On the subject of experimental introductions we have a good case where this would be possible if we received the cooperation of the Spanish, French or Italian government. The two Chondrilla insects which occur only in the eastern Mediterranean region could very well be introduced into the western Mediterranean region. If this were done and no cultivated plants were attacked in the western Mediterranean, this would be very good evidence for introduction into Australia.

ZWOLFER The time is up. I wish to thank all the participants of this lively and informative discussion.

END OF FIRST SESSION OF COLLOQUIUM

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UNSTRUCTURED COLLOQUIUM
(Second Half)

Dr. Fred Bennett, Moderator
CIBC Trinidad, West Indies

DREA I was impressed with the photographs of Lantana, and the dense mat it made over the areas. I just wondered, what if you had a very effective insect that would control Lantana in a given area, but this insect also attacked, to some degree, a crop in the area, would it be possible to arrange to pay an indemnity for the damage done to the crop?

ZWOLFER I think that in such a case the decision would be up to the organization who sponsored the research and I know that the Australians, for example, who are very strict, have after a while given authorization to introduce insects which actually did a little harm to economic plants just because their pest problem was so big. There are certainly cases where one has accepted an insect even one which does a minor damage to economic plants, if there is an urgent need to introduce something against a weed.

BENNETT This has not answered the question entirely about payment of indemnity. I don't know of any examples where actual payment has been made. Certainly it would be feasible if the situation warranted it. In the control of weeds with herbicides where the weed problem has been overriding there have at times been side effects which are tolerated on crops in the West Indies. The control of weeds in sugarcane has occasionally resulted in the drift of 2-4-D onto cotton and the sugar producers or the government have paid indemnity to the cotton people. In a lighter vein, some of those who were paid the indemnity made more money than those who finally reaped their crop! Of course this is on a temporary basis and it is a question, when considering the introduction of a phytophagous insect, of whether we can predict that a relatively minor crop now may always remain a relatively minor one. As the pattern of the economy changes, a minor crop may become a more important one. Whether we should evaluate the risk on present day conditions or on future possibilities poses a problem. I raised the point only for discussion, not to arrive at a serious conclusion. Politically, if not on scientific grounds, if this question did come up it might be possible to suggest, under certain circumstances, that if we want to control an insect introduced for the control of the weed we could go back and, as we do for the biological control of insect pests, bring in the parasites of the weed

insect to rectify the balance which was upset or bring in the weed control insect in the first place.

SANKARAN Dr. Bennett, regarding one topic mentioned here, "Control of weed pests with parasitic plants", two parasitic plants immediately come to my mind. One is Striga with which we are dealing at the Indian Station of CIBC and also there is the notorious dodder, (Cuscuta spp.). The weevil Smicronyx is known to attack Cuscuta in Pakistan. We have two species of Smicronyx, one is S. albovariegatus which produces stem, root and flower galls on Striga and the other is a new species, which is being described by Dr. Anderson of the U.S. National Museum. This latter species produces galls on Sopubia which is also a parasitic plant related to Striga. I wonder whether any other entomologists here have information on this weevil genus Smicronyx, i.e., whether it is confined to parasitic plants or it is merely a question of convergence, or whether there is any phylogenetic problem involved restricting Smicronyx to parasitic plants. The second question concerns the control of Mikania. This is not a parasitic plant but there is a Cuscuta which parasitizes Mikania and it has been suggested, as Dr. Bennett may be aware, that this may control the weed. Unfortunately this Cuscuta is not restricted to Mikania and may parasitize forest trees, so this is not being pursued seriously.

BENNETT Dr. Zwölfer is perhaps the most knowledgeable specialist of weevils here, perhaps his experience extends to the genus Smicronyx.

ZWOLFER I'm sorry I cannot answer this question.

BENNETT With respect to the possibility of biological control of Cuscuta initial attempts were made to introduce a species of Smicronyx into the Bahamas and into Barbados as well as an agromyzid from the Pakistan station. While cage tests in Barbados indicated that the agromyzid developed, there were problems in getting oviposition by the weevil on the Barbados Cuscuta, because that species of Cuscuta is different from the Pakistan species and possibly the reproduction did not occur on Barbados species. At any rate, so far, there is no evidence of establishment of either the weevil or the agromyzid following release. The Pakistan species of Cuscuta can be divided into two groups depending on the thickness of the stems. The species in the West Indies are intermediate between the thin-stemmed and thick-stemmed species. The insects mentioned came from the thick-stemmed species and now investigations are underway on the thin-stemmed species that are more similar in character to the species occurring in the West Indies.

BENNETT Does anyone have other topics to raise?

SANKARAN In relation to biological control of aquatic weeds, I think I have seen some correspondence about the partial control of aquatic weeds by insects. There is a report from south India on the value of the noctuid Namangana pectinicornis for control of Pistia stratiotes. The report says it is not desirable to use this noctuid because if the weed is not completely controlled, it actually pollutes the water and increases the breeding of mosquitoes. Pistia stratiotes is known to harbor some species of mosquitoes which are vectors of filarial disease and the report says that it is not desirable to use this insect because it doesn't control the plant completely and the roots are left undamaged below the water and they produce a fresh growth with the result that the weed is not controlled, and the partially destroyed weeds pollute the water and this encourages rather than discouraging the breeding of mosquitoes. I would like to have the opinion of others whether we should, in spite of this observation, go for an insect that is capable of giving only partial control, in the hope that some pathogens will take care of the rest of the problem.

ZWOLFER My question is, how can you predict there will be only partial control? Isn't this rather difficult?

SANKARAN Yes, I suppose we cannot predict it but once we introduce something and it gives only partial control will the end result be beneficial at all? That is the point.

ZWOLFER That is a risk we have to take with any agent we introduce.

BENNETT It might be possible to work with this noctuid elsewhere under experimental conditions to determine just what levels of damage do occur. Of course you cannot even on this basis apply these results exactly to another aquatic situation particularly if the nutrient levels in the two are different.

SANKARAN I think this weed is a problem in Ghana. Weren't you interested, Dr. Scheibelreiter, in the control of Pistia? Probably you could undertake some limited field trials on this.

SCHEIBELREITER Pistia has been mentioned as a problem in the Volta Lake but during recent years Pistia exists but is not a problem at all. Only on the man made lake at Barachese Dam is it a real problem. We have studied the insect species associated with Pistia and we may start making introductions next year.

ZWOLFER Among the topics suggested by Dr. Andres is the consideration of the use of organisms other than insects in the biocontrol of weeds. Now, you Dr. Bennett, have discussed this extensively for water weeds. I think it also concerns terrestrial weed control. Our choice is much smaller, and I'm wondering if anyone has considered so far the use of parasitic nematodes. We know that parasitic nematodes are among the very aggressive plant pests. Would somebody like to comment on this?

ANDRES Didn't the Russian investigators do something on nematodes? That is the only case I know of.

BENNETT It is perhaps a question of whether nematologists are late in entering the field of biological control because the profession is relatively younger than that of entomology, or whether those of us (mainly entomologists) who have been in biological control the longest have never seriously considered getting nematologists to work on the problem. Frequently, once someone has started something that shows some promise, then there is a tendency to jump on the band wagon. Certainly bringing to the attention of the group that work is underway in Russia may set certain of us thinking along these lines, at least to the point of making inquiries.

ANDRES I want to ask a question. I have never really worked with the life table approach to mortality studies of plants or insects and I am curious to know if anybody here is aware of anybody doing life table analysis work with plants. Is this a possible tool that we could use in some of our work, perhaps for evaluating the effect of insects, etc.?

ZWOLFER Dr. Harris and I have discussed this question. If there is a weed species with a high production of seeds and high population densities of seedlings and rosettes, a life table study might indicate that the destruction of seeds is not very effective (as there is a large surplus production) and that the control of seedlings and rosettes is rather pointless as they are quickly replaced by others. Dr. Harris suggests that in such cases attacking the shoot system of the weed may be the preferable agent. I think the life table approach would be useful to find out the weak points in the life cycle of a weed population.

SCHROEDER Whether entomologists working in the practical field of biological control will be able to conduct such life table work is another question. I think we need people like Dr. Cavers to support this. We need the interest of botanists, because the life table of the plant is a botanical question more than an entomological question. Our work comes in as an additional mortality factor because we are attempting to introduce a mortality factor which doesn't already operate on the plants we are trying to control.

BENNETT I think this points to the growing feeling that with many of these problems we need a team approach and certainly the practice of entomologists working with ecologists, etc. is a sound one. If the people that control the money can also be pursuaded thus, I think we would all be very happy about it.

ANDRES I was wondering, Dr. Frank, are you using a life table approach at all in any of your weed control studies?

FRANK No.

BENNETT There is perhaps growing skepticism among some of those using life tables for insect studies as to whether the effort in compiling straight life tables is worthwhile or whether you can employ your time better by another approach. I am not well enough versed to pass judgment on life table studies.

FRANK Would you explain this term life table, perhaps I misunderstood.

ANDRES As I understand it, one starts with a cohort of 100 or 1000 or whatever individuals. For example, you can start out with a seed population and then you have a certain amount of germination and some of the seedlings die from certain causes and you have a certain number of survivors that move on to the next stage of growth. Some die at this stage and so on until finally you have reached the adult stage or the reproducing stage of the plant, and the life cycle is finished. What you do is to try to record all the mortality factors acting on the different stages in the life cycle. For example, if you have something that would destroy a high percentage of the rosettes we could perhaps supplement the action with an insect or a fungus. The life table study might give us an idea of the optimum stage to interfere with the plant, even the best stage to apply a herbicide.

FRANK We do have what we call life history studies but they are not detailed to the extent that records are kept of the various causes of mortality and number of deaths. Occasionally we use something approaching life tables where we do keep records of numbers of deaths from a specific cause, but not the whole gamut of possibilities throughout the life cycle of the plant.

ZWOLFER I have seen some of the data of Dr. Wapshere and I think he is doing a life table approach. He had to leave, otherwise he could comment on this. He certainly has populations in the field where he counts individuals and where he follows the fate of individuals. He mentioned, for example, the reductions in numbers in plants from spring to fall, in plots with phytophagous insects and plots without.

BENNETT I have discussed this with some of my students, more as it applies to insects instead of plants, and on the comparative ease in doing this in areas where you have discrete generations as opposed to areas where you have continuous breeding and where there is difficulty in keeping the cohorts separate. Possibly with plants, if you have a long period of germination you may encounter a similar problem. The mathematicians perhaps will tell you it is just a matter of adding in a few more factors and feeding them into the computer to sort these things out.

ZWOLFER Certainly one of the problems is, if you have a weed which covers a broad ecological range, then a single life table study of a single population isn't enough, because you may get quite another picture if you study the insects or the plant in another ecological condition, so to be able to draw conclusions you have to make several comparative life table studies.

BENNETT This leads to another topic with which I am concerned. This is the difficulty in sampling or evaluating aquatic weed control compared with terrestrial situations, particularly if the aquatic weeds are floating populations and your whole sampling area may

move or, where there may be more change in the nutrient levels in the water from time to time during the year than there is in terrestrial situations. I am concerned about how to lay down sampling methods to really evaluate this. Obviously where you've got very spectacular control, photographic evidence is very convincing providing you can keep track of your areas! I wonder if anyone else has given much consideration to this and come up with any conclusions.

FRANK We have a study now in the Florida Everglades in which some attention is being given to this problem. Among other things, the nutrient levels are being monitored and the effects on plant growth observed over a period of years. To our knowledge this is the longest term study of this kind ever made. Short-term studies made previously, as you might expect, were quite inconclusive. As you indicated, accurate sampling is a major problem. In this instance, the difficulty was resolved by increasing the number of replicate samples until it could be shown statistically the errors involved were within an acceptable range.

ANDRES Maybe what we have to do is instead of measuring the mortality of the individual plant, find some way to measure the increment of growth of the plant. The insects might not particularly kill a plant but merely slow its reproduction or slow its growth rate and this might be enough.

SCHROEDER But in this case it wouldn't be any longer a life table approach.

We could call it an assessment of the impact of phytophagous insects on their host plants, or something like this.

BENNETT That certainly opens another avenue that we should explore. Turning again to floating aquatic weeds, it is also intriguing that if your population of weeds is moving down a river stream you might be able to introduce your insect on floating weeds near the source of the river and disperse it by this means. Obviously, the situations where this method would apply are limited. It comes back to sampling difficulties and keeping track of your populations.

The infestation of Salvinia on the Chobe River in Botswana to a large extent is considered a form of pollution, not necessarily now but in the future. Every year the river flushes out and subsequent recolonization occurs. In this situation the difficulties of sampling become even more apparent.

ZWOLFER In such cases, do you have populations if you have floating mats? I think you can't assess the population if there is no population.

BENNETT Your populations obviously change from place to place and season to season, and to evaluate the impact of an insect in this situation, is extremely difficult.

SCHROEDER The evaluation of the actual damage of an insect depends on whether the insects remain on the plant, and whether they can be counted again. We have to relate the damage to the numbers of insects present if we want to put this into some sort of life table. But, if the adults are feeding and these adults are moving, you may end up with 10 beetles on a plant with the damage of 30 others which have left in the meantime. So, this is another difficulty and it may be necessary to use the oviposition rate, or to try to relate damage to some figures which remain stable.

ZWOLFER Feeding marks, perhaps.

FRANK Some of these things certainly can be done insofar as floating plants are concerned. They may even be stabilized in some way. When it comes to submersed plants the situation is considerably different in that it is far more difficult to observe on a given population the plants, insects, or their effect. Too, there are other factors involved

that influence the populations of the submersed weeds. There are probably many causes of variability in populations that we are not even aware of.

BENNETT I was intrigued by Dr. Huettel's paper yesterday, perhaps he would care to speak more about his work.

HUETTEL There are several po' ential uses for allozyme electrophoresis which may be of interest to the participants. In the country of origin of a biocontrol agent it should be possible to use rare alleles as markers for dispersal studies. It is also possible to investigate, in the field, aspects of mating behavior such as inbreeding and the number of matings by females. It is also possible to reconstruct patterns of oviposition behavior. Another potentially useful prerelease study might be the determination of geographical populations with high average heterozygosity and therefore, perhaps, general genetic diversity. Insects from these populations might be the most adaptable for release purposes. A postrelease application of this technique would be to determine whether genetic drift occurs in introduced populations. If anyone has a problem to which these techniques, or the separation of sibling species, might be applied I would be happy to discuss it with them now.

SANKARAN Dr. Huettel, the technique which you outlined yesterday, for the separation of sibling species, is it possible to apply it to very minute insects like Trichogramma?

HUETTEL I think so. By pooling individuals from known populations you can run samples of very small insects and you could see, on a population basis, if there were qualitative differences. I don't think you could get quantitative data so you might have to look for discrete differences between populations in the same manner that the old protein electrophoresis with non-specific staining worked. It would be about the same sort of taxonomic technique.

SANKARAN We have made a point that doesn't pertain to biological weed control, but since we have extended the scope of your technique to other aspects of biological control, I thought we might take advantage of the knowledge which you have gathered.

ZWOLFER Dr. Bennett, could you raise the point, "The present studies and the potential for the biological control of weeds in Europe", which was proposed by Dr. Franz.

BENNETT Do you want to table this for discussion or do you want to comment on it.

ZWOLFER I want to bring it to discussion. It is regrettable that wilst a number of biological control workers are investigating Europe as a source of agents for biological weed control, no work is being done with regard to the control of noxious weeds in Europe. The only European country which carries out some work on biological weed control is the USSR, but I understand that most of the work there is done in the Asiatic parts. We have in Europe a number of introduced weed species which warrant attempts at biological control. One of the target weeds would be goldenrod, Solidago spp. The aspects of biological control of this weed were discussed at our first meeting (Delemont, 1969). Ambrosia spp. are weeds introduced from North America. Ambrosia is now widely spread in eastern Europe, in the Balkans, in southern France, in eastern Austria, etc. The pollen of Ambrosia causes allergenic reactions and that is one of the reasons why Dr. Kovalev in the USSR is investigating the possibilities of biological control of this weed. The North American insect fauna associated with Ambrosia has been studied by Dr. Harris and certain insects (e.g. the Noctuid Tarachidia candefacta) have been screened. Hence, a biological control program of Ambrosia in western Europe or in the Balkans could profit from the information and experience which is already available. Galinsoga spp., an agricultural weed of South American origin, is widely distributed over many European countries. Again, it might form a suitable target species for biological control. There are other plants which could be enumerated, e.g., Polygonum cuspidatum, of Japanese origin, which is noxious in certain parts of the British Islands.

One of the reasons why biological weed control has not as yet been attempted in Europe may be the fact that actually nobody knows which organization has to be contacted for introduction permits, etc. Whilst in North America and Australia procedures are comparatively simple, because these are continents with very large countries. In Europe we have to deal with the administrations of many small countries with corresponding jealousies and conflicts of interests. Nevertheless, I think we should try to promote the idea of biological weed control in Europe by discussing its possibilities with our European fellow entomologists and weed specialists. Now many people are becoming conscious of pollution problems, it may be possible to gain official support for biological weed control in Europe.

SCHROEDER I'm wondering why Dr. Franz has brought up this question, because he is Director of the Institute of Biological Control in Germany. I visited him recently and I asked him this question because we have talked about it in Delemont on several occasions. I was interested to learn that in the Federal Republic of Germany, Dr. Franz who is the director of a federal institute has difficulties in obtaining permission to conduct practical biological control work in the different provinces of Germany, without prior authorization of the provincial governments. As long as the legislation of a single country does not allow the free circulation of plants and insects within the country, we cannot expect to reach international agreements. This is the situation in Europe.

BENNETT Has Dr. Zwölfer given any consideration to publishing a paper as to the possibilities of biological control of weeds in Europe?

ZWOLFER Well, Dr. Peter Harris, Dr. Capek and myself have a manuscript in preparation concerning the possibilities of a biological control of goldenrod in Europe.

LITTLE I am most grateful to Dr. Zwölfer for suggesting intensive work on Ambrosia. This is a plant which is a double barreled menace to human beings, competing with crops and also causing untold misery to a large portion of the population in the form of hay fever. It extends another six weeks or so the conventional allergy season, which is imparted by graminaceous plants. I encountered this personally in the delta on the Danube in September. I feel that when a weed is a double menace to us it deserves high priority for attention.

BENNETT It would appear so. What is the approach of the Russian scientists on this? Is some exchange of material in connection with Ambrosia going on, or is it not a problem in Russia?

ZWOLFER It is a pity that Dr. Kovalev could not join us, as he would have had first-hand information on Ambrosia. He has liberated the North American Noctuid Tarachidia candefacta after careful screening tests. So far there is no exchange of material between the USSR and western Europe, but material is exchanged between North America and the USSR.

BENNETT If the insects become established, presumably they will spread across international borders, perhaps as fast as the weed is spreading. In other words, once an introduction has been made into one area of Europe, won't the insects spread as obviously as the weeds have spread?

ZWOLFER Yes, I understand. But, Dr. Kovalev is mainly working in the far eastern part of Europe and in Asia. Therefore, the Rumanians must wait, I'm afraid 20 years or so, before they get the benefit of the introduction. They would be doing better to speed it up by additional releases.

BENNETT Our time is up. I've enjoyed chairing this last session and I wish to thank the participants, and hope the discussions have been stimulating to all.

END OF SECOND SESSION OF COLLOQUIUM

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