

How Do We Advise the Pest Control Industry in the Post-Organochlorine Era?¹

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Abstract: Given the banning of organochlorines for use as termiticides in North America, and with the possibility of such bans occurring in future in Australia and elsewhere, how do we as entomologists advise the pest control industry in termite control? A brief historical review of pesticide bans and the relevance of these bans to the present situation are discussed. Suggestions are offered for entomologists to pursue an integrated pest management approach to termite control based on sound ecological parameters and social priorities.

Before attempting to offer suggestions as how best to advise the pest control industry in the post-organochlorine era, I think it is as fruitful to understand the social and political context in which bans on pesticide use have been imposed historically, as to offer resolutions that may receive the same treatment in the long-term.

So, how did bans on pesticide use come about? Were they imposed by scientists in government and industry? It would seem that was not the case. Before 1962, many scientists were expressing great concern as to the side-effects, the indirect effects, and the long-term effects of organochlorine pesticides. They were not only concerned with the target organisms themselves, but with other organisms, as the pesticides moved through the environment, following food chains as predator ate predator, and acting on people.

Egler (1964) considered that these scientists were ridiculed or ignored or silenced in a variety of ways, even by their own colleagues, and especially by the chemical industry and its chief advocates in the U.S. Department of Agriculture and the U.S. Food and Drug Administration. But their work and concerns were not lost to society. There came a change.

This change came in the form of a book, Silent Spring, written in 1962 by Rachel Carson, a marine biologist. As Ehrlich and others (1977) pointed out, "it is true that there were a few factual errors in Silent Spring, but in many ways Rachel Carson underestimated the hazards of DDT and certain other organochlorines. Nevertheless, she succeeded in awakening the public - and did so in a way that a more technical and highly documented book like Robert L. Rudd's (1964) Pesticides and the Living

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Landscape could not. Rudd, a zoologist, came to many of the same conclusions that were presented in Silent Spring, but because his book was not addressed to the general public it did not engender the level of attack that was directed toward the Carson book."

In the opinion of Ehrlich and others, "no biologist has made a greater contribution to humanity in this country than Rachel Carson. And recent events and government decisions have fully justified her position."

Soon after the U.S. Environmental Protection Agency (EPA) was created in 1970, it was given responsibility for the registration and regulation of pesticides. Litigation by the Environmental Defense Fund produced a court order early in 1971 for EPA to issue public notices of cancellation of the registration of DDT and to review DDT for suspension. The notices of cancellation for DDT, as well as aldrin, dieldrin, mirex, and the herbicide 2,4,5-T, were, of course, appealed. After lengthy hearings, EPA banned DDT for almost all uses in 1972. It found that DDT "posed an unacceptable risk to man and the environment." Restrictions were also placed on mirex. A ban followed a few years later.

Concern was expressed that banning of organochlorines would lead to increased immediate mortality from pesticides because the organophosphate compounds that would replace DDT have a higher acute toxicity even though they are much less persistent and presumably present a relatively small long-term risk. However, about 1969, occupational deaths from pesticides (mainly organophosphates) occurred at the rate of about 12 per year nationally. There was no sign of an increase into the mid 1970's (Ehrlich and others 1977).

The direct threat to humanity by organochlorines is difficult to assess (Anon 1989b). At present, however, it appears that, as alarming as the direct threat may be, the indirect threat is much more serious. These compounds have the potential for irreversibly damaging the capacity of ecological systems to supply those essential services without which civilization cannot persist (Ehrlich and others 1977).

In 1987, the EPA restricted the uses of organochlorines as termiticides, permitting only the use of chlordane as a soil barrier. Alternatives such as the organophosphates (chlorpyrifos [Dursban], and isofenphos [Pryfon 6]) and synthetic pyrethroids (cypermethrin [Demon], permethrin [Dragnet], permethrin [Torpedo], and fenvalerate [Tribute]) have been recommended by the EPA. These are currently the termiticides of choice by the pest control industry in the United States (Mix 1988).

These events have not unfolded in a "neutral environment," but rather, as a result of persistent political challenging by scientists, environmental groups, such as the National Coalition Against the Misuse of Pesticides (NCAMP), consumer and union groups, and the public of

our society's pesticide use. The National Academy of Science in the United States has been concerned with the impact of regulation on the development of new technologies to replace the conventional broad-spectrum chemicals that have dominated the pest control scene since 1950. Whether or not those required technologies will be generated within the chemical industry remains uncertain, and some think, unlikely (see Ehrlich and others 1977).

Now in 1989, we have the voluntary cancellation by the insecticide manufacturers of their organochlorines used as termiticides in the United States. In Australia, there has been mounting public concern over environmental and public health issues surrounding the use of these pesticides. Recent publicity in connection with pesticide residues in beef and an incident at the Streaky Bay School in South Australia following application of aldrin as a termiticide (Anon 1989a) has focussed attention on organochlorines in particular. Currently, all organochlorines are banned in South Australia (Anon 1989b), and in most other Australian states, for all purposes except as termiticides. The question being asked by some scientists and members of the pest control industry in Australia, is "will organochlorines be banned for all uses, as in the United States?"

Personally, I predict a similar trend in Australia in the not too distant future. There is a strong upswell of feeling by interest groups, such as the Total Environment Centre in Sydney, unionists in all states, and numerous environmental groups, to have these compounds completely banned. There has been wide publicity in the media on the topic, and the public perception has been one of health and environmental problems associated with past agricultural use and with the only currently approved use, as termiticides (Anon 1989b). Notwithstanding the reaction of a pesticide proponent in the pest control industry, terming such critics of pesticide use as "toxic terrorists" (Meadows 1988), the problem of chemical pollution will not readily diminish given current economic values.

INTERNATIONAL OVERVIEW OF TERMITE CONTROL

In May 1987, the International Research Group on Wood Preservation (IRGWP) conducted a survey of its 55 member countries to ascertain the economically-important termite species in the various zoogeographical regions, their damage ranking to timber-in-service, the chemicals used in control methods, and the status of the termite standards in the respondent countries. Table 1 summarizes the information collected in the survey so far (French and La Page 1989).

Countries that have standards for chemical control of termites include Canada, France, Greece, India, Italy, Japan, Spain, Australia, and the United States. Nigeria is presently preparing a standard. Organochlorines, organophosphates and synthetic pyrethroids are the most commonly used chemicals. Arsenical preparations are used in Fiji, Greece, Spain, Australia and Uganda. Japan is one of several countries that use gas fumigants as termiticides. Australia, Japan, Canada and the United States also register organophosphates as termiticides.

The methods of application were found to vary considerably between countries. The common practice of applying a chemical barrier over the entire exposed surface

area under a pier-type building is carried out in India, Japan, Nigeria and the United States. The treatment of soil adjacent to piers and supports, however, is the preferred procedure for most countries. The issue of compulsory soil-barrier termiticide treatment to new buildings was not directly addressed, though Indonesian authorities stated they do not insist on this approach, unlike most local authorities in Australia. Some countries, such as Fiji and Italy, do not carry out soil-barrier treatments. Treatment of existing buildings is done in most countries only as a consequence of infestation. However, Japan undertakes re-treatments every 5-10 years, probably because of the lower persistent organophosphates used. In Australia, many pest control companies carry out yearly soil-barrier treatments using organochlorines, although this is not stipulated in any Australian Standard. However, such "re-treats" are regular business practices in rural areas.

Table 1-- The major termiticides used in termite control

Region	Country	Termiticides used ¹					
		OC	OP	SP	GAS	AS	O
Ethiopian	Ghana	+	+	+	+	+	+
	Nigeria		+				WP
	South Africa		+				WP
	Tanzania	+	+				
	Uganda		+			+	
Palearctic	China (Nanjing)	+			+	+	Mirex
	France	+	+	+		+	
	Greece	+	+	+			
	Israel	+	+	+			
	Italy	+	+	+			
	South Korea	+	+			+	
	Spain	+	+	+		+	
	Yugoslavia	+					
Oriental	India	+			+	+	WP
	Indonesia	+		+		+	
	Japan		+		+		WP
	Phillippines	+					
Australian	Australia	+	+	+	+	+	Mirex
	New Zealand	+					
Hawaii and Oceanic Is.	Fiji	+			+	+	
	Hawaii	+	+	+	+		NCB
Nearctic	Canada	+	+				
	USA		+	+	+		IGR
Neotropical	Bolivia	+				+	
	Chile	+				+	
	Columbia	+			+	+	
	Uruguay	+				+	

¹OC = Organochlorine; OP = Organophosphate; SP = Synthetic pyrethroid; GAS = Fumigation; AS = Arsenicals; O = Other; IGR = Insect Growth Regulator; NCB = Non-chemical termite barrier; WP = Wood preservative treatment.

No country appears to have formulated specialized standards for drywood termite control apart from

recommending fumigants, as in North America and Australia. Yet in the Ethiopian, Hawaiian and Oriental regions, the risk of drywood termite damage exceeds that of subterranean or dampwood termites.

PROPOSED TERMITICIDES AND TERMITE CONTROL METHODS

Over the years many termiticides and termite control methods have been proposed worldwide, but in this paper the focus is on those applied in developed countries (French 1986, Mauldin 1986, and Lenz and others 1988). Assuming that the organochlorines are to be banned as termiticides, then the proposed termiticides of the future may be divided into two main groups, namely, pre-treatments and post-treatments.

Pre-treatments

Pre-treatments are complete or partial chemical soil-barrier treatments for buildings under construction. The chemicals proposed are organophosphates, synthetic pyrethroids, brominated hydrocarbons, carbamates, and slow-release formulations of these compounds. An alternative delivery system ("Peacock system") of underslab perforated piping has been promoted in Hawaii, in which termiticides (organophosphates) are pumped in under pressure from an external servicing port. Other pre-treatments include physical barriers and wood preservatives (such as boron compounds, copper-chromium-arsenic, light organic solvent preservatives, fluorinated lipids, and sulphones).

Post-treatments

Arsenic trioxide, used as a dust, is the only effective termiticidal use of arsenicals in Australia. It is legally and commercially available in Australia and the amount per treatment is small (ca. 3-5 g to eradicate a termite colony of > 1 million individuals).

Mirex, in the bait-block method, is effective when used for remedial treatments directed towards *Coptotermes* and *Reticulitermes* spp. This insecticide is registered for use in three states in Australia against the Giant Northern termite, *Mastotermes darwiniensis* Froggatt, and registration is being sought in Victoria and New South Wales for control of *Coptotermes acinaciformis* (Froggatt).

Fumigants, such as methyl bromide, are used in remedial treatments, particularly against drywood termites. However, exposing localized drywood termite colonies to heat and cold (using liquid nitrogen) may also offer a measure of control (Forbes and Ebeling 1986).

Other potential termiticides may be offered in bait-blocks and baiting systems. For example, insect growth regulators, including juvenile hormone analogs and chitin synthesis inhibitors, boric acid, and amdrosulfone could be incorporated into bait-blocks. The latter is a non-repellent delayed-action termiticide. If bait systems are used, large aggregations of termites can be exposed to small but direct amounts of termiticides, such as arsenic trioxide, amdrosulfone, boric acid, mirex, and inclusion compounds containing

toxins, and allowed to return to the colony and so transmit the toxin.

ALTERNATIVES TO CHEMICAL TERMITICIDES

Biological Control

Different methods of biological control exist, and include: bacteria, fungi, protozoa, nematodes, natural predators, natural enemies or competitors, pheromones, attractants, repellents, and insect growth regulators. However, many of these biological control agents are, at present, beyond the scope of practical application for the average pest control operator in Australia. Insect growth regulators and other chemical analogs would seem to have more commercial promise than organisms such as bacteria, fungi, nematodes, and natural predators. I have experimented with the natural enemies or competitors of *Coptotermes*, and call them "trojan termites." These are termites, usually of the same genus, but different species, that are collected from another colony. They are taken to the infested building, and dusted with a suitable toxin such as arsenic trioxide, then released into the active galleries of the termite species attacking the building timbers. When the two termite groups meet, they fight, and thus help to pass on the poison through the colony originally attacking the building, which subsequently leads to the death of the termite colony.

Although biological control of insect pests is increasingly being used in agriculture due to (1) pesticide resistance, (2) a growing awareness of probable health and environmental risks associated with using chemical pesticides, and (3) the financial costs of chemical control, some barriers do exist in refining such control methods.

Biological control products are usually less stable compared to organic chemicals. Significant evaluation is also required to ensure that live biological controls do not have unintended ecological consequences.

There are large costs in screening potential biological agents prior to obtaining registration. In Australia as of the 1 July, 1989, the Federal Government now charges \$20,000 to register a new chemical product. This will tend to preclude small companies from entering the market, even if their products are environmentally superior to what is already registered.

But there is a balance of forces between what society demands in insecticide selectivity and what society is prepared to pay for, though this balance is changing with increasing restrictions on the use of chemical insecticides. Biological control will probably become more important in the future, with the extent of development determined by economic forces.

Physical Barriers

Ant caps and shields

Ant caps are metal shields which are placed on the top of each pier beneath the building, and along the top of all foundations. However, because of problems in building construction, such barriers are readily bypassed by subterranean termites. These barriers work fine if the

buildings are regularly inspected, because they force the subterranean termites to build shelter tubes over them, thus exposing their presence to the inspector.

Non-Chemical Barriers

In 1957, Ebeling and Pence reported on the relationship of particle size to the penetration of subterranean termites through barriers of sand or cinders. This type of non-chemical barrier has recently been perfected in Hawaii to protect structures from attack by the Formosan termite, *Coptotermes formosanus* Shiraki (Tamashiro and others 1987). On the mainland United States, Ebeling and Forbes (1988) have applied for patent protection on the use of sand barriers. Laboratory and field experiments in Australia have shown similar relationships by challenging *Coptotermes* species with granite and basalt substrates (French 1989).

ADVICE TO THE PEST CONTROL INDUSTRY--A VIEWPOINT

The banning of DDT, for example, would no doubt be a laudable victory in the war to save the environment, but it would be disastrous to mistake such a victory as winning the war. The profound changes necessary to save the environment and society will not be made easily. Powerful opposition can be expected from economic interests. So how can scientists, particularly entomologists, assist in this arena and facilitate a more ecological approach to insect pest management?

First, entomologists need to think and act ecologically. They need to accept that the ideological status of ecology is that of a resistance movement. Its Rachel Carsons and Aldo Leopolds are subversive (as Sears (1964) called ecology itself). They challenge the public or private right to pollute the environment, to systematically destroy predatory animals, to spread chemical residues indiscriminantly, to meddle chemically with food and water; they oppose the uninhibited growth of human populations, the extinction of species of plants and animals, the domestication of all wild places, large-scale manipulations of the atmosphere (e.g., greenhouse effects) or the sea, and most other purely engineering or technological solutions to problems of and invasions into the organic world.

Second, their task is to inculcate basic ecological attitudes in the government, the pest control industry, and the public. They have to teach the population simple but basic ecological notions: a finite world cannot support or withstand a continually expanding population and technology; there are limits to the environmental sinks; ecosystems are sets of interacting entities, and there is no "treatment" which does not have "side effects."

Third, as ecologists, entomologists will have a central role in advising on the management of the environment. Thus, good management will depend on rather long-term studies of particular areas, since ecological situations are dependent both on time and locale. These two features also ensure that there will be a sizeable lag-time between posing the question and receiving the ecological advice, and a major job of the entomologists will be to make the existence of such lags known to the policy-makers. Entomologists will have to apply technology. For example,

integrated pest management systems will surely replace chemical control alone.

Fourth, entomologists need to ensure that the scientific establishment must become more closely regulated by collective decision-making processes. Upgrading the educational system (by words and deeds) and revising the role of mass media would prepare the public to play a more active role in directing scientific activities.

Finally, as Pirages and Ehrlich (1974) concluded, social priorities must be drastically altered to turn science inward to the study of people, their values, and their institutions. This area of inquiry will be vital to future survival, given the need to redirect human aspirations and consumption patterns. If social expectations and behavior are not altered, even the most earnest technological efforts will be unable to keep pace with growing human demands.

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