Discussion

Chairman (Ishikura): The presented papers are divided into two categories: One is under the joint program of FAO/IAEA on the radiation use for rice insect control and I would like to invite Dr. Ouye to make a brief summary of the presentations.

Ouye: I think what we covered can be divided into three areas; ecological, rearing, and radiation studies.

On the ecological study, some points were brought out in the discussion, so that more work should be done. But there useful informations already that can be used for the integrated control program. At this particular symposium, not much has been said on it. Perhaps some other day you will cover this area. So, for us, since our man-power was very limited, we must go on a narrow path.

Generally speaking, the contractors will next year emphasize ecological study as related to the rearing study. But we are not sure how far they will be done, because some of the contractors are only settled along as the contract continues.

Then, the second area we covered varies. As presented by Dr. Sakai, there are many artificial diets, the results of which we presented and also there are some which have been published. However, I don't see them used routinely for your laboratory stock culture. In case of one speaker, Kamano, he has gone through six generations on the artificial diet, and I believe he still maintaines the culture of *Chilo* on the artificial diet. But I think the artificial diet is still not so satisfactory.

Generally, most of the contractors are satisfied with their oviposition cages, but the cages are not standardized. For the larvae and adults rearing, most of the laboratories keep them at room temperature of about 25°C to 27°C. Most of the laboratories treat the eggs against diseases. They are treating them with aldehyde, some of them using hypochloride. They had not been using water radiant agent until we discussed this and decided to use it. But I believe the treatment dosage may change, because it will help you to get direct contact of the insanitary agent with the eggs.

Regarding what they will do, they will check the effect of density in their oviposition cages on egg production, mating, and longevity. Some of them also do work on the effect of photoperiod on mating and egg production. They feel that it may help, for example, in the problem with the *Tryporiza*, then with the larval diet studies. Many times eggs don't hatch in some laboratories. I'm not sure yet this is due to something other than mating.

One of the things that we discussed was some of the data from the people working in West India. The problem was that there was artificial rearing in which they have this phenomenon: when you rear moths on apples, the hosts produce normal moths, but when you place them on the artificial diet, the moths get smaller. However, a laboratory in Canada has been able to increase the size by adding polypeptides, so that the public tries that type of work. Therefore, we are hoping that particular artificial diets will be standardized someday in the near future.

The third area was on radiation. This area was very specialized and so I just briefly say that the radiation type work as well as the competition type test is not completed yet. We try to do more dosage studies, then look into the F_1 stability phenomenon that is very common in *lepidoptera*. We check the competitiveness or ability of irradiated moths to try to increase the ability to compete with the untreated males.

Chairman (Ishikura): In the last three days and this morning, so many papers have been dealt with ,and since I was not alawys here, so I cannot follow the actual pictures which were made by these papers. But, for the convenience of general discussion, last night I just briefly went through all the papers. And this is my feeling

that there were at least three big groups of the insects which were discussed in the course of the FAO/IAEA session as well as the TARC session.

One of them is the stemborer. As for the stemborer there is a very concise and excellent summarized paper of Miss Hattori on the recent knowledge of the stemborer species which is distributed in Asian countries. However, there's some notification that the species itself is not well identified, and that there may be some points to be discussed regarding a species of stemborers in relation to the rice growing in Asia. The stemborer problems are extensively treated in the course of the seminar on the aspect of ecology, and there was implied the possible application of this ecological findings to the control or suppresion of stemborer population. As right now Dr. Ouye mentioned, many people have found many rearing techniques.

The second group is the sucking insects of leafhoppers and bug species. Although in this case there are some taxonomical new findings, yet these new fidings are some sort of a new headache to the applied entomologists, because the species' names are quite changing. So my old knowledge has almost become very obscure, and I am afraid that I may find much difficulty in evaluating recent publications, if these new scientific or newly authorized scientific names are used afterwards. So many people gathering here can take interest in this taxonomical problem of the leafhoppers and bugs.

And the second item of the leafhopper would be on the possible use of the future resistant rice varieties for the actual leafhopper control. The papers presented by Dr. Pathak and some other people regarding the development of resistant varieties and some basic information regarding the mechanism of resistance would be of interest.

And another somewhat unique report would be the paper presented by Dr. Kishimoto on the mass flight range of leafhoppers. If this theory on mass flight range is correct, a forecasting system in this country as well as in other countries should be changed. At least in making more correct forecasting of occurrence of leafhoppers, I think we require some international cooperation or the new equipment such as ladders which can detect a flying mass of the leafhoppers while they are in the air.

The third group would be the gall midge and other flies. There's the maggot which bores into the stems of rice plants. The papers of Dr. Fernando as well as Dr. Tanongchit were quite full of the new findings, but I'm rather confident that there are many things which require further investigation on the gall midge. To my thinking, from the biological aspect of the gall midge, the rice stem maggot, which is mentioned in the paper presented by Dr. Koyama, is somewhat similar in the behavior to the stemborer within the rice plant. I suspect that there may be some similarity which could be remarked in the developing of the control of the gall midge and the rice stem maggot. In this connection to the gall midge, they lied importance on the varietal resistance.

As you may know, so far the rice insect control was hoped to be practiced by use of pesticides. The chemical control of rice insects had been recommended very extensively in this country, but because of the environmental polution resulted from it we have now to search for substitutive methods. In this respect, the utilization of varietal resistance will be more and more promising at least from the report made at this occasion.

I hope finally that the concise report of Dr. Ouye and what I said right now, and some comments to be made by Dr. Pathak would serve as the background of the general discussion.

Chairman (Pathak): As Dr. Ishikura pointed out, more than 30 papers presented during the last 3½ days furnished evidence of the vast knowledge that has acumulated on the insect pests of rice. When we had the first International Symposium on this subject at the International Rice Research Institute (IRRI) in 1964, the information available on some of these subjects was rather meager. By bringing this recent infor-

mation together, this symposium has accomplished a very valuable task. I want to congratulate Dr. Yamada and his colleagues for organizing such a fine symposium and also I appreciate the opportunity given to me to participate in it.

This morning, I asked Dr. Yamada as to what he wished me to do as a Co-Chairman of the concluding session. He said that the objective of the Tropical Agricultural Research Center (TARC) is to assist other countries in their endeavor to increase food prduction, and would like my remark to be very much oriented towards this goal. This is a very noble objective and the International Rice Research Institute is also dedicated to the same course. Thus we have a common objective.

There are unlimited possibilities for the Japanese entomologists to assist their colleagues in their research endeavor in developing countries. Many distinguished and highly diligent Japanese scientists, assisted by very able associates, are investigating the various aspects of basic and applied entomology. Such efforts are frequently not possible in several other Asian countries where a rather limited number of entomologists have to cover the various aspects of the plant protection for all crops. Besides, these entomologists also have to devote a considerable part of their time to administrative and other affairs. Since some of the pest problems in Japan are in many ways similar to those in other parts of Asia, the information obtained in Japan can be with some modifications adopted for these countries as well. At present, TARC can make a significant contribution by making available the information of the work done here, (this is particularly important beceause the bulk of the literature from Japan is published in Japanese), and by exchange visits of entomologists from Japan and other countries. TARC has already made a good start along these lines, but further expansion of such activities should prove very useful.

Another problem many entomologists frequently encounter is that of proper identification of insect pests. At present there is not a good Taxonomic Research Institute in Asia, and most often insect specimens sent to American or European insect museums take a long time to be identified. This is probably because the insect fauna of Asia is considerably different from that of Europe or America, and naturally the taxonomists give priority to collections from their own area. I fully realize that it involves a large capital to establish and run an insect identification center, but the fact is that it is urgently needed. One possibility is to strengthen the already existing taxanomic laboratories, and to appoint a coordinator for identification of insect specimens from tropical Asia. He may also encourage taxonomists in other countries, and thus develop a team of specialists on all major group of insects.

Now, a few comments about the subjects covered in this symposium.

Currently people all over the world are getting deeply concerned about the extensive use of pesticides. This issue was raised on several occasions during the symposium although the detailed aspects of the use of pesticides is scheduled to be covered next week in the JACODEC conference on pesticides. Of course, most of us do realize that at present the only method of immediate reduction in pest populations is by the use of pesticides, and probably this will continue to be so for the next several years to come. This is primarily so because many species of insects are rice pests of major economic significance and no alternative method of insect control offers the possibility of being effective for all these species. Currently, in most of the developing countries in spite of severe crop losses by insect pests, only about 15 to 20% of the farmers are using pesticides and often at lower than recommended rates. At this stage a dampener on the use of pesticides may act as a major hurdle against the green revolution which is at the "take off" stage in most Asian countries. We should be conscious of the problems of pesticides, and proceed carefully so as not to block the actual agricultural development and at the same time avoid the hazards caused by pesticides. Insecticides should

be used, but only when they are needed.

Information on the persistence of pesticides from temperate areas like Europe, U.S.A., and Japan may not hold true for the tropics. One example of the short life of some of the pesticides in rice fields in the tropics is that of Gamma-BHC. While under upland conditions this compound is known to persist for several years, it gets reduced to very low levels within 20 to 30 days in the flooded fields of rice. This breakdown is accomplished primarily by bacteria. We had a similar situation with diazinon. This compound was used as a standard insectiicide for insect control at the International Rice Research Institute for a period of 3½ years giving extremely effective control. However, on its repeated applications to the paddy fields, the development of a bacterium has been recorded that breaks diazinon down completely, sometimes in less than 24 hours.

The feasibility of using varietal resistance as a method of insect control was discussed in four papers during the symposium. This method appears to have a good promise against the stem borers, the leafhoppers, the planthoppers, the rice stem maggot and the rice gall midge. The results obtained so far appear to be very encouraging, and entomologists, geneticists and plant breeders are, for the first time, working together to develop varieties of rice resistant to various insect pests. However, the approach is still new for rice, and more intensive work is warranted. The unique advantage of this method is that the varietal resistance affects insects at all levels of population density, and it is compatible with other methods of insect control.

The biological control of insect pests in the tropics has received few concerted efforts. Several entomologists who initiated their career as biological control specialists later on turned out to be taxonomists because of limited facilities for insect identification and the rather rich and comparatively unexplored insect fauna of the tropics. Still this method of insect control appears to be very valuable in equiclimatic tropical Asia where the host plants and the insect pests are present year round. There is a real need to intensify efforts on this subject.

In recent years, there has been quite interest in the use of insect attractants and sterilants. We do not know at this stage as to what aspects of this, if any, will have practical possibilities in tropical Asia. However, basic studies on some of the more common insect pests deserve immediate attention. Some experiments at the International Rice Research Institute have established the existence of a very definite sex attractant in the striped borer female moths which can be extracted and used for attracting male moths. Also, it has been observed that several chemosterilants, when fed to the borer moths, did not affect their matings but caused up to 50% reduction in the total number of eggs laid and in the hatchability of the eggs.

An integration of all these methods appears to be a more efficient and practical approach of rice insect pest control than the use of any one method alone. A good start on certain aspects of control has been made but still we have a long way to go.

Chairman (Ishikura): Shall we now open the floor for the general listeners to discuss? Now we like to discuss the major items Dr. Pathak and myself have suggested. Or is there any other items which participants are interested in?

Yamada: I'm not an entomologist, but I had been a research worker in agronomy of rice. I have some questions in my mind. The problem is related to the ecological study of rice insect. The problem is the assessment of a damage of the crop caused by insect pests interm of rice yield. How to assess it, and what is the actual percentage of the damage caused by the insect incidence with different population density under different conditions. In case of stemborers, for example, we count the number of the dead heart or we count the number of the white head. I think I can say that the percentage of the white head to the total number of panicle may indicate the loss of yield,

though not so exactly but at least to an appreciable extent. But in case of counting of the dead heart, I don't know whether the percentage of the dead heart to the total number of stem can indicate the loss of yield or not. In order to establish the economic control practice or in order to determine the economic injury level of the insect population, it will be essential to have reliable assessment of crop damage. This is my question which I have in my mind always.

The second question which came up in my mind after having listened to the presentation of delegates from different countries is on the method of the screening of variety for particular kind of insect. At this symposium, the distinguished delegate from India reported that a variety PTB 18 is highly resistant to the gall midge, but a distinguished delegate from Indonesia reported that this variety is not found resistant in Indonesia. I also remember that Mr. Hidaka mentioned that this variety is not found resistant in Indonesia. I also remember that Mr. Hidaka mentioned that this variety is not found resistant in Thailand. Is this inconsistency caused by the difference of the environment or difference of the screening method? In this connection I would like to point out the importance of the standardization of screening method to determine varietal difference in resistance to each kind of insect pests.

Chairman (Ishikura): I think that very recently FAO compiled a very extensive report of the method of the assessment of loss caused by various insect pests and diseases. And I referred to the book, but regarding stemborers, very little information was described.

Reddy: I think you have referred to the FAO symposium on crop losses. Very little information is actually available on that subject. And we seem to have progressed to some extent, but still there needs to be studied in that direction. I am talking about not only stemborers, but other pests. Because no plant pathologist apparently but the chairman and Dr. Yamada has suggested that there needs to be a standardized method of assessing crop damage.

Now I'd like to call our attention to the extension worker when this recommendation goes to a lot of public. For what scientists consider right is very difficult to practice. Why extension workers in different areas aren't really advised on what stages to tell the farmer that this is right so you'll get compensation and on what stages they should use. But the actual estimation is very difficult, no doubt. It may have to be continued for not one season but a year. There needs to be a standardization with regard to estimation of losses which FAO with the cooperation of all the countries concerned has established. As Dr. Yamada suggested with regard to the standardization of the varietal testing for resistance, I think somebody should sit down and write up some methods which are presently being used and then extension people meet in some conference and accept the mthod which is actually applied.

Chairman (Ishikura): Dr. Reddy's second question was to standardize the method of the screening of rice varieties to a particular insect pest. Is there any idea to improve the procedure of the screening of rice varieties? Mr. Fernando, don't you have any idea?

Fernando: I don't know, because I've been working on technique of screening gall midge. I think we have to get together in some place to decide which techniques are really the best.

Reddy: I am not to say anything further, Mr. Chairman. But just to clarify what point you have arranged about the standard and Dr. Fernando has said. I think people are interested in the subject to decide the screening method. This has been done for the uniform some years before testing method. Now it has been internationally accepted and followed but has something that could be developed for this. And recently in the International Rice Commission Meeting, they also suggested the similar method

for bacterial leaf blight. So it should not be difficult, I'm sure, with rice entomologists if they cooperate with rice pathologists.

Wongsiri: I just want to ask this question to Dr. Pathak. This past April when IRRI invited entomologists and other scientists also attending at IRRI, I don't know whether you discussed this on spring moth of the gall midge or not.

Chairman (Pathak): Yes, we did. Dr. Yamada discussed the problem of some varieties which were resistant at one time or the other. Of course the result was the possibility of the same disease, but one of the difficulties which India had was the gall midge center where they didn't have entomologists for the last 50 years. So their data is really not comparable. But and large, at IRRI, standard procedures for screening for resistance for leaf hoppers, stem borer, and gall midge are available.

Dyck: I've just a couple of comments and one question on the subject of integrated control of test management. I would like to suggest that we do more in a line of making a package control and try it out experimentally in different countries. Now we leave out this to extension entomologists. But I'd like to suggest that we try to put together all our ideas for control of a given crop, rice, and not just chemical control of stemborers and somebody else does something on a varietal resistance for leaf hoppers. They can crop, I mean, in different seasons and different places. So we begin to actually integrate the method, not leave it up to the extension people who don't have the resources and certain experiences in research. That's my first point. So let's experimentally try out our test manageemnt system.

Secondly, on sampling the insect pest, we have really talked about this sampling in the field. And someday, I'm thinking, I'll sit down and try to write some way of sampling rice insects. But this would probably be restricted to the tropics in a way. And I would like to encourage first of all somebody to write a paper on the subject of all pests to put all together, so that extension people have a good idea of all the ecological problems involved in sampling rice pests. So please, let's put the together, if we can, so that everybody has assess to the sample techniques, and therefore the data becomes comparable.

And lastly I ask a question of the people connected with atomic energy. Will stemporer control be possible in the tropics by releasing sterile males? Now we've been talking about *Chilo* and the reports, I think, all from Taiwan, Japan and Korea. What about the Philippines, Indonesia, Malaysia, Ceylon, and so on. Is sterile male technique possible in the tropics or is this basicly related to the summer season situation only?

Ouye: As I mentioned the other day, I think it's pre-mature to try to answer to that one, mainly because we need to know more about the question you asked previously, in other words, what we have at present for crop protection, plant sanitation or whatever term you want. For if you know that, then, you can begin to put your dollar and cents.

I said the control is theoretically feasible. In the tropics you have flactuation ups add downs. Theoretically you yourself, all of you, are encouraging different methods to lower population. The population can be lowered? Theoretically it can be controlled, but more important is the question: is it practical? In some instances the other method is already available, to me I feel as available, but nobody proved it yet. One of the things we talked about was the cultural practices. I'm sure if you really use the word "integrated" as truly defined by FAO and if you apply integration control cannal into some areas of rice cultivation, I'm sure you can come up with the very expensive package deal. But you have to put it into practice.

Chairman (Ishikura): Dr. Dyck raised the very interesting proposal of the integrated control of rice insect. Reflecting my experience over there, the first target was, in the case of our rice protection, was the stemborer, and many entomologists, includ-

ing myself, fixed chemical control of the stemborer. The stemborer was supressed by the extensive use of BHC as well as organophosphate, but in the course of the use of BHC, it raised a new problem of population increase of leaf hoppers. And the contamination of B by the DH residue was very recently reported.

But anyhow, in discussing integrated contro lof rice insect pest, we have to recognize the rice pests as a whole, not as a single pest. In this connection, I guess that Dr. Ito or Dr. Kiritani may have some idea to the approach of the integrated control, since these two doctors are rather proud, because they are ecological entomologists, not chemical entomologists.

Itô: I would like to say my opinion very frankly. Japan has developed very efficient methods of control by chemicals for rice crop pests. However, in addition, we experienced some harmful effects such as the increase of new pests and development of resistance and insect residues. This is the symposium of the Tropical Agriculture Research Center, so I'd like to consider on the peculiarity of tropical regions concerning the harmful effect of insecticides. Some peculiarity of tropical region is considered to strengthen the harmful effect of insecticides. Many ecologists said that, in the environment which is very favorable to an insect pest, density-dependence mortality factors may be very important, but in the fringe zone of an insect pests species, for example, the arid zone, and the cool temperate zone, density-independent factor such as climate, may be more important than the density-dependent factors. In many parts of tropics, there is a rich fauna of natural enemies. We destroy these natural enemy fauna by insecticides. The harmful effect caused by this may be more serious in the tropics than in the cool temperate or arid zone.

Second is, in many countries, for example, Thailand and India, there are long rivers, watershed. In Japan, the amount of insecticides used is far larger than in many parts of tropical areas. However, in Japan most of the rivers are very short, and most of them are torrents, therefore, insecticides may flow out to the sea quickly. However, in many long rivers, like the Ganges, even when we use a small amount of insecticides biological contamination may cause a very high dosage in the understream, such as we saw in Mississippi River. There is, however, another factor that high speed of catalysis may favor the destruction of insecticide residues in the tropic rivers.

We have to make sure these points. In the book, "Ecology and Resource Management", Prof. Watt introduce that white men's development policy of agriculture and land use in East Africa is considered to be bad. White men cultivated savanna of East Africa and made grassland and reared cows and sheeps. However, recent study revealed that the meat production per year per hectare is far higher when we use the meat of natural ungulates than we use cow's meat. In the wet and hot climate of South-eastern Asia, I think, entomologists and agriculturists must develop new types of agricultural development policy and agricultural technique. Agricultural science which has developed in the temperate countries as in the United States, Europe and Japan, will be very valuable in the future. However, this has only a limited value to Tropics, I think.

I'd like to answer Dr. Pathak's problem. Dr. Pathak says IRRI's approach is to apply the screening of insect resistant variety. This is very valuable suggestion, I think. For this, I suggest to you that value of a parameter, instantaneous rate of natural increase, r_m. We culculate the sum number of female survival multiplied by the age-specific fecundity $R_o=\Sigma l_x m_x$ and then $r_m=\log_e R_o/T$, here T is the mean duration of a generation, for each rice varieties. Although this is an idealized rate of increase, we can compare this value for varieties we use, then we can obtain an information which can not be obtained from informations on mortality or natality only. This is a integral of mortality and natality. This may serve as better information on the value of resist-

ance, I think. Thank you very much.

Chairman (Ishikura): Thank you very much, Dr. Ito for the very gloval ecological application of food production. And he compared the temperate tropical country, and the tropical country should be recognized quite different from the temperate country, particularly small country as Japan. And he referred to the long river such as Ganges. In this connection, I suspect that Dr. Banerjee, who is the director of plant protection service in India, may have some idea whether Dr. Ito's idea is applicable to a huge country like India. Could you make some comment on the use of chemical insect control of rice in connection with the integrated control of rice pest?

Banerjee: We are also thinking of integrated control only at the moment what we have recently surveyed and found that it is applicable to only 20% of the area. So that problem which you are facing in Japan has not yet appeared. I think the position is not too bad at the moment to be worried about, but we are trying to develop integrated control in the consultation with Indian Agricultural Research Institute.

In this connection, I want to point out one thing about the sterilization and control. It may be possible for a little island or where this type of work is valid, and we can extend he work in those areas. But I feel that in a big country like India the possibility is not large. Biological control which we had attempted was successful in islands. In some areas in India, too, it has been successful, but in general, I have not been able to see any success in biological control in a country like ours.

Kiritani: I'd like to introduce a wrong example which shows what was followed by the overuse of insecticides in paddy fields. The resurgence of the green rice leafhopper population in Japan can be explained in terms of the following Dr. Moore's schema (1967).

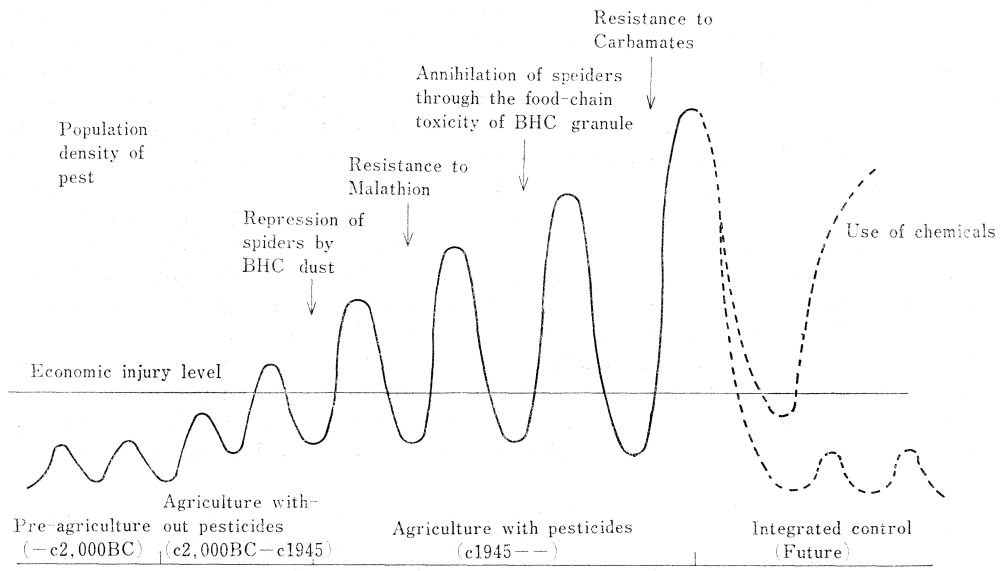


Fig. 1. Diagram illustrating the historical development of control of *Nephotettix cincticeps* in Japan.

Application of technical BHC in dust or emulsion form to *Chilo suppressalis* was very effective in preventing borers' damage, though it did not decrease the population of moths (Miyashita, 1963). Unfortunately, BHC was less effective to leafhoppers, but

was very effective to spiders which prey on leafhoppers. Experiments showed that spiders, in general, were twenty times more susceptible to γ-BHC than the leafhopper (Kawahara *et al.*, in press). Thus, controlling *Chilo* by BHC, we also annihilated spiders in the paddy field, and this eventually caused resurgence of the leafhopper.

We counteracted the increase of leafhoppers by Malathion, but it was less than six years before the leafhopper acquired a high degree of resistance to Malathion. Carbamate insecticides succeeded organophosphates as a promising material, but the leafhopper has already developed the resistance to carbamate insecticides in some localities in Japan.

The first lesson is that we contradicted ourselves by providing the conditions which work in favour of the propagation of leafhoppers on the one hand, and by meeting symptoms as they call for attention on the other. Secondly, the speed of development of insecticidal resistance was unintentionally accelerated by selecting individuals out from a larger leafhopper population than otherwise.

About 1962 and onwards, dust and emulsion of BHC were replaced largely by the formulation of granules. It has been believed that BHC became less toxic to spiders due to the change of formulation. But the increase in the population still continued. Our experiment (Kawahara and Kiritani, unpublished) demonstrated that granular BHC killed spiders through food chain: from irrigation water through rice plants and leafhoppers to spiders. Leafhoppers were led to suck the rice plants treated with commercial dosage which contained BHC enough to kill *Lycosa* spiders even 3 weeks after the application of BHC granules to the potted rice plants. This is our third failure.

Finally, the last failure which we made is the use of *technical* BHC instead of γ-BHC or lindane. Technical BHC is composed of four different isomers α, β, γ, and δ. Among the isomers, β-BHC which contained 5–14 percent of technical BHC is chemically very stable and also fat-soluble, but has no insecticidal activity. Now it makes up 97–98 percent of the total residues of BHC found in human fat as well as in human milk. The problem of β-BHC as an environmental pollutant is so important that the use of BHC and other chlorinated hydrocarbons on paddy field is put under a ban this year in Japan.

Chairman (Ishikura): Very recently Dr. Kiritani has contributed a very extensive critical paper on the importance of integrated control to the *Scientific Pest Control* from Kyoto University. But unfortunately it is written in Japanese. So as Dr. Pathak pointed out, these papers should be translated into English, or I'd request Dr. Kiritani to rewrite in English.

Pathak: I am much impressed with the comments of Dr. Itô and Dr. Kiritani regarding the pesticides, their persistence and the integrated method of insect control. The point raised by Dr. Itô that persistence and transport of pesticides with water currents of long rivers should be investigated is very important. I do not know of any such study being conducted in tropical Asia.

The adverse effects of pesticides on natural enemies certainly must not be overlooked but at the same time should also not be over emphasized. There are many areas in the tropics where even though pesticides have never been used several insect pests occur in epidemic proportions. Natural parasitization in these areas are frequently very low. I believe that specialists on biological control, on pesticides and on ecology should work on a collaborative basis and try to find out as to what role is being played by a particular approach in controlling a pest species. Only then we would be able to make any significant progress towards the integrated method of insect control.

Kiritani: I partly agree with Dr. Pathak on the limitation of biological control. But I dare to say that we have to discriminate two different approaches in biological control; one is the case of control of invaded insect pests by introduction of natural

enemies from abroad and the other is the case where endemic pests are to be controlled by endemic natural enemies.

An attempt to control *Chilo suppressalis* by an egg parasite, *Trichogramma japonicum*, was carried out by Prof. Iyatomi in the pre-war period. He released a great deal of egg parasites which were reproduced in the laboratory to raise the percentage parasitism. Although the percentage parasitism of eggs could be increased by the mass-release for the current generation, yet this effect did not persist up to the next generation or the 2nd brood. A further detailed study conducted by Prof. Iyatomi showed that the higher the percentage parasitism of eggs, the greater the number of eggs with two parasites or more. Multiple—parasitism, in turn, affects adversely the physiological constitution of ensuing parasite population to such an extent that the possible efficiency of parasite population became lower than otherwise.

This and other evidences suggest us that the mass rearing-and-release of endemic natural enemies against the endemic pest lends to meet with failure under natural conditions. But it does not mean that natural enemies are not important to the control of insect pests: for if it had been not for natural enemies, we should have had much more insect pests than now.

As most of our rice pests are endemic, the best way of biological control of paddy pests, it seems to me, is the manipulation of the environment to encourage the activities of natural enemies and the minimum use of pesticides in the paddy field.

Itô: I probably agree with Dr. Pathak that we must use insectiicides, but I like to stress that the integrated way of control where insecticides and natural enemies are combined. Fortunately IRRI concentrated its eoffrt at first on the study on the resistant variety. This is, I think, a very good policy. However, we must make study on the ecology of the endemic pest. That is the cause contributing to the phenomenon that some insects become a pest of rice but other insects eating rice plant do not. It may be a very useful way to develop the integrated control, if we conbine this to systems approach.

Ouye: It's appropriate only in islands, in general. However, we might say that it's a matter of concepts: for example, if you think of a large area in the whole north American Continent as an island, a whole American continent can be an island.

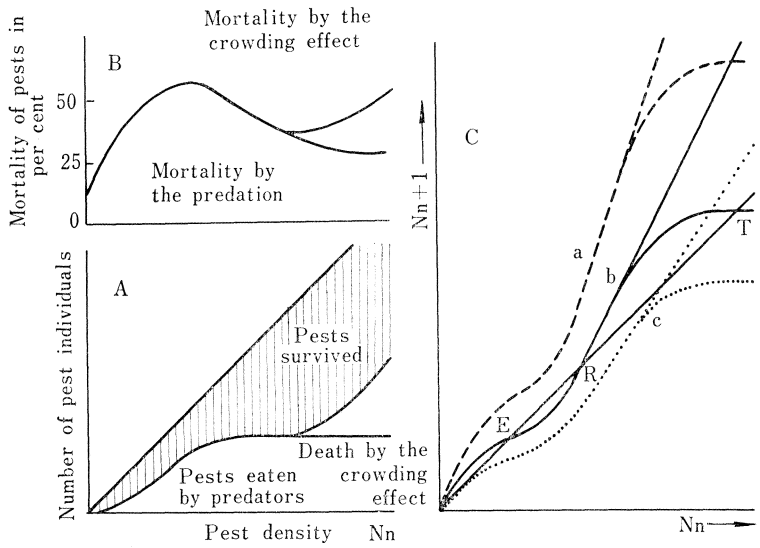
You know California is among the largest cotton growing states in the United States. 90% of cotton comes from San Joaquin Valley. There they have a sort of integrated control program, using, as Dr. Itô mentioned, biological control as one of the methods. I guess most of you know that the entomologists in the State of California think it integrated control. I think it's bad if you try to attribute or try to push one method. Because in many cases you need just a partial control of one method to add to an existing method, which causes population decline to get below economic threshold.

I think many people here come from the country just beginning to depend on the insecticides. In a first place I think all of us agree that generally you must have some insecticides to come up with the better system. But you know the problems of pollution and insecticide residues is peculiar to a highly developed country and I think it's a good lesson to the country which is beginning to depend on insecticides to learn that lesson and not to follow step by step the development which took place from the early DDT years to the present. And I heard actually that an African country has been trying not to use intensively insecticide application, but trying to use it when necessary. This is just a little comment.

Chairman (Ishikura): Is there any other comment or opinion?

Takahashi: I agree to the opinion of Dr. Itô and Dr. Kiritani, but I like to add comment from the theoretical standpoint. Dr. Holling in Canada proposed the S-shaped curve of predation as shown in Fig.A which presented the relation between the prey

density and the number of the prey eaten by an individual predator. When the pest density is very high the pest population has some harmful effects of overcrowding as shown in Fig.A. The shaded area in the figure shows that the pest insects escaped from the predation by natural enemies and from the effect of overcrowding. In the next generation, when the insects produce their offsprings at a constant rate, the reproduction curve of the pest insect can be obtained as shown in Fig.C.



Another type of the reproduction curve, the relation between the number of a certain generation and that of the next generation, was discussed by Dr. Kiritani and others in the yesterday's session. In one occasion the reproduction curve of b-type in Fig.C crosses with the 45° line at 3 points and we have two equilibrium points at E and T. If the net capacity for increase is small, the curve takes the c-type in Fig. C and the pest population will go to extinction. If it is large, the curve becomes the a-type and the equilibrium at E never occurs. Among many natural enemies, especially the polyphagous predators can be expected to have the S-shaped predation curve, such as birds, mammals, spiders ,coccinlid beetles, carabid beetles and some of hymenopterous parasites.

Here, I like to give a comment to the discussion in the session including Dr. Yamada's question on the resistant variety which has a very big controlling effect in some locality while it has less effect in the other locality. I think if the pest insect in its environment has the relation shown in Fig.A and b or in Fig.C, the resistant variety will get a controlling effect. But, if the environment does not allow this relation or the pests have a big reproductive rate, their reproduction curve never crosses at E but crosses at T. In the latter case, when we can add some reducing effect on the reproductive rate of pests, the equilibrium point will come at E. If this is lower than FIL the insect may not be a pest.

This is a simple theoretical comment. I hope you would consider this point of view in the field.

Chairman (Ishikura): Thank you, Dr. Takahashi, Where are you writing this opinion?

Takahashi: I have written this in the *Researches on Population Ecology* Vol. 6, 28–36 (1964), and recently also in the *Shokubutsu Boeki,* (Plant Protection Tokyo) Vol. 25, 259-266 (1971) which is written in Japanese.

Chairman (Ishikura): The discussion is now heated, but unfortunately time is almost up. If you agree I'd like to close the discussion. Thank you very much for your kind cooperation.