BULLETIN DE L'INSTITUT ROYAL DES SCIENCES NATURELLES DE BELGIQUE
BULLETIN VAN HET KONINKLIJK BELGISCH INSTITUUT VOOR NATUURWETENSCHAPPEN
SUPPLEMENT, 70: 17-21, 2000
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Plant research overview, current activities, and priorities

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Introduction

The new Department of Plant and Invertebrate Sciences was created in late 1996 at the Charles Darwin Research Station (CDRS) by the incorporation of the station's entomology programme into the former Department of Terrestrial Plants, and the creation of a new quarantine programme. These moves have reinforced a welcome trend of integration of the station's research and conservation programmes on different groups of organisms. The interests of the department now include all of the terrestrial biodiversity of the Galápagos, with the exception of the vertebrates.

The invertebrates and quarantine programmes are dealt with by other contributors to this symposium, although overlap exists with plant programmes especially in monitoring for introduced species, studies of natural enemies of introduced plants, and in mutual reporting and participation in field survey work. There has also been increasing collaboration and programme integration between the station and other institutions with similar goals and interests, especially the Galápagos National Park Service (GNPS) and the Provincial Agriculture Department (DPA). Work on introduced species in the agricultural zones is carried out in collaboration with the DPA, while interaction with the GNPS is increasingly extensive in planning conservation action which may be recommended as a result of the station's research. The increasing integration has largely come about as a result of renewed interest in attacking the problem of introduced plants, by the Department of Plant and Invertebrate Sciences as well as by the GNPS and DPA, since all need to work together in order to achieve success in this area. A number of collaborative research and conservation measures have also led to increased contact between the Department and the GNPS, especially the Isabela project and fencing for threatened plants on Floreana and Santiago.

Research by visiting scientists

Botanical research carried out by CDRS itself is entirely directed towards conservation of the natural ecosystems of Galápagos and is thus all of an applied nature. In addition to our own research and conservation projects, the station's visiting scientist programme provides valuable additional contributions to this work. Visiting scientists' research projects may in theory be less closely related to conservation but in fact, during the last two years, all such projects have had obvious immediate conservation benefits. Visiting scientists' projects on plants during this period have included the following important studies:

1. Intra-population genetics of small isolates. A project by Drs H. Adsersen and M. Philip from Copenhagen University, to investigate the extent of intra-population variability in a range of endemic species, each of which comprises a number of isolated populations. This project should provide a better understanding of the conservation value of the populations studied, permitting more rational allocation of conservation resources to the most endangered and taxonomically valuable populations. More immediately, the project also provides information on the status of the populations studied, many of which have declined dramatically since earlier studies in the 1970s and 1980s.
2. Long-term monitoring of vegetation change, especially in relation to the presence of introduced herbivores. This project, headed by Dr Ole Hamann of Copenhagen University, has been in progress for some 20 years. It has provided, and continues to provide, valuable information on the effects of introduced herbivorous mammals on the vegetation of affected islands, and of the results of control and eradication campaigns. The project operates on several islands, including Pinta, Santa Fé, and Santa Cruz.
3. DNA-based taxonomic studies of endemic plant groups. This project has been in gestation for several years, and is now expected to begin in 1998. It is to be carried out by a group of researchers, mostly from the University of New Mexico, and with contributions from Copenhagen University, San Francisco University (Quito), and CDRS. The project will examine relationships within endemic plant groups, beginning with the endemic genus *Scalesia*. The information will contribute to our knowledge of the evolution of this group and the relation-

ships between its member species, which will again help in identification of the most distinctive and therefore valuable populations.
4. Other visiting scientist projects in preparation include research on the genetics of the ferns of the archipelago, and a study of the microflora, hitherto the most neglected part of the Galápagos plant community.

Current plant programmes at CDRS: research and conservation

Our own research work concentrates on two main themes: research for the protection of native plants, and research for the control of invasive introduced plants. These two themes reflect our overall goal of protection and restoration of native Galápagos ecosystems. In addition to research, the programmes in each of these themes take the conservation process further, by:
— assisting the GNPS in the formulation of management plans;
— raising funds not only for research but also for conservation action;
— organizing conservation action in collaboration with the GNPS and DPA;
— disseminating knowledge of the Galápagos flora and its problems.

This additional, non-research activity is more expensive than the actual research, requiring finance far in excess of the comparatively limited sums needed for field and laboratory investigations. In particular, a project funded from 1996 to early 1998 by the Ecuadorian-Canadian Development Fund (FECD), aimed at improving agricultural zone management in order to reduce the problem of invasive species present in the agricultural zones of the islands, has been one of the most expensive projects within the department during that period. Similarly, the costs of direct protective action for endangered plants and plant communities, by fencing, are extremely high due to the inaccessibility of the sites to mechanized transport. As examples, fences constructed during 1997 on Santiago and Floreana for the protection of the two rarest plants in Galápagos (*Scalesia atractyloides* and *Linum cratericola*) cost $2,000 and $16,000 respectively, while two enclosures to protect the last remnants of tree-fern forest on Alcedo volcano cost about $25,000.

The eradication of introduced species offers a further example of the high costs of conservation action in Galápagos. In order to eradicate one of the highest priority targets, the quinine tree *Cinchona succirubra*, from Santa Cruz, the only island on which it occurs, a continuous programme is required, extending probably over 20 years, costing in the order of $2 million. However, despite the expense, such a programme is essential if we are to remove the greatest threat to the two most threatened vegetation zones of the island, the Fern-Sedge and Miconia Zones.

In addition to specific research and conservation actions, the Department maintains and develops, as research tools, the CDRS Museum, Herbarium, and Database of the Galápagos Flora. The Herbarium and Database are essential resources for most of the department's programmes, as well as for visiting scientists' projects. All researchers are encouraged to submit their specimens and records, while department staff routinely add to both Herbarium and Database. The database was completely redesigned during 1997, to enable a greater range of information to be included, particularly data on threat status. As part of the current process of assessment of the threat status of native species (see below), and of the reinvigorated introduced plants programme, both the herbarium collections and the database are currently undergoing extensive revision and expansion.

Research for the protection of native plants and plant communities

The priority objectives of this work are:
— to discover which species and communities are most threatened;
— to prioritize conservation action;
— to initiate protection.

Current research activities that contribute to these objectives include:
1. A review of the distribution, abundance and status of the endemic plant taxa of Galápagos and their categorization according to the new IUCN threat criteria. This key project is currently unfunded but has been initiated with the assistance of international volunteers. The process includes a review of published and unpublished information on distribution, abundance and status, and its incorporation onto base maps of the islands. This process relies heavily on the specimens and records in the CDRS Herbarium and Database of the Flora of Galápagos. In the course of extracting the information, the herbarium specimens are revised, which has the additional benefit of correcting errors of attribution and identification and therefore improving the value of the herbarium and database themselves. The project should indicate not only which taxa are most threatened according to our existing knowledge of the flora, but will also indicate gaps in that knowledge and improve further research planning.
2. Long-term monitoring of the effects of introduced herbivores in critical sites (e.g. Alcedo, Santiago) and on critical taxa (e.g. *Scalesia* populations). This activity includes work on a variety of projects, including especially the interdepartmental Isabela Project and the Department's own Santiago project (funded by Frankfurt Zoological Society). Work on Santiago commenced in the 1970s, but techniques were only recently standardized sufficiently to permit valid comparisons between successive surveys. The project on Alcedo began in 1995, with standardized methodology developed by the Department (MAUCHAMP, 1996). A preliminary analysis of the data collected so far indicates that the monitoring techniques used are adequate to reveal seasonal changes in the

vegetation and the effects of the current El Niño event, and should therefore also reveal longer term changes consequent on the presence of goats and donkeys and on their present control and ultimate eradication. An expansion of this activity to other sites is envisaged, especially to the other volcanoes of northern Isabela, and eventually to other islands.

3. Surveys of sites and studies of populations thought to be threatened, to identify key sites for protection. Projects contributing to this activity have so far been piecemeal and largely without dedicated funding. However, other projects (e.g. on introduced plants, long-term monitoring) permit concurrent site surveys for threatened species in areas which could not otherwise be visited. However, this activity will expand enormously during the second half of 1998, with funding from the UK's Darwin Initiative providing for intensive surveys over the next few years. These surveys will concentrate on taxa identified as requiring further survey during the first activity listed above, and on poorly-known sites.

The work on Santiago Island will commence with additional finance from FZS. The Santiago project includes surveys to identify additional sites for protection by fencing, until the critical problem of the presence of goats on the island can be tackled. Currently, some 50% of the flora of the island is represented within existing exclosures, and the aim is to increase this proportion to include at least all threatened taxa within protected sites. The Santiago project also provides for detailed study of selected threatened taxa, in order better to understand their ecological requirements and plan conservation action. The wider Darwin project focuses on survey work throughout the archipelago, with an additional provision for the establishment of an *ex situ* cultivation and reintroduction facility at CDRS. This will be used to augment the populations of selected endangered species in protected sites. Additional conservation activities of this kind, which go beyond applied research, include:

4. Production of management plans for threatened species and communities, and key sites. The results of the research in the first three activities above will be used to write management plans for all threatened taxa and for the most critical sites for conservation of the Galápagos flora. This work will be carried out in collaboration with the GNPS, and is partly financed by the Darwin Initiative project mentioned above. It forms a critical stage in the translation of research results into conservation action.

5. Protective action. This activity has so far consisted entirely of constructing fences to protect priority taxa and sites. In recent months finance has been provided by FZS and the British Government for fences on Floreana, Santiago, and Alcedo, and further work will be carried out under the Darwin Initiative project. The work is done by the GNPS and contracted labour, but the task of fund-raising largely falls on CDRS. A further contribution to this activity is provided by the projected *ex situ* cultivation facility, which will permit population enhancement in addition to simple protection from further damage.

Research for the control of invasive introduced plants

Whereas the activities for protection of native plants are centred primarily on the Galápagos National Park itself, the activities with respect to introduced plants focus equally on park and inhabited zones. Priority objectives within this theme include:

— devising a means of prioritizing the problems of invasive species;
— designing control tactics (methodology) and strategy (including the prioritization process);
— initiating control.

Current research activities which contribute to these objectives include:

1. Design of the prioritization system. Discussions have been held with staff of the New Zealand Department of Conservation, who have developed and implemented such a system in a country whose problems with introduced species resemble closely those of Galápagos. It is envisaged that a similar system will be developed for Galápagos, although this activity is currently unfunded, and will not proceed more than slowly unless dedicated funding can be secured. Although a prioritization system can be initiated comparatively easily, it will require much complementary research in order to obtain the information required to base the prioritization on sufficiently good information. Research is especially needed on the ecology of introduced species, especially those known to be invasive in Galápagos, and those which are potentially invasive, based on knowledge from other parts of the world.

2. Ecological studies of the effects of invasive species on native plant communities. Surprisingly little research has been done on this problem to date, but a new project began in 1998 to investigate the effects of the invasion by *Cinchona succirubra* on the Miconia and Fern-Sedge vegetation zones of highland Santa Cruz, and it is hoped to begin a similar project on *Psidium guajava* in the near future. Despite the presence of several problem species for very many years, and early recognition of their invasive tendencies and ability to replace native species, we have almost no information on the mechanisms of invasion, nor on the detailed effects, such as which native species are worst affected, and which seem relatively unaffected, by invasion of their host communities. No project in this activity yet has funding, but the Cinchona project is currently being carried out by a research student volunteer.

3. Studies of the distribution and spread of introduced species. The principal source of invasive plants is known to be the inhabited zones of the islands, where cultivated plants are introduced, usually deliberately, for ornament or agriculture. Control planning will therefore attempt to achieve integrated action for inhabited zones and park. However, the effects on the introduction of plants by human activities within the national park itself had not been studied, until a project commenced in 1996 with financial support from the Monsanto Corporation. This project has surveyed a variety of sites on all inhabited and

selected uninhabited islands, recording introductions at tourist visitor sites, quarries, and rubbish dumps, and along roads and tracks, in order to assess the impact of these various human usages of the park on the spread of introduced plants within it. This work will assist in planning for the management of the national park.

4. Control trials. A number of trials of control techniques have been carried out in Galápagos over the past 20 years, but with very little concrete result. Past trials were reviewed during 1997, and it was discovered that the great majority were not established rigorously, nor were they monitored in sufficient detail and for long enough to reveal the true effects of the treatments. Following this review, a new series of trials was designed to test control methods on 13 of the most severe invaders, and was commenced in early 1998. Monitoring according to a newly-designed system will continue for at least two years, during which further trials will be planned and initiated. This work has been partly funded by Monsanto, but current finance is not adequate to cover the foreseen monitoring period.

5. Monitoring of new introductions and the spread of introduced plants within inhabited zones. No systematic work on this problem has been done to date, but a project to design a monitoring system has been initiated with the aid of funds from FECD. Final design and implementation of the system will depend on further funding being found. At present the detection of new introductions relies on ad hoc reports and casual surveys and there is an urgent requirement to systematize this process. Additional conservation activities which go beyond applied research, and extend to active management and control include:

6. Control manual. In order to ensure that control activities be properly applied within the sensitive ecosystems of Galápagos, a guide to appropriate techniques is urgently required. Currently, farmers and national park staff are using a variety of often ineffective techniques in order to attempt control of invasive plants. Based upon the review of former trials, a first draft for a control manual was drawn up in 1997. This will be refined by the incorporation of results from current trials and information from other parts of the world. The production of the manual is currently on hold pending acquisition of funding.

7. Control campaigns in inhabited zones. This activity focuses on restoration of abandoned land in the agricultural areas, as part of an integrated programme of agricultural improvement, whose ultimate aim is to reduce the threat of invasion of the national park by introduced plants originating in the inhabited zones. Work over the past few years has included promotion of land restoration and replacement of invasive species, through farm forestry using non-invasives. This is part of a long-term programme to change agricultural practices in the islands so that they become less damaging to the natural ecosystems of Galápagos, a project whose funding (by FECD) unfortunately terminated in March 1998.

The department has also recently become involved in direct control of invasive plants in inhabited zones, as it had formerly been in the early 1990s. This work has commenced with an initiative taken by the community of Santa Rosa, in highland Santa Cruz, who wished to eradicate *Rubus niveus* from their land. Our involvement is in the provision of advice and training, and limited financial input in the form of herbicide provided by Monsanto. It is hoped to expand this programme to other communities and other problem species, but such an expansion will depend entirely on securing funding for this currently unsupported project.

8. Control campaigns in the Galápagos National Park. The role of CDRS is in the provision of advice, on both the relative seriousness of the problem species and on appropriate control techniques. A further critical aspect of CDRS participation in this activity is in fund-raising. If the most serious invaders of the national park are to be brought under control, and perhaps even eradicated completely, then a massive financial investment is required. This will require a funding search on a scale at which neither the GNPS nor CDF has much experience, but which is crucial if we are to prevent the extinction of native species and the loss of entire native plant and animal communities.

Fund-raising: the first priority

As will have been seen from the foregoing, the finance available for the work of the Department is very small compared with the size of the research and conservation problems it is trying to tackle. In recent years, most funding has come from a very few sources: research on invasive plants has been almost entirely dependent on a series of very small grants from Monsanto, and on spin-off funding from a broader agricultural zone management project. Similarly, research on native plants has been dependent on FZS and Isabela Project funds for specific islands, and now on the Darwin Initiative for a broader review. Within the research programmes themselves, the most difficult element of funding to obtain has been core money for maintenance of the Department, especially for staff salaries. We have managed to circumvent this difficulty to a slight extent by the use of volunteers, but this situation is far from ideal, and funding uncertainties over the past year have even led to the loss of staff from positions which should be permanent, but which have had to be suspended owing to loss of financial support.

For CDRS's plant research activities themselves, funding must be increased, especially for work on invasive species, which is comparatively very poorly financed. But for conservation management of both native and introduced plants, current funding is completely inadequate, with no money available for control of invasive species and very little for fencing. The greatest shortfall is for action against invasive species, where nothing adequate to the size of the problem will be done unless the GNPS can find sufficient funding to establish and operate a dedicated plant control unit.

In addition to seeking greater funding for the Department's own programmes, and working with volunteers, increased emphasis is currently being placed on promoting interest outside Galápagos in research problems within the archipelago, and on establishing collaborative projects with outside institutions. This may bring access to a greater range of funding sources as well as enabling research to go ahead which is beyond the current capacity of the Department. Access to corporate finance also needs to be improved, and this option is being pursued for the introduced plants programme.

Conclusions

The work of the Department of Plant and Invertebrate Sciences over the past two years has seen both encouraging developments and disappointments. The department has slightly increased the size of its staff working on plants, and additional appointments are planned for 1998.

The invasive plant programme, neglected since the early 1990s, has been reinstated but suffers from a serious lack of funds, and from the loss of the large agricultural zone management project. The native plant programme is about to benefit from the Darwin Initiative grant for surveys, but is still unable to go ahead as fast as we should like with critical aspects such as the review of threat status of endemic taxa, nor for herbarium development.

The money available for action on plant conservation is still completely inadequate when compared to the scale of the problems. There have been some hopeful developments, but much more effort is required if we are to reverse the conservation battle, which we are currently losing. At present, native plant communities are still being progressively replaced by ones largely consisting of introduced species. Our goal is to achieve the opposite.

Acknowledgments

I thank Sarah Wilkinson, whose comments on a draft of this paper helped to improve it.

References

MAUCHAMP, A., 1996. Monitoreos de vegetación en Galápagos: manual de procedimientos, version 1.0. Unpublished report, CDRS.

Note

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