Meetings

Systematic Entomology: Distribution of Insects in the Pacific

Developments in systematic entomology that contribute to understanding of entomogeography and origins of insects in the area of the Pacific Ocean were reviewed by Japanese and American entomologists at a seminar in Washington, D.C., 4–8 December 1967. The seminar was arranged under the U.S.–Japan Cooperative Science Program, and was sponsored by the Japan Society for the Promotion of Science and the National Science Foundation. The Smithsonian Institution was host to the seminar; Secretary S. Dillon Ripley and Assistant Secretary Sidney R. Galler of the Smithsonian, and Dr. Teruo Ichinose, First Secretary (scientific attaché) of the Japanese Embassy, participated in the opening session.

The true oceanic islands of the Pacific have no genetic relation to the continental land masses. They originated in regions where the earth's crust was changing. Some of these islands subsided and reemerged, or were connected or disconnected in various combinations with present and past islands. These circumstances, and the diverse dispersal potentials of plants and animals, have profoundly influenced the composition of the flora and fauna found there.

Terrestrial biota reached the oceanic islands through three principal means (other than through the agency of man): marine drift, wind, and aid from other organisms. The different groups of insects, with different capacities for dispersal, show varied representation in the islands—what one would expect if access to the islands were left to chance. Some of the islands show a high percentage of endemism; among native Hawaiian insects the percentage of endemism approximates 99 percent. According to E. C. Zimmerman (Bishop Museum), "The insect faunas of the true oceanic islands characteristically show evidence of explosive evolution and adaptive radiation, because descendants of early immigrant species occupied a great variety of ecological niches created during the maturity and decay of these islands." It is the variety of ecological niches, rather than their numbers, that needs to be emphasized. This trend is illustrated by bees of the subgenus *Nesoprosopis* found in the Hawaiian Islands (Y. Hirashima, Kyushu University). About 60 species occur there, although none is found on the North American mainland or in the South Pacific. The divergent speciation in the Hawaiian *Nesoprosopis* makes determination of ancestral affinities uncertain, but they appear derived from Oriental stock of the genus *Hylaeus*. In contrast, the drosophilid flies of the subgenus *Hirtodrosophila* in the Hawaiian Islands appear derived from south Asiatic stock, rather than from east Asiatic stock as has been supposed. About 30 of the 70 known species of *Hirtodrosophila* occur in the Pacific area (T. Okada, Tokyo Metropolitan University). This conclusion is based upon an analysis of 11 sets of taxonomically important characteristics, including the state of the folds or coils in the ventral receptacle.

The ability of insects to cross oceans depends on their habits and vagility in immature and adult stages. Some strong-flying insects such as dragonflies have been captured at sea more than 450 km from the nearest land, yet there is less odonate fauna in Japan than on the adjacent Asiatic mainland, indicating that relatively few species have traveled long distances. Adults of other insect groups, particularly moths and delphacid leafhoppers, may be transported long distances over water by air, even though they are not strong fliers. Collections of insects made in 1967 on a Japanese weather observation ship, located 500 km from land, included two rice pests, *Nilaparvata lugens* and *Sogatella furcifera* (Delphacidae), and a notorious field-crop pest, *Prodenia litura* (Noctuidae) (S. Asahina, National Institute of Health, Tokyo).

Small insects transported as adults by air currents or as facultative ectoparasites in the feathers of migratory birds would cross marine barriers and should show a wide distribution in ocean areas. The biting midges (Diptera: genus *Culicoides*), for example, are well represented throughout the Pacific Ocean area. This group is also semiaquatic in the immature stages and could be transported on floating plant materials (W. W. Wirth, U.S. Department of Agriculture).

There are two general types of microlepidopterous fauna on the oceanic islands: endemic fauna descended from early chance arrivals at habitable islands, and moths whose larvae feed on refuse or decaying vegetable matter and are thus transported by seafaring man. Among the endemic species there is a close correlation between the presumed age of the groups and the islands on which they occur, the phylogenetically older groups occurring on the older islands (K. Yano, Kyushu University, and J. F. Gates Clarke, Smithsonian Institution).

Phytophagous insects which as adults tend to be terrestrial are relatively unsuccessful in crossing water barriers. Chrysomelid beetles, for example, as adults require food at frequent intervals, and their bodies are vulnerable to desiccation. Their larvae often require specific plant parts for protection and will not survive if exposed. Species of this group abound in all tropical and temperate continental areas, but are poorly represented in the oceanic islands. The fauna there is disharmonic, indicating random selection of faunal elements (J. L. Gressitt, Bishop Museum). Some of the apterous weevils (family Curculionidae) apparently dispersed in the western Pacific primarily via land bridges during interglacial times, and some forms may have reached Japan on floating materials. Such means of dispersal result in a phylogenetically uniform fauna, with fewer major faunal elements involved. None of the apterous genera of short-nosed weevils reached the Nearctic region. Land bridges were apparently the chief means by which termites dispersed in the Pacific area during the Cretaceous and Tertiary periods. Although new colonies are established primarily through flights of alates that mate after flight, termites are relatively weak fliers and do not diapause or store reserve nutrients in their bodies, so they would not cross water barriers except with the aid of man (K. Morimoto, Government Forest Experiment Station, Tokyo).

Flightless ectoparasitic insects of warm-blooded animals probably encounter the greatest difficulty in crossing large water barriers. Extension of their range depends on a precarious means of dispersal, and to survive in a new area they require acceptable hosts. The species of the genus *Paracimex* (family Cimicidae, bedbugs) are associated only with swifts of the genera *Chaetura* and *Collocalia*. Only the spine-tailed swifts of the genus *Chaetura* and the *esculenta* group of species of *Collocalia* are known to host *Paracimex*. Extensions of range are presumably accomplished through chance transport, on a host, of a gravid female bug. Accordingly, the distribution patterns of *Paracimex* are complex (N. Ueshima, University of California, Berkeley).

The present-day insect fauna of the Japanese archipelago apparently resulted from several centrifugal waves of dispersal from the adjacent continental area, influenced by certain classical water barriers. North of Watase's Line, between Yaqu Island and Amami-Oshima, the fauna is essentially Palearctic, whereas to the south they are Oriental. Blakiston's Line, in the Tsugaru Strait, which divides the Euro-Siberian and Manchurian subregions, was a less effective barrier to dispersal of insects than to mammals and birds. The fauna is also influenced by dispersal that occurred before water barriers existed there. The fauna of the Ryukyu Islands is particularly interesting since dispersal of insects of continental origin can be traced by three separate routes: the first from southwest to northeast via Taiwan, the second from north to southwest via Kyushu, and the third directly from continental China prior to separation of the islands from the Asiatic mainland (T. Ishihara, Ehime University, and K. Yasumatsu, Kyushu University).

The role of the Bering Strait area, Beringia, in the exchange of insects between the land masses of Eurasia and North America is evident from a comparison of their faunas, which are so similar that they are commonly treated together as the Holarctic fauna. An analysis of the Diptera (true flies) of the Nearctic and Palearctic regions supports the idea that a considerable exchange of species took place, probably during Wisconsin time, when there was a temperate flora and fauna in Beringia. Similar evidence is available in the semiaquatic bugs of the family Saldidae, which feed on other small organisms, usually insects. The leafhopper fauna of northwestern North America contains some elements that appear to be relicts of groups now best represented (in terms of numbers of species) in the Palearctic region; a continuous range for the ancestors of these forms is presumed during the time the climate of Beringia was temperate (R. I. Sailer, U.S. Department of Agriculture, and John D. Lattin and Paul Oman, Oregon State University).

The seminar participants recommended the following: (i) an intensive study of the insects in the land areas bordering the northern Pacific area, including the Bonin islands, through joint field expeditions and cooperative taxonomic studies by Japanese and American scientists, and (ii) development and implementation of methods to extend knowledge of the long-distance aerial movement of insects over water and of the factors responsible for such movements. It was also recommended that there be a follow-up conference during the fall of 1969 or the spring of 1970, with the preferred meeting site being Fukuoka, Japan. Organizers for the seminar were: for Japan, K. Yasumatsu; for the United States, P. Oman and K. V. Krombein.

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Photorespiration

Experimental problems and interpretations of the phenomenon of photorespiration were discussed at a conference held at Case Western Reserve University, Cleveland, Ohio, 5–8 February 1968. Representatives were invited from several major laboratories around the world now investigating this problem. Major areas under discussion included the techniques of gas analysis and the measurement of photosynthesis and photorespiration; the problem of nonmetabolic carbon dioxide exchange in leaves; photorespiration: its substrates, its relation to photosynthesis and dark respiration, its response to changes in external factors; and taxonomy, genetics, and productivity.

It was concluded that techniques now used to measure carbon dioxide exchange in leaves have major limitations because they cannot account for the internal cycling of carbon dioxide. Rates of photorespiration may approach the rate of apparent or net photosynthesis; true photosynthesis or gross carbon dioxide uptake must be correspondingly higher. If it were possible to selectively inhibit photorespiration, the productivity of crop plants might be nearly doubled. Work done with oxygen isotopes, and the analysis of experiments involving competition between oxygen and carbon dioxide, suggests that in plants having a positive carbon dioxide compensation point there is competition between oxygen and carbon dioxide for light-generated reducing power. In plants having zero compensation no such competition is evident, suggesting that the reducing system in these plants is insensitive to or protected from oxygen.

The general conclusion that glycolate is a major substrate for photorespiration has been well supported, and there is sufficient glycolic acid oxidase in leaves to account for even the highest estimated rates of photorespiration. The pathways for the genesis of glycolic acid are still obscure, however. Some experiments support the earlier idea that it is derived from ribulose diphosphate or other pools of intermediates in the carbon dioxide fixation cycle.

There is a clear distinction between the processes of light and dark respiration, based on their differential sensitivity to oxygen, temperature, inhibitors, and on the specific activity of substrates used for respiration after the supply of $^{14}CO_2$. Considerable evidence supports the idea that photorespiration is closely related to photosynthesis in a mechanistic way. Conditions which affect photosynthesis equally affect photorespiration; the development pattern of photorespiration closely follows that of photosynthesis. The substrate pools for photorespiration are small, rapidly turned over (with a half-life of seconds or a few minutes), and are derived from recent photosynthate. At low carbon dioxide levels, some carbon from sources distant from photosynthesis is also used in photorespiration.

There is a clear relation between the phenomenon of zero carbon dioxide compensation and leaf anatomy. Groups of zero-compensation plants have been taxonomically distinguished on the basis of anatomical vegetative characteristics. There is no relation, however, to the major taxa; zero compensation is probably a recent development which has arisen in tropical members of several major groups. Analysis of the productivity of mutants has shown that the