FROM CESAR'S 2008 ANNUAL REPORT – REPRINTED WITH PERMISSION.

DIRECTOR'S REPORT

The year 2008 marks the final year of our Special Research grant that established CESAR. It therefore seems timely to reflect on our achievements over the last 9 years. When we started the CESAR program, we were mainly an academic research operation with a strong focus on postgraduate training and publishing in the scientific literature, and limited interaction with industry or the community apart from some specialist work on pest organisms. Now CESAR is regarded as a quality provider in the areas of pest control, population genetics assessments, insect genomics, and climate change adaptation. We lead large funded efforts in climate change adaptation in the Alps, provide evolutionary input into models predicting changes in the distribution of pests and threatened organisms under climate change, collaborate with biochemists in pesticide design, interact with the community on environmental issues, and advise government on biodiversity management. We have developed expertise in identifying and working with a wide range of insect groups, we assess population processes in mosquito vectors of disease with traditional and emerging genetic markers, and we use the same types of markers to assess threatened species including mammals, plants and fish.

As well as developing research programs with strong community, industry and government links, CESAR has made a substantial contribution to knowledge with some key discoveries and publications. Early CESAR research helped identify the genetic basis of resistance to Bt toxins in pest moths and helped to identify a mechanism of resistance that cut across several chemicals. This "super resistance" was found to be associated with a transposon, an element of DNA that had affected the expression of a gene by "jumping in" to the host's DNA. This contribution led to a fundamental change in the way that transposons are seen – they have the potential to contribute to the adaptive evolution of organisms. CESAR's chemical stress program has also contributed to a shift in the way we see resistance to chemicals evolving via detoxification. Previously this process was seen as involving an increase in the expression of detoxification genes, but CESAR research has now shown that this is an uncommon response. CESAR's chemical program has also made a huge contribution to understanding the function of different genes involved in detoxification – and in some cases linking these to unexpected phenotypes critical in development.

CESAR's climate research program has effectively used the Australian east coast as a "laboratory" to investigate climate change adaptation. By focussing on the cosmopolitan species *Drosophila melanogaster*, and through collaborations with overseas labs, the CESAR program has led to discoveries of new genetic polymorphisms involved in climate change adaptation. We now have a much better appreciation of the role of genes like *Hsr omega*, *frost*, *dca* and many others as well as inversions. CESAR research has shown how climate adaptation can be driven by changes in the timing of reproduction as well as shifts in resistance to climate extremes. Moreover, we have shown how the performance of insects can be measured under field conditions, and highlighted how the costs and benefits of insect responses can be measured. Finally, the program has provided a new way of monitoring climate change through the use of genetic markers.

Our research has not only focused on cosmopolitans but also on sensitive species from rainforest environments. We were the first group to point out that these species have a limited adaptive capacity and are therefore much more susceptible to climate change in the long run. We have made progress in incorporating evolutionary thinking into conservation planning for

biodiversity maintenance, and increased our understanding of the adaptive potential of species in threatened environments including plants in the alpine area. All of this work has led to a new theoretical framework for understanding how species can become ecological specialists and a new perspective on how adaptive potential might be monitored.

We have improved our understanding of many pest organisms over the last few years. CESAR research clarified the species status of several important pests including wheat curl mites, eriophyoid mites and earth mites. We have used genetic markers to measure movement rates in pest organisms and incorporated this information into new biocontrol programs. CESAR scientists developed a new framework for sustainable chemical use on farms, and highlighted new resistance problems for specific chemicals. We also showed how landscape features could be used to help control pests by promoting beneficial organisms and highlighted the value of vegetation including grasslands. We edited two major volumes on sustainable pest control. Our pest work also led to several major insights into the maintenance of sexuality in animals. This included a new perspective on how asexual organisms can maintain genetic variation and evolve even in the absence of sex.

As well as developing genetic monitors of environmental change, CESAR research has been successful in promoting monitoring using the enormous diversity that exists at the species level in some insect groups. We helped develop a new way of assessing toxicants in sediments that can be coupled with existing approaches to identify factors contributing to a loss of waterway health. We applied this method coupled with an assessment of abnormalities to identify new undiagnosed sources of pollutants in waterways including the Murray River. Our work took advantage of new molecular techniques to overcome taxonomic problems associated with species level assessments. We also highlighted problem pollutants such as hydrocarbons in urban areas.

CESAR research has not shied away from controversy when our data are inconsistent with the views of other groups. We have been involved in controversial work assessing the impact of genes on trait variability that might enhance rates of evolution and shown that effects on variability were often overstated. We have also carefully tested (and failed to support) a theory that evolution might be enhanced by bottleneck events in populations. Our work on genetic markers of population structure have highlighted that strategies aimed at controlling two moth pests targeted at specific areas are likely to fail because movement rates are much higher than indicated by previous work. We have also failed to substantiate clinal patterns in some genes and traits proposed by other research groups.

At the end of our 9 year funding cycle, CESAR has I believe fulfilled and surpassed all the expectations that we had for the centre back in 2000. The CESAR name is widely recognised within the agricultural and environmental research communities. Papers produced through CESAR are having a large impact - as reflected both in the high citation rates of CESAR scientists and in the high number of citations accumulated by individual papers. Our work is published in the best scientific literature across a very broad range of areas. Members of CESAR have received plaudits from peers and had many invitations to present at scientific and community meetings. We have served on government committees, editorial boards, and assessment panels. We have broadly trained a large body of students and postdocs, and our people have moved on to become academics, teachers, consultants, extension workers, biodiversity officers, agricultural scientists and researchers. We have been successful in raising the awareness of invertebrates, climate change, evolution, and genomics within the community through the media.

Where to next for CESAR? In 2009, we will continue to exist but only in name. Our funding base remains strong and diverse, with projects funded by the Grains Research and

Development Corporation, Melbourne Water, the Commonwealth Environment Research Fund, the Australian Research Council, Grape and Wine Research and Development Corporation, Gates Foundation and several other groups. However we will lack an administrative core, a group of interacting students and postdocs, seeding funding for joint approaches and initiatives, the ability to jointly assess equipment and technology requirements, and a broad base for training. Core expertise in genomics and insect culturing will be lost with the departure of key staff. Research in the centre will suffer, particularly in our ability to be innovative and interdisciplinary. We will attempt to gain new centre funding for 2010 with a new set of targets although the core areas being covered by CESAR will remain the same. These are high quality entomology and evolutionary genetics with a strong focus on providing solutions for environmental sustainable food production, the maintenance of biodiversity under climate change, pest control and environmental monitoring. Research in these areas remains critically important as environmental degradation accelerates but our population continues to grow.

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