

## One Hundred Years of Acarology in the Hawaiian Islands

Sabina Fajardo Swift

Department of Plant and Environmental Protection Sciences, University of Hawaii at Manoa, 3050 Maile Way, Gilmore 310, Honolulu, Hawaii 96822, USA. E-mail: sabina@hawaii.edu

(Presidential address, Pacific Entomological Conference,  
1999, Ala Moana Hotel, Honolulu, Hawaii)

As we enter into the new millennium, the national picture for systematic acarology is less than encouraging (Krantz, 1996). Aside from the paucity of funding and fewer mite workers, the study of mites is generally ignored by entomologists and biologists. The most frequent explanations for this are the small size of mites, their hidden existence, and the generally poor level of taxonomic knowledge. Besides, before mites can be studied, detailed and often times laborious preparation needs to be done prior to microscopic examinations. Unlike relatively large and beautiful insects such as Hawaii's Kamehameha butterfly (*Vanessa tameamea*) or *Megalagrion* damselflies, mites don't make excellent "show-and-tell" animals. Despite this, acarology has become an established biological discipline nationally and internationally, that has progressed tremendously in the last 20 years. Studies are being conducted in areas that seemed unthinkable some years back such as DNA sequencing for phylogenetic reconstructions; genetic improvement (Hoy, 1985) and gene transfer (Houck et al., 1991).

Mites rival insects in their global diversity, abundance, and ubiquity (Lindquist, 1983). From 30,000 species estimated by Radford (1950), Evans (1992) estimated 600,000 species including the present undescribed species. Here in the Hawaiian Islands, 619 species have been recorded (Nishida, 1997, Swift and Norton, 1998) and even more are still to be discovered. The oribatid mites alone are estimated to be 175-200 species in Hawaii (Swift and Norton, 1998).

The Hawaiian Archipelago is the most isolated set of islands in the world, located in the middle of the Pacific Ocean, 4000 km from the nearest major land mass and 1600 km from the nearest island group (Simon et al., 1984). Its isolation and the presence of diverse aquatic and terrestrial ecosystems including caves (Howarth, 1991), has facilitated evolution of a tremendous number of endemic species (Zimmermann, 1948; Carlquist, 1980). These endemic taxa have become the major focus of ecological, systematic and evolutionary studies. The diversity of the Hawaiian mite fauna is not an exception to this pattern. Although studies on mites have been sporadic, there are a century of studies of mites in the islands. I would like to share with you today how acarology came about in the islands, the many island and off-island biologists, acarologists and entomologists who have contributed to what is now known in the field, and, what lies ahead for our mitey friends.

### Beginning of Acarology in Hawaii

A cooperative zoological exploration was initiated by the Sandwich Islands Committee of Great Britain and the British Association for the Advancement of Science to study the flora and fauna of the Sandwich Islands (= Hawaiian Islands) in 1890 (Manning, 1986). Robert C.L. Perkins (Fig. 1) of Oxford University, at age 26, was selected to start the monumental collection effort. When he left England, he had received requests from colleagues and other biologists to collect specific groups—beetles, birds, and snails (Manning, 1986). While no one requested mites, David Sharp, an English coleopterist who worked on



**Figure 1.** Robert C. L. Perkins.

Carabidae, encouraged Perkins to take with him Sharp's sieve as part of his collecting gear to separate insects (probably beetles) from leaf litter. Undoubtedly fortuitously, Perkins collected the beetle-like oribatid mites from sieve extractions. Seventy-six specimens of oribatid mites (Suborder Oribatida or Cryptostigmata) were the first mites collected from the Hawaiian Islands (Pearce, 1910). These specimens formed the base that brought the Acari fauna of the Islands to the attention of mite workers in Europe and in North America.

These mites were collected from 1892–1902 from most of the high islands (see Table 1). I give Perkins credit for saving the above mites; unlike most entomologists today who probably would have thrown the mites away for lack of time to process them properly and scarcity of acarologists willing to provide identification. Not being a mite worker, Perkins sent his collection to the mite specialist N.D.F. Pearce, also of London. Pearce (1910) commented in *Fauna Hawaiiensis*, “unless a collector's attention has been specially directed to the group, their small size will inevitably lead him to overlook them. I do not know by what method these specimens were collected, and am only surprised that so many were obtained.” Of the nine species identified by Pearce, seven were well known British species, but two were described as new to the Hawaiian Islands (Table 1) (Pearce, 1910). Some of these species were later redescribed by Jacot (1934) as new species, and an undescribed genus is still awaiting description (Swift and Norton, 1998).

**Table 1. Oribatid mite species reported by N. D. F. Pearce (1910) and their island distribution.**

Genus/species	Island Distribution
<i>Oribata globula</i> Nic	Hawaii, Lanai
<i>Oribata alata</i> Herm	Kauai, Lanai, Hawaii
<i>Oribata ovalis</i> Nic	Kauai
<i>Oribata lapidaria</i> Lucas, 1846 (= <i>Humerobates rostroramellatus</i> Grandjean, 1936)	Hawaii
<i>Oribata oriformes</i> Pearce (= <i>Cardioribates oriformis</i> [Pearce, 1910])	Hawaii
<i>Notaspis lucorum</i> Koch	Maui, Hawaii
<i>Neoliodes theleproctus</i> (?) Hermann (= <i>Liodes theleproctus</i> [Hermann, 1804])	Kauai, Lanai, Molokai, Hawaii
<i>Hoploderma dasyopus</i> Duges (species inquirendae)	Kauai, Oahu, Lanai, Hawaii
<i>Tegeocranus pustulatus</i> Pearce (="Cepheus") new genus	Molokai

### Contributors to Hawaiian Acarology after Perkins and Pearce

The contributions of R.C.L. Perkins and N.D.F. Pearce would have been moot if entomologists and other biologists had not recognized the importance of the Hawaiian mites. Like other biological fields, it was through descriptive natural history that acarology became established. Mite systematists from continental USA retired in the islands and encouraged graduate students in studies of their particular mite groups (e.g., James M. Brennan - Trombiculidae) and some came on sabbatical and worked with graduate students and local acarologists (e.g., R.W. Strandmann, H. A. Sengbusch). But a few residents of Hawaii, who received their graduate degrees conducting research on mites, continued to work on Hawaiian mites. I will introduce some of the outstanding personalities and major contributors to Hawaiian acarology in the order that they published on Hawaiian acarofauna, making them known to the global scientific community.

**Arthur Paul Jacot** (Fig. 2). One of the early American acarologists from New York, Jacot is considered the foremost oribatologist from North America. A young man of many interests, his systematic and ecological work concentrated primarily on the Oribatida. Jacot became involved with Hawaiian oribatid mites because of some questions concerning Pearce's (1910) report on *Oribata alata* Hermann, 1804 (Jacot, 1934). He requested a loan of *O. alata* from the Bishop Museum where the type series was deposited. This initial inquiry resulted in an invitation for a week visit to Hawaii for both Jacot and his wife by Alexander Hume Ford of the Pan-Pacific Research Institute (now MidPacific Institute). When Hawaii entomologists learned of Jacot's presence in the islands, he was presented with unidentified specimens of oribatid mites from collections of E.H. Bryan, Frederick Muir, Cyril Pemberton and R.H. van Zwaluwenburg. After having described four Hawaiian species in 1928 and 1929 (*Eupthiracarus* [*Indotritia*] *hawaiiensis*, *Galumna swezeyi*, *Udetaliodes hawaiiensis* [= *Liodes*], and *Udetaliodes swezeyi* [= *Liodes*]), Jacot produced



**Figure 2.** Arthur Paul Jacot.

the first substantive monograph on Hawaiian oribatid mites (Jacot, 1934). He reassessed some of Pearce's species records, proposed five new genera, 19 species and five new subspecies, and speculated extensively on the origin of the Hawaiian fauna. Jacot's 1934 paper became the touchstone for further additional studies of Hawaiian oribatid mites and presumably of other mite groups during the next six decades.

**Irwin M. Newell.** A good friend and colleague of the late J. Linsley Gressitt, Newell came to Hawaii from the University of California at Riverside, where he worked on the water mites (family Halacaridae) of Antarctica. While at the Bishop Museum, he described three new mite species from the islands: the halacarid species *Copidognathus matthewsi* (parasitic on lobster), and two were new oribatid species from the Big Island, *Tuberemaeus papillifer* and *Tetracondyla* sp. (= *Dolicheremaeus damoeoides* [Berlese]) (Newell 1956a, 1956b).

**Jun-ichi Aoki.** A well known oribatologist from Yokohama National University, Aoki described 10 new mite species and recorded a handful of new state records. His publications on oribatid mites from bird nests (Aoki, 1966), and a semiaquatic oribatid mite *Hydronthrus crispus* (= *Trhypochthoniellus crassus*) whose habitat is submerged stems and leaves of taro in Hanalei, Kauai (Aoki, 1964a), are two of his interesting discoveries. The



**Figure 3.** Frank H. Haramoto.

oribatid mites of Laysan Island were also studied by Aoki (1964b), and he discovered eight species, five of which were new. Aoki is retired but is still actively working with students and postdocs at Yokohama University.

**Frank H. Haramoto** (Fig. 3). In 1966, Haramoto finished his dissertation on the biology and control of *Brevipalpus phoenicis* (Geijskes), a tenuipalpid mite pest of papaya. He took the intensive acarology course at Ohio State University and, since he was the only staff in the Department of Entomology with acarology training, taught the graduate level Acarology course at the University of Hawaii from 1967 to 1980. Haramoto was not a mite taxonomist, rather an applied acarologist. With his graduate students and colleagues, he conducted applied mite research on house dust mites (Sharp and Haramoto, 1970) and cyclamen mites (Haramoto and Boyle, 1958). Garrett and Haramoto (1967) assembled a catalog of Hawaiian mites which became the Hawaiian mite list for 20 years. Perhaps his most significant contribution was teaching acarology during the 1960s and 1970s giving us internationally known scientists such as M. Lee Goff of the University of Hawaii and Vikram Prasad, publisher of the *International Journal of Acarology*. Roy Furumizo of the Hawaii Department of Health, Vector Control Branch, another former student, pursued acarology at the University of Cali-

fornia at Berkeley. Haramoto retired from the University of Hawaii in 1981.

**Vikram Prasad.** The only known phytoseiid mite species recorded from the Hawaiian Islands aside from the purposely introduced species for biological control (*Neoseiulus californicus* [McGregor], *Mesoseiulus longipes* [Evans], *Iphiseius degenerans* [Berlese], and *Phytoseiulus persimilis* Athias-Henriot) were those of Prasad (1968a, 1968b, 1968c). Prasad also described two species of mites in the families Ascidae and Otopheidomenidae from moths (Prasad, 1968d, 1968e). I think Prasad's greatest accomplishment and contribution, not only to Hawaiian acarology but to the global community, is his 25 continuous years as publisher and editor-in-chief of the International Journal of Acarology, the only acarology journal in North America.

**Ilse Bartsch.** Bartsch, of the University of Hamburg, Germany, studied the marine mites from sandy intertidal beaches of Oahu, Kauai and Hawaii. She described 17 new species in five genera (Bartsch, 1979, 1988, 1989). She hypothesized for the first time how these marine mites feed based on the morphology of leg I and the gnathosoma. She is now retired but still actively describing water mites from other geographic areas.

**Russell W. Strandtmann.** An internationally known acarologist, Strandtmann came to the Bishop Museum from Texas Tech University in the 1970s. He specialized on the taxonomy of the eupodoid mites, primitive groups such as the family Nanorchestidae (Strandtmann, 1981, 1982a-d), and numerous mesostigmatic parasitic mites (see Swift, 1997). While at Bishop Museum, Strandtmann and Goff (1978) described some of the eupodoids of the Hawaiian Islands, including two endemic genera *Hawaiieupodes* and *Pilorhagidia*, both from the Big Island. Since most of the Hawaiian eupodid mites were collected from elevations of 2000 feet and above, they suspected the presence of mostly boreal forms reflect a sampling artifact; the austral forms usually found in dry, humid, lowland habitats were left uncollected. When Strandtmann first came to the Bishop Museum, he brought with him one of his acarology students from Texas Tech University, L. Eileen Garrett, who, together with F. Haramoto, produced the 1967 Hawaiian Acari catalogue.

**Miloslav Zacharda.** Recorded cave mites from the Hawaiian Islands include only five species in the family Rhagidiidae (Zacharda, 1980). Four of these species were described by Zacharda: *Foveacheles goffi*, *Foveacheles tenorioae*, *Parallelorhagidia hawaiiensis*, and *Poecilophysis arena* (Zacharda, 1980). Zacharda is still actively conducting research in the Czech Republic (formerly Czechoslovakia).

**Frank J. Radvosky.** The study of evolution of parasitism in Mesostigmatic mites (Gamasida) is Radvosky's expertise (Radvosky, 1969). With JoAnn Tenorio, he coauthored papers on soil arthropods (Radvosky and Tenorio, 1981a) and the ectoparasites of rodents (Radvosky and Tenorio, 1981b). An altitudinal study of mites on rodents along a transect on Mauna Loa, Hawaii was conducted with other biologists as part of the International Biological Program (Radvosky et al., 1979). Radvosky is presently based at Oregon State University and continues to publish on ectoparasitic mites.

**JoAnn M. Tenorio.** Tenorio's taxonomic research on the Hawaiian Acari includes studies on the subfamily Hypoaspidae (Tenorio, 1982), Parholaspididae (Tenorio and Marshall, 1977), *Lynxacarus* from cats (Tenorio, 1974), and ectoparasites of Hawaiian rodents (Tenorio and Goff, 1974). While at Bishop Museum, she published catalogs of the Mesostigmata of the Hawaiian Islands (Tenorio et al., 1985) and on the Acari types housed at the Bishop Museum Entomological Collection. She joined the University of Hawaii Press in 1987, which ended her acarological career.

**M. Lee Goff** (Fig. 4). Internationally-known chigger (families Trombiculidae and Leeuwenhoekiidae) systematist and forensic entomologist, Goff's acarine research was mostly on the chigger fauna of New Guinea. He was one of three acarologists at the Bishop Museum from 1973 to 1982. He accepted an entomology position at the University of Ha-



**Figure 4.** M. Lee Goff.

waii in 1983 where he had been a lecturer since 1982. This was where I took my first graduate course in acarology, Entomology 672. Although other acarologists before him collected Hawaiian mites from islands other than Oahu, Goff identified and recorded many of these mites in the Proceedings of the Hawaiian Entomological Society (see Goff, 1987). A large number of mite state records are from his collections. One of his many legacies was his dedication to teaching acarology and systematics (and also immature insects, medical entomology and undergraduate entomology courses), and encouraging students to go into acarological systematics (Tuti Hadi, Wayne A. Brown, Jose Diaz-Paxtot, Sabina F. Swift). In 1987, he published the Catalog of Acari of the Hawaiian Islands, with 104 families in 466 species. At present, he teaches acarology at the University of Hawaii and occasionally describes new species of chiggers. Goff's current research interest is in arthropod community succession on decomposing remains—forensics. The applications of forensics to homicide cases has taken him to courtrooms as an expert witness on numerous occasions (Goff, 2000). He frequently travels conducting forensic workshops and giving presentations worldwide.

**Wojciech Niedbala.** An oribatid mite (*Euptyctima*) systematist, I met Niedbala in Ceske Budejovice, Czech Republic (formerly Czechoslovakia) in 1990 at the VIII International Acarology Congress. I asked him if he would look at my collection of *Euptyctima* mites

from Kauai Island and he willingly accepted. In 1994, he hypothesized on the origin of euptycytimous mites in the Hawaiian Islands, and in 1998, he described 6 new species including an endemic (Niedbala, 1998). He is at the Mickiewicz University in Warsaw, Poland.

**Roy A. Norton.** After Jacot (1934), Norton is the other well-known oribatologist from New York to come to the Hawaiian Islands. I invited Norton to the islands in 1997 to identify the Museum's oribatid mite collection under the joint Visiting Scientist Program of the National Science Foundation and the Bishop Museum. Norton's two-week visit increased the generic diversity of Hawaiian oribatid mites by 85% and resulted in a preliminary checklist incorporating new records, and current taxonomic changes with discussion of the origin of the fauna (Swift and Norton, 1998).

### Other Contributors

Many colleagues contributed to Hawaiian acarology either by collecting the mites, actually conducting taxonomic studies and publishing them, mentoring students, or curating mite collections. Some of these colleagues are Howard Sengbusch (Oribatida) (Sengbusch and Sengbusch, 1984); Robert Husband (Podapolipidae) (Husband, 1984, 1986; Husband and Sinha 1969); James M. Brennan (Trombiculidae) (Brennan, 1965; Brennan and Amerson 1971); Peter and Janos Balogh (Oribatida) (Balogh, 1985); and Carl J. Mitchell (Acari ectoparasites) (Mitchell, 1964a, 1964b); C. Ray Joyce (Acari ectoparasites) (Joyce 1953-65, see Goff 1987); and Nixon Wilson (Acari ectoparasites) (Wilson, 1964a, 1964b, 1966; Wilson and Lawrence, 1967).

### Hawaiian Acari Catalog and Checklist

The first Hawaiian Acari catalogue was assembled by Garrett and Haramoto (1967). This was an important mite publication that synthesized most mite reports from the Notes and Exhibitions of the *Proceedings of the Hawaiian Entomological Society*, including hosts and habitats and island distributions. Two hundred ten species in 67 families and 138 genera are included in the catalogue. Sengbusch and Sengbusch (1984), after collecting in Kahoolawe Island, published a short checklist of oribatid mites from Kahoolawe with 11 species representing 10 families. Tenorio et al. (1985) revised and updated the Hawaiian Mesostigmata with addition of 89 species bringing the total of known mesostigmatic mites to 133 species.

Because of growing interest in island mites and the appearance of many new records since the publication of Garrett and Haramoto's catalogue (1967), Goff (1987) (20 years later) put together "A *Catalog of Acari of the Hawaiian Islands*," listing 466 species representing 104 families. This list was later incorporated in the comprehensive first (1992), second (1994) and third editions (1997) of "*Hawaiian Terrestrial Arthropod Checklist*," of the Bishop Museum that includes the Hawaiian Acari (572 species in 323 genera and 121 families) (Nishida, 3rd ed. 1997). A year later, a checklist of Hawaiian oribatid mites by Swift and Norton (1998) raised tremendously the total number of mite taxa in the Hawaiian Islands (Table 2). These catalogs and checklists played significant roles in the spread of information and brought attention to the Hawaiian mites as workers speculated on the biogeography, evolution, and origin of the acarofauna.

### Role of the Hawaiian Entomological Society

Before the first volume of *Fauna Hawaiiensis* came out in 1910, the Hawaiian Entomological Society had already been formed (1904). New records of mites and other arthropods discussed during monthly meetings of the Society were published in the *Proceedings of the*



**Table 2. Acari taxa in the Hawaiian Islands, 1967 to 1998.**

Source	Species	Genera	Families
Garrett & Haramoto, 1967	210	138	67
Goff, 1987	466	265	104
Nishida, 1994	521	293	113
Nishida, 1997	572	323	121
Swift & Norton, 1998	618	369	156

*Hawaiian Entomological Society* (PHES), the Society's scientific journal.

From 1905 to 1960, many mite taxa were reported in PHES by members of the Society (see Garrett and Haramoto, 1967) including mites affecting human and animal health (see C.R. Joyce in Garrett and Haramoto, 1967; Alicata, 1947) and pests of prevailing important crops (see Boyle, W.W.; Haramoto, F.F.; Nishida, T. in Garrett and Haramoto, 1967). The free-living, predatory mites found in soil remained unknown although a few species were reported after Jacot's publication of his oribatid mite monograph in 1934.

Undoubtedly, the Hawaiian Entomological Society and its scientific journal have played a major role in the proliferation of Hawaiian acarological information. Although there were difficulties in mite identifications due to lack of taxonomic keys and specialists, early entomologists in the islands reported the presence and damage of mites through descriptive natural history. Although misidentifications occurred, most of which were later corrected, records of the presence of mites in the islands were established. The "Notes and Exhibitions" section, unique to PHES since its inception, carried most of these mite records.

Garrett and Haramoto (1967) in their catalogue of Hawaiian Acari included an extensive list of Society members who reported on mites, foremost among them were W.W. Boyle, E.H. Bryan Jr., L.M. Chilson, F.H. Haramoto, and C.R. Joyce. After 1967, M.L. Goff reported many new records in the Proceedings (for several years). G.W. Kirkaldy, D.T. Fullaway, J.F. Illingworth, E.M. Ehrhorn, C.E. Pemberton, O.H. Swezey and F.X. Williams were entomologists in the 1920s who actively reported discovery of mites in Hawaiian ecosystems.

### **Future of Acarology in the Hawaiian Islands**

Worldwide, insect and mite systematists are becoming extinct—they die, they retire, or they get terminated and their vacant positions are not refilled. (The author's appointment as Collection Manager of Arachnida at the Bishop Museum was terminated two weeks after giving this presidential address in February 1999.) Trained acarologists don't get enough time to do research, and if they do, their research is often derailed to work on projects deemed more important by employers. Despite the dismal picture, the Hawaiian acarofauna has the potential to become a major player in biodiversity initiatives being sought by institutions. Because of the isolated location, relatively recent geologic history of the islands, high endemism, and uniqueness of the biota, scientists want to study the Hawaiian fauna to draw evolutionary evidence from population dynamics, molecular systematics, biogeography, and biological control. With the latest publication of the preliminary oribatid mite checklist by Swift and Norton (1998), several colleagues from worldwide institutions are

now working on the Hawaiian oribatid mite groups trying to unravel phylogenetic relationships that hopefully will give us clues to the source of our island mite biota. Recent papers such as the mite communities on 'Ohi'a at two Natural Area Reserves of Kaua'i (Swift and Goff, in press), findings of two species of mites on a mummified human remain (Swift, in preparation), description of a new species of *Eremaeozetes* (Oribatida: Eremaeozetidae) from Molokai (Schatz, 2000), and a paper on the taxonomy of Hawaiian Camerobiidae (Bolland and Swift, 2000) are proof that Hawaiian acarology is not only alive but thriving.

Mites on economic plants have not been a real focus of study in the islands. However, with the shift from sugar cane and pineapple monocultures to diversified agriculture, the importance of mites associated with the new crops may change the systematic and integrated pest management focus of mite research. Use of predatory mites as biological control agents in integrated pest management programs will be the way of the future. Hopefully, this will bring needed funding for taxonomic studies of both pest and predatory mites.

The Bishop Museum has an extensive Acari collection of parasitic and free-living mites both from the Hawaiian Islands and other geographic regions, many of them unidentified. The Acarology Laboratory of the Department of Plant and Environmental Protection Sciences at the University of Hawaii at Manoa houses the world chigger collection of the US National Museum (Smithsonian Institution) composed of approximately 1000 primary and secondary types (Goff, pers. com.) in 51,000 identified slide preparations (Goff, 1989) and an undisclosed number preserved in alcohol. Between the world renowned chigger collection, a total of 554 Acari types (102 of them Hawaiian) kept at the Bishop Museum (Nishida, pers. com.), and the uncollected extant mites out in the wild, acarologists will continue to come to the islands to search and research unique habitats and ecosystems of this biologically diverse but neglected group of animals.

### Conclusions

The smallness of mites is no longer a drawback for anyone who studies these ubiquitous animals. The new optic technologies, use of transmission and scanning electron microscopes, the advent of polymerase chain reaction (PCR) in genetic amplification, and advances in phylogenetic reconstruction using molecular and morphological techniques with available cladistic computer programs will continue to impact acarology. Mites will continue to prove as excellent experimental organisms in many fields of biology. Whether systematic acarologists survive or go extinct, the field of acarology will move forward. In the Hawaiian Islands, the presence of unique mite taxa, characteristic of what this isolated island archipelago offers, will continue to attract acarologists from around the world.

### Acknowledgment

I thank M. Lee Goff, University of Hawaii, and Gordon M. Nishida, Bishop Museum, for critical reading of the manuscript and for continuous support. Peter Follett, U.S. Department of Agriculture at Hilo, greatly improved the manuscript with further editing. To friends who left the Bishop Museum before me, those who are still there, and friends downsized in February 28, 1999, you are part of the threads in my museum tapestry. I thank you for a unique experience.

### Literature Cited

- Aoki, J. 1964a. A new aquatic oribatid mite from Kauai Island. *Pacific Insects* 6: 483–488.  
Aoki, J. 1964b. Some oribatid mites from Laysan island. *Pacific Insects* 6: 649–664.

- Aoki, J.** 1966. Oribatid mites from bird's nest on Midway Island (Acari: Cryptostigmata). *Pacific Insects* 8: 770–776.
- Balogh, P.** 1985. Some interesting Oribatuloidea Wooley, 1956 from the Hawaiian islands (Acari: Oribatei). *Opusc. Zool. budapest* 19–20: 57–61.
- Bartsch, E.** 1979. Halacaridae (Acari) from Oahu Island (Hawaiian Archipelago). *Entomol. Mitt. Zool. Mus., Hamburg* 6: 1–12.
- Bartsch, E.** 1988. Arenicolous Halacaridae (Acari) in Hawaiian waters. *Proc. Hawaii. Entomol. Soc.* 28: 213–228.
- Bartsch, E.** 1989. New species of *Copidognathus* (Acari: Halacaridae) from Hawaiian Islands. *Entomol. Mitt. Zool. Mus. Hamburg* 9: 229–246.
- Brennan, J.M.** 1965. A small collection of chiggers (Acarina: Trombiculidae) from the north central Pacific. *J. Parasitol.* 51: 888–892.
- Brennan, J.M.** and **A.B. Amerson.** 1971. Six new species and additional records of chiggers from the central Pacific (Acarina: Trombiculidae). *J. Parasitol.* 57: 1311–1317.
- Carlquist, S.** 1980. Hawaii: a natural history. SB Printers, Honolulu. 468 pp.
- Evans, G.O.** 1992. Principles of acarology. CAB International, Wallingford. 563 p.
- Garrett, L.E.** and **F.H. Haramoto.** 1967. A catalog of Hawaiian Acarina. *Proc. Haw. Entomol. Soc.* 19: 381–414.
- Goff, M.L.** 1987. A catalog of Acari of the Hawaiian Islands. *Univ. Hawaii Res. Ext. Ser.* 75: 1–75.
- Goff, M.L.** 2000. A fly for the prosecution. Harvard University Press, Cambridge, MA., 225 p.
- Haramoto, F.H.** and **W.W. Boyle.** 1958. Control of the cyclamen mite on *Jasminum sambac* (L.) in Hawaii. *J. Econ. Entomol.* 51: 431–433.
- Houck, M.A., J.B. Clark, K.R. Peterson,** and **M.G. Kidwell.** 1991. Possible horizontal transfer of *Drosophila* genes by the mite *Proctolaelaps regalis*. *Science* 253: 1125–1129.
- Howarth, F.G.** 1991. Hawaiian cave faunas: macroevolution on young islands. pp. 285–295. *In* E.C. Dudley (ed.). *The Unity of Evolutionary Biology*. Dioscorides Press, Portland, OR., 588 p.
- Hoy, M.H.** 1985. Recent advancement in genetics and genetic improvement of the Phytoseiidae. *Annu. Rev. Entomol.* 30: 345–370.
- Husband, R.W.** 1984. *Dilopolipus*, *Panesthipolipus*, and *Stenopolipus* (Acarina: Podapolipidae), new genera from the Indo-Australian region. *Internat. J. Acarol.* 10: 251–269.
- Husband, R.W.** 1986. New *Podapolipus* from Australia and Hawaii. *Internat. J. Acarol.* 12: 187–209.
- Jacot, A.P.** 1928. New oribatoid mites. *Psyche* 35: 213–15.
- Jacot, A.P.** 1929. Concerning the genus *Neoliodes* (Oribatoidea-Acarina). *Am. Micros. soc. Trans.* 48: 30–43.
- Jacot, A.P.** 1934. Some Hawaiian Oribatoidea (Acarina). *Bernice P. Bishop Mus. Bull.* 121: 1–99.
- Joyce, C.R.** 1953. Notes and Exhibitions. *Proc. Hawaii. Entomol. Soc.* 15: 13.
- Joyce, C.R.** 1965a, b. Notes and Exhibitions. *Proc. Hawaii. Entomol. Soc.* 19: 22–23, 25.
- Krantz, G.W.** 1996. Specialization and systematics in acarology: reflections and predictions, pp. 1–4. *In*: Mitchell, R., D.J. Horn, G.R. Needham and W.C. Welbourn (eds.). *Acarology IX: Vol 1, Proceedings*. Ohio Biological Survey, Columbus, Ohio.
- Lindquist, E.E.** 1983. Some thoughts on the potential for the use of mites in biological control including a modified concept of “parasitoids,” pp. 12–20. *In*: Hoy, M.A., G.L. Cunningham and L. Knutson (eds.). *Biological Control of Pests by Mites*. Univ. California, Berkeley.
- Manning, A.** 1986. The Sandwich Islands Committee, Bishop Museum, and R.C. L. Perkins: Cooperative Zoological Exploration and Publication. *Bishop Mus. Occas. Pap.* 26: 1–46.
- Mitchell, C.J.** 1964a. Ectoparasitic and commensal arthropods occurring on the rats of Manoa Valley, Oahu (Acarina, Anoplura and Siphonaptera). *Proc. Hawaii. Entomol. Soc.* 18: 413–415.
- Mitchell, C.J.** 1964b. Population structure and dynamics of *Laelaps nuttali* Hirst and *L. echidninus* Berlese (Acarina: Laelapidae) on *Rattus rattus* and *R. exulans* in Hawaii. *J. Med. Entomol.* 1: 151–153.
- Newell, I.M.** 1956a. The new genus *Tetracondyla* in the Pacific (Acari: Oppiidae). *Proc. Hawaii. Entomol. Soc.* 16(1): 113–21.
- Newell, I.M.** 1956b. A parasitic species of *Copidognathus* (Acari: Halacaridae). *Proc. Hawaii. Entomol. Soc.* 16: 122–25.
- Niedbala, M.** 1994. Origin of euptyctimous mites (Acari: Oribatida) in Hawaii. *Biol. Bull. Poznan* 31: 83–99.

- Niedbala, M.** 1998. Euptyctima (Acari: Oribatida) of the Hawaiian islands. Proc. Hawaii. Entomol. Soc. 33: 125–146.
- Nishida, G.M.**, ed. 1997. Hawaiian terrestrial arthropod checklist. Bishop Mus. Tech. Rep. 12, 263 p.
- Pearce, N.D.F.** 1910. Acarina. Fauna Hawaiiensis 3: 702–04.
- Prasad, V.** 1968. Three moth mites (Acarina: Mesostigmata) from Hawaii, with description of a new species. Ann. Entomol. Soc. Am. 61: 129–132.
- Prasad, V.** 1968a. Some phytoseiid mites from Hawaii. Ann. Entomol. Soc. Am. 61: 1459–62.
- Prasad, V.** 1968b. Some *Typhlodromus* mites from Hawaii. Ann. Entomol. Soc. Am. 61: 1369–72.
- Prasad, V.** 1968c. *Amblyseius* mites from Hawaii. Ann. Entomol. Soc. Am. 61: 1514–21.
- Prasad, V.** 1968d. *Noctuseius treati*, a new genus and species of moth mite from Hawaii and Easter Island. Ann. Entomol. Soc. Am. 61: 411–13.
- Radford, C.D.** 1950. Systematic check list of mite genera and type species. Internat. U. Biol. Sci. Ser. C, No.1: 1–232.
- Sengbusch, H.G.** and **C.H. Sengbusch.** 1984. A preliminary checklist of oribatid mites from the island of Kahoolawe, Hawaii (Acari: Oribatida). Internat. J. Entomol. 26: 190–193.
- Sharp, J.L.** and **F.H. Haramoto.** 1970. *Dermatophagoides pteronyssinus* (Trouessart) and other Acarina in house dust in Hawaii. Proc. Hawaii. Entomol. Soc. 22: 583–589.
- Simon, C., W.C. Gagne, F.G. Howarth,** and **F.J. Radovsky.** 1984. Hawaii: a natural entomological laboratory. Bull. Entomol. Soc. Am. 30: 8–17.
- Strandtmann, R.W.** and **M.L. Goff.** 1978. The Eupodoidea of Hawaii (Acarina; Prostigmata). Pacific Insects 19: 121–143.
- Swift, S.F.** 1997. Bibliography of Russell W. Strandtmann. Internat. J. Acarol. 23: 293–298.
- Swift, S.F.** and **R.A. Norton.** 1989. Some oribatid mites (Acari: Acariformes) from Mt. Kaala, Oahu. Bishop Museum Occas. Pap. 42: 50–52.
- Swift, S.F.** and **R.A. Norton.** 1998. Preliminary report on oribatid mite (Acari: Oribatida) diversity in the Hawaiian Islands. Bishop Museum Occas. Pap. 57: 1–44.
- Tenorio, J.M.** 1974. a new species of *Lynxacarus* (Acarina: Astigmata: Listrophoridae) from *Felis catus* in the Hawaiian Islands. J. Med. Entomol. 11: 599–604.
- Tenorio, J.M.** 1982. Hypoaspidae (Acari: Gamasida: Laelapidae) of the Hawaiian islands. Pac. Ins. 24: 259–274.
- Tenorio, J.M., D.A. Denmark** and **S.F. Swift.** 1985. Catalog of Acari in the Hawaiian islands. I. Mesostigmata (or Gamasida) (Acari). Internat. J. Entomol. 11: 599–604.
- Tenorio, J.M.** and **V.G. Marshall.** 1977. Parholaspidae (Acari: Mesostigmata) from the Hawaiian Islands, with description of a new species of *Parholaspulus*. Pac. Ins. 17: 319–338.
- Wilson, N.** 1964a. New records and descriptions of Rhinonyssidae, mostly from New Guinea (Acarina: Mesostigmata). Pacific Insects 6: 357–388.
- Wilson, N.** 1964b. *Ixodes laysanensis*, a new species of tick from birds on Laysan Island (Metastigmata: Ixodidae). J. Med. Entomol. 1: 165–168.
- Wilson, N.** 1966. New records and new species of *Mesonyssus* (Mesostigmata: Rhinonyssidae) from pigeons and doves (Columbiformes: Columbidae). J. Parasitol. 52: 1210–1213.
- Wilson, N.** and **R.F. Lawrence.** 1967. A new species of *Listrophorus* from *Mus musculus* in Hawaii (Astigmata: Listrophoridae). Acarologia 9: 625–631.
- Zacharda, M.** 1980. Soil mites of the family Rhagidiidae (Actinedida: Eupodoidea). Morphology, systematics, ecology. Acta Univ. Carol.-Biol. 20:489–785.
- Zacharda, M.** 1982. The cavernicolous fauna of Hawaiian lava tubes. 13. A new subgenus and two new species of Rhagidiidae (Acari: Eupodoidea). Pacific Insects 24: 275–280.
- Zimmermann, E.C.** 1948. Insects of Hawaii. Vol. 1. Introduction. University of Hawaii Press, Honolulu.