INVITATIONAL LECTURE :

TRENDS AND PRIORITIES IN MAYFLY RESEARCH

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The papers that are now being published on Ephemeroptera indicate that the future is very bright for research on this small order of insects.

Various workers are now starting to discard their provincial look at the Ephemeroptera. Some are studying various groups on a world basis which is in my opinion the only reasonable approach to many problems. It often has been the case that even on one continent, a particular genus has borne one name in one part of the continent and another name elsewhere on the same continent because workers were not adequately aware of literature from far beyond their home borders. In some of the recent papers specialists now consider two or more continents in classification studies (e.g., PETERS and EDMUNDS, 1970 for genera, and TRAVER and EDMUNDS, 1969 for species). This international approach is a very healthy trend.

There was a tendency among the European workers for many years to be very provincial. They studied the mayflies of their own country and seldom gave adequate attention to the literature, and especially study of the specimens, from their neighboring countries. It is very gratifying now to see studies coming out that span all of Europe rather than just one country (e.g., MÜLLER-LIEBENAU, 1970) and study that involves examination of many thousands of specimens including those from other countries than the subject of the report (e.g., LANDA, 1969). In the European literature on mayflies we have had enough of the compilation of the work of others.

There has been a significant increase in the number of good life history studies. Some of these studies follow the insects through their entire life cycle rather than simply associating the nymphal stages with the adults (e.g., LANDA, 1969b). We must do more work on life histories. Some species can now be cultured readily in the laboratory (FREMLING, 1967).

We need also to continue to associate the life history stages of numerous species. Many years ago I set my goal as being able to study the nymph or larva of every mayfly genus in the world. I didn't realize then that perhaps we might have to end up naming another 100 genera or so during this time, but I now think that this is quite probable. We are now to the point where a very high percentage of the genera of mayflies have at least one of the species reared, although this is much more than the literature indicates because there is so much yet unpublished.

A few years ago in the United States the granting agencies shaped much mayfly research by failing to fund research proposals that were focused on regional or local taxonomic studies of mayflies. If one was willing to study mayflies on a much broader geographic basis or study in some remote area, it was much easier to get funds. There has been some reversal in this trend and so now we are getting a balance. Regional and local studies are needed (e.g., BURKS, 1953) because this is the only way that we will be able, in many cases, to construct useful and meaningful keys that will allow us to determine all of the immature stages. When you try to key out every species of a large genus no matter where it occurs it can become complex. We need the local studies along with the investigations of larger scope.

We have at the present time very little knowledge of what ecological requirements mayfly species have. There are very few species for which we have any reasonable parameters. In our laboratory, recently, we have started to assemble data to plot the range of cyclic temperatures that some species experience in nature. We have virtually no such data and it is one of the things that we must know. Man is now concerned about thermal pollution of streams and yet we know very little about thermal requirements of mayflies. Many of the present studies on thermal pollution are based on studies where thermal pollution already exists, or laboratory studies subjecting mayfly larvae to thermal stress to see at what point they die or do not thrive. Actually the critical temperature may be in the egg stage. We must set a high priority on knowing the prime ecological parameters that various species require.

To get this ecological data we need the taxonomic data to enable workers to recognize the species. Ecological data is significant only if we know to what species it applies. It is virtually impossible to become an aquatic ecologist if you have no knowledge of what organisms you are studying. We must know in an ecological study if we are working with two species or one, whether or not we have a different species or the same species studied by another ecologist. We need to know a great deal more about the taxonomy of mayflies. The literature contains some superb ecological work done on some aquatic groups of insects in Europe, but this is possible only because of the advanced state of knowledge of the taxonomy of the insects. Until North Americans can identify immatures, we will be unable to produce sophisticated ecological research on mayflies. All I have to do to send most North American mayfly workers into shock is to say "*Stenonema*" or "*Baetis*" or some other genus whose taxonomy is chaotic. In some groups not only are we unable to identify the species, we even wonder what the species is in the genus. Some of the work now going on will correct some of these faults. But this represents the unfortunate state of the science.

I have some serious concerns about priorities and the future of mayfly studies. Beginning entomology students see in their textbooks the detailed morphological work done by SWAMMERDAM several centuries ago on *Palingenia* a mayfly which was then very abundant in Holland. Apparently *Palengenia* now is extinct in Holland completely. Man has changed the habitat and the genus has disappeared from most of western Europe. West of the Russian border it is found primarily in the Danube and a few of its tributaries. The genus *Ametropus* also was described from Holland but is not reported from there since. I am not sure if it is extinct there but apparently it is gone from most of Europe, a victim of man's "improvement" of his environment. Over a century ago *Ephoron virgo* emerged in such great numbers from the Vltava River in Prague that their bodies were swept from beneath lights to use as food for captive birds. I have seen tremendous swarms of *Ephoron* and you will see such data on other genera during this conference. Although *Ephoron virgo* is not gone from the Vltava River in Prague, there are now very few. The fascinating little mayfly, *Proposistoma*, also used to occur in the Vltava. It is no longer there. Many rivers are changing and the fauna is disappearing, especially this is so in the big rivers. There are relatively few miles of big rivers in the world. And big rivers attract people and industry. We end up with most big rivers heavily polluted. The big river fauna is in great danger, at a crisis stage in many parts of the world. We either study it now or we forget about studying it.

One encouraging note is the appeal by Maria KEFFERMÜLLER (1959) to set aside part of the Warta River in Poland as a sanctuary to be protected because three very interesting genera of big river mayflies occur in that river — the very peculiar genus *Behningia* (whose relative, *Dolania*, you will see on the Blackwater River), the unusual genus, *Oligoneurisca*, a sand dweller,

and *Ametropus*. I hope that the Polish people are more enlightened than most of us are and that they will protect that stretch of the Warta River for the preservation of mayflies. Man worries about the protection and survival of a species of rhinoceros. People look at you as if you are peculiar if you want to preserve a bird species. But if you say, "I'd like to have this river set aside to preserve a mayfly species" then people question your sanity.

A number of years ago, I found one of the best collecting sites I had ever encountered. The Green River in Wyoming and Utah was the home of several marvelous mayfly genera, the carnivorous heptageniid genera *Anepeorus* and *Pseudiron*, a new genus of siphlonurid carnivore related to *Acanthrometropus* which will soon be described, the oligoneuriid genus *Lachlania*, the baetid genus that Traver and I recently named *Dactylobaetis*, and the leptophlebiid genus that I named *Traverella*. The genus *Ametropus* was there in considerable numbers. This locality on the Green River is now under 150 to 200 feet of water. It is behind a dam and the water downstream from that dam has changed so much that all of the mayflies that I named have disappeared from a long stretch of the river. It is a terrible example of mismanagement by man. LEHMKUHL (1970) recently has found in the South Saskatchewan River many of the same mayflies that I found in the Green River. But there are already stretches of the South Saskatchewan that are modified or polluted and these marvelously adapted mayflies are absent.

I would like to speculate a little bit about what I think I see happening to rivers when they become polluted with organic wastes. As organic material is added to overload a river system, the number of species starts decreasing. At the same time, the total biomass of insects increases so that there are more and more pounds of aquatic insects in the river, but of fewer species. As pollution increases, the surviving species are principally filter feeders occurring in great numbers. This great biomass is an effective filter system. But to make a filter system like this remove phosphates and nitrates you must harvest them from the water. Aquatic insects are especially important in that they are self-harvesting. Much harvested organic material is thus returned to the land, although some insects end up back in the river. As the organic load increases, the total oxygen demand of all of these organisms gets so great that the oxygen level drops to a critically low point and a massive die-off occurs; it may be possible to restore the insects if the river is flushed out to give the system a chance to start over, but what may happen is that the river will essentially become a dead system. Dead systems are much more likely to persist in lakes. I look upon this problem as equivalent to falling off a cliff. Organic load can be added up to a certain point, but once it gets to the point where it demands so much oxygen that it kills the aquatic insects, you have fallen over a cliff that must be overcome by lowering the organic load down to that which the river can handle without the filtering and harvesting system by insects. The difficulty is getting the organic load down to a place where the organisms can live is much greater than it was before. It appears that this is happening in some of the major river systems.

In some cases I believe we eliminate species from a stream by modifications of temperature. In temperate regions most mayflies evolved in a cyclic temperature environment which provides them with significant clues to coordinate the various stages of their life history. If we modify the temperature regime of a river we may take away one or more critical life history signals and the species disappear, not because of pollution but because of lost temperature signals. At the outfalls of some western high dams the water appears to provide a good environment for aquatic insects. But at some of these there are very few genera of aquatic insects, although these occur in great numbers. We have started some research at Utah on the thermal regimes required for certain mayfly species.

I can summarize my concern by noting that when organic material is added to a river productivity goes up and for a while this may be good. Then with more pollution the productivity gets higher and the public complains that there are many insects around shops and restaurant and demand control. Of course control defeats attempts to clean water systems by self-harvesting insects, but if you really dislike insects as much as some people, the control seems like Utopia. There are an increasing number of places in the world where you can sit on a river bank in an open restaurant and eat a salad or drink a glass of beer with a light above your dinner table and not have to worry about having an insect fall in your salad or having an adult mayfly alighting in your beer. When this occurs, it is almost too late to start worrying about the river.

Résumé

Tendances et priorités dans les recherches sur les éphémères

On observe une tendance à une amélioration de la qualité des recherches effectuées sur les éphémères. Les études locales cèdent la place à d'autres d'une plus grande portée géographique. Les recherches de bonne qualité sur les cycles vitaux deviennent de plus en plus fréquentes mais leur nombre est encore insuffisant. On observe maintenant un équilibre entre les études de caractère régional et celles de caractère international. Il y a un besoin urgent de données écologiques sur les exigences des espèces. Cependant celles-ci dépendent d'une bonne connaissance de la taxonomie et c'est pourquoi le développement des recherches en écologie est limité par nos connaissances taxonomiques.

Le danger que de nombreuses espèces disparaissent, comme cela est le cas dans certaines parties de l'Europe, est grand, particulièrement dans les grandes rivières. La faune de celles-ci doit être étudiée maintenant avant leur disparition. La survie de la faune exige la protection des rivières. Beaucoup de rivières sont déjà polluées, équipées de barages et ont leurs eaux modifiées thermiquement. L'enrichissement organique créé par l'homme a une action sur un nombre croissant d'insectes aquatiques. De tels insectes ne devraient pas être contrôlés par l'homme.

Zusammenfassung

Richtungen und Prioritäten der Eintagsfliegenforschung.

Man kann eine Tendenz zur Verbesserung der Qualität von Eintagsfliegenforschung feststellen. Provinziale Artikel machen denjenigen Platz, welche geographisch weitläufiger sind. Es besteht eine bedeutende Zunahme in guten Lebenslaufstudien; aber mehr sind nötig. Die Tendenz ist jetzt, regionale und internationale Artikel auszugleichen. Ökologische Daten über natürliche Bedürfnisse der Arten sind äusserst notwendig. Ökologische Daten sind hingegen von taxonomischen Studien abhängig, und der Grad der Verfeinerung von ökologischen Studien ist durch taxonomische Kenntnisse begrenzt.

Es besteht die Gefahr, dass viele Arten aussterben werden, wie in bestimmten Teilen von Europa, besonders in grossen Strömen. Grosse Flussfaunas müssen jetzt studiert werden, bevor sie aussterben. Flüsse verdienen Schutz zur Erhaltung der Fauna. Viele Flüsse sind schon verschmutzt, eingedämmt, oder ihr Wasser ist thermal verändert. Überflüssige Zahlen von aquatischen Insekten sind oft durch des Menschens organische Bereicherung verursacht. Solche Insekten sollten nicht vom Menschen bekämft werden.

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