continued)

Subplot No. and Species (from 25 to 75 m point)
(note, 6 x 10 m subplots)

d.b.h. Class	11	12 M	12 Ch	12 I	13 M	14 Ch	15 Ch	15 M
2								
4		.	..	.		.	.	
6								
8								.
10								
12					x			
		3			1	1	2	

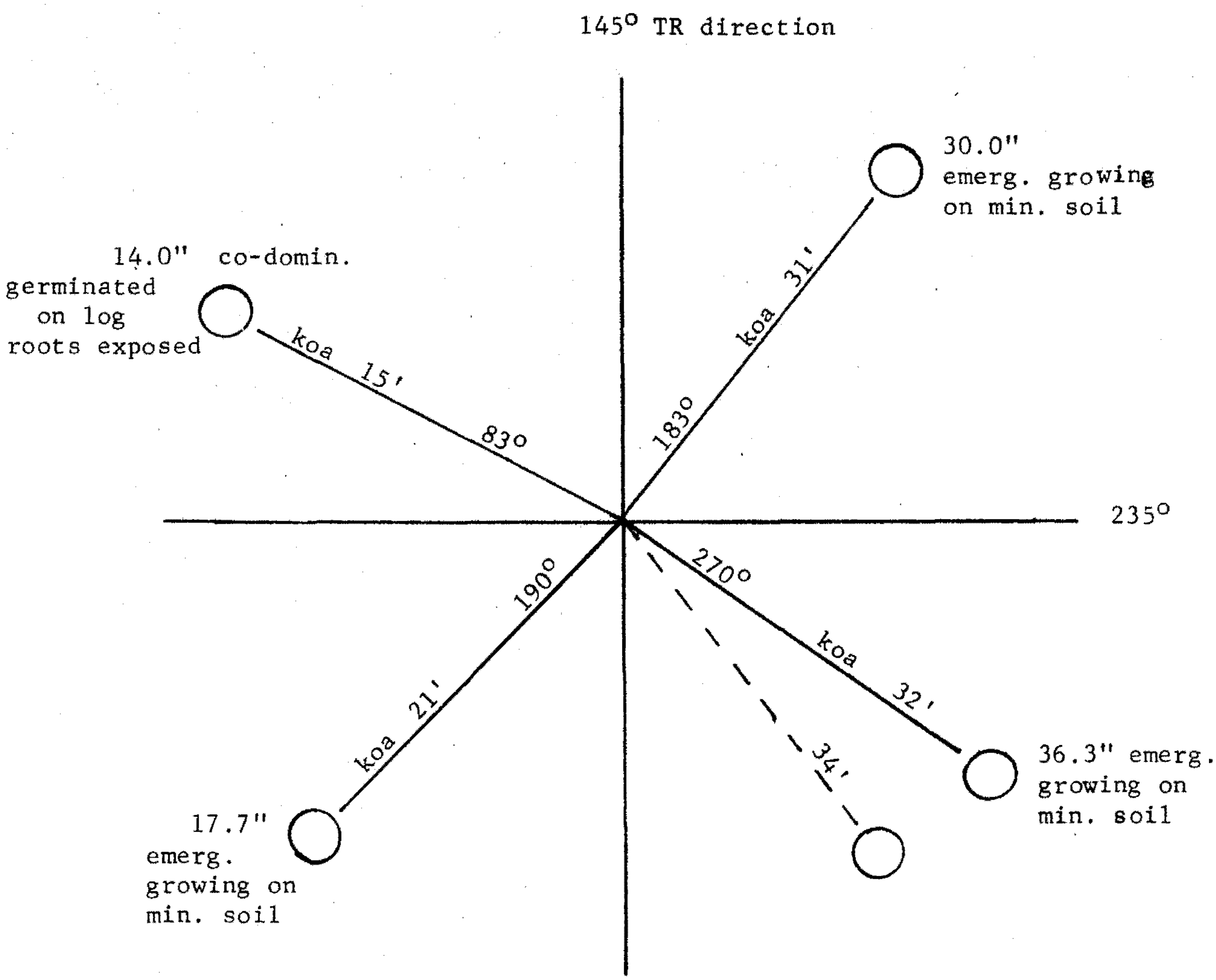
"x" means snag = dead tree

/ note: redo item 7 as we decided at first to sample these trees in 4" d.b.h. classes._ Also record if not growing with stem base on fallen log or pile of rotting wood by encircling, i.e. ⊙ _/

Plot 01 TR 1 Sept. 27/70

8. Four trees above 13" d.b.h. and nearest to sampling point, measured for diameter, distance and direction in four quarters.

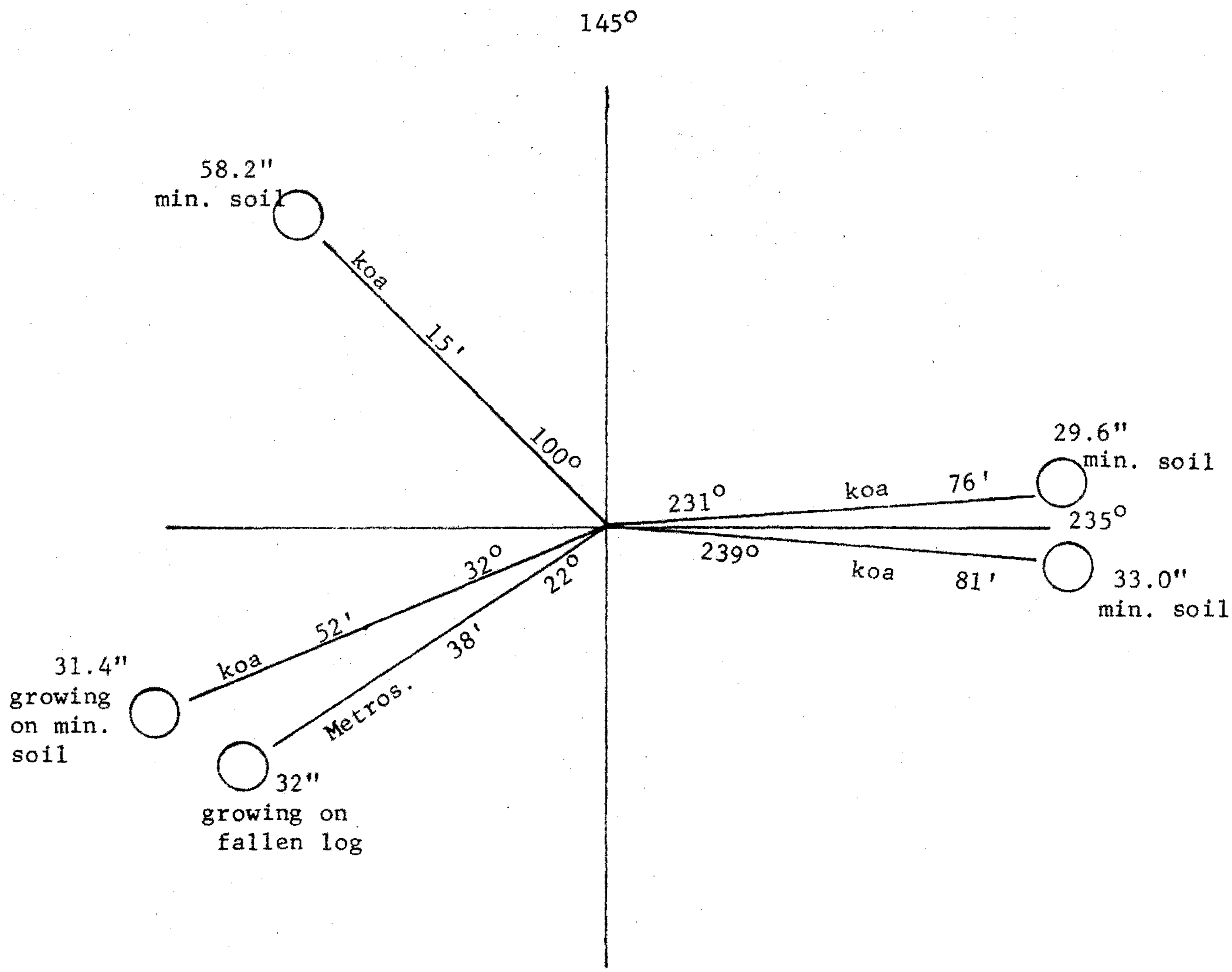
Starting point



Plot 01   TR 1   Sept. 27/70

50 m point

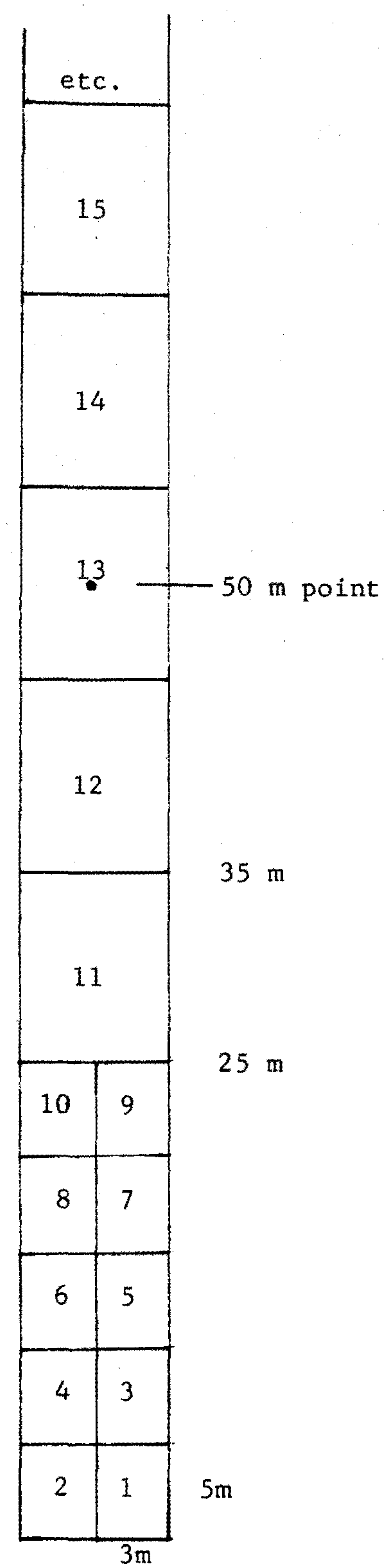
Note: a windfall area here
sev. young koa coming up
on logs



(in future will only use the nearest tree above 13" d.b.h. The choice here falls on Metrosideros in the 2nd quarter).

Plot 01 TR 1 Sept. 26/70

9. Flow diagram and remarks



Starting Pt.

Plot 01

additional plants collected

36 Polypodium pellucidum (outside plot)

43 Riccia type broad-leaved liverwort collected in subplot 7

10. Soil depths samples (not yet taken)

Report on establishment of 7 phenological observation stations.

C.H. Lamoureux
J. Porter

During visit to park on Nov. 21-23, a series of plots were established to form the basis for repeated observations on phenology and growth of Metrosideros. At each plot ten trees were tagged (with orange streamers and numbered aluminum tags), measured for breast height circumferences, and notes on phenology were made. From one tree in each plot cambial samples were taken to determine degree of cambial activity. Observations on phenology will be made and cambial samples will be obtained from now on at approximately monthly intervals. The group of entomologists working on the fauna associated with Metrosideros collected materials from some of the marked trees in several of these plots.

The plots which have been established include:

LOCATION	M-D PLOT #	ALTITUDE (feet)	METROSIDEROS TREES NUMBERED P-
* Base of Holei Pali	32A	600	51-53
* Naulu Forest	5	1700	61-63
Hilina Pali	2 (Near)	2200	131-140
Hilina Pali Rd. (Mauka)	1	3700	121-130
Thurston Lava Tube	4	3950	111-120
Mauna Loa Strip Rd.	18	3900	91-100
Mauna Loa Summit Trail	16	7000	71-80

* Only three trees per plot marked at this time. If current eruption does not cover plots more trees will be selected later.

Additional plots will be established in at least two locations:
a) along the Hilo-Kona Highway in the park at 4025 ft. (M-D Plot 52);
b) along the Mauna Loa Strip Road at 4100 ft. (M-D Plot 62).

On future trips trees of species other than Metrosideros will be marked and sampled periodically in these plots, and additional plots will be established as necessary to include such dominant trees as Acacia koa and Sophora chrysophylla.

During the November trip, some notes were taken on phenology of Sophora between the upper end of the Mauna Loa Strip Road and plot 16, but no individual trees were marked or measured.

Report on fern study. R.M. Lloyd

Four days were spent on the Big Island in order to visit specific areas and choose possible sites for establishment of permanent plots for study. (10/31-11/3,1970). The entire area covered included the volcano area, the south portion of the Chain of Craters Road the the Saddle Road. Four tentative locations for future work were selected. It is expected that two or three more will be added to this list in the future. Those selected are as follows:

1. IBP study area, about 10 miles north of Volcano
2. 1955 lava flow in Puna District on highway 13 at road to Opihikao
3. 1750 lava flow on highway 13, 0.85 miles north of intersection of routes 13 and 137 (at Kaima)
4. 1855 lava flow on Saddle Road, 19.8 miles west of intersection of routes 19 and 20, on route 20.

In addition to site visits, spore collections and herbarium voucher specimens were taken of 33 individuals, representing the major fern species which predominate at each of these locations. These include species of *Nephrolepis*, *Sadleria*, *Polypodium*, *Cibotium*, *Pteridium*, *Dicranopteris*, *Dryopteris*, *Microsorium*, *Asplenium*.

In addition, a visit was made to the fumerol area 300 m~~iles~~ south of Puhimau Crater and a collection of *Schizoloma cordatum* Gaud. was made.

Carolyn Corn
G.C. Ashton

Genecological studies on Metrosideros.

Branch specimens with ripe capsules are being collected for taxonomic identification, seed germination, gel electrophoresis, and progeny tests. Collections so far include plants from windward Hawaii, Maui, and Oahu. Once the fertile seeds from the collected capsules are given light and water, they germinate in 4-6 days. They grow well in diverse substrates, such as laterite, sand, tree fern, sphagnum moss, vermiculite and perlite. The standard soil substrate being used is 1:1:1 sphagnum moss, tree fern, and top soil. The three month old seedlings are growing very slowly, and are about an inch in height. They will soon be large enough to pluck off leaves for gel electrophoresis tests, and are beginning to show individual morphological differences that will be recorded in the progeny tests.

Germination

Branches that have ripe unopened capsules are collected from trees at different elevations. Then each branch is identified according to Rock's revision of the genus. The mature capsules on the branches are air dried until each capsule splits longitudinally along three carpels exposing a multitude of small seeds ranging from 1/2 to 3 mm long. The seeds germinate readily when placed on moist filter paper in petri dishes with a light source. The percent germination for each plant is recorded in figure 1 according to the variety that the seed came from. Individual plants of the same variety exhibit a large amount of variation in their germination. For instance, the most collected variety, typica, has 0 to 74 percent germination. Average germination is indicated by squares, and if additional trees are sampled, average germination per variety may be relatively constant.

In figure 2 the germination of the seeds is plotted according to the elevation that they were collected. The dark circles indicate windward Maui and the open circles indicate windward Hawaii (i.e. Mauna Loa and the Saddle Road) collections. Percentages can vary greatly at one locality, for instance at 4000 feet, 1 to 74 percent germination may be found between trees. The reason for the variation is not known, although further investigations will possibly show a close correlation between the number of flowers blooming per unit area and the number of viable seeds. Average germination at each elevation is indicated by squares. These averages may be smoothed out by using more trees, at $\pm$ 1000 feet elevation from those recorded in the graph. This gives a rather flat line that dips at the upper and lower elevations.

The genus survives from an area just behind the salt spray zone at sea level to 8300 feet on Mauna Loa. Although more samples will have to be otbained from the extreme elevations, the data in figure 2 indicates that Metrosideros is less able to produce numerous offspring at the extreme localities of the Kau Desert (200') and upper Mauna Loa (7500' to 8300'). These areas seem to be marginal spots where the genus is just able to survive and produce a few flowers and viable seeds a year. Precipitation is recorded as 30 to 40 inches a year with an unrecorded amount

Figure 1.

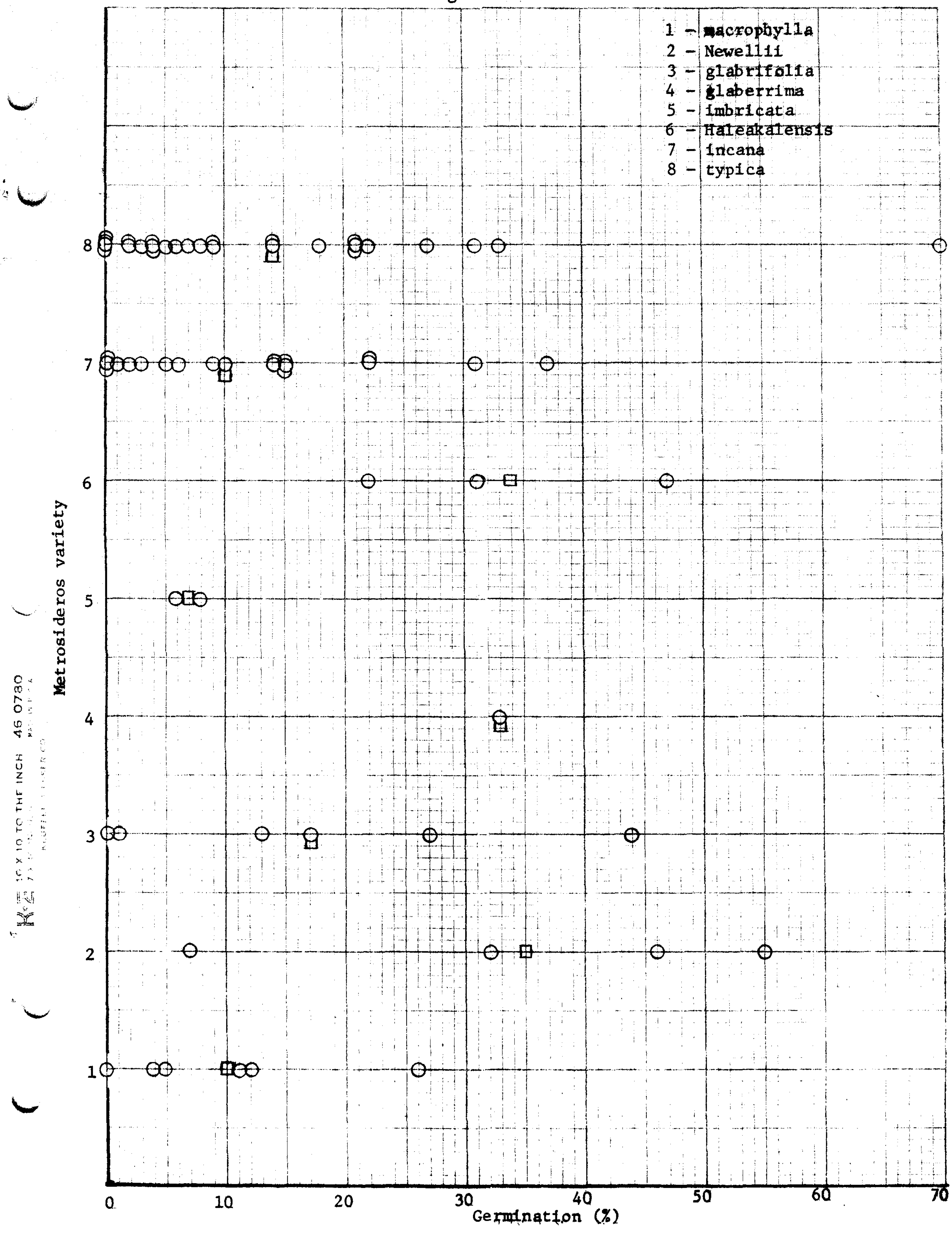
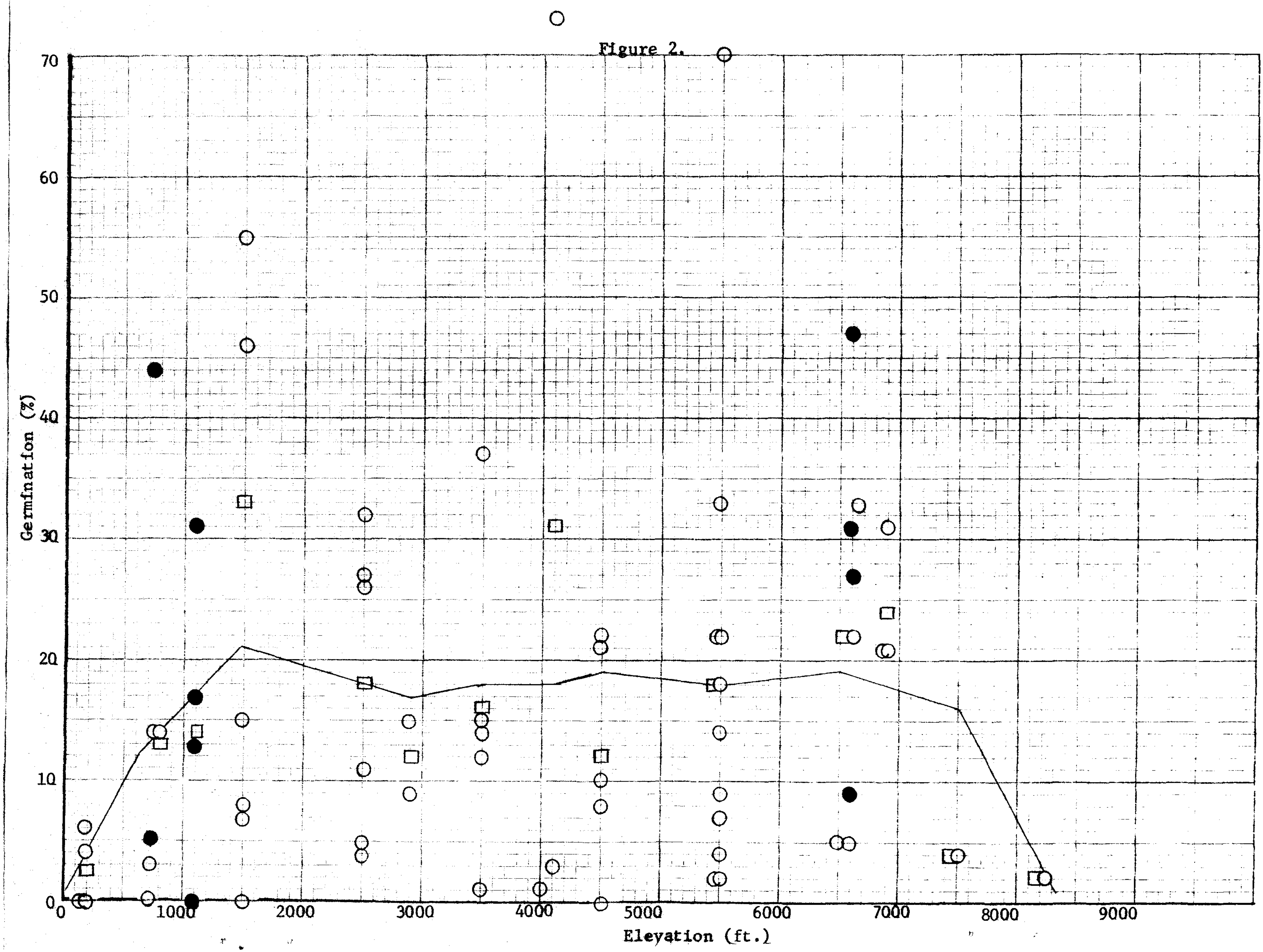

1 - macrophylla
2 - Newellii
3 - glabrifolia
4 - glaberrima
5 - imbricata
6 - Haleakalensis
7 - incana
8 - typica
Metrosideros variety
Germination (%)
0
10
20
30
40
50
60
70
1
2
3
4
5
6
7
8
10 X 10 TO THE INCH 46 0780

Figure 2.



Germination (%)
Elevation (ft.)
0
10
20
30
40
50
60
70
1000
2000
3000
4000
5000
6000
7000
8000
9000

of dew formation and drip at night. Both areas have very little cloud cover and large daily temperature fluctuations. Very few birds frequent these areas and strong winds are common. Here Metrosideros is the only surviving tree species with individuals spaced from 20 to 1500 feet apart.

Pollination

Pollen is found frequently on the stigmas of Metrosideros flowers, yet few observations have been made on how the pollen travels from anther to stigma. Various bird and insects visit the blossoms. Unfortunately in many areas new introduced insects and birds are taking over the pollinating role. For instance, the introduced honeybee Apis mellifica is now the chief pollinator on Oahu and many parts of the outer islands. This makes observations of important native pollinators difficult. Also, many spots in the mature forests are hard to observe since the blossoms are high off the ground with tree fern fronds blocking one's vision. Therefore, my preliminary observations are largely from lava flow areas and ridges where the trees are small and accessible.

On the island of Hawaii very few introduced honeybees are seen along the Chain of Craters Road and Mauna Loa Strip Road. This makes it a good spot for pollination studies. At the two extreme Metrosideros localities, Kau Desert and upper Mauna Loa, very little bird activity is seen. A native bee (Nesoprosopis sp.) gathers nectar in these areas from various flowering species. When the bee lands on a Metrosideros blossom it either lands on the stamens and moves down the style or perches on the side of the flower and probes into the flower's base without rubbing against the anthers. Each flower has a bee visiting it every few minutes when there is clear sky and not too strong a wind. None of the native bees collected had visible pollen attached to their bodies. When these same plants are checked for seed germination they range from 0 to 6 percent germination. These factors indicate that these bees are not effectively pollinating these plants.

On the Palikea-Mauna Kapu Ridge of the Waianae Mountains in Oahu a native wasp, Polistes exclamans, is seen visiting Metrosideros blossoms only on mornings that have full sunlight before 11 AM. The same plants are frequented by the introduced honeybee which also visits these blossoms. However, the honeybee accumulates pollen as well as nectar. The honeybee's surface area is covered with pollen and is undoubtedly a far more effective pollinator than the wasp visitor. On each trip the honeybee moves from flower to flower on the same tree rarely visiting nearby trees. The honeybee's behavior of gathering food from a profusely flowering tree probably is resulting in a large amount of inbreeding in these ohia trees. Before the arrival of these honeybees in 1857, a large amount of flower visits are attributed to the Hawaiian honeycreepers which move from tree to tree gathering food, thereby increasing the chances of outcrossing in the trees they visit. In fact, the honeybee appears to be so effective in its ability to obtain nectar and pollen, it may be robbing the honeycreepers of their food and causing them to decrease in number.

A small amount of pollination may be occurring by wind. The pollen is very sticky which would indicate that it is not wind blown. However, the absence of insect and bird pollinators in extreme elevations; wind causing closely associated flowers to rub together; and the fact that some fertile seeds are being set (0 to 6 percent); makes one suspect that wind plays a small part in the flower's pollination.

If one puts a pollination bag over an inflorescence of buds, no seeds are produced. Also, if the flower is de-staminated and bagged, no seeds are produced. These experiments, plus the fact that a variable percent germination takes place from one tree to the next (0 to 74 percent), makes me suspect that there is little or no apomixes occurring in the genus.

The timing of maturity of the male and female parts plays an important role in the outcrossing of the plant. The stamens and styles are positioned in a way that the stamens mature first, then the style elongates and matures slightly below, at the same height, or slightly above the anthers. This variation in stylar to stamen length gives the plant elasticity in pollination behavior. In good weather the stamens are intact at the time of stylar maturity, although if the weather is rainy the stamens fall off sooner.

Birds are probably the most important factor in Metrosideros pollination within the rainforests. However, no direct observations can be cited yet.

Techniques are presently being worked out for preserving fresh pollen by freezing techniques for later crosses. Also preliminary crosses are being made to establish the exact timing of stamen to stylar maturity. Once these techniques are established, crosses between various varieties will begin.

Transplants and clones

A technique is being sought whereby each variety can be reproduced vegetatively and planted in a common environment with other varieties. However, the genus is difficult to root. Normal horticultural rooting techniques using branches do not work. Also air layering induces callous formation with no root formation. Chemicals, including anti-auxins, are being tried to induce this callous tissue into root formation.

Fire

Metrosideros trees of 35 to 40 feet in height were burned by fire resulting from new lava flows in August. Foresters fighting the fire described the fire as burning along the ground in Andropogon grass then burning up through the occasional trees. A month later the capsules on these trees had dried and split open with the wind actively dispersing the seeds onto the cooling lava. However, no seed germination was obtained when the mature capsules from three burned plants were collected from 3 to 5 feet off the ground. The fire on and next to the lava flow was probably too hot. Seed introductions that will serve as pioneer plants on the lava flow will have to be made from a greater distance away from the flow or from a later crop of seeds produced from those trees that recover from the fire.

References

Fullaway, D.T. and N.L.H. Krauss. 1945. Common Insects of Hawaii. Honolulu.

Neal, Marie C. 1965. In Gardens of Hawaii. Bernice P. Bishop Museum Special Publication 50. Honolulu. 924 pages.

Rock, Joseph F. 1917. The Ohia Lehua Trees of Hawaii. Botanical Bull. 4, Division of Forestry, Honolulu. 76 pages.

First activity report on algae study. M. Doty

I. Two field trips to the major transect area involving six man days' time have been made. In addition major collaborators, e.g., Drs. Malcolm Brown and I.A. Abbott, have inspected the Park area in order to better devise their possible roles.

II. The initial taxonomic work is underway. It was initiated by collection and processing of 60 trappings spaced from +50 feet elevation (the bluff edge) to +6500 feet elevation (upper end of Mauna Loa Truck Trail), several months apart and from the initial 30 of which 41 separate unialgal cultures have been made. Preparations are completed for making another similar lot of isolates from the trappings made on the second field trip.

This work is expected to be completed next year in collaboration with Dr. Malcolm Brown who spent a day in the Park and several days in Honolulu making arrangements for this work. This entailed a special trip to Hawaii by Dr. Brown at no expense to the Hawaii IBP.

III. The techniques for quantitative sampling of the algal communities are being assembled. A sonicator has been obtained for this purpose (it arrived 3.XII.70), and experiments on trapping have led to the second trapping being conducted with much improved results. Further developmental studies are currently underway. Two graduate students may become involved in this; at least they have shown an interest in beginning next semester. A third student is expected to begin next summer.

IV. Planning with Dr. Brown and the graduate students has led to compiling the following budget for our needs during 1971-72. (see "Second-year budget")

Progress report on roles of fungi. Gladys E. Baker

Ecological roles of fungi

In the original proposal the principal investigators emphasized the unique character of the biota in the Hawaiian Archipelago, the islands having served as an area of "spectacular evolution under extreme isolation" (p. 1, Abstract). They further note that Hawaiian endemic forms are unable apparently to compete and survive under the circumstances of current conditions (increased human population, introduced plants and animals), and that we should understand the original native environment in order to use it wisely and preserve it. Toward this end 4 common objectives were given for a number of investigators concerned with different disciplines including mycology (B-8).

To fit mycology into this program more pertinently some rearrangement of ideas expressed in B-8 is necessary, for this statement was prepared while Dr. Baker was on sabbatical leave. Fungi by virture of their constant adaptability, ability to survive for long periods of inactivity, and ease of dissemination do not necessarily provide the best material for a study of speciation and rate of evolution. Finding endemic fungi probably depends on demonstrating their dependence on other endemic organisms. Their role in stabilizing or contributing to fragility of ecosystems is important, as stated in B-8, but if based on parasitism will be difficult to demonstrate unless this is evidence for epiphytotics. A study of parasitism is properly the province of plant pathologists, and it is suggested that such an extension of this program be made sometime.

Variation and differences in fungal populations can be used as indicators for significant trends in the vegetation cover. Among the many fungal habitats related to the vegetation, the phyllosphere and rhizosphere are probably the most important as these would display the closest association with the plants. Air mycota, soil mycota and fungi of the litter zone must be considered but possibly only as contributors to the major populations. In any of these populations it is important to evaluate the members as permanent (living and active) and as transitory species. Soil fungi fluctuate between these two states depending on nutrients available. Those of the litter zone exhibit succession correlated with decay. Phyllosphere fungi show succession correlating with senescence.

Since very little data is available, the program will start with the selection of sites and suitable endemic plants. Comparative studies of the mycota in the phyllosphere and rhizosphere will be in order then for populations characteristic of the endemic plants with those of introduced plants and those in areas exhibiting change in the vegetation cover (cut-over areas, e.g.).

These studies begin officially January 1, 1971, with the appointment of Mr. B.K.H. Lee as research assistant. A "head start" has already been made. Mr. Lee accompanied Dr. Mueller-Dombois and his group to the island of Hawaii September 24-25, 1970. He used Plot 1, Kilauea Forest for samples of soil, litter, dead wood, fern rhizome and living leaves of Cheirodendron sp., Acacia koa, Metrosideros sp. To date, results of analyses show a higher number of species in the soil, but a much more unique mycota in the phyllosphere population.

Since the initiation of this program Dr. Goos has left the University of Hawaii. Therefore, a second research assistant is requested for the seond year as the volume of work involved is too much for one to accomplish successfully.

D. Elmo Hardy
M.D. Delfinado

Progress report on Diptera project.

Because of the shortage of funds this project has been limited to a study of Diptera breeding in fresh water habitats. These environments are extremely important in gaining an understanding of the evolutionary development of the Hawaiian biota. Many remarkable groups of flies have speciated in aquatic habitats and we feel it will be possible to chart their evolutionary development from the primitive marine forms to those which are now restricted to special niches in fresh water streams.

One graduate student, Joaquin Tenorio, is assigned to this project and is using part of the study for his Ph.D. thesis. He is doing a biosystematic study of the Hawaii Ephydridae and has conducted intensive surveys of these flies throughout the Islands (partially supported by IBP). Knowledge gained from these studies should be especially useful for evolutionary studies since a number of endemic species have developed in fresh water and show obvious relationships to marine species. These flies have adapted to a wide assortment of freshwater habitats and have apparently remained remarkably stable compared ot other Diptera, such as Canaceidae which have "invaded" the fresh water streams from the ocean and have speciated by Islands and in some cases by streams in special niches in fast flowing water.

Mr. Tenorio has now recorded 43 species of Ephydridae in Hawaii. He has biological data on approximately half of these and has done detailed biological studies on most of the endemic species. The systematic studies will be incorporated as a chapter in the Insects of Hawaii, vol. 13 Diptera Acalyptratae which is now being prepared.

Under IBP support a survey of the faunas of streams in the Kohala mountains and the Wailuku river, Mauna Kea, Hawaii was made. This was to compare the faunas of streams flowing off the Kohala Mts. (overland streams) with a stream which results from seepage from the rainforest on the mountain (Mauna Kea).

This survey gave much valuable data, we found seven families of flies, represented by at least 17 species living in close association in the fast flowing water and obtained biological data on ca. eight species belonging in three families. Two of the genera, Telmatogeton Schiner and Procanace Hendel (Chironomidae and Ephydridae) are maritime breeders in other parts of the world; living on wave swept rocks along rough seacoasts over much of the world. In Hawaii these have invaded fresh water, have adapted to breeding in fast flowing streams and are very restricted in distribution and habitat.

The Chironomidae are known to have polytene chromosomes so the Telmatogeton should be excellent for genetic studies and it is anticipated that studies of the aquatic Diptera should be extremely important in gaining an understanding of speciation. Preliminary investigation of Neoscatella (Ephydridae) indicate that these have good metaphase chromosomes and genetic technics may be useful in working out the evolutionary development of this group.

Preliminary surveys of the aquatic flies have now been conducted on all of the islands. Now we need to do specific habitat studies in as many of the streams as possible. Techniques need to be worked out for rearing as many of the species as possible. A simulated fast flowing stream habitat has been constructed in the laboratory and it is hoped that we may be successful in bringing materials in from the field and rearing species under laboratory conditions.

We have found to date eight families and at least 30 species of flies associated with fresh water streams in Hawaii. Most of these are native and at least half are undescribed. The preliminary studies have provided data concerning habits and biologies of many of these and much of the ground work has now been laid for doing genetic, and other refined studies, involving the aquatic Diptera.

Progress report on Sciaridae project. W.A. Steffan

One field trip was taken to the Kilauea Forest Reserve study site. The primary purpose of this first trip was to survey the study site in order to determine which sample techniques would be feasible for population studies of Sciaridae.

Four sampling techniques were used and the r esults from each are listed below.

1. The Malaise Trap; since it was up continuously, has yielded the largest number of species and specimens. The first week about 70 Sciaridae were collected, the second week about 80, and the third and fourth weeks combined about 400. Only the first collection has been identified and yielded the following specimens.

   a) *Sciara hoyti* (Hardy)
   b) *Spathobdella setigera* Hardy
   c) *Ctenosciara hawaiiensis* (Hardy)
   d) New species #2 (unplaced)

2. The CDC Miniature Light Traps were set up both in the Kilauea Study Site and in Bird Park. Fewer specimens were taken but they were alive and could be used in the genetic studies. *Bradysia* n. sp. #4 was taken in both areas along with other nematocerous Diptera.

3. The most productive for short sample periods and the most suitable for the conditions found in the Kilauea Study Site was a 1-meter square of unbleached muslin placed on various substrates for 1-2 hours. One sheet yielded over 30 live adults of the 3 species listed below. Note that *Hyperlasion magnesensoria* has not been collected in the Malaise Trap.

   a) *Sciara hoyti* Hardy
   b) *Hyperlasion magnesensoria* (Hardy)
   c) *Spathobdella setigera* Hardy

4. Sweeping yielded only two species, one of which has not been collected as yet by any other method.

   a) *Ctenosciara hawaiiensis* (Hardy)
   b) New species #1 (unplaced)

Laboratory studies have involved culturing as many of the Hawaiian Sciaridae as possible and have been very successful. The following species have been successfully reared for at least one full generation:

1. *Bradysia radicuum* (Brunetti)
2. *Bradysia spatitergum* (Hardy)
3. *Bradysia tritici* (Coquillett)
4. *Bradysia impatiens* (Johannsen)
5. *Bradysia* n. sp. #4
6. *Sciara molokaiensis* Hardy

7. *Scatopsciara nigrita* Hardy
8. *Lycoriella* n. sp. #1
9. *Lycoriella* n. sp. #2
10. *Plastosciara brevicolcorata* Hardy
11. *Plastosciara* sp.
12. *Scythropochroa* n. sp. #1
13. *Hyperlasion magnesensoria* Hardy

Collaboration with other invesigators has been very satisfactory and includes the following participants:

1. Dr. G.E. Baker has agreed to identify the fungi associated with Sciaridae.

2. Dr. Y.K. Paik plans to do population studies of *Bradysia impatiens* and *Bradysia tritici*.

3. Mr. William Steiner will use the Hawaiian Sciaridae for his graduate studies. This will involve biochemical techniques similar to those used by Johnson in his study of *Drosophila* esterases.

4. Dr. D.E. Hardy's Drosophila group has provided several collections of Sciaridae from their field collections.

5. Mr. W.C. Gagné has also provided a large collection of Sciaridae from his field collections.

Interim report, fieldwork on Big Island. J.L. Gressitt

21-22 Nov. participated in general surveys in parts of the Mauna Loa transect.

21 Nov., Plot 32. Sparse Metrosideros on old a'a-pahoehoe areas at 180m. Marked trees by Lamoureux, Nishida-Haramoto. Lower Chain of Craters Road, below lava.
Under bark: silver fish (Thysanura) - 2 adults; some young seen
centipede (Scolopendra ? spinipes) - 2 adults
geckos (dark brown) - 2

Plot 5. Naulu Forest, 1550 m.
Diospyros (dead) trunk: Lepidopt. larva borers (several)
Metrosideros (un. bark): Millipede - 1
Centipede (Scolopendra ?spinipes) - 1
small cockroach - 1
red prostigmatic mite - 2
(on bark): gecko (black) - 1
cockroach parasite (Ampulex) - 1
Aleurites (on bl. buds): small coccinellids (2)
Cocculus (Menispermac.): leaf-miner in leaves - mod. abundant

Plot 33. Below Naulu, mod. sparse Metrosideros-Diospyros forest, 330m
Metrosideros stems: scale insect (wax scale)

Kipuka Ki. Plot 39. 1260m.
Acacia koa: dead fallen branches on road; kept in box at Hdq. house for rearing: contain Diptera and Coleoptera larvae; case-bearing (flat) Lepidoptera larvae; minute adult beetle (?Cucujidae).

22 Nov. Park headquarters vicinity: medium-sized spider on ohia.
Hilina Pali Road near Chain of Craters Road: psyllid in ohia leaf galls abundant
"Hot spot" off Chain of Craters Road: Medium large spider, on fringe
Isopod "
small moths (2 spp.) near center, flying

23, 25 Nov. in Kilauea Forest Reserve study area beyond weather station (lower). (24 Nov. spent on reconnaissance with Bianchi in Kulani Prison area; climbed Kulani Cone tower for view of Kilauea Forest Reserve and environs; went to bulldozed areas, including Twin craters with silted unique lake, etc.; also Army nerve gas experimental area in forest reserve).

Study area: Set up an additional Malaise trap inside forest, at edge of first study quadrat.

Set up 13 sets of attractant logs for cerambycid project along marked (blue) route into study area: (12 sets of 3 each: koa, ohia & naio=Myoporum).

No.	Left or Right of track	Situation	Bait ("3" = koa, ohia & naio)
1	R	Elevated horizontal log-branch, 10m ex "road" before large Mal. trap	3
2	L	On old slender stump	3
3	L	On tree fern	3
4	overhead	Hanging on dead ?ohia	3
5	R	on fallen small koa	3
6	R	on large horizontal log & roots across track	3
7	L	Tree fern	3
	(50 m or more gap; then small Malaise trap; then first orange ribbons)		
8	L	Slender tree, left of track	3
9	R	Hanging from leaning Cheirodendron	3
10	R	On leaning Cheirodendron	3
11	L	Upper branch of log with blue and orange ribbons on log	3
12	R	On Cheirodendron with small koa tree	3
13	L	On horizontal log with blue & orange ribbons hanging	koa & naio only

Rearing: A large carton of naio (Myoporum) branches was sealed up for rearing adults, in garage at house in park.

Maui I.

On 27 November, search was made for cerambycid larvae in Vaccinium and Styphelia on the slope of Haleakala, just below Park boundary. Evidence of old, suspected, cerambycid borings were found in Styphelia. No records exist for these hosts on Maui. One carton each of trunks were set up for rearing adults and left in Haiku.

C-3

Communication letter to Park Superintendent on *Acacia* psyllid infestation, Mauna Loa transect. C.J. Davis

While on an I.B.P. field trip on the Mauna Loa Strip, 22 July 1970, we stopped at the Kipuka Kulalio portion of the I.B.P. transect at approximately 1645 meters.

An extremely heavy infestation of the Acacia psyllid, *Psylla uncatoides* was observed on *Acacia koa*, the first record of this pest in Hawaii Volcanoes National Park. It was doing extensive damage to the terminal growth of koa and I considered it serious enough to warrant weekly observations.

I discussed this pest with your personnel and made arrangements for our Hawaii Resident Entomologist, Ernest Yoshioka, to make these observations. This has been accomplished and on a visit to this locality on 18 August, we were pleased to note almost complete recovery from this pest. Psyllid populations were low but what effect this residual population will have on new terminal growth remains to be seen.

Would it be possible for your staff to make periodic observations and report findings to our Survey Entomologist, Kenneth Kawamura, State Department of Agriculture, Entomology Branch, P.O. Box 5425, Honolulu, Hawaii 96814?

It is possible that natural eaemies of *P. uncatoides* are holding it in check on the Mauna Loa Strip and may be responsible for the koa recovery noted. We have some evidence of this but I do not have a complete report from Ernest Yoshioka of my Hilo staff.

The *Acacia* psyllid was first discovered on Oahu in 1966 and has since spread to Kauai, Maui and Hawaii. It was first observed on the Big Island at Kawaihae Uka, Kohala District on *Acacia koaia*, a rare tree, in March of this year.

For further information see report of Beardsley (C-5).

dated September 1, 1970.

C-4

W. Gagné

Proposed sampling program for IBP transects

The purposes of the sampling techniques outlined below are firstly, some of those in conjunction with Objective 1 (Speciation) for (a) estimates of the numbers and variation in numbers of each species at all defined locations, leading to a dynamic assessment of speciating and non-speciating organisms, such that possible contrasts in seasonal or other types of population size variation may be detected and (b) the study of competition for discerning elements of competition between species. For Objective 2 (Stability and fragility) some of these would be (a) a quantitative assessment of population sizes and (b) for the assignment of the structural position of some Heteroptera within each ecosystem along the transects. In the course of achieving these objectives the raw data for Objective 3 (Biomathematical relationships) would be provided.

It is proposed that the sampling procedure for the Kilauea koa forest to be part of an integrated sampling program on the 2 ecological dominants (ohia and koa) in the Mauna Loa and Mauna Kea transects. Sampling stations will be established in adjacent ohia and koa stands located on lava substrates of different ages such that there will be a cross-section of communities from those newly established on young lava to apparent climax communities. Approximately 5 sites for each species will be selected corresponding roughly to establishment on new substrate, transitional (trees approximately 5 years old and 1 m or higher), canopy closure, young forest and climax forest.

The arthropod fauna will be sampled by spraying the foliage with insecticide and catching the falling arthropods in cloth funnels suspended beneath the trees. A pyrethrin spray, synergized with piperonyl butoxide will be used to provide very fast knockdown with minimal residual effect. The spray will be applied with a gasoline powered, hydraulic sprayer to thoroughly wet the foliage,

The shape and size of the sampling funnels will vary according to the size of the trees to be sampled. In the transitional stages where the branches of the trees are near the ground, a flat sheet approximately $3m^2$ will be used. Ropes will be passed through the perimeter of the sheet and fastened to the trunks. In the closed canopy and young forest stages where the lower branches are several meters above the ground, a funnel $3m^2$ x 1m deep will be fastened to the trunks of 4 trees selected such that roughly a fourth of the crown of each tree will extend over the funnel. Thus each funnel will sample 4 quarters and a complete sample in each stand of these 2 species will consist of approximately 4 funnels in each stand such that a fourth of each of 16 trees respectively, will be sampled. In the oldest stages (climax forest) the funnels used will be $6m^2$ and about 2m deep. These will be attached between 6 trees such that 3 will be on each of 2 sides to provide the same relative sample as that taken in the younger stands.

Sampling will be carried out once a month at each site throughout the year and the same tree will never be sampled more than once a year.

The spray will be applied at dawn before substantial insect activity is underway. Large plant fragments and debris dislodged will be removed before the catch is emptied into covered plastic trays for preliminary sorting at the lab. During the first phase of sorting, specimens to be dry mounted, pinned and etc. for identification will be immediately removed and the rest of the sample will be preserved in IsO-Carnoy such that a record of the chromosome content of the sample will be obtained for studies such as the genetic polymorphism and population genetics of the species obtained, to "kill two birds with one stone" so to speak. As a reference collection is assembled, the need to specially treat unknown species will decrease.

Estimates of sampling error will periodically be made by plastic packaging samples in the field and fumigating them in the lab to provide, by extrapolation some idea of the amount of the sample missed and the type of organisms being overlooked because of the sessile habits or whatever.

Seedling and root sprouting koa and ohia too small to be sampled effectively by the spray technique outlined above, will be examined visually. Those individuals touching a line 100 m long across the sampling area will be so examined and every 10th individual will be uprooted for lab examination of internal root and stem borers, and etc.

To obtain comparative estimates of the insect activity within and into the Kilauea koa stand, Malaise traps will be erected at the edges of the virgin and logged forests and within each.

Exclusion cages will be assembled in each of the communities. In this way the insect community can be removed manually or with the non-residual spray and the dominant phytophages and their predators and parasites can be introduced into the cages in various combinations to gain some numerical assessment of the population dynamics of the phytophages alone and in combination with their suspected controlling agent(s) - for example, the introduced koa psyllid and its suspected mirid predator, a <u>Psallus</u> species, together and separately.

Wherever possible the sampling stations will be established in conjunction with a weather station to maintain correlation with the climatic parameters. Also for comparative purposes, initially a set of koa and ohia sampling stations will be established at roughly the same altitude on the transect on the windward face. It is anticipated that as the program expands and more help is budgeted that a number of such sampling stations will be similarly established throughout both the Mauna Loa and Mauna Kea transects, but with close attention being paid to the physical limits of the operation of a great number of sampling stations. Perhaps, initially, it will be sufficient to set up sampling stations at elevations comparable to the Kilauea koa forest on both transects.

To this sampling proposal I am attaching a preliminary list of the Heteroptera (true bugs) whic occur or which there is good reason for expecting them to occur in the two Big Island transects. I would have liked to have compiled a list of all the insects in these two transects but the task is too immense for one person alone to attempt. It is hoped that each of the entomological investigators will compile such a list for his respective group so that we have at least the rudiments of the fauna that can be expected to be encountered in the course of this sampling program.

List of Insects Occurring in Big Island Transects

TAXON	TRANSECT Mauna Kea	TRANSECT Mauna Loa	BIOLOGY & COMMENTS
HETEROPTERA			
Plataspidae			
*Coptosoma xanthogramma	X	X	Phyt.[1] Legumes: Canvalia, Strongylodon, Erythrina
Cynidae			
*Geotomus pygmaeus	X	X	Terrestrial, among grasses
*Rhytidoporus indentatus	X	X	" "
Pentatomidae			
Oechalia acuta	(X)[2]	X	Pred.[3] Lepidoptera larvae on many hosts.
O. bryani	X	X	ditto,espc. on Sophora and Metrosideros
O. ferruginea		X	ditto,up to 4000'
O. grisea	X	X	" , " ,Metrosideros
O. hirtipes		X	" ,No host plants known.
O. koanohi		X	As for acuta. Grass feeding
O. pacifica	X	X	" " " . Myoporum, Dodonea
Scutelleridae			
Coleotichus blackburniae	X	X	Phyt. Acacia koa
Rhopalidae			
Ithamar hawaiiensis		X	Phyt. Chenopodium, Sida.
Liorhyssus hyalinus	X	X	Phyt. No hosts recorded
Lygaeidae			
*Geocoris pallens	X	X	Pred. on terrestrial insects
Metrarga nuda	X		Phyt. Seeds of Freycinetia
Neseis (Trachynysius) o. ochraisis	(X)	X	Phyt. Seeds of Sophora & Pelea
N.(T.) o. maculiceps		X	Phyt. Seeds of Sophora
N. (T.) f. fasciatus	X	X	Phyt. Seeds of Rubiaceae
N. (T.) hiloensis	X	X	Phyt. Seeds of Pipturus
N. (T.) nitidus comitans	X	X	Phyt. Seeds of Pipturus
N. (T.) n. pipturi	(X)	X	Phyt. Seeds of Pipturus
N. (T.) saudersianus		X	Phyt. Seeds of Urera,Sapindus
N. (T.) whitei		X	Phyt. Seeds of ?
Nesocymus calvus		X	Phyt. Seeds of Carex
Nesomartis psammophila	(X)	(X)	Phyt. Seeds of Eragrostis
Nysius beardsleyi		X	Phyt. Seeds of Dodonea
N. blackburni	X	X	Phyt. Seeds of Amaranthus, Sophora,Dubautia,Clermontia
N. communis	X	X	Phyt. Seeds of numerous hosts
N. deletulus	X		Phyt. Seeds of Dubautia scabra

(continued, next page)

TAXON	TRANSECT Mauna Kea	Mauna Loa	BIOLOGY & COMMENTS
N. kinbergi	(X)	X	Phyt. Seeds of Erigeron
N. mauiensis		X	Phyt. Seeds of ?
N. montivagus		X	Phyt. Seeds of ?
N. lichenicola		X	Phyt. Seeds of Eragrostis
N. longicollis		X	Phyt. Seeds of ?
N. delectus	X		Phyt. Seeds of many hosts.
N coenosulus	X	(X)	Phyt. Seeds of Styphelia
N. rubescens		X	Phyt. Seeds of ?
N. terrestris	(X)	(X)	Phyt. Seeds of Argyroxiphium, Sida, Wikstroemia, Hibiscus, Dubautia, Styphelia, Sophora, Portulaca
Oceanides bryani	X	X	Phyt. Seeds of Euphorbia, Psychotria
O. nimbatus	(X)	X	Phyt. Seeds of Vaccinium (and others)
O. nubicola		X	Phyt. Seeds of Myoporum
O. pteridicola	X	X	Phyt. Seeds of Metrosideros
O. vulcan		X	Phyt. Seeds of ?
*Pachybrachius nigriceps	X	X	Phyt. Seeds of Lythrum
*P. pacificus	X	X	Phyt. Seeds of grasses
Tingidae			
*Teleonemia scupulosa	X	X	Phyt. Sap of Lantana camara
*T. vanduzeei	X	X	Phyt. Sap of Lantana camara
Reduviidae			
*Empiocoris rubromaculatus	(X)	X	Pred. on many arthropods
E. whitei	(X)	X	" "
Nesidiolestes insularis		X	" "
*Ploiaria insolida	(X)	X	" "
*Zelus renardi	(X)	X	" "
Nabidae			
Nabis blackburni	(X)	X	" "
*N. capsiformis	X	X	" "
N. curtipennis	X		" "
N. innotatus		X	" "
N. kahavalu		X	" "
N. kaonohuila		X	" "
N. koelensis		X	" "
N. lusciosus		X	" "
N. oscillans		X	" "
N. pele		X	" "
N. subrufus	X	X	" "
N. tarai	(X)	X	" "
N. vulcanicola		X	" "
Anthocoridae			
Lasiochilus denigratus	X	X	Pred. on many arthropods; on Antidesma, Cibotium, Coprosma

TAXON	TRANSECT Mauna Kea	Mauna Loa	BIOLOGY & COMMENTS
Lasiochilus montivagus		X	Pred. on many arthropods
Orius persequens	X	X	" " ; hemimetabolous insects on many plant
Physopleurella mundula	X	X	Pred. on many arthropods
Xylocoris sp.	X		" in Chenopodium
Miridae			
*Fulvius variegatus	(X)	(X)	" "
*Hyalopeplus pellucidus	X	X	Phyt. many plants (Dodonea)
Kamehameha lunalilo	X	X	Pred.? predominately on ferns
Koanoa hawaiiensis	X	X	Pred. on many arhtropods, some under bark
Nesidiorchestes n. spp.	(X)	X	Pred.? predominately in leaf litter
Nesiomiris hawaiiensis	X	X	Phyt, sap of Ilex anomala
N. n. spp.	X	X	Phyt. sap of native Araliaceae
Orthotylus spp.	X	X	Phyt. sap of many native plant particularly Rubiaceae, Pipturus, Sophora
Psallus iolani		X	(?Gen arthropod predator, host specific)
P. kanakanus		X	" "
P. kassandra		X	" "
P. kirkaldyi		X	" "
Pseudoclerada kilaueae		X	(?Gen arthropod predator, mossy trunks of native plants
P. morai	(X)	(X)	" "
*Rhinocloa forticornis	X	X	Gen. arthropod predator on native & introduced plants
Sarona adonias	X	X	Phyt. sap of Metrosideros
S. n. spp.	X	X	Phyt. sap of Pipturus, Pelea, Myoporum
Sulamita dryas		X	Phyt. sap of ?
S, lunalilo		X	Phyt. sap of Freycinetia, Fagara
S. n. spp.	X	X	Phyt. sap of sev. other native plants
Trigonotylus (hawaiiensis)	X	X	Phyt. sap of native grasses
Veliidae			
*Microvelia vagans	X	X	Pred. arthropods on surface of pools and streams
Hebridae			
*Merragata hebroides	X	X	" "
Saldidae			
Saldula oahuensis	(X)	X	Pred. on arthropods along stream
Saldula sp.	X	X	Pred. on arthropods on mossy tree trunks in rain forest
Corixidae			
*Trichocorixa reticulata	X	X	Phyt. on aquatic algae

* Introduced or probably so.
1 Phytophagous.
2 Bracketed material indicates probability of being so indicated.
3 Predaceous.

C-5

Progress report on effects of sap-sucking Homoptera on Hawaiian ecosystems.

J.W. Beardsley

Since work on this research topic was initiated during June 1970, we have concentrated on the ecology and population dynamics of Homoptera which feed on Acacia koa, particularly the Acacia psyllid, Psylla uncatoides (Ferris and Klyver). Most of thework was conducted on the Mauna Loa transect in Hawaii Volcanoes National Park. Some supplementary observations were made in the Koolau Mountains on Oahu.

Psylla uncatoides is a recent accidental introduction into the Hawaiian Islands. It was first discovered on Oahu in 1966 and on Hawaii in Mar.,1970. Very heavy populations have been observed on Acacia species, including the endemic A. koa. The recent advent of this insect in Hawaii and its potential for developing large and damaging populations appear to make this species an ideal subject for a study of the impact of an introduced organism on an important element of the endemic biota.

Three sampling sites were selected in the Koa-savannah and mountain parkland sections of the transect, at altitudes of 4,300 ft., 5,300 ft. and 6,600 ft. respectively. The upper site is at the upper limit of koa growth in this region. Samples of koa terminals were taken at each sample site at intervals of approximately six weeks, beginning on July 22. As the koa psyllid breeds only on young phyllodes and juvenile foliage, the outer four inches of twigs with young leaves was selected as the sampling unit. Ten randomly selected terminals were bagged and cut at each sample site, and brought to Honolulu, where all stages of psyllids, as well as other insects, were counted.

Results

At the time of the initial survey field trip on July 22, koa psyllid populatinns were extremely high at all three sites. Although only three samples were actually collected and counted at that time,these averaged about 43 adults, 227 nymphs and 419 eggs per sample. These populations appeared to represent an initial population explosion of the psyllid following its invasion of the Island of Hawaii. By August 26, when the first complete sampling was made, populations had declined drastically. At this time virtually all koa twigs exhibited a dieback of the terminal three to six inches, which is believed to have been caused by psyllid feeding during the initial outbreak. Two subsequent samples taken on October 7 and November 16 respectively, showed a moderate to slight resurgence of psyllid populations on new growth put forth following the initial dieback. It is of interest that this resurgence of psyllid populations was greatest at the highest site (6,600 feet) and least at the lowest site (4,300 feet). To date these resurgent populations have remained at a relatively low level, approximately 1/5 to 1/30 of the outbreak levels observed in July.

No evidence of insect parasites of the psyllid was found. A number of predator species were found feeding on psyllid eggs and nymphs. These included larvae of several introduced and endemic species of Neuroptera, and larvae and adults of one introduced coccinellid beetle. These species have been identified, but we are not yet able to evaluate their effectiveness.

T. Nishida
F.H. Haramoto
L. Nakahara

Progress report on faunal research on *Metrosideros*.

Studies to date have been limited to working out sampling methods and to the selection of sampling sites so that the desired information on the fauna of *Metrosideros* could be obtained most efficiently and economically. Various extraction methods such as washing, beating, brushing, and flotation have been tried, but extraction by means of Tullgren funnels has proven most fruitful in sampling most of the arthropods that live on the aerial parts of *Metrosideros*. A battery of 30 Tullgren funnels was assembled and used to extract the arthropods from *Metrosideros* twig and bark samples collected on November 21-22, 1970 from six plots located at different elevations on the southeast slope of Mauna Loa on Hawaii.

A twig sample consisted of 10 terminal branches per tree and three such samples were taken from each plot. A bark sample consisted of about 200 gm of material scraped from the trunk per tree and three such samples were taken from each plot. Each sample was placed in a Tullgren funnel and allowed to dry under a 40-Watt electric bulb for four days. The bark and twig samples were collected from one variety of *Metrosideros*, *M. collina* var. *incanna*, from each of the six sampling sites on a transect 600, 1700, 3600, 3800, 4000, and 7000 feet above sea level on the southeast slope of Mauna Loa. Examination of some of the extracts of the Tullgren funnels has revealed that there exists a rich fauna of arhtropods on the aerial parts of *Metrosideros*. For example, from one of the bark samples obtained from a tree at 3700 ft. elevation 773 specimens of arthropods representing at least 30 different species were extracted. Among the most numerous of the arhtropods were mites of the suborder Cryptostigmata. Of the total arthropods, 631 of them were cryptostigmatic mites of the families Nanhermanniidae, Achipteriidae, Euphthiracaridae, Phthiracaridae, Galumnidae, Cerotizetidae, and Trhypochthoniidae. From the twig sample from the same tree , 138 specimens of arthropods were extracted and once again mites made up more than 50% of the fauna. Of particular interest was the presence of so many cryptostigmatic mites so high up in the tree. These mites are normally soil-inhabiting organisms.

Most of the species extracted from the bark and twig samples were not pests of *Metrosideros* but were species normally found in close association with lichens,mosses, and fungi. The more important phytophagous arthropods found feeding directly on *Metrosideros* were mealybugs, eriophyid mites, and gall-forming psyllids. Another interesting group of arthropods that occurred in large numbers was the predaceous mites and insects.

C-9(1)

Progress report on soil and duff inhabiting arthropods and vertebrate parasites.

F.J. Radovsky

A. Soil and Duff

1. Field studies and collections

Field work was conducted on the island of Hawaii on 14-18 June (F.J. Radovsky and M.L. Goff), 21-22 July (F.J.R., IBP Orientation trip), and 19-22 October (M.L.G.), of 1970. A total of 87 samples were taken, principally on or near the Mauna Loa transect from 3280 to 8200 ft. (1000-2500 m) and the Mauna Kea transect from 460 to 9250 ft. (140-2820 m). Wherever possible, these were associated with transect zones, dominants in the vegetational community, and plants forming the duff samples taken. Most samples were duff or soft humus. When we begin sampling deeper zones and primarily mineral soils, it may be necessary to use flotation and/or agitation techniques, in addition to Berlese funnels, for recovery of arthropods.

Collections made from fumaroles have yielded mites and insects. Collembola were recovered from a sample for which an in situ temperature of 78°C was recorded with a mercury bulb thermometer. It is essential that we obtain equipment to provide accurate point source measurements of sample temperatures for future studies.

2. Processing and identification

All collected samples have been extracted in Berlese funnels. The funnels have smooth flat inner surfaces and drying was by equilibration with room atmosphere with moderate RH, rather than by a heat source. Both factors tend to increase the percentage of arthropod recovery. Arhtropods were sorted into general groups (Mesostigmata, Oribatei, Coleoptera, Collembola, other apterygotes, etc.). Oribatei, forming a major component of the fauna, have been forwarded to Dr. Sengbusch. Other Acarina are being mounted at the Bishop Museum. Preliminary sorting to family and in some cases to genus has been started.

Contacting other specialists was delayed because of the absence of Radovsky in September and October on overseas work, but this will be recommenced immediately.

B. Parasites of Vertebrates

1. Field studies and collections

Vertebrates were collected for parasite recovery on the 14-18 June and 19-22 October trips referred to above. Mammals collected were *Mus musculus* (11), *Rattus rattus* (7), *R. norvegicus* (9), *R. exulans* (15), and *Herpestes auropunctatus* (3). In addition to brushing for ectoparasites, a part of each series of hosts was washed individually in detergent solution; this technique yields fur mites, and other parasites when present, that are usually missed by brushing.

A permit has been obtained from the Division of Fish and Game to collect Hawaiian land birds, including small numbers of the 3 commonest endemic drepanids and the one endemic flycatcher. Collecting will be done in an area outside Volcanoes National Park. Dr. Berger loaned us approximately 15 specimens of endemic birds in liquid preservative. At least 3 species of feather mites and 1 species of nasal mites were obtained from them. Six bird nests just collected on Hawaii and Oahu within a few days of being vacated and 6 others that had been held for several weeks or months, including several of native birds, were processed in Berlese funnels and a number of parasites recovered.

2. Processing and identification

All of the collected parasites have been sorted and series mounted. These have been identified to family and the species from endemic birds to genus or species.

<u>Plan of next work</u> C-9(2)

Arthropod fauna of soil and duff; parasites of vertebrates

Qualitative and quantitative studies will be conducted on the arthropod faunal composition of soil and duff, in relation to substrate type, vegetational origin and association, age, altitude, proximity and microclimatic influence of volcanic activity, etc. While comparative data will be obtained from other islands and areas, the main emphasis will be on the established transects on the island of Hawaii. This will permit maximum utilization of data obtained by others in interpreting results and will provide information of most use to investigators working on other phases of the project, including synthesis of general conclusions. Because the habitat has received little attention in the past, considerable effort initially will be directed toward qualitative sampling and basic systematic studies. The collaboration of many specialists will be needed to carry out this primary phase. The overall objectives are to obtain knowledge of (1) species composition of arthropods associated with different soils and leaf litters in Hawaii; (2) succession of arthropods in soils of volcanic origin, relative to species requirements and effect of arthropods on the substrate; (3) extremes of temperature tolerance among arthropods colonizing substrates influenced by volcanic activity (fumaroles, etc.); (4) evolution of selected groups in the archipelago; (5) physical and biotic factors influencing habitat specificity; (6) respective roles of specificity and natural barriers in isolation and speciation. These objectives closely correlate with the 4 principal objectives of the Hawaii Subprogram.

The basis for the second part of this project, concerning parasites of vertebrates, was outlined in the original proposal (C-9). Arthropod parasites will be emphasized, and other parasites will be collected in conjunction with research projects of collaborating scientists (Gordon Wallace on <u>Toxoplasma</u>, J. Frankel on <u>Sarcocystis</u>, at present).

C-9(1)

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Plan of next work C-9(2)

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These 2 subjects are combined because they can be most conveniently administered as a single project and because combined field work is practical. Collection of vertebrates, removal of parasites, and preparing vertebrates for identification and permanent reference requires considerable effort in the field. Collection of soil and duff samples for Berlese extraction can be done in a relatively short time, even when it is essential that quantities be determined, precise collection data recorded, and physical parameters measured. Extraction of arthropods from nests can be carried out with the same techniques used on soil samples. Sorting and processing of arthropods from soil or from vertebrate hosts involves the same or similar methods. Some of the participating specialists, particularly for Acarina, work on both free-living and parasitic groups.

Report on IBP field trips to Hawaii. A.J. Berger

This report covers the two trips I have made on the IBP project since its funding last June. I took part in the general survey led by Mueller-Dombois on July 21-24, and with the smaller group on Nov. 20-22,1970.

The birds of Volcanoes National Park are relatively well known because of the work done there by Paul Baldwin, William Dunmire, and other park naturalists during the past 30 years. There have been some notable changes in numbers and species of birds between 1940 and 1970, but there have been few census studies published during the past decade. Some of the rarer species found in the 1940's apparently no longer occur in the Park.

As for the transects and study plots within Volcanoes Park, very few native birds are found as high as 8,000 feet. I saw three Hawaii Amakihi (Loxops virens) at 8,000 feet on July 22, 1970, but at that time of year, the birds very likely were merely moving through the area. Don Reeser and Patrick Crosland of the Park Service and Winston Banko of the Rare and Endangered Species Program reported that in the past, they had seen the Hawaiian Thrush at elevations between 7,000 and 9,000 feet on the trail to the summit of Mauna Loa. I neither saw nor heard any thrushes on July 22, 1970. Two introduced species of birds (Japanese White-eye and Red-billed Leiothrix) occur from below Park Headquarters (3,800 feet) to at least 7,500 feet elevation.

The prime habitat for native birds within the Volcanoes National Park is in the vicinity of Thurston Lava Tube and similar high-rain areas. The number of native birds drops off rapidly as soon as one passes through the transition area between the rain forest (e.g., at Thurston Lava Tube) and the summer dry area (e.g., the 1938 "hotspot" region). I saw only two species of native birds (Apapane and Amakihi) in that area on Nov. 22, 1970.

The Hawaii Amakihi has the widest range of any native bird species within the Park. I have found it at elevations from 8,000 feet downward to about 1,800 feet at the Naulu picnic area on the Chain of Craters Road.

Paul Baldwin did his Ph.D. thesis on the three most common drepanids (Apapane, Iiwi, and Amakihi) in Volcanoes National Park. Although it would, of course, be possible to do further work on these three species within the Park, there are far more challenging and important studies that should be made on the breeding biology and the ecological relationships of the endemic birds in areas outside of the Park, on Maui and on Kauai.

The Kilauea Forest Reserve (Bishop Estate Land) is one of the finest native forests I have seen on the Big Island, and, in my opinion, everything possible should be done to preserve it intact. Whether or not this proves to be possible, the area should be studied intensively, according to plans of Mueller-Dombois. The period from July to November is the poorest time of the year to study the endemic birds, especially with regards to obtaining fairly accurate census data. I intend, therefore, to devote considerable energy in this area with my Research Assistant during January through June.

Despite the fact that many endemic birds apparently are in the post-breeding, molting period during the general period from July to November, a large number of thrushes was singing in this forest on July 23 and on November 20, 1970. This forest undoubtedly supports as high a concentration of thrushes as any other area in Hawaii. Elepaio, Apapane, and Amakihi also are present in good numbers. Thus far I have seen two species of introduced birds in the Kilauea Forest Reserve: White-eye and Leiothrix, and I have found nests of both species there.

A surprising discovery on November 21, 1970, was the sighting of a single Cattle Egret along the Chain of Craters Road at an elevation of about 900 feet.

Field trips during the coming months should provide more precise information on population sizes within the study plots and undoubtedly will reveal the presence of other species of native birds.

D-1

Preliminary Status of Native Birds, Kilauea Koa Forest,[1]
Kau District, Island of Hawaii
(List compiled by Winston Banko, Biologist, Hawaii National Park, Oct.1970)

1. Hawaiian Hawk (Buteo solitarius)

   Found only on Island of Hawaii. Populations are apparently declining. Resident in Kilauea Koa Forest, but rare. Species listed as endangered by U.S. Department of Interior.

2. Hawaii Thrush (Phaeornis obscurus obscurus)

   Found only on Islnd of Hawaii where a widespread population exists. In Kilauea Koa Forest it is locally abundant in undisturbed areas, common to rare elsewhere.

3. Hawaii Elepaio (Chasiempis sandwichensis sandwichensis)

   Found only on Island of Hawaii where populations are widespread. In Kilauea Koa Forest this race is locally abundant in undisturbed areas, common to rare elsewhere.

4. Hawaii O-o (Moho nobilis)

   Formerly found only Island of Hawaii. Now thought extinct. Once presumably resident in Kilauea Koa Forest.

5. Hawaii Amakihi (Loxops virens virens)

   Found only on Island of Hawaii where populations are widespread. In Kilauea Koa Forest, Hawaii Amakihis are locally abundant in some areas, common to rare elsewhere.

6. Hawaii Creeper (Loxops maculata mana)

   Found on Island of Hawaii where status is unclear. Resident in Kilauea Koa Forest. This bird is a potential candidate for U.S.D.I.'s list of endangered species.

7. Hawaii Akepa (Loxops coccinea coccinea)

   Found only on Island of Hawaii. Populations apparently declining. Resident in Kilauea Koa Forest. Hawaii Akepa is included in proposed revision of U.S.D.I.'s list of endangered species.

8. Hawaii Akialoa (Hemignathus obscurus obscurus)

   Formerly found only on the Island of Hawaii. Now thought extinct. Once resident in Kilauea Koa Forest.

9. Akiopolaau (Hemignathus wilsoni)

   Found only on the Island of Hawaii. Once abundant and widespread. Resident in Kilauea Koa Forest, but rare. Listed by U.S.D.I. as an endangered species.

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1. Includes koa forest common to Kilauea Forest Reserve and land

10. Ou (<u>Psittirostra psittacea</u>)

    Once common on all the major islands. Now found rarely only on Kauai and Hawaii. Formerly in Kilauea Koa Forest where current status is uncertain. Listed by U.S.D.I. as an endangered species.

11. Greater Koa finch (<u>Psittirostra palmeri</u>)

    Formerly found only on the Island of Hawaii. Now thought extinct. Once resident in Kilauea Koa Forest.

12. Apapane (<u>Himatione sanguinea sanguinea</u>)

    Formerly very abundant on all major islands. Now absent from Lanai and rare on Molokai. The most numerous bird in Kilauea Koa Forest today.

13. Iiwi (<u>Vestiaria coccinea</u>)

    Formerly found on all major islands, now apparently extinct on Molokai and Lanai. Widespread though not abundant resident of Kilauea Koa Forest.

14. Mamo (<u>Drepanis pacifica</u>)

    Formerly found only on Island of Hawaii. Now thought extinct. Once presumably resident in Kilauea Koa Forest.

D-2

Sampling plan for the roof rat, _Rattus rattus_,
in the Kilauea koa-ohia-tree fern forest.
(see report B-2)

P. Quentin Tomich

A sampling program for the roof rat, _Rattus rattus_, is suggested to coincide with the layout for the comprehensive plant ecological survey in the koa-ohia-tree fern forest.

Quarterly trapping with 80 live traps in two lines of 40 traps each, with trap spacing at 15 m and traps run for 3 consecutive nights, should be adequate. The lines should be run on separate transects, for example, Stations 1-4 and 12-15; in the following quarter, 7-10 and 16-19. In this manner no area would be trapped more frequently than once in 6 months.

A supply of 200 traps will provide 40 spares. Traps should be numbered for easy reference to trap site, and can be hung on trees when not in use. Fresh coconut is recommended for bait. Rats caught can be marked and released, which may be preferred, or removed, depending on the needs of the individual investigators. If food preferences of rats are to be studied, snap traps will be needed, to kill the rats on capture.

REFERENCES CITED

Atkinson, I.A.E. 1969. Rates of ecosystem development on some Hawaiian lava flows. Ph.D. thesis, University of Hawaii. 197 pages.

Doty, M.S. and D. Mueller-Dombois. 1966. Atlas for bioecology studies in Hawaii Volcanoes National Park. Univ. of Hawaii. Botanical Science Paper No. 2. 507 pages.

Mueller-Dombois, D. 1967. Ecological relations in the alpine and sub-alpine vegetation on Mauna Loa, Hawaii. J. of Indian Bot. Soc. 56(4): 403-11.

Mueller-Dombois, D. and V.J. Krajina. 1968. Comparison of east-flank vegetations on Mauna Loa and Mauna Kea, Hawaii. Proc. Symp. Recent. Adv. Trop. Ecol. 2: 508-520.

Smathers, G.A. 1967. A preliminary survey of the phytogeography of Kipahulu Valley. In Scientific Report of the Kipahulu Valley Expedition. R.E. Warner, Ed. Chapt. 4. (Topographic vegetation profile, p. 180-81).

Proposed IBP Grant Budget, 02 Year, 1971-72

BUDGET SUMMARY

		Requested from NSF	Institution Contribution
I.	University of Hawaii	$ 321,828	$ 59,066
II.	B. P. Bishop Museum	$ 136,402	$ 20,075
	TOTAL REQUESTED	$ 458,230	$ 79,141

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

SUMMARY

		NSF Funded Man Months			UH Funded Man Months			PROPOSED	
		Cal	Acad	Sum	Cal	Acad	Sum	NSF	UH
A.	SALARIES AND WAGES								
	1. Principal Investigator & Fac. Assoc.								
	2 Co-principal investigators		5	4		5		17,879	12,376
	18 Senior Personnel	3		12	11	8		24,153	37,293
	Sub-Total							42,032	49,669
	2. Other Personnel								
	5 Research Associates			6				8,942	
	2 Asst. Researchers	24						22,464	
	1 Junior Researcher	6						4,614	
	1 Technician	12						10,380	
	1 Asst. in Research	6						5,025	
	15 Graduate Assistants		75	15				68,730	
	Student Help							15,600	
	Sub-Total							135,755	
	Total Salaries and Wages							177,787	49,669
B.	FRINGE BENEFITS							15,796	9,397
	Total Salaries Wages and Fringe Benefits							193,583	59,066
C.	PERMANENT EQUIPMENT							13,395	
D.	EXPENDABLE SUPPLIES AND EQUIPMENT							15,315	
E.	TRAVEL								
	1. Domestic							23,070	
F.	PUBLICATION COSTS							1,000	
G.	OTHER COSTS							5,940	
H.	TOTAL DIRECTOCOSTS							252,303	59,066
I.	INDIRECT COSTS								
	1. On-campus 40.37% of Salaries & Wages ($157,533)							63,598	
	2. Off-campus 29.26% of Salaries & Wages ($20,254)							5,927	
J.	TOTAL COSTS							$ 321,828	$59,066

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Administration Investigators: D.Mueller-Dombois, A.J.Berg
Project Code & Title: University of Hawaii

	NSF Funded Man Months Cal/Acad/Sum	UH Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES				
1. Co-principal investigator & Fac. Assoc.				
D. Mueller-Dombois, Assoc. Prof. (CI-4)	5		8,359	
A.J. Berger, Prof. (CI-5)		5		12,376
Total Salaries and Wages			8,359	12,376
B. FRINGE BENEFITS			1,625	2,185
Total Salaries, Wages and Fringe Benefits			9,984	14,561
C. PERMANENT EQUIPMENT				
D. EXPENDABLE SUPPLIES AND EQUIPMENT			1,000	
E. TRAVEL				
1. Domestic Two round trips to mainland for scientific meeting (air fare, per diem and other expenses)			1,300	
F. PUBLICATION COSTS				
G. OTHER COSTS				
Housing and maintenance			1,500	
H. TOTAL DIRECT COSTS			13,784	14,561
I. INDIRECT COSTS				
1. On-campus 40.37% of Salaries & Wages ($8,359)			3,375	
J. TOTAL COSTS			$ 17,159	$14,561

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Botany Investigator: D. Mueller-Dombois
Project Code & Title: B-1, Vegetation-environment correlation studies.
B-2, Plant to plant interactions. Studies of distributional dynamics.
B-4, Life history studies of important plants: angiosperms.

	NSF Funded Man Months Cal/Acad/Sum	UH Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES				
1. Principal Investigator & Fac. Assoc.				
D. Mueller-Dombois, Assoc.Prof.(CI-4)	2		3,837	
Sub-Total			3,837	
2. Other Personnel				
G. Spatz, Asst. Res. (R-3)	12		11,232	
Graduate Asst. (G-2)	5	1	4,470	
Graduate Asst. (G-1)	5	1	4,300	
Student Help			500	
Sub-Total			20,502	
Total Salaries and Wages			24,339	
B. FRINGE BENEFITS			2,930	
Total Salaries, Wages and Fringe Benefits			27,269	
C. PERMANENT EQUIPMENT				
Construction of disseminule traps			500	
D. EXPENDABLE SUPPLIES AND EQUIPMENT			600	
E. TRAVEL				
1. Domestic				
21 inter-island trips (air fare, per diem and other expenses)			2,200	
F. PUBLICATION COSTS			400	
G. OTHER COSTS				
H. TOTAL DIRECT COSTS			30,969	
I. INDIRECT COSTS				
1. On-campus 40.37% of Salaries & Wages ($17,817)			7,193	
2. Off-campus 29.26% of Salaries & Wages ($6,522)			1,908	
Total Indirect Costs			9,101	
J. TOTAL COSTS			$ 40,070	

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Botany Investigator: C.H. Lamoureux
Project Code & Title: B-3, Growth rates and anatomy of woody plants in relation to environment

	NSF Funded Man Months Cal/Acad/Sum	UH Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES				
1. Principal Investigator & Fac. Assoc. C.H. Lamoureux, Assoc. Prof. (CI-4)	2	2	3,837	3,344
2. Other Personnel Technician (X-2)	12		10,380	
Total Salaries and Wages			14,217	3,344
B. FRINGE BENEFITS			2,307	650
Total Salaries, Wages and Fringe Benefits			16,524	3,994
C. PERMANENT EQUIPMENT				
D. EXPENDABLE SUPPLIES AND EQUIPMENT			800	
E. TRAVEL				
1. Domestic 18 trips to Hilo, Hi. (air fare & per diem)			1,240	
F. PUBLICATION COSTS				
G. OTHER COSTS				
H. TOTAL DIRECT COSTS			18,564	3,994
I. INDIRECT COSTS				
1. On-campus 40.37% of Salaries and Wages ($14,217)			5,739	
J. TOTAL COSTS			$ 24,303	$ 3,994

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Botany Investigator: D.C. Friend
Project Code & Title: B-5, Life history studies of important plants: ferns.

	NSF Funded Man Months Cal/Acad/Sum	UH Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES				
1. Principal Investigator & Fac. Assoc. D.C. Friend, Prof. (CI-5)	2		4,490	
2. Other Personnel Graduate Assistant (G-2)	5 1		4,470	
Total Salaries and Wages			8,960	
B. FRINGE BENEFITS			282	
Total Salaries, Wages and Fringe Benefits			9,242	
C. PERMANENT EQUIPMENT				
D. EXPENDABLE SUPPLIES AND EQUIPMENT			200	
E. TRAVEL				
1. Domestic 6 trips to Hilo, Hawaii (air fare and per diem)			600	
F. PUBLICATION COSTS				
G. OTHER COSTS				
H. TOTAL DIRECT COSTS			10,042	
I. INDIRECT COSTS				
1. On-campus 40.37% of Salaries & Wages ($8,960)			3,617	
J. TOTAL COSTS			$ 13,659	

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Botany — Investigators: C.A. Corn & G.C. Ashton
Project Code & Title: B-6, Metrosideros

	NSF Funded Man Months Cal/Acad/Sum	UH Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES				
1. Principal Investigator & Fac. Assoc.				
2. Other Personnel				
C.A. Corn, Asst. in Res., (X-1)	6		5,025	
Student Help			900	
Total Salaries and Wages			5,925	
B. FRINGE BENEFITS			1,039	
Total Salaries, Wages and Fringe Benefits			6,964	
C. PERMANENT EQUIPMENT				
D. EXPENDABLE SUPPLIES AND EQUIPMENT			1,300	
E. TRAVEL				
1. Domestic Inter-island travel (air fare and per diem)			1,090	
F. PUBLICATION COSTS				
G. OTHER COSTS				
H. TOTAL DIRECT COSTS			9,354	
I. INDIRECT COSTS				
1. On-campus 40.37% of Salaries & Wages ($5,925)			2,392	
J. TOTAL COSTS			$ 11,746	

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Botany   Investigators: M.S. Doty & M. Brown
Project Code & Title: B-7, Ecological and evolutionary role of the algae.

	NSF Funded Man Months Cal/Acad/Sum			UH Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES						
1. Principal Investigator & Fac. Assoc. M.S. Doty, Prof.(CI-5)			2	1	5,909	2,574
2. Other Personnel Graduate Assistant (G-2)		5	1		4,470	
Total Salaries and Wages					10,379	2,574
B. FRINGE BENEFITS					294	464
Total Salaries, Wages and Fringe Benefits					10,673	3,038
C. PERMANENT EQUIPMENT						
Polaroid camera and stand					700	
Wild field microscope					800	
Total Equipment					1,500	
D. EXPENDABLE SUPPLIES AND EQUIPMENT					800	
E. TRAVEL						
1. Domestic						
Two round trips, Chapel Hill, N.C. to Hilo via Honolulu for M.Brown and Assistant					940	
Twelve trips to Hilo, Hi.(air fare and per diem)					1,130	
Total Travel					2,070	
F. PUBLICATION COSTS						
G. OTHER COSTS						
H. TOTAL DIRECT COSTS					15,043	3,038
I. INDIRECT COSTS						
1. On-campus 40.37% of Salaries & Wages ($10,379)					4,190	
J. TOTAL COSTS					$ 19,233	$ 3,038

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Botany Investigator: G.E. Baker
Project Code & Title: B-8, Ecological roles of the fungi.

	NSF Funded Man Months Cal/Acad/Sum	UH Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES				
1. Principal Investigator & Fac. Assoc. G.E. Baker, Prof. (CI-5)		2		6,188
2. Other Personnel (2) Graduate Assistants (G-2)	10 2		9,100	
Total Salaries and Wages			9,100	6,188
B. FRINGE BENEFITS			490	1,092
Total Salaries, Wages and Fringe Benefits			9,590	7,280
C. PERMANENT EQUIPMENT				
Leica Camera			600	
D. EXPENDABLE SUPPLIES AND EQUIPMENT			500	
E. TRAVEL				
1. Domestic 8 trips to Hilo, Hi. (air fare and per diem)			500	
F. PUBLICATION COSTS				
G. OTHER COSTS				
H. TOTAL DIRECT COSTS			11,190	7,280
I. INDIRECT COSTS				
1. On-campus 40.37% of Salaries & Wages ($9,100)			3,674	
J. TOTAL COSTS			$ 14,864	$ 7,280

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Botany Investigator: Clifford W. Smith

Project Code & Title: B-10, Lichen Communities in Hawaii

	NSF Funded Man Months Cal/Acad/Sum	UH Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES				
1. Principal Investigator & Fac. Assoc. C. W. Smith, Asst. Prof (CI-3)	2	2	3,283	2,860
2. Other Personnel Student Help			2,600	
Total Salaries and Wages			5,883	2,860
B. FRINGE BENEFITS			49	552
Total Salaries, Wages and Fringe Benefits			5,932	3,412
C. PERMANENT EQUIPMENT				
D. EXPENDABLE SUPPLIES AND EQUIPMENT			450	
E. TRAVEL				
1. Domestic 2 round trips to Hilo, Hawaii (air fare and per diem)			225	
F. PUBLICATION COSTS				
G. OTHER COSTS				
H. TOTAL DIRECT COSTS			6,607	3,412
I. INDIRECT COSTS				
1. On-Campus 40.37% of Salaries & Wages ($5,883)			2,375	
J. TOTAL COSTS			$ 8,982	$ 3,412

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Entomology Investigator: D. E. Hardy
Project Code & Title: C-1, Biosystematics of Hawaii Diptera

	NSF Funded Man Months Cal/Acad/ Sum	UH Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES				
1. Principal Investigator & Fac. Assoc.				
D. E. Hardy, Entomologist (R-5)		2		4,502
M. D. Delfinado, Asst. Ent. (R-3)	3		3,414	
H. L. Carson, Prof. (CI-5)				
2. Other Personnel Student Help			5,000	
Total Salaries and Wages			8,414	4,502
B. FRINGE BENEFITS			798	1,133
Total Salaries, Wages and Fringe Benefits			9,212	5,635
C. PERMANENT EQUIPMENT				
D. EXPENDABLE SUPPLIES AND EQUIPMENT			400	
E. TRAVEL				
1. Domestic 18 inter-island trips (air fare, per diem and other expenses)			1,350	
F. PUBLICATION COSTS				
G. OTHER COSTS				
Freight, postage, communication			100	
H. TOTAL DIRECT COSTS			11,062	5,635
I. INDIRECT COSTS				
1. On-Campus 40.37% of Salaries & Wages ($8,414)			3,397	
J. TOTAL COSTS			$14,459	$5,635

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Entomology Investigator: J. W. Beardsley
Project Code & Title: C-5, The effects of sap-sucking Homoptera on the stability and fragility of Hawaiian ecosystems

	NSF Funded Man Months Cal/Acad/Sum	UH Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES				
1. Principal Investigator & Fac. Assoc.				
C. W. Beardsley, Assoc. Ent. (R-4)		1		1,881
2. Other Personnel				
Graduate Assistant (G-2)	5 1		4,470	
Total Salaries and Wages			4,470	1,881
B. FRINGE BENEFITS			244	357
Total Salaries, Wages and Fringe Benefits			4,714	2,238
C. PERMANENT EQUIPMENT				
50mm macrolens for Pentax camera			150	
Storage case			200	
Total Equipment			350	
D. EXPENDABLE SUPPLIES AND EQUIPMENT			300	
E. TRAVEL				
1. Domestic				
10 trips to Hilo, Hawaii (air fare and per diem)			620	
F. PUBLICATION COSTS				
G. OTHER COSTS				
H. TOTAL DIRECT COSTS			5,984	2,238
I. INDIRECT COSTS				
1. On-Campus 40.37% of Salaries & Wages ($4,470)			1,805	
J. TOTAL COSTS			$ 7,789	$ 2,238

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Entomology — Investigators: T.Nishida & F.H.Haramoto
Project Code & Title: C-6, Behavior and population dynamics of endemic insects

	NSF Funded Man Months Cal/Acad/Sum	UH Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES				
1. Principal Investigator & Fac. Assoc.				
T. Nishida, Entomologist (R-5)		1		2,288
F. H. Haramoto, Assoc. Ent. (R-4)		1		1,738
Sub-Total				4,026
2. Other Personnel				
Graduate Assistant (G-1)	5 1		4,300	
Total Salaries and Wages			4,300	4,026
B. FRINGE BENEFITS			243	756
Total Salaries, Wages and Fringe Benefits			4,543	4,782
C. PERMANENT EQUIPMENT				
D. EXPENDABLE SUPPLIES AND EQUIPMENT			750	
E. TRAVEL				
1. Domestic				
24 trips to Hilo, Hawaii (air fare and per diem)			1,500	
F. PUBLICATION COSTS				
G. OTHER COSTS				
H. TOTAL DIRECT COSTS			6,793	4,782
I. INDIRECT COSTS				
1. On-Campus 40.37% of Salaries & Wages ($4,300)			1,736	
J. TOTAL COSTS			$ 8,529	$ 4,782

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Entomology — Investigator: E. W. Huddleston

Project Code & Title: C-8, The role of ants in ecosystem structure and function in Hawaii

	NSF Funded Man Months Cal/Acad/Sum	UH Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES				
1. Principal Investigator & Fac. Assoc.				
2. Other Personnel				
E. W. Huddleston, Prof., Texas Tech. University			4,890	
Graduate Assistant (G-2)	5	1		
Student Help			600	
Total Salaries and Wages			5,490	
B. FRINGE BENEFITS			253	
Total Salaries, Wages and Fringe Benefits			5,743	
C. PERMANENT EQUIPMENT				
Temperature Controller			300	
D. EXPENDABLE SUPPLIES AND EQUIPMENT				
E. TRAVEL				
1. Domestic: 4 round trips, Lubbock, Texas to Hilo and inter-island travel (air fare and per diem)			2,500	
F. PUBLICATION COSTS				
G. OTHER COSTS				
Maintenance and Operation			840	
H. TOTAL DIRECT COSTS			9,383	
I. INDIRECT COSTS				
1. On-Campus 40.37% of Salaries & Wages ($5,490)			2,216	
J. TOTAL COSTS			$11,599	

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Entomology Investigators: P. C. Chabora & A.J.Chabora
Project Code & Title: C-10, Evolutionary interaction of the Hawaiian Drosophilidae and their hymenoptercus parasites

	NSF Funded Man Months Cal/Acad/Sum	UH Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES				
1. Principal Investigator & Fac. Assoc.				
2. Other Personnel				
P. C. Chabora, Asst. Prof., Queens College	2		3,724	
A. J. Chabora, Asst. Prof., Queens Coll.	2		1,600	
Total Salaries and Wages			5,324	
B. FRINGE BENEFITS			44	
Total Salaries, Wages and Fringe Benefits			5,368	
C. PERMANENT EQUIPMENT				
D. EXPENDABLE SUPPLIES AND EQUIPMENT			400	
E. TRAVEL				
1. Domestic 2 round trips, New York City to Honolulu (air fare and other expenses)			1,200	
F. PUBLICATION COSTS				
G. OTHER COSTS				
Field expenses			1,000	
H. TOTAL DIRECT COSTS			7,968	
I. INDIRECT COSTS				
1. Off-Campus 29.26% of Salaries & Wages ($5,324)			1,558	
J. TOTAL COSTS			$9,526	

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Entomology Investigator: W. C. Mitchell
Project Code & Title: C-11, Biology-ecology and control insects attacking the silversword

	NSF Funded Man Months Cal/Acad/Sum	UH Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES				
1. Principal Investigator & Fac. Assoc. W. C. Mitchell, Entomologist (R-5)				
2. Other Personnel Graduate Assistant (G-2)	5 1		4,790	
Total Salaries and Wages			4,790	
B. FRINGE BENEFTIS			247	
Total Salaries, Wages and Fringe Benefits			5,037	
C. PERMANENT EQUIPMENT				
3 Hygro-Thermographs			600	
D. EXPENDABLE SUPPLIES AND EQUIPMENT			800	
E. TRAVEL				
1. Domestic Travel to Maui, Hawaii (air fare, per diem and other expenses)			1,200	
F. PUBLICATION COSTS				
G. OTHER COSTS				
H. TOTAL DIRECT COSTS			7,637	
I. INDIRECT COSTS				
1. On-Campus 40.37% of Salaries & Wages ($4,790)			1,934	
J. TOTAL COSTS			$ 9,571	

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Entomology Investigator: M. Tamashiro
Project Code & Title: C-12, Effect of diseases in endemic populations of insects

	NSF Funded Man Months Cal/Acad/Sum		UH Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES					
1. Principal Investigator & Fac. Assoc.					
M. Tamashiro, Assoc. Ent. (R-4)			2		2,821
2. Other Personnel					
Graduate Assistant (G-2)	5	1		4,790	
Total Salaries and Wages				4,790	2,821
B. FRINGE BENEFITS				247	536
Total Salaries, Wages and Fringe Benefits				5,037	3,357
C. PERMANENT EQUIPMENT					
Low temperature Biochemical Oxygen Demand cabinet, Precision Model 805				575	
D. EXPENDABLE SUPPLIES AND EQUIPMENT				500	
E. TRAVEL					
1. Domestic					
14 trips to Hilo, Hawaii (air fare and per diem)				870	
F. PUBLICATION COSTS					
G. OTHER COSTS					
H. TOTAL DIRECT COSTS				6,982	3,357
I. INDIRECT COSTS					
1. On-Campus 40.37% of Salaries & Wages ($4,790)				1,934	
J. TOTAL COSTS				$ 8,916	$ 3,357

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Vertebrates Investigator: A. J. Berger
Project Code & Title: D-1, Life history and functional anatomical studies of the Hawaiian honeycreepers (Avian Family Drepanididae)

	NSF Funded Man Months Cal/Acad/Sum			UH Funded Man Months Cal/Acad/Sum			PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES								
1. Principal Investigator & Fac. Assoc. A. J. Berger, Prof. (CI-5)			2				5,683	
Sub-Total							5,683	
2. Other Personnel R. J. Raikow, Asst. Researcher (R-3)	12						11,232	
Graduate Assistant (G-2)		5	1				4,630	
Sub-Total							15,862	
Total Salaries and Wages							21,545	
B. FRINGE BENEFITS							2,700	
Total Salaries, Wages and Fringe Benefits							24,245	
C. PERMANENT EQUIPMENT								
Special Detecting sensor camera							600	
D. EXPENDABLE SUPPLIES AND EQUIPMENT							500	
E. TRAVEL								
1. Domestic 14 inter-island trips (air fare, per diem and other expenses)							2,450	
F. PUBLICATION COSTS							400	
G. OTHER COSTS								
H. TOTAL DIRECT COSTS							28,195	
I. INDIRECT COSTS								
1. On-Campus 40.37% of Salaries & Wages ($21,545)							8,698	
J. TOTAL COSTS							$ 36,893	

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Vertebrates   Investigator: Q. P. Tomich
Project Code & Title: D-2, Ecology of introduced rodents.

	NSF Funded Man Months Cal/Acad/Sum	UH Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES				
1. Principal Investigator & Fac. Assoc.				
2. Other Personnel				
Q. P. Tomich, State Dept. of Health, Research Unit, Honokaa, Hawaii				
Graduate Assistant (G-2)	5 1		4,790	
Total Salaries and Wages			4,790	
B. FRINGE BENEFITS			247	
Total Salaries, Wages and Fringe Benefits			5,037	
C. PERMANENT EQUIPMENT				
D. EXPENDABLE SUPPLIES AND EQUIPMENT			800	
E. TRAVEL				
1. Domestic 2 round trips, Hilo to Honolulu (air fare and per diem)			190	
F. PUBLICATION COSTS				
G. OTHER COSTS				
H. TOTAL DIRECT COSTS			6,027	
I. INDIRECT COSTS				
1. Off-Campus 29.26% of Salaries & Wages ($4,790)			1,402	
J. TOTAL COSTS			$ 7,429	

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Vertebrates Investigator: R. E. MacMillen
Project Code & Title: D-3, Physiological ecology of some terrestrial Hawaiian birds and mammals

	NSF Funded Man Months Cal/Acad/Sum	UH Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES				
1. Principal Investigator & Fac. Assoc.				
2. Other Personnel R. E. MacMillen, Assoc. Prof. University of California, Irvine	2		3,618	
Total Salaries and Wages			3,618	
B. FRINGE BENEFITS			30	
Total Salaries, Wages and Fringe Benefits			3,648	
C. PERMANENT EQUIPMENT				
D. EXPENDABLE SUPPLIES AND EQUIPMENT			665	
E. TRAVEL				
1. Domestic 1 round trip, California to Honolulu, and inter-island travel (air fare, per diem and other expenses)			670	
F. PUBLICATION COSTS				
G. OTHER COSTS				
H. TOTAL DIRECT COSTS			4,983	
I. INDIRECT COSTS				
1. Off-Campus 29.26% of Salaries & Wages ($3,618)			1,059	
J. TOTAL COSTS			$ 6,042	

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Vertebrates Investigator: G. C. Whittow
Project Code & Title: D-4, Adaptation of some small introduced and immigrant Hawaiian mammals to their environment: A study in physiological ecology

	NSF Funded Man Months Cal/Acad/Sum	UH Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES				
1. Principal Investigator & Fac. Assoc. G. C. Whittow, Researcher (CI5-R)		3		6,188
2. Other Personnel Graduate Assistant (G-2)	5 1		4,790	
Total Salaries and Wages			4,790	6,188
B. FRINGE BENEFITS			247	1,122
Total Salaries, Wages and Fringe Benefits			5,037	7,310
C. PERMANENT EQUIPMENT				
Temperature probes, meteorological instruments, construction of calorimeters			1,000	
D. EXPENDABLE SUPPLIES AND EQUIPMENT			800	
E. TRAVEL				
1. Domestic 6 trips to Hilo, Hawaii (air fare and per diem)			380	
F. PUBLICATION COSTS			200	
G. OTHER COSTS				
H. TOTAL DIRECT COSTS			7,417	7,310
I. INDIRECT COSTS				
1. On-Campus 40.37% of Salaries & Wages ($4,790)			1,934	
J. TOTAL COSTS			$ 9,351	$ 7,310

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Genetics Investigators: G. C. Ashton & M. P. Mi
Project Code & Title: E-1, Genetic analysis of populations

	NSF Funded Man Months Cal	Acad	Sum	UH Funded Man Months Cal	Acad	Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES & WAGES								
1. Principal Investigator & Fac. Assoc.								
G. C. Ashton, Prof. (CI-5)				1				1,237
M. P. Mi, Assoc. Prof (CI-4)					1			1,672
Y. K. Paik, Prof (CI-5)			2				3,220	
Sub-Total							3,220	2,909
2. Other Personnel								
K. C. Sung, Jr. Researcher (R-2)	6						4,614	
Graduate Assistant (G-2)		5	1				4,470	
Total Salaries and Wages							12,304	2,909
B. FRINGE BENEFITS							1,430	550
Total Salaries, Wages and Fringe Benefits							13,734	3,459
C. PERMANENT EQUIPMENT								
D. EXPENDABLE SUPPLIES AND EQUIPMENT							3,000	
E. TRAVEL								
F. PUBLICATION COSTS								
G. OTHER COSTS								
1. 360/65 Computer time							1,000	
2. Support of 1130 Computer							500	
3. Key punch rental							850	
4. Computer cards							150	
Total Other Costs							2,500	
H. TOTAL DIRECT COSTS							19,234	3,459
I. INDIRECT COSTS								
1. On-Campus 40.37% of Salaries & Wages ($12,304)							4,967	
J. TOTAL COSTS							$ 24,201	$ 3,459

Proposed IBP Grant Budget, 02 Year, 1971-72
University of Hawaii

Section: Microenvironmental Analysis Investigator: P. C. Ekern
Project Code & Title: G-1, The water and radiation budgets along IBP transects.

	NSF Funded Man Months Cal/Acad/Sum	UH Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES				
1. Principal Investigator & Fac. Assoc. P. C. Ekern, Prof (CI-5)				
2. Other Personnel Student Help			6,000	
Total Salaries and Wages			6,000	
B. FRINGE BENEFITS			50	
Total Salaries, Wages and Fringe Benefits			6,050	
C. PERMANENT EQUIPMENT				
Radiation and Weather Measure Instruments			7,370	
D. EXPENDABLE SUPPLIES AND EQUIPMENT			750	
E. TRAVEL				
1. Domestic 13 round trips to Hilo, Hawaii (air fare and per diem)			915	
F. PUBLICATION COSTS				
G. OTHER COSTS				
H. TOTAL DIRECT COSTS			15,085	
I. INDIRECT COSTS				
1. On-Campus 40.37% of Salaries & Wages ($6,000)			2,422	
J. TOTAL COSTS			$ 17,507	

Proposed IBP Grant Budget, 02 Year, 1971-72
B. P. Bishop Museum

SUMMARY

	NSF Funded Man Months Cal	Acad	Sum	BM Funded Man Months Cal	Acad	Sum	PROPOSED NSF	PROPOSED BM
A. SALARIES AND WAGES								
1. Principal Investigator & Res. Assoc.								
Co-principal Investigator			1		2		2,278	5,000
8 Senior Personnel		8	9		7		21,621	9,088
Sub-Total							23,899	14,088
2. Other Personnel								
3 Technicians	24						11,200	
4 Field/Lab. Asst.	23			3			11,300	2,500
1 Plant Identifier	12						7,000	
1 Computer Operator	12						7,308	
1 Maintenance Man	8			4			6,000	2,000
1 Secretarial/Clerical	12						6,800	
Sub-Total							49,608	4,500
Total Salaries and Wages							73,507	18,588
B. FRINGE BENEFITS							5,881	1,487
Total Salaries, Wages and Fringe Benefits							79,388	20,075
C. PERMANENT EQUIPMENT							1,600	
D. EXPENDABLE SUPPLIES AND EQUIPMENT							1,665	
E. TRAVEL								
1. Domestic							8,945	
2. International							1,180	
Total Travel							10,125	
F. PUBLICATION COSTS								
G. OTHER COSTS							2,100	
H. TOTAL DIRECT COSTS							94,878	20,075
I. INDIRECT COSTS								
1. On-campus 56.49% of Salaries & Wages ($73,507)							41,524	
J. TOTAL COSTS							$ 136,402	$20,075

Proposed IBP Grant Budget, 02 Year, 1971-72
B.P. Bishop Museum

Section: Administration Investigator: J.L. Gressitt
Project Code & Title: B.P. Bishop Museum

	NSF Funded Man Months Cal/Acad/Sum	BM Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED BM
A. SALARIES AND WAGES				
1. Principal Investigator & Res. Assoc.				
J.L. Gressitt, Entomologist		2		5,000
2. Other Personnel				
Plant Identifier	12		7,000	
Computer Operator	12		7,308	
Maintenance Man	8	4	6,000	2,000
Secretarial/Clerical	12		6,800	
Total Salaries and Wages			27,108	7,000
B. FRINGE BENEFITS			2,169	560
Total Salaries, Wages and Fringe Benefits			29,277	7,560
C. PERMANENT EQUIPMENT				
D. EXPENDABLE SUPPLIES AND EQUIPMENT				
E. TRAVEL				
1. Domestic				
1 round trip to mainland for scientific meeting (air fare and per diem)			650	
F. PUBLICATION COSTS				
G. OTHER COSTS				
Vehicles - gas and maintenance			2,000	
Shipping and postage			100	
Total Other Costs			2,100	
H. TOTAL DIRECT COSTS			32,027	7,560
I. INDIRECT COSTS				
1. On-campus 56.49% of Salaries & Wages ($27,108)			15,313	
J. TOTAL COSTS			$ 47,340	$ 7,560

Proposed IBP Grant Budget, 02 Year, 1971-72
B. P. Bishop Museum

Section: Entomology Investigator: W.A. Steffan
Project Code & Title: C-2, Ecology and evolution of Hawaiian Sciaridae.

	NSF Funded Man Months Cal/Acad/Sum	BM Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED BM
A. SALARIES AND WAGES				
1. Principal Investigator & Res. Assoc.				
W.A. Steffan, Entomologist	2 2	2	6,140	3,250
2. Other Personnel				
Technician	12		5,600	
Technician	6		2,800	
Total Salaries and Wages			14,540	3,250
B. FRINGE BENEFITS			1,163	260
Total Salaries, Wages and Fringe Benefits			15,703	3,510
C. PERMANENT EQUIPMENT				
D. EXPENDABLE SUPPLIES AND EQUIPMENT			100	
E. TRAVEL				
1. Domestic Inter-island travel (air fare, per diem and other expenses)			420	
F. PUBLICATION COSTS				
G. OTHER COSTS				
H. TOTAL DIRECT COSTS			16,223	3,510
I. INDIRECT COSTS				
1. On-campus 56.49% of Salaries & Wages ($14,540)			8,214	
J. TOTAL COSTS			$ 24,437	$ 3,510

Proposed IBP Grant Budget, 02 Year, 1971-72
B. P. Bishop Museum

Section: Entomology Investigator: J.L. Gressitt
Project Code & Title: C-3(a), Hawaiian Cerambycid beetles (and certain other woodborers)

	NSF Funded Man Months Cal/Acad/Sum	BM Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED BM
A. SALARIES AND WAGES				
1. Principal Investigator & Res. Assoc.				
J.L. Gressitt, Entomologist	1		2,278	
G.A. Samuelson, Entomologist	2		2,222	
C.J. Davis, Assoc. Entomologist				
2. Other Personnel				
F. Howarth, Lab. Assistant	9	3	4,500	2,500
Total Salaries and Wages			9,000	2,500
B. FRINGE BENEFITS			720	200
Total Salaries, Wages and Fringe Benefits			9,720	2,700
C. PERMANENT EQUIPMENT				
Construction of cages			600	
D. EXPENDABLE SUPPLIES AND EQUIPMENT			400	
E. TRAVEL				
1. Domestic				
Inter-island travel (air fare, per diem and other expenses)			2,980	
F. PUBLICATIONS COSTS				
G. OTHER COSTS				
H. TOTAL DIRECT COSTS			13,700	2,700
I. INDIRECT COSTS				
1. On-campus 56.49% of Salaries & Wages ($9,000)			5,084	
J. TOTAL COSTS			$ 18,784	$ 2,700

Proposed IBP Grant Budget, 02 Year, 1971-72
B. P. Bishop Museum

Section: Entomology Investigator: E.G. Munroe
Project Code & Title: C-3(b); Lepidoptera: Pyralidae.

	NSF Funded Man Months Cal/Acad/Sum	BM Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED UH
A. SALARIES AND WAGES				
1. Principal Investigator & Res. Assoc. E.G. Munroe, Entomol., Ent. Res. Inst. Ottawa, Canada				
2. Other Personnel				
Field Assistant	6		2,800	
Total Salaries and Wages			2,800	
B. FRINGE BENEFITS			224	
Total Salaries, Wages and Fringe Benefits			3,024	
C. PERMANENT EQUIPMENT				
D. EXPENDABLE SUPPLIES AND EQUIPMENT				
E. TRAVEL				
1. Domestic Inter-island travel (air fare, per diem, and other expenses)			850	
2. International 1 round trip from Ottawa, Canada to Honolulu for E.G. Munroe			550	
Total Travel			1,400	
F. PUBLICATION COSTS				
G. OTHER COSTS				
H. TOTAL DIRECT COSTS			4,424	
I. INDIRECT COSTS				
1. On-campus 56.49% of Salaries & Wages ($2,800)			1,582	
J. TOTAL COSTS			$ 6,006	

Proposed IBP Grant Budget, 02 Year, 1971-72
B. P. Bishop Museum

Section: Entomology   Investigator: W.C. Gagné
Project Code & Title: C-4, Phytophagous insects - sap and seed feeders (Heteroptera).

	NSF Funded Man Months Cal/Acad/Sum			BM Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED BM
A. SALARIES AND WAGES						
1. Principal Investigator & Res. Assoc. W.C. Gagné, Assoc. Entomologist	5	2		4	7,600	3,900
2. Other Personnel						
Total Salaries and Wages					7,600	3,900
B. FRINGE BENEFITS					608	312
Total Salaries, Wages and Fringe Benefits					8,208	4,212
C. PERMANENT EQUIPMENT						
Funnels					500	
D. EXPENDABLE SUPPLIES AND EQUIPMENT					500	
E. TRAVEL						
1. Domestic Inter-island travel (air fare, per diem and other expenses)					1,650	
F. PUBLICATION COSTS						
G. OTHER COSTS						
H. TOTAL DIRECT COSTS					10,858	4,212
I. INDIRECT COSTS						
1. On-campus 56.49% of Salaires & Wages ($7,600)					4,293	
J. TOTAL COSTS					$ 15,151	$ 4,212

Proposed IBP Grant Budget, 02 Year, 1971-72
B. P. Bishop Museum

Section: Entomology Investigator: R.S. Beal
Project Code & Title: C-7, Litter-inhabiting and inquilinous coleopterous scavengers of the Hawaiian Islands

	NSF Funded Man Months Cal/Acad/Sum	BM Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED BM
A. SALARIES AND WAGES				
1. Principal Investigator & Res. Assoc. R.S. Beal, Jr., Prof. & Grad. Dean, Northern Arizona Univ., Flagstaff				
2. Other Personnel				
B. FRINGE BENEFITS				
C. PERMANENT EQUIPMENT				
D. EXPENDABLE SUPPLIES AND EQUIPMENT			200	
E. TRAVEL				
1. Domestic				
1 round trip from Flaggstaff, Az. to Honolulu (air fare and other expenses)			275	
Inter-island travel (air fare, per diem and other expenses)			250	
Total Travel			525	
F. PUBLICATION COSTS				
G. OTHER COSTS				
H. TOTAL DIRECT COSTS			725	
I. INDIRECT COSTS				
1. On-campus 56.49% of Salaries & Wages ($ 00.00)				
J. TOTAL COSTS			$ 725	

Proposed IBP Grant Budget, 02 Year, 1971-72
B. P. Bishop Museum

Section: Entomology Investigator: F.J. Radovsky
Project Code & Title: C-9, Parasites of vertebrate animals of Hawaii.

	NSF Funded Man Months Cal/Acad/Sum	BM Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED BM
A. SALARIES AND WAGES				
1. Principal Investigator & Res. Assoc.				
F. J. Radovsky, Acarologist	1 1	1	3,659	1,938
2. Other Personnel				
Field Assistant	6		3,000	
Laboratory Technician	6		2,800	
Total Salaries and Wages			9,459	1,938
B. FRINGE BENEFITS			757	155
Total Salaries, Wages and Fringe Benefits			10,216	2,093
C. PERMANENT EQUIPMENT				
Telethermometer ($400) Comparator ($100)			500	
D. EXPENDABLE SUPPLIES AND EQUIPMENT			400	
E. TRAVEL				
1. Domestic Inter-island travel (air fare, per diem and other expenses)			1,270	
F. PUBLICATION COSTS				
G. OTHER COSTS				
H. TOTAL DIRECT COSTS			12,386	2,093
I. INDIRECT COSTS				
1. On-campus 56.49% of Salaries & Wages ($9,459)			5,343	
J. TOTAL COSTS			$ 17,729	$ 2,093

Proposed IBP Grant Budget, 02 Year, 1971-72
B. P. Bishop Museum

Section: Entomology — Investigator: Y. Hirashima

Project Code & Title: C-13, Systematic and ecological studies of Nesoprosopis of Hawaii, with special reference to its evolution and conservation (Hymenoptera: Colletidae: Hylaeinae).

	NSF Funded Man Months Cal/Acad/Sum	BM Funded Man Months Cal/Acad/Sum	PROPOSED NSF	PROPOSED BM
A. SALARIES AND WAGES				
1. Principal Investigator & Res. Assoc. Y. Hirashima, Prof., Kyushu Univ., Fukuoka, Japan	2		2,000	
2. Other Personnel Field Assistant	2		1,000	
Total Salaries and Wages			3,000	
B. FRINGE BENEFITS			240	
Total Salaries, Wages and Fringe Benefits			3,240	
C. PERMANENT EQUIPMENT				
D. EXPENDABLE SUPPLIES AND EQUIPMENT			65	
E. TRAVEL				
1. Domestic Inter-island travel (air fare, per diem and other expenses)			600	
2. International 1 round trip from Fukuoka, Japan to Hawaii for Y. Hirashima			630	
Total Travel			1,230	
F. PUBLICATION COSTS				
G. OTHER COSTS				
H. TOTAL DIRECT COSTS			4,535	
I. INDIRECT COSTS				
1. On-campus 56.49% of Salaries & Wages ($3,000)			1,695	
J. TOTAL COSTS			$ 6,230	