BOOK REVIEW

THE NATURAL HISTORY OF LARVAL MOSQUITO HABITATS. Marshall Laird. 1988. Academic Press, London and San Diego. 555 + xxvii pp. $135.00.

A mosquito "breeding place" to mosquito control workers means the water where larvae are found. Of course this expression is incorrect and actually absurd because larvae don't breed. The more appropriate terminology is "larval mosquito habitat," and Marshall Laird brings together from numerous, widely scattered sources, including his own research, a vast amount of information about the environments in which larvae are found. Laird begins by rather thoroughly reviewing the extensive literature on classification of larval mosquito habitats. He then proposes a new system. Eleven categories are initially described. There follows a discussion partly for the purpose of justifying the new "Standard System."

In Chapter 2 more than 50 pages are devoted to discussions of natural and artificial container habitats. Attention is drawn to the fact that several important food plants, e.g., papaya, breadfruit, banana, furnish larval habitats for a variety of mosquito species including some disease carriers. The importance of fuel drums as habitats is emphasized, and old tyres (sic) receive appropriate attention.

Chapter 3 is entitled "Methods, Techniques, and Source Books." Because both physicochemical and biological factors in the environment have been monitored by the author, he explains his methods. A review is provided of the large number of books and articles needed to identify plants and animals present in the numerous, varied bodies of water.

Twelve chapters consist of descriptions in great detail of examples of the 11 categories which are the basis of the system of classification. Category 1, Flowing Streams, is exemplified by a drainage ditch in Singapore. It was sampled 18 times over a period of 18 months. Four samples included Culicidae; 2 *Culex* spp. and 1 *Anopheles*. The abundance of epibionts may have made this stream a relatively poor habitat. The number of species of organisms identified from the Singapore ditch totals 147; an additional 25 are determined to genus. The word "ecology" does not appear, but much information is provided about the environment of the stream. Relationships among various organisms are discussed. Ciliate protozoans receive special attention.

The example of Category 2, Ponded Streams, was an intermittently ponded stream (drain) near a Singapore airport, 25 samplings in 23 months. Seven species of mosquitoes were collected. Pollution encouraged large populations of protozoa. *Culex fuscanus* larvae were important predators of other mosquito larvae. However, the "bewildering complex of pathogens, parasites, predators, and competitors" did not reduce mosquito larval populations below the "common to abundant" level. Over 170 organisms were identified to species, plus 25 to genus.

The author did not study Category 3, Lake Edges, in detail. A lake on one of the Solomon Islands was observed casually; 3 species of mosquitoes were present. References are made to work by the Rockefeller Foundation, the Tennessee Valley Authority, and the U.S. Department of Agriculture (in El Salvador).

Category 4A, Swamps, is exemplified by a brackish, shaded mangrove swamp on the edge of a coconut plantation in Singapore, sampled 15 times during 20 months. Six species of mosquitoes were collected. Over 90 organisms were identified, most of them to species. For Category 4B, Marshes, the representative was a pool ca. 10×7 m and 0.3 m deep centrally, in Singapore, sampled 31 times in 12 months. Cattle grazed nearby. Eight species of mosquitoes were taken. Diatoms were uncommon in comparison with several other habitats. More than 124 organisms were identified, nearly all to species.

Duckponds represent Category 5A, Shallow Permanent Ponds. The example is a Singapore pond heavily covered with duckweed, sampled 39 times during a period of 20 months. Mosquitoes were never abundant; 5 species were found. This pond was biologically rich, quantitatively and qualitatively. Over 244 species of organisms were identified. Category 5B, Shallow Permanent Ponds—Fishponds, is exemplified by a pond near the previously mentioned duckpond. It was larger and more heavily polluted and was used for producing water hyacinth for pig food and for culture of Chinese Grass Carp. Human and porcine feces and superphosphate fertilizer stimulated biological activity. Mosquito larvae were never abundant; 5 species were taken. More than 270 taxa were determined. Obviously this was a complex ecosystem.

Category 6, Shallow Temporary Pools, is exemplified by a small snow-melt pool near False River, Ungava, Quebec, sampled 21 times during May and June. It yielded a "total of 276 taxa of

living organisms." Of these, 114 were diatoms. *Aedes communis* was the dominant mosquito. Larvae were abundant.

Category 7, Intermittent Ephemeral Puddles, is exemplified by a site near a Singapore airport. During a period of 4 months, 32 collections were made. This puddle was fully exposed to light and was dried up about 30% of the observation period. Mosquito larvae were present in 12.5% of the collections; only 2 species were identified. Diatoms were scarce. Taxa identified totaled 60.

The example for Category 8, Natural Containers, is the leaves of the pitcher plant, *Sarracenia purpurea* L. var. *purpurea* (l.) Wherry in a peatland bog in Newfoundland. *Wyeomyia smithii* (Coq.) larvae were found in 142 pitchers; the contents of 16 pitchers were searched for microorganisms. More than 43 species were pitcher inquilines; 22 taxa were victims. Somewhat parenthetically, the author reports that there have been hundreds of fashionable research projects concerning mosquitoes and phytotelmata with "a disappointingly small contribution towards the control of mosquito pests . . ."

A 5 × 4 × 1 m deep container concreted on bottom and sides near a Singapore airport represents Category 9, Artificial Containers. It was similar to Indian "tanks," a rather large container, used to grow water hyacinth for pig fodder and sporadically fertilized with pig feces. It was sampled 13 times during 15 months. Mosquito larvae were always present. More than 178 taxa were identified. Protozoa were abundant.

Categories 10 and 11 are Natural and Artificial Subterranean Waters. Crabholes comprise a familiar example of Category 10. *Deinocerites* species are almost restricted to this habitat. "At least 140 species of mosquitoes occur among the burrow associates of gecardinid crabs." Category 11 often provides ideal conditions for *Aedes aegypti* (relatively clean water) and *Culex quinquefasciatus* (dirty water). Septic tanks, of course, may harbor large populations of the latter. In cities, storm and sewage drains frequently provide perfect examples of Category 11.

"General Discussion and Conclusions" is the title of the final chapter—98 pages. Here, there is continued emphasis on taxonomic diversity in the various habitats. More thorough sampling will no doubt reveal the presence of larger number of species of bacteria and fungi. The abundance of taxa in the small snow-melt pool is considered significant. Decaying *Calamagrostis* provided much organic matter and contributed much to the highly complex ecosystem. A discussion of protozoa as very important components of mosquito larval habitats is followed by an evaluation of the effects of organic enrichment. At lower levels of pollution (polysaprobic zone), bacteria are predominant. When more oxygen is available, protozoa and algae are more common. Diatoms and rotifers receive considerable attention. The complex relationships among the numerous microorganisms cannot be easily explained. Laird confirms the fact that tubificid worms are good indicators of pollution.

Concerning the subject of larval food, it is a well known fact that "larvae of most species swallow anything in the water they inhabit which can enter their mouths" (Howard et al. 1913). Many researchers, including Laird, have examined gut contents; it is often difficult to identify the organisms present because many have been partially digested. Bacteria are undoubtedly of greatest importance, followed by protozoa. The extent to which diatoms and other algae contribute to larval nutrition has not been ascertained. Laird summarizes a large body of literature but does not address the question of the association of a given larval species with a particular type of microbiota. However 15 pages are devoted to discussing the question "Can larval food management contribute to mosquito control?" In some instances larvae starve because they cannot digest the microbiota present in the habitat. Sometimes mosquito larvae compete unfavorably with other organisms such as chironomids. Various aspects of the bionomics *Scenedesmus* spp. receive detailed attention. These algae often form water-blooms and are generally not digested by mosquito larvae. Laird's conclusion is that manipulation of the larval diet has no practical value for mosquito control.

Much research has been conducted with the objective of discovering predators or perfecting the use of predators. There have been many failures, and Laird describes some. Fish, chiefly *Gambusia,* have earned a good reputation. Some other predators such as *Toxorhynchites* actually show promise. Research on cyclopoids is reviewed.

In the last 11 pages Laird reviews current knowledge of epibionts, parasites and pathogens. There are natural cycles which make management of the environment difficult or impossible. Examples are given of facultative parasitism and evolving parasitism. Heavily polluted microhabitats encourage high taxonomic diversity including epibionts. Few mosquito endoparasites were found by Laird. There can be little reason for optimism concerning the practical application of some of the intensively studied parasites. Mermithids are too sensitive to high temperature. Problems involving alternate hosts prevent commercial development of *Coelomomyces* spp. and *Amblyospora* spp.

Readers of *The Natural History of Mosquito Larval Habitats* will be impressed by the biolog-

ical diversity and dynamism of the various environments. The author carefully acknowledges indispensable assistance from a large number of specialists which made possible identification of the numerous taxa. Whether or not the proposed standard system for classifying mosquito larval habitats becomes widely accepted is relatively unimportant. The inventory is unique and will serve as a baseline for many years. Several of the examples of habitats produced few mosquitoes. The snow-melt pool was the most productive. It would have been logical to bring into focus heavy breeders-producers such as ricefields, salt marshes, irrigated pastures and semipermanent watered areas where flood-water species thrive.

This reviewer discovered a very small number of rather inconsequential technical errors. He disapproves of the fact that titles of papers are not included in the list of references. But he approved of the limited use of fancy ecological terms. With the publication of this book culicidology takes a giant step forward.

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