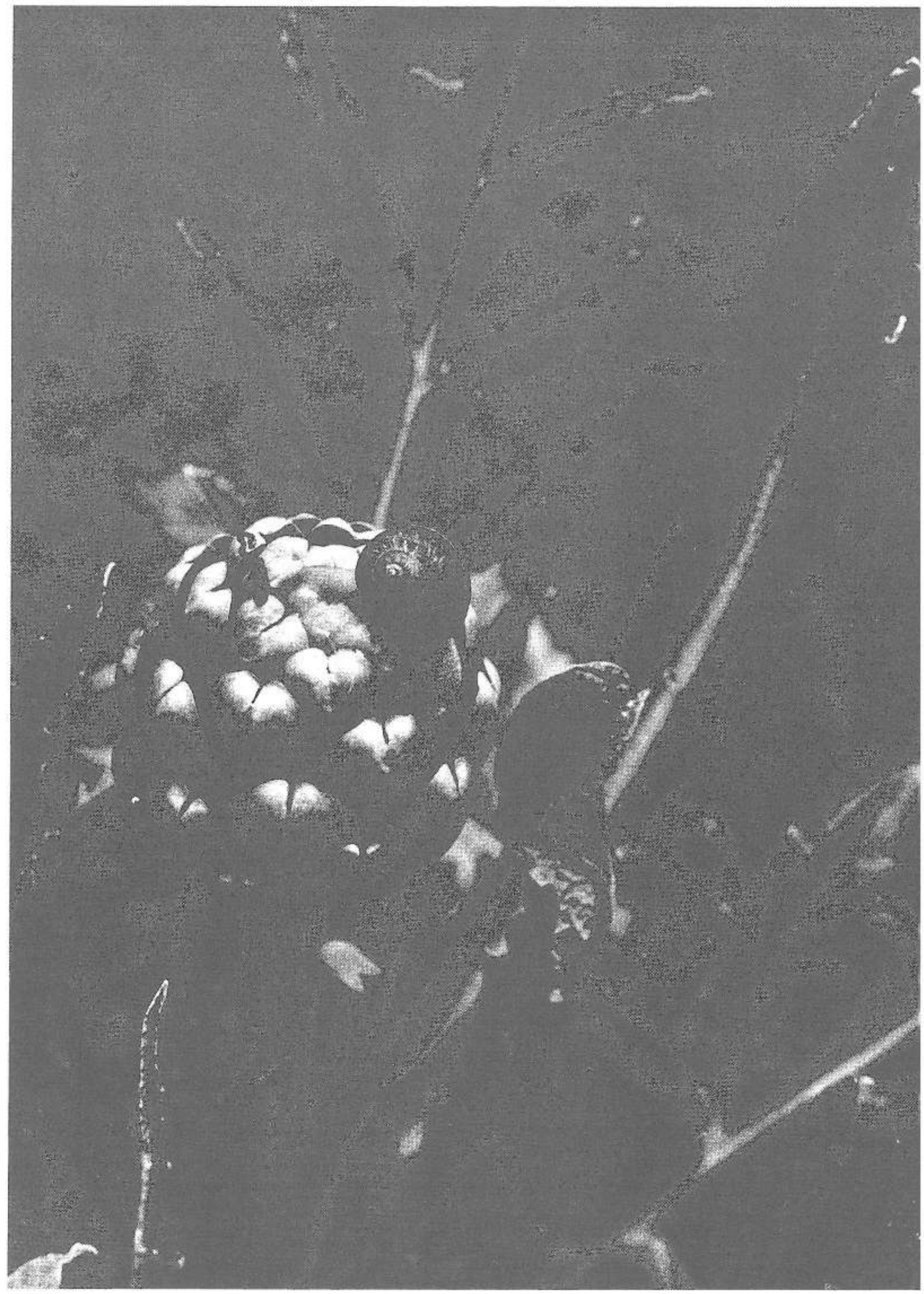


9

Getting Them Back on the Farm

A pest is an artificial, nonbiological, totally subjective human label for an organism that happens to do something we don't approve of.
Dr. Donald Chant

One of the not so subtle charges frequently laid at the doorstoop of the petitioners at the Madison hearings was that they were, in the words of one unofficial industry spokesman, "a bunch of goddam birdwatchers." There was an element of truth in this allegation. For the most part, those testifying against DDT at Madison were theoretical scientists unconcerned with the practicalities and problems of agriculture. This was simply brought out by McLean in his cross-examination of Wurster when he asked the biologist if he had ever worked on a farm or had any experience with actually controlling insect pests. His answer was, of course, no.

As fine as the experts testifying for the petitioners were as scientists, they were all urbanites trying to tell the farmers what to do; instead of the traditional American legislative problem of rural domination, the farmers were being threatened by the big city fellers. But Yannacone was shrewd enough to include at least a token force of men intimately concerned with the day-to-day problems of feeding a potentially hungry nation. For this reason, perhaps the testimony of Drs. Robert van den Bosch, Paul De Bach, and Donald Chant, showing the world that there was an alternative to the widespread use of chemical pesticides, was among the most significant elicited by the petitioners at the hearings.

Here were three scientists who plainly and authoritatively explained to the public, and perhaps even to some farmers, that the bill of goods being sold to them by the pesticide salesmen was not necessarily the correct one. In spite of all the high-powered advertising carried by agricultural trade journals attempting to prove that Brand X pesticide is all that stands between the farmer and financial ruin, there are ways of controlling pests whose populations exceed the threshold of economic damage—without poisoning the world.

The most eloquent of Yannacone's triumvirate was Dr. van den Bosch, an ex-advocate of DDT. (His abdication may have seemed to the industry as incongruous as that of a policeman suddenly becoming a flower child.) Possessing a homespun humility, itself a rarity at the hearings, a practical knowledge of agriculture, and by far the best sense of humor exhibited by any witness, he told his story superbly.

Mr. Yannacone: Would you please tell us what you have been doing professionally since you received your doctorate?

Dr. van den Bosch: I was on the staff of the University of Hawaii Agricultural Experiment Station for two years specializing in a study of the biological control of the oriental fruit fly. . . . Subsequent to that period, I spent 12 years at the University of California at Riverside in the Agricultural Experiment Station specializing in biological control of a variety of insect pests and in the integrated control of pests, particuarly of cotton and alfalfa. Then, in 1963, I transferred to Berkeley and have, since that time, been specializing or working more or less in the areas that I just described. . . .

I teach; I have graduate students; and I do a considerable amount of foreign work seeking parasites and predators of various pest insects. . . .

Q: Now, Professor, in the course of your regular professional activities, do you have occasion to render advice and consultation on the control of insect pests of agricultural crops?

A: Well, my work largely entails research on agricultural pests and recommendations for their control.

Q: And are these recommendations for their control such that they have economic implications? In other words, Doctor, are they put into practice in the actual agricultural industry?

A: Yes, they are.

Van den Bosch then went on to explain that he had been involved with DDT as far back as 1947 when it was being used on alfalfa and observed that, even then, he had seen some secondary problems with it. But then Yannacone guided his witness toward the meat of his testimony.

Q: Now, Doctor, in the regular course of your professional activities, starting with your original association with the University of California, have you had occasion to recommend the use of DDT?

A: Yes, I have.

Q: And as recently as when did you so continue the recommendation of the use of DDT?

A: Well, the cotton recommendations, which were actually formulated last fall, that is, the 1968 cotton recommendations, incorporated the DDT-toxaphene mixture. . . .

Q: Now, Doctor, at the present time, do you still recommend the continued use of DDT in the agro-ecosystem?

A: I personally have decided that I will not endorse this recommendation in the future.

Q: Now, Professor, will you please tell us the basis for this change of opinion?

A: Well, it's the accumulated experience with this material—and here I'm speaking of DDT—its impact on the agro-ecosystem; its direct impact on the arthropod fauna [insects] in the, say, the cotton agro-ecosystem. It's the very recent information that points up the movement of the material out into the biosphere or the world ecosystem, its persistence, and the clear evidence that it is affecting biological mechanisms within the species remote from the area of application. All have contributed to my personal decision that, in essence, there is enough of this material in the environment and there should be a moratorium on its use. . . .

Q: Now, can you tell us why it took so long for you to form the opinion that DDT should no longer be recommended for use within the agro-ecosystem?

A: Well, like many of us, when Pandora's box, so to speak, was ripped open in the middle forties, particularly from an ecological standpoint we were dealing in almost total ignorance. This was the guilt shared by most of the entomologists. There were farsighted people who anticipated these problems, but, nevertheless, most entomologists eagerly seized these [pesticides] and threw them into the agro-ecosystem or into the general ecosystem totally ignorant of the genetic and ecological implications in their use. For years problems developed, such problems as environmental contamination, secondary pest outbreaks, pest resurgence, resistance to insecticides and, either through intellectual ineptitude, ignorance, inertia, or some other factors, these developments simply were not grasped in their total significance.

However, they did set the framework for scattered people over the world to begin to develop studies as to the why, the reasons, the basis for these problems. And, in a very long sense, I simply have to say it's taken time and tremendous effort, tremendous amounts of manpower to develop the background studies to pinpoint these [pesticide] problems so that they will be accepted, as you might say, scientifically valid. . . .

I am a scientist. I work on the basis of the scientific approach, I think that way, and I have to prove things to myself scientifically. I am speaking now as an individual in the evolution of my thoughts on this matter.

Now much of this information is coming together very rapidly. And the picture that has evolved is very distressing to me.

You see, as an experimental or as an applied insect ecologist, I have a very broad range of responsibilities. I have a responsibility as a scientist to develop adequate, sophisticated, high-caliber derived data of this sort. I have the economic consideration of the agricultural community that I serve. I have the responsibility to the general population as far as fitting my findings into the general environment. And all of these things [occur] simultaneously. We have to fit [them] into a pattern which will tell us: Is practice A, which will kill pest A, outweighed by its disadvantages as regards chlorinated hydrocarbons in tuna in the Japan Sea? . . . So it's a very complex thing.

And, frankly speaking as an agro or an applied insect ecologist, we have not received either the administrative or the financial support for the kind of studies we are doing. If there has been concern about the environment and pollution, it has been in the area of public health, in the area of wildlife safety, not in the area of the actual agro-ecosystem itself, that is, what happens to arthropods, the non-target species in the system. So we have been, in effect, working on a shoestring with, in many cases, almost administrative indifference.

[This] is a long way of saying why it has taken us this long a period of time to come to these decisions. . . .

Q: Well, Professor, at this time, in order to form an informed professional opinion as an applied insect ecologist, is it necessary to have information from other diverse disciplines?

A: Yes, it is. In fact, even though some of us aren't aware of this, we are developing what might be called a systems approach to pest control. The inputs, the elements concerned, the diversity of the problem, the complexity of the problem simply means that we can no longer approach pest control either unilaterally as individuals, that is, [through] research, or through unilateral techniques such as to have fully objective chemical control or biological control or cultural control or genetic control. It's a system, we call it integrated control. And all over the world this philosophy, this approach is developing.

It so happens, I suppose, in California . . . we have been the most aggressive about it. Maybe this derives from the fact that we are the greatest users of insecticides in the United States, perhaps the world. We have run the gamut of problems. We have more or less survived our period of penance, and we are now working our way out of the jungle, so to speak, into this more rational approach.

Van den Bosch proceeded to amplify his position on integrated control and its implications:

Mr. Yannacone: Now in the course of your systems approach to pest control and the understanding of pest problems, do you develop personal expert competence in these diverse disciplines, or do you secure such assistance---

Dr. van den Bosch: . . . As I say, our approach is evolving. . . . When we consider pest control in the ecological context, we don't simply have an animal there that we decide must be killed; we have sociological considerations. . . . When I recommend a procedure for pest control, I don't only have the economics of that particular crop and that particular pest, I have 20 million people in the state of California, their water, their air, their soil, their recreation. You might say I have San Francisco Bay and the Pacific Ocean, and perhaps the penguins in Antarctica to bring into this thought.

Now there are areas in there outside of my range of competence, and we have economic considerations. Someone says it's not our business to worry about the economics of pest control, they say all we are supposed to do is kill insects. Well, this of course is a horrendously erroneous idea. But we have to bring in economists to analyze the economics of our programs. This again, is outside the pale of my competence. So we are bringing in economists; we are making economic studies of pesticide use; and we are relating them to the sociological aspects, the ecological aspects.

As you see, it becomes a very complex and very integrated type of situation with a great number of specialties and competences involved.

Insofar as I'm concerned, this is the pattern of modern pest control; this is the way we are going. . . .

Van den Bosch then turned to the important concept of what constitutes a pest.

Dr. van den Bosch: There are two very major considerations in this integrated approach. One is the ecosystem. That includes you and me and the birds and fish and the atmosphere as well as the crop and its pests and its natural enemies. The other is what we call the economic threshold or the economic injury level. And [here] —and we have found it particularly true in the cotton crops—the fundamental practice of the last 20 years [has been] to kill an animal because it was there.

Well, after years now of intensive studies with our two key [cotton] pests, the bollworm and lygus bug, [we find] that the somewhat arbitrary economic thresholds that were employed are totally invalid. In fact, with both species we find, in most instances, more or less regardless of their abundance, that these animals are not causing damage, that is, damage that will compensate for all the other things you do when you --- it is an artificial control measure. Now we find these creatures doing damage in certain situations, at certain times, at certain places. And our responsibility is to identify those situations and attack [these] creature[s] in those places and at those times. So right now I would anticipate that we are going to have a very flexible type of economic threshold, or variable thresholds for these two pests.

Then he went on to describe biological or unilateral control in a simple way.

Dr. van den Bosch: In its unilateral sense, [biological control] is the use of parasite predators and pathogens for the regulation of pest abundance. I guess you could say that that's the classical sense. It implies manipulation of these things. However, the school that I belong to, which is the DeBachian school, . . . considers biological controls as a natural phenomenon, essentially the regulation of, in this case, insect abundance or numbers or populations by biotic agents.

There is a difference, you see, because—and this has been at the root of many of the problems that, in the last 20 years [have occurred]—there is this great natural force, one of the very large elements of what we call natural control that is comprised of these parasitic predators and pathogens, these biotic agents that regulate animal numbers and plant numbers . . .

Because your artificial practices have so often disturbed this more or less quite unrecognized hidden complex of species, we have had problems, especially with the use of broad-spectrum, ecologically unsophisticated insecticides.

Then he went into control.

Dr. van den Bosch: . . . I went into the semantics of this word "control," because it's a very, unfortunately, a very misunderstood word; to the man who has a cotton field full of bollworms that are destroying a third of his crop, control is the decimation of that isolated or localized population. He does this normally by applying an insecticide.

"Control" in the broad context means regulation which has a long term and areawide connotation. So we have to clear up the point here [of] what we mean by "control."

He then described various modes of unilaterally controlling insect pests.

Dr. van den Bosch: We have genetic control. This can take several manifestations. The more or less forthright manifestation is the development of a . . . plant variety resistant to a particular insect. Now that is control in the long term sense. . . .

There is . . . a classic case where they brought the male from two subpopulations of a mosquito—at least on an experimental basis—from one extreme of its distributional range . . . [and have] released it, at least experimentally, in Malaysia [at the other extreme of its range] against females of its own species. The matings produced infertile eggs. This is a long story, but exemplifies genetic control. . . .

Then there's cultural control, the use of agricultural practices, late planting or how you irrigate, how you plant your seed, when you plant your seed. We are developing agricultural control or manipulation of the lygus bug in California through the strip planting of alfalfa in cotton fields. The bug has an affinity for alfalfa, it has an affinity for *leguminous* plants in that group and is actually attracted into these strips and remains there rather than infesting the cotton.

Dr. van den Bosch then told the classic DDT story.

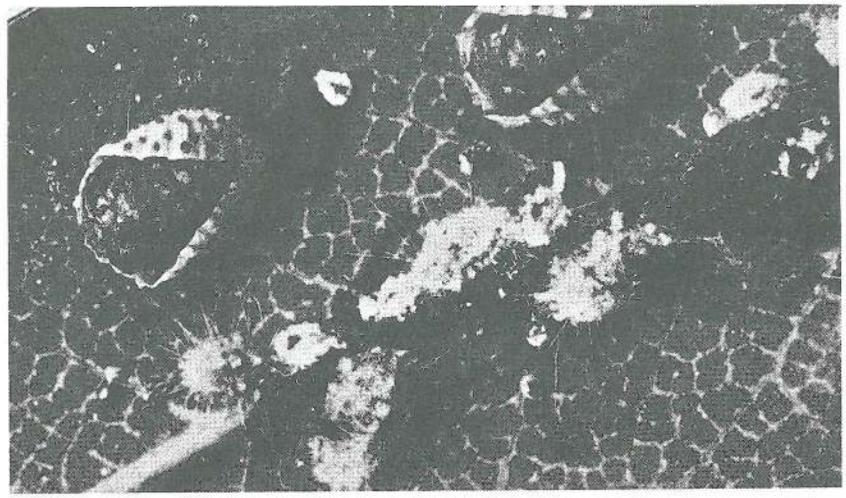
Dr. van den Bosch: . . . The coastal plain of Peru is essentially rainless. However, streams drain out of the Andes through valleys and empty into the Pacific Ocean. There is a sequence of about 40 of these self-contained ecosystems up and down the coast of Peru, each of which is separated by a severe desert. So here we have a little entity, the Canete valley, that has all the elements of, say, the Missouri River valley or San Joaquin valley. . . . It's 50,000 acres of greenery and animals and so on and so forth. Well, they grow cotton in this valley and sugar cane and vegetables.

In the late forties they instituted an [insect] control program based on the then available chlorinated hydrocarbon insecticides for cotton pest control. Within a period of a relatively few number of years following this practice, several of the insect pests had developed resistance to these insecticides; new pests had developed; and, in essence, they had more or less created a monster. With the development of the resistance, they shifted to other kinds of insecticides [in the same chlorinated hydrocarbon family] and the problem worsened to the extent that they had doubled the number of pest species, their pest control cost had spiraled, and their yields were the lowest in a decade.

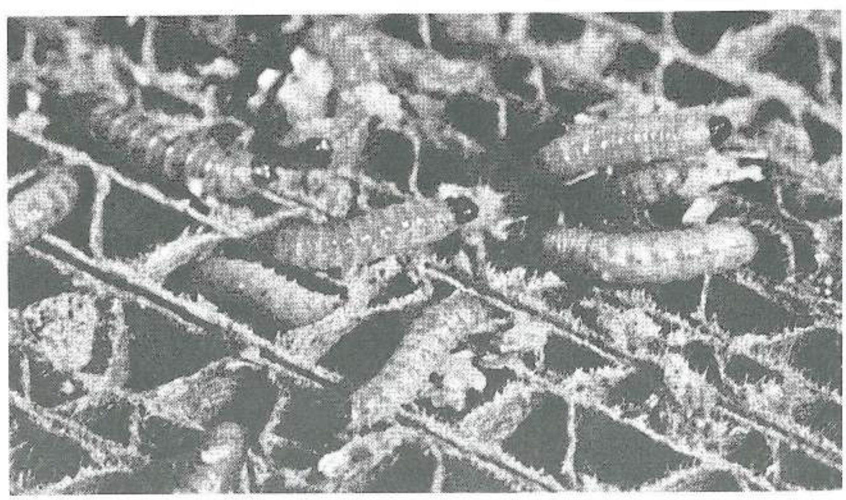
Then [the farmers] threw up their hands and said: "How do we get out of this?" And they went to an integrated control program and since then they have had their highest yields.

The point I'm making here is here in this case, picking specifically a chemical pest control, but in a very dramatic situation, the unilateral use of one method created a monster, so to speak. And

Pupae of Vidalia beetle with young of cottony cushion scale which they are eating.

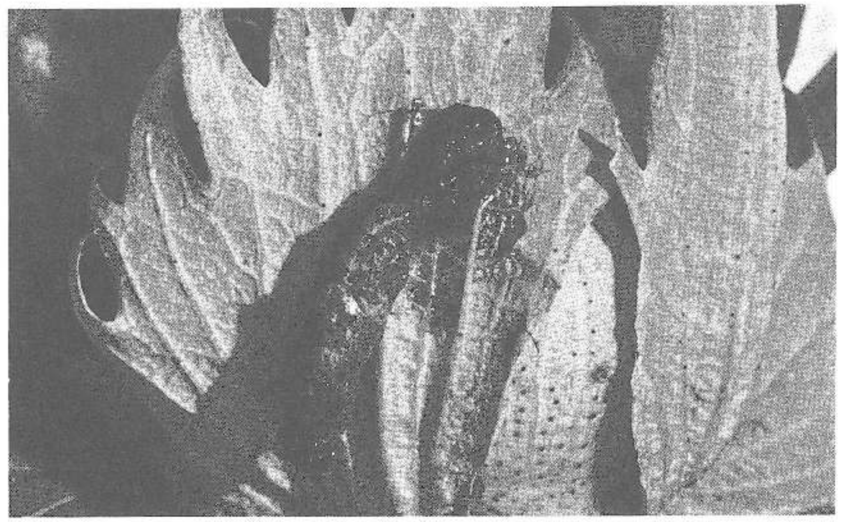


Bollworm larvae go into hibernation after which they will emerge as moths which will be sterilized and released.



If there is a group of animals that has met the competitive challenge of man and held its own, it is the Insecta. Abundance, diversity and adaptability are the key characteristics which have helped insects to stand up to their more clever competitor. And quite ironically, man, the thinking animal, has actually played into his enemy's strength by relying overwhelmingly on a single combat technique—chemical control.
Robert van den Bosch

Bollworm larva 24 hours after exposure to a virus.



it's there in the record for everyone to see; it's a lesson for all of us to learn.

Examiner Van Susteren: May I interrupt for a moment.

What you have just said is you cannot utilize any specific system of pest control, there has to be a generalized attack on the whole problem utilizing the biological, the genetic, the chemical, the natural, and so on, all in a certain balance?

Dr. van den Bosch: Yes. The important point is that we have to smoothly integrate these things.

And more stories about the un-magic of the unilateral use of persistent pesticides flowed from van den Bosch.

Dr. van den Bosch: . . . In the 1940's, when DDT's insecticide properties were discovered, it was like a magic pill had been dropped into the hands of man. Prior to that time he's had to use "lousy" insecticides, some plant roots or leaves, or some heavy-metal-type materials [like arsenic]. They weren't very good insecticides, but they weren't biocides. . . .

You all know about lead arsenate in apples and other things, but [arsenic compounds] didn't tear up the environment. We had no experience with the genetic, the adverse genetic or ecological characteristics of the modern insecticides.

Now the modern insecticides, the synthetic organic materials, were developed by chemists and toxicologists, and they were largely exploited by people who were thinking in terms of the economics; I mean economics from the standpoint of marketing.

> No ecological thought whatsoever went into these materials originally. Essentially none is going in now. And this is the basic root of the problem. These are ecologically crude materials, and they have an enormous overall impact on the environment, when we consider there are probably a million and a half species of insects and insect-like creatures. . . .

It was then McLean's turn to work on van den Bosch, but the "scientific convert," as one Madison newspaper called him, proved too tough a customer to be bullied.

Q: Doctor, in your direct testimony you mentioned a problem of lack of sufficient funds for your area of inquiry. Isn't it true that this is a universal complaint we all have?

A: Well, I suppose that's the more or less patented lament of the bureaucrat or the research scientist.

I think perhaps, as you are aware, there's a—has been a—I hate to use the word "attack," but a "complaint" in certain quarters that the universities are shirking their duty to the chemical industry because we aren't screening insecticides any more. . . .

You see, what happened . . . is that we got, I calculated, for the University of California at one time, I think it was, 350 or 400 thousand dollars, something like that, over a certain period to do some kind of research on chemicals.

Now I and the people in my capacity didn't get one dollar. But the research that these funds engendered was screening of insecticides, new insecticides and their economic exploitation. . . .

Q: Economic evaluation?

A: Yes, that's a better word. Exploitation sounds evil.

This, in other words, had a mushrooming effect on the problems which confront ecologists like me. It shoved one set of problems ahead, and it set us back. I spent the last five years, about half of my time, evaluating insecticides. I am a biological control specialist. . . . I evaluated insecticides because of their impact on our [environment]. I want to know what their impact is on the beneficial or the *entomophagous* arthropods in the environment. If the impact of these chemicals is deleterious, when it comes to making the insecticide recommendations for cotton and alfalfa in California, I bring those data to light in these meetings and I say no or I say yes.

But when I work with the natural enemies of the bollworm, say—I have about a dozen and a half to study—that is, little insects which eat the bollworm, parasitize it or sting it . . . (and every candidate chemical that comes into our system for screening more or less is put to the test on the basis of these criteria), I get no external support for this kind of study.

This struck a sensitive nerve for McLean, and he tried to show that what van den Bosch was saying was incorrect; that industry's approach to university screening of pesticides was the right path. But the entomologist was determined to show how the industry's unilateral approach to killing insects was dangerous, in that it took no ecological factors into consideration.

Dr. van den Bosch: This may be the traditional pattern, but . . .—this relates to the registration of insecticides for use by the federal government—they seek certain criteria, mainly efficacy of the material [and] data on performance [and] on the mammalian toxicity. These data are inadequate for our purpose in California, you see. We do not accept federally registered insecticides for use on cotton in California, because there is no local data collected. . . .

There is a tremendous burden on me and my colleagues to obtain these additional data, because there may be 25 materials registered for use on cotton by the federal government [and] a thousand salesmen in the state of California who have every right to recommend these materials. . . .

We have to further screen these materials. It is necessary that we do this, because if we don't get the adverse data, then these materials are going to be sold in California. And many of them have very adverse ecological characterisitics. . . .

McLean saw he was getting in over his head and changed tacks. He questioned van den Bosch about the possible dangers of importing insects into new areas, mentioning a bee which was not noxious in Africa but very much so in South America. He asked:

Q: Do I recall reading recently of an importation of a Brazilian—I mean an African bee into South America that prospered and became quite a problem to people down---
A: That's right. . . .
Q: It was not thought to be a noxious insect in Africa, but it became so in South America?
A: That's right. This is the type of thing we in our organization for the introduction of "beneficial" insects through our system of screening would more or less preclude.

Now I don't know whether the bee was a deliberate introduction into Brazil or whether it was accidental, but it has turned out to be a noxious insect.

I believe the gypsy moth was brought into the United States because somebody thought it was a lovely insect; the Klamath weed was brought into Australia because some sentimental European had an affinity for its lovely yellow flower.

We are talking about two situations. When we import insects for the suppression of other insects, we are basically dealing with a phenomenon known as density dependence. We go through a series of screening processes, [and here] we have 70–80 years of experience. These are special kinds of insects adapted to prey upon or parasitize other insects. . . . Because of the density-dependent nature of these insects, they act as governing agents. If they are effective, they cause the crash and permanent suppression of the pest they are introduced to control. Being density dependent, their numbers then crash, also. And thereafter, a state of regulatory equilibrium is maintained where the pest and parasite more or less fluctuate in an interrelated way at relatively low density. . . . There is no case on record where one of these things has become noxious.

At this point McLean tried to bring up the example of the starling as a bird introduced into this country which has become a serious pest. Van den Bosch replied:

Dr. van den Bosch: But may I garnish that statement a bit?

So are about half our major pest insects, exotic species. This is the reason why they are pests, because they have, through one medium or another, escaped their native habitat and the adapted parasites and predators that affect them in those habitats; they have gotten into our environment, and they flourish.

The principle of classic biological control is to attain the adapted natural enemies of these escapees, bring them back into association with their host, and hope they will regulate them at this permanently subeconomic damage level.

So the matter of immigrant exotic species in our North American environment is very commonplace. In fact, my Dutch father is one of them.

Further information about integrated control was to come forth from two other witnesses for the petitioners. The first was perhaps the world's most eminent specialist in biological control, Paul De Bach, an entomologist and Professor of Biological Control at the University of California at Riverside. He, too, testified on the alternative to the heavy broadcasting of chemical pesticides.

Mr. Yannacone: Now, Professor, would you tell us just what is meant by the term "biological control of insects"?

Dr. De Bach Biological control is the effect of natural enemies in the regulation of host population densities. In the broad sense, man doesn't have to enter into the utilization of natural enemies. In other words, they can bring about biological control on their own, and of course, frequently do. I might carry it further and say this is the commonplace thing in nature among insects and crops and natural ecosystems to find biological control of various insects and other arthropods occurring.

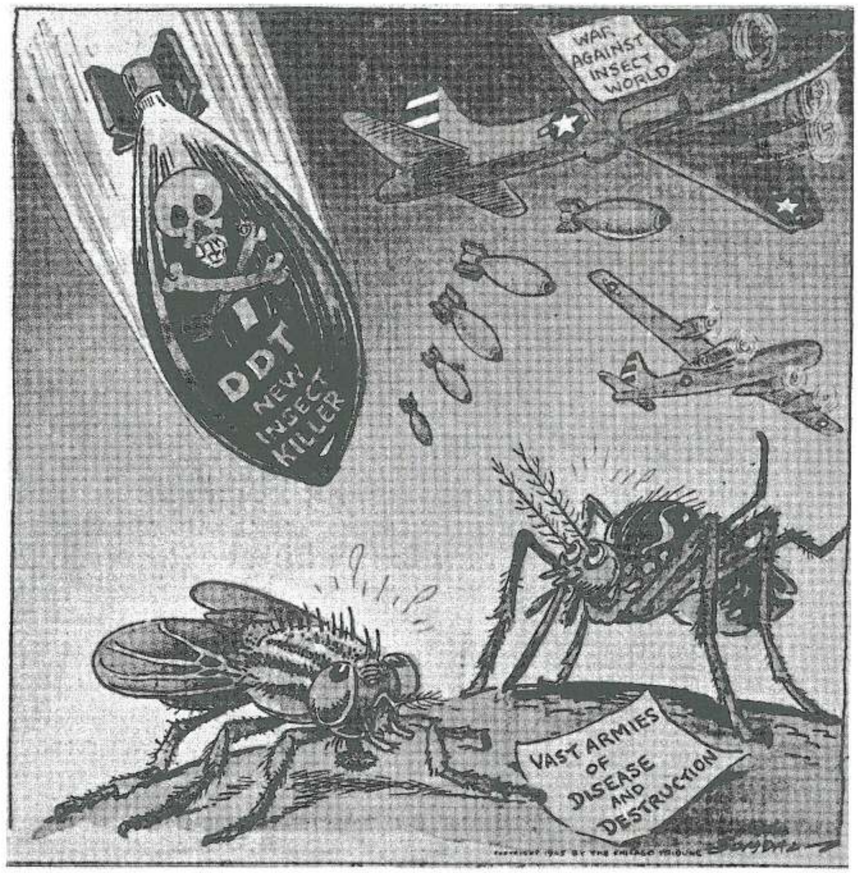
When you get into crop ecosystems, entomologists frequently speak of biological control from the standpoint of man's activities and what we do to either keep biological control from being disturbed or to augment it.

You can think of three phases of biological control: Importation of natural enemies from abroad, from some other area; bring[ing] in new natural enemies to take care of pests you may have that don't have adequate enemies. Another phase is to conserve the enemies that you have in an area. In other words, get rid of deleterious activities. [These] can be of various types, such as adverse chemicals; you may modify adverse effects of cultural practices such as some types of mowing or harvesting or merely raising dust, which is deleterious in some cases. . . . You can provide requisites that natural enemies need; for example, sources of nectar or honeydew, sources of shelter or places to build nests for predatory wasps.

Then another possibility, which is sometimes called augmentation of natural enemies, involves the mass culture in insectories [and] the periodic colonizing of natural enemies in the field. This is a feasible procedure, for example, when . . . let's say, you have a very effective natural enemy, potentially effective, but the winters are a little too cold and it doesn't quite come through . . . in the numbers that would enable it to successfully control the pest at a very low level. So, by raising these in the insectory and colonizing them in the spring, say getting them started sooner [so that] they would naturally build up later on, you may be able to keep this pest at very low levels throughout the world. This is being put into practice more and more today in many places throughout the world. . . .

Then De Bach spoke of integrated control.

Dr. De Bach: I look on integrated control as an attempt or a means of maximizing the utilization and effectiveness of natural enemies in any crop ecosystem, and doing this by developing the methods which are least injurious to natural [pest] enemies which are always common in any given crop, regardless of where you are. . . . What I am saying is that every crop has many potential pests which can be made accidentally, if you do the wrong things, into serious pests. So in integrated control you utilize the methods which are, say, least injurious to all these potential pests and their natural enemies so that you keep them as minor or non-pests,



1945

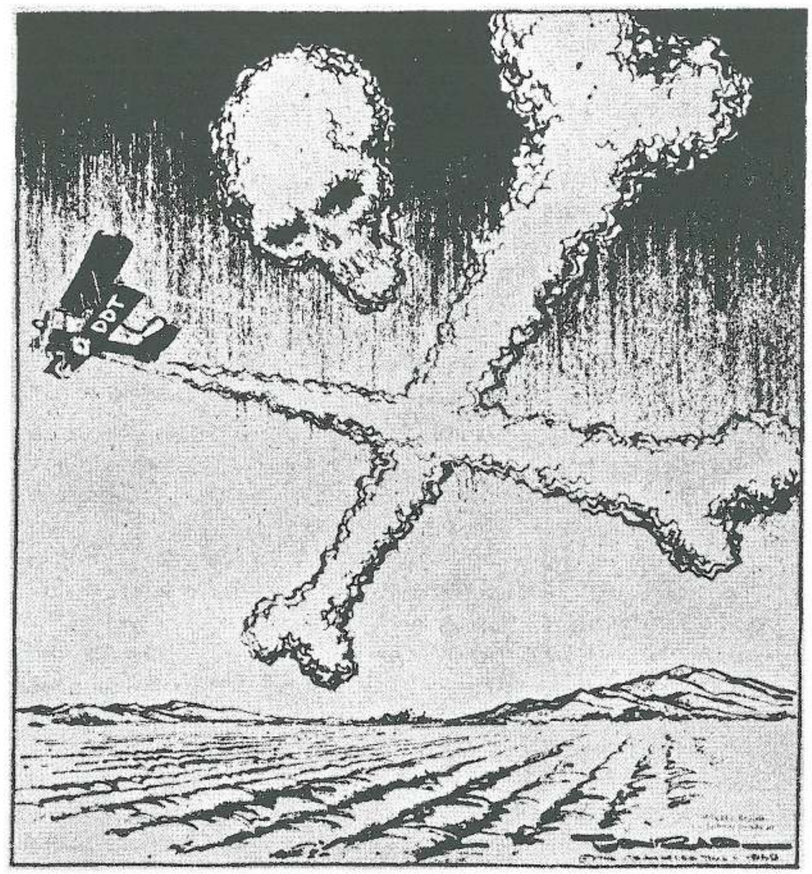
and you utilize a method, then, to treat the one or two or perhaps three pests which [still] occur in a particular crop.

So integrated control can use chemical control in connection with the conservation [and] utilization of natural enemies; it could use cultural control; it could use, for example, sterile male techniques; [or] various modifications and new approaches in entomology that are being studied today and are being tried out. . . .

Mr. Yannacone: Do you want to tell us how chemical pesticides can be used to augment the biological control portion of an integrated control practice?

A: Chemical pesticides come into an integrated control program from the standpoint of being the best materials that you can find, experimentally, to control the pest or pests which don't have . . . adequate natural enemies. In other words, perhaps economic damage will occur if you don't treat these pests.

[Then] your objective is not to find an insecticide which will kill this one pest and, perhaps, say kill 99 per cent of it. [This]



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> is the old-line thinking in entolmology: . . . you get the poison that kills this one thing you are thinking about, and you forget everything else. [Then] you get into the situation where so many growers and agriculturists around the world are today. [Instead,] you test various alternatives and then you pick the insecticide for the pest which you find by experimental study really requires an insecticide—and this may not always be easy to tell when you are studying a disturbed ecosystem. There are many pests today which are secondary, which have good natural enemies, except the natural enemies are unable to operate due to upsets and disturbances from other practices going on in the agro-ecosystem. So, by studying these various alternative insecticides, you pick out the one which gives the best overall control of the whole system. And this is what you call integrated control.

Then De Bach turned to his own experience with DDT. Beginning with World War II when the pesticide was being hailed as a "wonder drug" for agriculture, he showed how, in van den Bosch's words, the chemical had opened a Pandora's box of side effects.

Dr. De Bach: Well, I first used [DDT] when I was in the United States Department of Agriculture in the southern states . . . in 1943–1945. . . . [There] the white-fringed beetle is an extremely difficult thing to control, because the larva is the stage that does the damage, and these are in the soil. So, during the latter part of the war, we got something like 2½ pounds of DDT for testing. (This was one of the high priorities at that time. . . .) It was, well, entomologically, the hottest thing you'd ever heard of. We were able to put [DDT] on a few acres—on very small plots. And it really looked good compared to the material we had before.

From the first mortality counts we made, [it] looked so fantastic that the story went around that we were going to completely eradicate the white-fringed beetle. Of course, this never happened. We still have white-fringed beetles.

[The] idea was prevalent throughout the country at that time [that] DDT was . . . the ultimate solution. (I have seen that [idea] applied to other things as well.) But, as we know now from experience . . . [DDT] wasn't the final answer. . . . To my knowledge we have never achieved eradication with any other insect, that is, as a species, any place in the world. . . .

. . . Upon my return shortly after this work in the south of California, the fame of DDT had spread. It was found to be a rather effective control for the citrus thrips in the Central Valley of California, and it was enthusiastically applied in 1945. In 1946 they found that the cottony cushion scale, which had been the first great example of biological control in the world, had become the major pest in this whole valley. . . .

The cushiony scale, up to then, had been a rare insect since 1890 when it was successfully controlled by a beetle, a predatory beetle called the Vidalia that was brought in from Australia in 1888 and 1889. This beetle was very successful within a year in reducing the cottony cushion scale to such low levels that it was never again of any consequence. In fact, [it was] generally hard to find, until it was upset in 1946 and 1947 by the widespread use of DDT in the Central Valley.

We were called up there. We found that citrus groves were literally encrusted in some cases with the cottony cushion scale to the extent that trees were actually killed.

I don't know how many of you have had experience with how difficult it is to kill a citrus tree. It's not easy because, particularly with any kind of an insect, you can get tremedous infestation [which] may kill twigs or branches. But, to kill an entire tree, it really has to be an enormous infestation. But this is what we had.

I saw entire large groves defoliated by the cottony cushion scale due to the killing of the predacious lady beetles by DDT.

And these groves, for example, didn't come back. The ones that were defoliated might not have been killed, but they would go without crops for perhaps two or three years.

The situation was so serious among the growers up there then, that they were actually trying to buy, and were buying when they could get them, these beetles for one to two dollars apiece.

In the winter of 1946, we surveyed intensely throughout this whole area and we couldn't find a live Vidalia beetle. Now this is over literally hundreds of square miles. In 1947 of course, this infestation [continued]. It was obvious to anyone at this time what the cause and effect were. [But] at first it wasn't, you see, because at that time people didn't have experience with this phenomenon [of resurgence], they really didn't realize that insecticides . . . like DDT could do this.

And their first answer, their first thoughts among the entomologists were: Gosh, it must be something in the climate, something must have changed to do this. But it soon became obvious to everyone that there wasn't any other explanation. We were able to prove, by experimental tests, by testing the beetle, and by comparative tests in which DDT was put onto plots and not put onto other plots that this great upset occurred due to the use of DDT.

So we reintroduced the beetle into the valley in 1947 and modified and, in fact, essentially dropped the use of DDT up there. . . . And since that time, there hasn't been any real problem with cottony cushion scale there or any other place in California. . . .

De Bach furnished a similar story about the California red scale which also became a major pest after the use of DDT, and then he began talking again about integrated control.

Dr. De Bach: . . . We need to point out to growers and entomologists and agriculturists in general that 90 per cent of the potential pests in a given crop have good natural enemies. In order to do this, [we can] upset these natural enemies, in other words, kill them or decimate them to the point where they are no longer effective in controlling the pests. And by comparing this plot where you eliminated them or decreased their effectiveness with an adjacent plot where you didn't do this, you can show whether biological control is, in fact, occurring.

So we found, as I say, early that DDT was a very good candidate material to do this sort of thing; and I have used DDT since . . . to disrupt agro-ecosystems by putting DDT at regular intervals in certain dosages which will kill natural enemies but not kill the pest insect which these natural enemies would normally keep under control.

For example, I could put DDT on citrus trees and kill them by getting rid of the natural enemies of the California red scale or the citrus red mite. The red mite in California is now, and did become very rapidly, . . . a major pest following the first usages of DDT there.

Yannacone then asked De Bach what he thought about DDT's place in integrated control.

Dr. De Bach: No, it's certainly not compatible. It's by far the worst material that I can imagine to try to use in an integrated control system. DDT is so long lasting, so persistent, and so generally deleterious to natural enemies across a broad front . . . that it's, as I say, the worst material I could think of to try to work into an integrated control program.

By the time De Bach testified, Willard Stafford was handling the cross-examination of witnesses for the industry's DDT Task Force. The smooth trial lawyer from Madison almost immediately became involved in an argument with De Bach over the biological control of specific insects in Wisconsin.

Mr. Stafford: Now, is it your testimony that there is a biological control which could be used effectively and economically in the state of Wisconsin for the control of aster yellows disease . . . ?

After an argument over the question, De Bach replied:

Dr. De Bach: I can say that there may be an effective enemy here now. But you couldn't tell if there is if you are using DDT for the control of this leafhopper. . . . I've seen this situation time and time again where DDT is used: a grower is treating for a pest which has effective natural enemies, but which are precluded from action because of this.

Stafford threw out a few more questions at De Bach, but, unable to get through his intellectual defenses, he allowed him to get off the stand unscathed.

The next agricultural specialist to appear was Dr. Alfred Chant of the University of Toronto. He added more data on integrated control.

Dr. Chant: . . . Most organisms, and certainly most insects, the vast majority, 98 or 99 per cent, are being controlled at the present moment without the intervention of man at all. These species are being controlled by factors in their environment, largely parasites, predators, or disease organisms that we have to take no action against at all.

From that point, many entomologists recently have arrived at the conviction that this kind of regulation or control is what we must be striving for with the few species of insects that do create economic problems in our agricultural and forest industries. This can be achieved, and had been achieved in many places . . . by biological control, which has proved to be a success in many cases around the world: [there are] over 200 instances of successful biological control.

The point I want to make here is that the success in biological control is most emphatically and demonstrably a product of the research effort that goes into [it]. The parts of the world, notably California, some European countries, Canada, and Australia, that have invested sufficient time and effort in research in biological control are exactly those countries where this method has overwhelmingly paid off. Where entomologists choose to ignore or neglect the possibilities of biological control and don't support it in the way it should be supported, obviously it doesn't pay off. . . .

The purpose of any pest control program is to protect crops and thereby save money. And it's axiomatic that the cost of the control program must not exceed the value of the crop saved. It is the determination of the balance between the cost of a program in all of its ramifications and the savings to the agricultural or forest industry that determines the so-called economic threshold.

Insect populations vary from time to time, from season to season. And, in every instance, the insect population will vary from below the economic threshold to a point above the economic threshold. When the insect pest is varying upwards and approaching the economic threshold, is the time, and the only time, that one should consider putting into operation some control mechanism to prevent the pest population from exceeding that point where the cost of control is balanced by the cost of saving. . . .

The economic threshold is a very complex statistic. It depends, not only on the obvious things—the cost of the material or the control program being used, the market conditions of the commodity that's under consideration, the cost of labor at the time, and this type of thing—but, over and above that, most people realize there are many other components to be considered. . . . These may have to do with the possibility of creating problems elsewhere from pest control activities, the possibility of adverse effects to other areas, other ecosystems, other factors in the environment than the one [with] which you might be primarily concerned.

Van Susteren then interjected this comment which Chant agreed with.

Examiner Van Susteren: What you have just said, then, is that the same type approach that you use in this thing is the type of approach that an industry might use in regards to cost accounting?

Then Chant continued.

Dr. Chant: One of the chief advantages of thinking in terms of economic thresholds is the realization that must follow from this consideration that one must not use pest control practices unless they are required. That sounds rather naïve and simple, but I think you will find, if you look at local spray calendars all over the United States . . . that, in most instances, this principle is ignored.

There is no point in using a pest control practice unless the pest you are concerned with is approaching or exceeding the economic threshold. And yet most spray calendars don't point this out to the grower, and suggest, in fact, routine applications at so many days interval. In some instances, it's been demonstrated that these control practices are applied even when the pest is totally absent, let alone at a level below the economic threshold. . . .

The present use of pesticides could be reduced by 50 per cent today on the basis of the knowledge that we already possess . . . Two principles would be involved in this. The first principle is: Do not spray until necessary. . . . The second one, and possibly even more important, is not to try to achieve unrealistic levels of control or indeed eradication. What one is simply trying to do is to return the pest population to a level below the economic threshold.

In the long run, the three agricultural witnesses who testified at Madison may have been the most important ones at the hearing. For, despite all of the testimony about the direct environmental damage being caused by DDT, we still must feed a huge population.

This economic necessity presents extremely complex problems needing the sorts of complex answers being provided by such men as van den Bosch, De Bach, and Chant; men experienced in the practical difficulties of intensive agriculture as well as in the problems of preserving the ecosystem on which all agriculture and food production is based.

Yet it is difficult to talk about widespread integrated control of insect pests in a country where the chemical pesticide industry does a billion dollar a year business, and can exert enormous pressures, both on the farmer and the legislature. Nonetheless, if this country doesn't start listening to the words of the integrated control specialists, then its problems will continue to multiply like those insect pests on a cotton field.