Summary

Jeff Waage,
IIBC, Silwood Park, Buckhurst Road Ascot, Berks, SL5 7TA UK

It is a challenge to summarize a meeting as diverse as this one. Thankfully it has been held together by a common thread. A silken thread, perhaps, spun by a larva of *Plutella xylostella*, defiantly clinging to a glossy leaf, covered in chemical residue and fungal spores, out of sight of a foraging parasitoid, for a moment at least. That common thread which ties us all together here has been, perhaps, a lifeline at times for each of us as we try to gain and hold onto an understanding of such heavy subjects as ichneumonid taxonomy and biochemistry of resistance mechanisms. It would have been much easier to hold concurrent sessions, so that we could each concentrate on the familiar and avoid the unknown. But this would have denied us one of this workshop's greatest achievements. No one here now has an excuse to ignore each other's approach to DBM management nor, after the last session's papers in particular, to seek single technology solutions to our common problem.

In the five years since the last workshop, DBM and its lepidopteran relatives like *Trichoplusia*, *Hellula*, *Crocidolomia*, *Pieris*, and others, have been at least as active as we have. The problem they pose has grown, it has spread, and the miracle cures of the past, such as IGRs and *Bacillus thuringiensis* have shadows hanging over them today. To find a silver lining in that cloud, I think it is significant that the appearance of DBM resistance in North America has brought the full force of American entomological expertise to bear on the problem, as we have seen so well represented at this meeting. I am sure their contribution will be of great benefit to ongoing programs in the tropical world.

We began this workshop learning about advances in the components of integrated pest management for *Brassica* pests, the elements of the strategies which we put together today. We also learned, in a few short papers, how little we really knew about the behavior and ecology of DBM, its movement (dare I say migration) and its mating behavior, and how much less we knew about the other moth pests on cruciferous crops.

The potential for plant resistance was made clear, specifically through the protection conferred by leaf glossiness, with all its complex genetic sources. The potential to put the strong antibiosis demonstrated into other *Brassica* lines must certainly exist.

Another technology, pheromone trapping, has pervaded this workshop. How many slides have we seen of a *Brassica* crop with a little pheromone trap emerging above the canopy? The use of pheromone traps to aid research and to gain a basic understanding of pest phenology seems now to be a standard tool. We should not underestimate how much of an advance this is. But beyond this we have heard how, in Japan, the use of pheromones for mating disruption has moved from elegant theory to practical reality. All we need now is to get the price down.

Our discussions of microbial pesticides control focused, most appropriately, on *B. thuringiensis*. I would not have thought, 10 years ago, that *B. thuringiensis* would be so popular today. As a purveyor of parasitoids and predators, I would have dreamed it, but not seriously thought it would come true. We seem now well into our second generation of *B. thuringiensis* technology. At this workshop we have heard of extensive and impressive trials of genetically engineered *B. thuringiensis*, and of the particularly exciting development of putting *B. thuringiensis* genes into long-lasting bacterial cells for foliar application. We skirted the issue of engineering *B. thuringiensis* into crucifers, which I take as a collective message of silent concern.

The clouds gathering over the use of *B. thuringiensis*, with the demonstration of resistance in Hawaii and elsewhere, are most worrying. We all want to know how local and stable this resistance might be and whether new genetic technologies can really keep us one step ahead of DBM's impressive physiology. But we have been reminded as well that there are other promising pathogens, fungi, and viruses, which deserve more study.

I am conscious of a personal bias towards the kinds of biocontrol agents which you can see and count. However, even in a field I thought I knew well, I have learned a lot. We have seen the use of parasitoids chronicled in the Pacific, in Asia, in the Caribbean and on a very small island off Africa. We then learned that all of the parasitoids which we have spread around the world may not be what we thought they were after all. As always, we come back to the taxonomist, grudgingly and late, for help.

Most heartening has been the very real and substantial success of parasitoids like *Diadegma semiclausum* in the highlands of Taiwan and Malaysia, and the real efforts to spread other useful parasitoids into farming systems by demonstration trials and by encouraging farmers to use microbials to assist their establishment. The hot lowlands, however, remain a challenge, and point to a need for further study of new agents from warmer regions. The diversity of parasitoids which we have seen described from Romania, at the heart of DBM's region of origin, is most encouraging. Finally, we are left with an awareness that in parasitoids and pathogens we have only a part of our biocontrol armory, and that predators now deserve our attention too.

All of these challenges will be better met by the establishment during this workshop of a Global Working Group on DBM within the International Organization for Biological Control (IOBC).

Throughout the workshop, there have been frequent reminders of the potential antagonism between pesticides and natural enemies, ranging from detailed studies of pesticide effects to the salient lesson of the Cameron Highlands, where pesticide use delayed for so many years the benefits of *Diadegma* which that region now enjoys.

As our pesticide armory dwindles, it is refreshing to learn of the continuing promise of neem extracts, and progress with that and other selective pesticides. But it is significant that the part of this workshop dedicated to chemical control was so dominated by the subject of resistance. In a series of detailed papers, we have seen research groups around the world try to piece together the patterns of resistance. The intricacies of cross resistance within the insect growth regulators, the organophosphorus and other groups point to a great range of mechanisms and some continuing disagreement. But one thing is clear, there are many processes and much variation governing the stability of resistance. This, and the apparent extreme localization of resistance, for instance of *B. thuringiensis* resistance in Hawaii and chemical pesticide resistance in Florida, gives hope to resistance management.

Many presentations took this positive approach, providing us with strategies, and even evidence of resistance management. It was also significant that the International Organization for Pesticide Resistance Management (IOPRM) chose this workshop to hold its first meeting on the development of programs for pesticide resistance management on DBM. We are anticipating considerable progress in the programs to be established by this new organization.

We reached the final session on IPM with many IPM tools and technologies, including perhaps some which we thought we might have lost. These methods are being cleverly woven into IPM programs around the world. Many exciting local innovations have been introduced in these IPM packages, alongside the methods we learned about earlier in this workshop. The striking success of mustard intercropping in India, and the potential for yellow sticky traps are examples.

We have heard of activities in several countries towards development of thresholds for pesticide application against DBM, with emphasis on 'softer' pesticides, where necessary, and the incorporation of natural enemy action into spray decisions. One has a feeling of it all beginning to come together. So that we do not grow too complacent, however, we have been reminded as well that IPM is a strategy which, in the end, must be implemented and not just studied. We have seen some, perhaps too little, involvement of farmers in the development of appropriate IPM methods. The economic bottom line of IPM has been driven home in farming communities as diverse as southwestern USA and Malaysia, and we are left with the clear challenge for some years hence, of coming back to our next workshop with improved, more practical IPM programs out of the hands of researchers and into the hands of farmers.

I would like to close by saying how impressive were the contributions and level of discussion, the high quality of research reported with the willingness to share information. We owe thanks to our hosts in Taiwan, and to the organizers of this workshop.