FORMER REGULAR PROJECT:

CODE: **CHI:01**

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PROJECT: **Chemical ecology of plant-insect interactions**

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Staff			**Students**			
Academic PhD	Academic Other	Tech-Nicians	Sandwich PhD	Local PhD	Sandwich MSc/MPhil	Local MSc/MPhil
1		7		2		3

Awarded degrees	**84/96**		**1997**		**1998**		**1999**		**2000**		**2001**		**2002**	
S=Sandwich; L=Local	S	L	S	L	S	L	S	L	S	L	S	L	S	L
PhD	3	1	1				1	2				1		
MSc/MPhil/Licentiate	1	6		1		1			1			1		

Publications	**84/96**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
International journals	80	8	7	12	5	10	8
National journals	8			1	2	2	3
Conference reports	88		24	12	17	13	9

Arrangement of work-shops/symposia/conf.	4	1		1	1	1	1

Visits by IPICS staff/ Swedish scientists	11/12	2/1		1/			

No. of participants trained in IPICS prog.	Sweden or other country in Europe	Regional laboratory
Until December 2002	8	1

IPICS funding (total for the specified period)	Period of funding	Fellowship months (total no.)	Training costs (k-SEK)	Other costs (k-SEK)	Total (k-SEK)
	1984- Dec 2002	111	585	3466	4051

Cooperation initiated	1984
Final year	2002

SUMMARY OF THE PROJECT CHI:01

In the last few decades, the dependence on fossil-fuel-based fertilizers and pesticides has increased dramatically. This increased input of agrochemicals in arable crops can not be sustained in time, since agrochemicals pollute the environment, their production depends on non-renewable resources, and resistant strains of pests are continously emerging. A deeper understanding of the relationships between a host plant and its associated insects, and also of the mechanisms of intraspecific communication in the insect species, may provide new low cost alternatives for control applicable in integrated pest management systems.

Chemical Ecology is a new discipline of science dealing with chemicals determining the interactions between organisms. Until recently, most work in this field dealt with the discovery of new compounds responsible for the interactions. More recently, the frontiers of Chemical Ecology have expanded and become more difuse, even to the point of addressing problems at macroecological and evolutionary levels. The activities we carry out, by covering a range of organisms, problems, and techniques, are situated at such frontier. They constitute a multidisciplinary approach to understanding biological interactions in which chemistry plays the key role.

Thus, the Chemical Ecology Laboratory has approached the problem of pest resistance in crops through the study of the chemicals involved in the interaction between aphids and plants, both in the artificial environment prevailing in wheat, a major crop in Chile and the world, and in the natural environment in which the hosts are native plant species. The following are among the problems which have been addressed: chemical mechanisms of defence of cereals against aphids and biotic and abiotic factors that modulate them, gene flow in aphid populations associated with cereal crops, chemical modification of plant and aphid chemicals in order to study their mode of action and to enhance their activity, mechanisms of host-finding by aphids, semiochemicals in intraspecific and interspecific interactions involving aphids, description of aphid-plant associations under native conditions, and insect-plant interactions in a biogeographical context.

The main research accomplishments of the Chemical Ecology Laboratory at Universidad de Chile may be summarized as follows. We described the ecological role of hydroxamic acids (Hxs), a family of secondary metabolites in cereals, in the interaction of cereals with aphids along a gradient of biotic and abiotic environmental variables, and explored molecular interpretations of their mode of action. We further used the cereal-Hx-aphid system to test ecological theories of optimal forraging and plant defence. Finally, we engaged in bioprospecting in order to find natural sources of chemicals with potential use as insecticides.

Hxs protect cereals against aphid attack through antibiosis and feeding deterrency. The electrophysiologically-monitored feeding behavior of aphids in wheat seedlings and in artificial diets, and the localization of Hxs in both aphids and plants, led us to design a model for the chemical interface between an aphid and a wheat plant. In this model, aphids detect the Hx aglucone while piercing mesophyll cells in search of the phloem and consequently experience its feeding deterrency, and ingest the Hx glucoside while feeding from the phloem and consequently suffer its toxicity.

The decomposition of Hxs in solutions, and their reactions with enzymes, were the basis for the interpretation of many aspects of their biological activity. DIMBOA, the main Hx aglucone in wheat, decomposes through a series of steps involving the opening of the heterocyclic ring to an aldol, its reaction to form an isocyanate, and its further closure to give a benzoxazolinone. DIMBOA reacts with thiols through reduction and/or addition reactions, and with amines through addition reactions. These reactions were responsible for the inhibition of the model enzymes papain and chymotrypsin, respectively, and provided a basis for the understanding of the bioactivity of DIMBOA at a molecular level.

Aphid feeding on a plant sets off an induction of Hxs in the area of attack which was shown to arise from the reallocation of constitutive Hxs from other tissues. These results supported the modification of the Theory of Optimal Defence to include the concept of induced chemical defenses *i.e*. higher allocation of defenses to plant tissues where attack has occurred. On the other hand, the efficiency of resource exploitation by a cereal aphid was shown to increase with exposure to such resources, a change attributed to the presence of high levels of Hxs in the plant. These results supported the extension of the Theory of Optimal Forraging explicitely to take into account plant secondary metabolites.

We have also contributed to the field of intraspecific chemical communication in aphids by describing aggregation and spacing semiochemicals involved in the regulation of aphid populations on a cereal plant.

On a more applied front, we have participated in the isolation and structure elucidation of numerous chemical constituents of native plants from Chile and in the testing of their insecticidal activity. Of particular interest have been naphthoquinones in *Calceolaria* spp. with activity against insects resistant to available insecticides, which are the subject of a patent.

The range of techniques employed in these studies is wide. Studies of insect feeding behaviour use electropenetration graph recording equipment, which provide an instantaneous picture of the position of an aphid stylet within the plant tissue. The chemical interface between aphid and their host plant is examined through whole plant analysis or by collecting and analyzing phloem sap through the stylet of a feeding aphid which had been severed from its body by microcauterization using a radiofrequency pulse. Studies on population ecology make use of various molecular biological techniques to ascertain the genetic make-up of aphid populations. Study of host finding by insects and insect intraspecific chemical communication uses equipment for the collection of volatiles emitted by aphids or plants, the determination of their effect on aphids in an olfactometer, the gas chromatographic separation of the sample, and the identification of active components using mass spectrometry.

Keywords: pest resistance, cereals, aphids, hydroxamic acids, DIMBOA, bioinsecticides, aphid pheromones

Training, research visits:

Year	Participant (months)	Research host	Research field
73/74	Hermann Niemeyer(12)	P Ahlberg, UU	Org chemistry
84/85	Hermann Niemeyer (3)	J Pettersson, SLU	Insect-plantinteractions
85/86	Sylvia Copaja (6)	J Löfqvist, LU	Insect pheromones (analyses)
85/86	Hector Bravo (6)	T Liljefors, CC,Lund	Insect pheromones (sy
86/87	Sylvia Copaja (5)	As above	As above
86/87	Hector Bravo (5)	As above	As above
86/87	Arturo Givovich (6)	J Pettersson, SLU	Insect-plant interactions
87/88	Arturo Givovich (5)	J Pettersson, SLU	Insect-plant interactions
87/88	Hermann Niemeyer (3)	J Pettersson, SLU	Insect-plant interactions
93/94	Hector Asencio (5)	F Dajas, IIBCE, Montevideo, Uruguay	Pharm screening
90/91	Liliana Cuevas (12)	L Jonsson, SLU	Plant enzymology
91/92	Victoria Leighton(9)	L Jonsson, SLU	Plant enzymology
91/92	Andrés Quiroz (4)	J Pettersson, SLU	Insect-plant interactions
92/93	Andrés Quiroz (4)	J Pettersson, SLU	Insect-plant interactions
93/94	Victoria Leighton(3)	L Jonsson, SLU	Plant enzymology
93/94	Liliana Cuevas (9)	L Jonsson, SLU	Plant enzymology
98	Ernesto Gianoli (14)	J Pettersson	Entomology

Other visits to Sweden:

H Niemeyer	1984, 1986, 1987, 1989, 1991(2), 1993(2), 1994, 1995, 1996 (2), 1997, 1999
F J Pérez	1990
A Givovich	1992
C Ramirez	1998

Visits by IPICS staff/reference group:

R Liminga	1984, 1987(Febr), 1987(Nov), 1988, 1989, 1990, 1991, 1993, 1995, 1997
Å Bergengren	1987, 1989
L Sjöblom	1997
M Åkerblom	1997, 1999

Visits by Swedish scientists engaged in the cooperation:

T Norin	1989, 1995
J Pettersson	1989, 1991, 1993, 1995, 1997
P Baeckström	1989, 1995
L Jonsson	1990, 1991
M Friberg	1990
J Sandström	1991 (2m; research work)

J Weibull	1993/94 (9 months; research work)
K Johansson	1995

Funding: (k-SEK)

Years	Training/ Exchange	Other project costs (equipment etc.)	Total
1984/88	409	395	804
1988/89	-	111	111
1989/90	-	197	197
1990/91	162	297	459
1991/92	-	272	272
1992/93	14	250	264
1993/94	-	285	285
1994/95	-	275	275
1995/96 (18 months)	-	325	325
1997		241	241
1998		238	238
1999		229	229
2000		201	201
2001		110	110
2002		40	40
Total	**585**	**3466**	**4051**

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1) International Foundation for Science (IFS): Eduardo Fuentes-Contreras
2) FONDECYT
3) Presidential Chair in Sciences
4) MISTRA/IFS