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STATUS AND FUTURE OF HUMAN RESOURCES IN COCCIDOLOGY.

ABSTRACT

STATUS AND FUTURE OF HUMAN RESOURCES IN COCCIDOLOGY.

This paper reviews responses to a survey on the current status of researchers active in coccidology, with an emphasis on systematics but including work on morphology, biology, ecology, biological and chemical control of scale insects and on preparation of data bases. The 39 responses provide a short assessment for 38 countries and 15 U.S. States, with the activities and/or whereabouts of about 243 researchers. Thirteen of the 32 active researchers (41%) will reach retirement age within five years; however, the average time to retirement for this group was 11.7 years. There has been a decline in the number of women in graduate training, while, from the 17 graduate students being trained in coccidology, only six are doing research in systematics.

Key words: funds, training, public awareness, research areas.

INTRODUCTION

Ferris (1957) prepared a history of coccidology, which reviewed also the types of research that coccidologists were involved in at that time. The recent loss of many coccidologists due to death, retirement or to changes in the emphasis in entomology and systematics suggests that this might be a good time to assess the present status and future prospects for research in this field. A two-page questionnaire was, therefore, mailed to 54 colleagues. This received a 73% response and the replies described the activities and/or whereabouts of about 243 persons, and these are discussed below by continents and alphabetically by countries. The addresses for most of the active workers listed below are found in The Scale, volume XXI (March 1997).

EUROPE

Armenia - L. Mkrtchian, R.N. Sarkissov and A. Zakharian are currently still active, but M.A. Ter-Grigorian has retired. **Austria** - C. Stumpf is a Ph.D. candidate with P.L. Lambdin at the University of Tennessee, working on the asterolecaniids of the Neotropical Region; this suggests a possible reactivation of scale research in Austria. **England** - J. Cox unfortunately resigned from the

British Museum after a short but distinguished career in coccidology. D.J. Williams, although retired some years ago, continues writing major monographs (Williams & Granara de Willink, 1992; Williams & Watson, 1988a, 1988b, 1990). At Wye College, University of London, where C.J. Hodgson (Hodgson, 1994; Ben-Dov & Hodgson, 1997a, 1997b) and M.W. Copland are active, the former is currently revising the soft scales of New Zealand with R. Henderson and of Australia with P. Gullan; his Ph.D. student H.A. Vahedi from Iran, is working on *Porphyrophora* in western Asia; Copland has had several Ph.D. candidates working on the biocontrol of scales; M. Heidari is also at Wye doing graduate research on mealybugs and their predators. C. Mallumphy works on some of the quarantined pest species at the Ministry of Agriculture; G.W. Watson (Williams & Watson, 1988a, 1988b, 1990) maintains an interest in scale systematics, based at the Natural History Museum. J. Alford, M. Cronin and D. Ponsonby at Canterbury Christ Church College, studied the environmental factors affecting population size of *Pulvinaria regalis*. **France** - M. Canard retired five years ago and is no longer actively working on Coccidae, but I. Foldi, P. Kreiter, D. Matile-Ferrero, A. Panis, M.J. Perrot-Minnot, C. Pinet and C. Richard are active. D. Matile-Ferrero and Y. Ben-Dov are collaborating on a revision of the mealybugs in the Mediterranean Region, while I. Foldi is working on margarodid systematics. L. Goux continues publishing while in his nineties, but R. Mamet, after making significant contributions on the coccoids of Mauritus and the surrounding area, died in 1997. **Georgia -** G.O. Japoshvili works on population dynamics of scales, while V.A. Yasnosh and E.S. Tabatadze are working on the biology and natural enemies of scale insects. Z.K. Hadzibejli died on 2nd Feb. 1999. **Germany** - G. Köhler in Leipzig and H. Schmutterer in Giessen are still active, the latter working on a book on the scale insects of Germany although he retired five years ago; his Ph.D. student, C. Hippe, is completing his research in Switzerland in 1998. H.P. Heckroth, B. Fiala and U. Maschwitz work on scale insect-ant-plant systems in S.E. Asia. **Greece** - S.S. Paloukis has died and L.C. Argyriou has retired; only P. Katsoyannos continues to work on economically important scale insects. **Hungary** - F. Kozár (Kosztarab & Kozár, 1988) is very active; G. Ördögh retired last year but he continues to write on economic pests. G. Vinis took a job in another field and so she is no longer working on coccoids. **Italy** - The largest number of active European coccidologists are working here: D. Battaglia, G. Viggiani and others specialize on chalcid wasp parasites, while G. Tremblay and R. Ponzi are working on scale insect symbionts. At least nine others are active: A.P. Garonna, S. Longo, S. Marotta, G. Mazzeo, S. Nucifora, G. Pellizzari, F.

Porcelli, A. Russo and A. Tranfaglia; in addition, there are at least five graduate students, one working on systematics (P. Fontana), three on coccoid biology and one on biological control. A. Russo, S. Longo and G. Mazzeo are working on the scale insect fauna of Sicily, IPM on *Citrus* and on monitoring models for *Planococcus citri*. V. Lupo, in his nineties, is in retirement. **The Netherlands** - M.G.M. Janzen is active in scale research. **Poland** - A. Dziedzicka, H. Komosinska and B. Zak-Ogaza have retired. J. Koteja, B. Lagowska, E. Podsiadlo and T. Szkleviewicz are all active. I. Bielenin has passed away. **Portugal** - I.M. Fernandes has retired, but José C. Franco is currently active in faunistics and in studying pest scales. E.M.B. Silva and A. Mexia are working on the histology of mealybugs. **Russia** - G.M. Konstantinova (Moscow) has retired but E. Danzig (Danzig, 1993) in St. Petersburg and E. Kozarzhevskaya in Moscow are currently active. Danzig will be publishing a monograph on the mealybugs of Russia in parts. Both V. Trjapitzin and E.S. Sugonyaev, scale parasite specialists, are currently active in St. Petersburg. **Spain** - A. Blay has expressed an interest in Diaspididae; G. Perez-Guerra (Perez-Guerra & Kosztarab, 1992) moved to Germany to work on forest insects. **Switzerland** - C. Hippe is active on scale research. **Ukraine** - E.M. Tereznikova has retired. **Other Countries** - apparently, there are no active scale insect researchers in Albania, Belarus, Belgium, Bosnia, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, Ireland, Latvia, Macedonia, Moldavia, Norway, Romania, Slovakia, Slovenia, Sweden, Ukraine or Yugoslavia (Serbia).

MIDDLE EAST

Iran - M. Kaussari, in his nineties, is retired but Miss M. Moghaddam is now employed to work on scale insects in Tehran. H.A. Vahedi is working on the *Porphyrophora* of Iran for a Ph.D. at Wye College. **Israel** - Y. Ben-Dov, D. Blumberg, E. Dunkelblum, Z. Mendel, M. Wysoki, and co-workers (students and extension officers) work at the Department of Entomology, Volcani Center, on scale insect population dynamics, chemical ecology, IPM, host-parasite relationships and taxonomy. Y. Ben-Dov is an active systematist (Ben-Dov, 1993, 1994; Ben-Dov & Hodgson, 1997a, 1997b), engaged mainly in the development of SCALENET (a computerized database of the scale insects of the world - along with D. Miller, USDA - see Miller *et al.*, this volume) and on a revision of the Mediterranean mealybugs. Z. Mendel and D. Blumberg are active in classical biocontrol and IPM of scale pests. S. Gross, Ministry of Agriculture, Tel Aviv, works on citrus mealybug control. E.

Dunkelblum and Z. Mendel are active in the identification, field bioassay and application of scale insect pheromones. U. Gerson, Faculty of Agriculture in Rehovot, has worked mainly on mites recently. We recently lost a great scientist in David Rosen (Rosen, 1990a, 1990b), specialist on scale parasites. **Turkey** - although P. Önder, O.Z. Soylu and M.S. Tuncyürek have retired, at least ten more remain active: S. Cobanoglu, T. Colkesen, L.B. Erkiliç, F. Erler, I. Karaca, Y. Karsavuran, B. Kaydan, S. Özgökçe, C. Öncüer, D. Senal, C. Sengonca, S. Toros, N. Uygun, S. Ülgentürk, B. Yasar and Z. Yoldas. These colleagues work mainly in biological control and the IPM of scale insects. Z. Düzgünes died in December 1991. **Other Countries** - apparently, there is no ongoing scale research in Jordan, Iraq, Lebanon, Saudi Arabia or Syria.

AFRICA

Besides the activities on cassava mealybug control, it appears that there is not much scale insect research (especially systematics) anywhere besides the following countries: **Egypt** - the following are active researchers: Ain Shams University, Faculty of Agriculture, Department of Plant Protection, Cairo: A.A. Amam, A.H. Amin, M.A. Risk and H.E.A. Sakr. Ministry of Agriculture, Plant Protection Institute, Dokki, Cairo: S. Abd-Rabou, M.M. Abo-Setta, S. Afifi, M.M. Asfour, S.M. El-emary, S.A. El-wan, S.M. Fahyem, M.W. Ghabbour, A.A. Gomaa (Head of Dept.), A. Hanafi, E. Helmy, N. Hussein, Z.K. Mohammad, M.H. Tawfik (1999-Head) and A.S. Youssef. Also A.I. Ezz, although retired, is still active. Unfortunately Samia M.A Nada died in 1997. National Research Center, Dokki, Cairo: R.M. Salah and H.S. Salama. In addition, F.A. Mahmond, M.K. Hamdy and A.G. Hegazi are working on the antimicrobial activities of scale secretions. Alexandria University, Faculty of Agriculture, Department of Plant Protection: M.F. El-Minshawy and S. El-Khair. Unfortunately, Professor Y.M. Ezzat passed away a few years ago. **Ethiopia** - W. Wakgari is currently completing graduate work on coccoids with J.H. Giliomee in South Africa. **Republic of South Africa** - I.M. Millar, Plant Protection Research Institute, Pretoria, and J.H. Giliomee, University of Stellenbosch, are both active in systematic research; Giliomee is due to retire in three years but has a Ph.D. candidate, W. Wakgari from Ethiopia, who is working on the biology and ecology of *Ceroplastes destructor*. Giliomee has already trained H.J.M. Loubser (male Dactylopiidae) and C.A. de Klerk (Margarodidae), and has supervised the Ph.D. studies of J. Schoonees and M.B. Georgala, who both worked on *Aonidiella aurantii*, but both have died. T. Brink worked on the chemical and biological control of scales, and E.C.G. Bedford works on IPM of citrus pests in Nelspruit.

ASIA

China - three coccidologists are no longer working: Professor B.L. Young (also known as Bain-Lay or Yan Ping-Lan) has died, Z.Q. Wang is very ill and I.O. Zhou has retired. Dr. F.T. Tang (Tang Fangde, 1991, 1992; Tang Fangde & Hao, 1995) is due to retire next year, but Dr. San-an Wu is active. I have had no word from T.C. Wang in Beijing, who is apparently working in administration at present. **India** - K. Bohidar works on the morphology of male coccoids; P.R. Kumar and B.K.R. Gopal are still interested in mealybug ecology and control; S.M. Jalaluddin has expressed an interest in the Diaspididae. Most present researchers are working on lac insects, e.g., S.C. Agrawal. R.K. Varshney retired in 1997 from his extensive faunistic studies at the Indian Zoological Survey and has not been replaced. S.M. Ali and S.A. Shafee died and I have no information on R.K. Avasthi. **Japan** - S. Takagi retired two years ago but continues working on the systematics of the Diaspididae and Beesoniidae. K. Mori, the Science University, Tokyo, works on scale pheromones. I have no records on the present activities of S. Kawai and the biochemist Y. Tamaki although the former is probably working in tropical agriculture. **Kazakhstan -** R. Jashenko (= Yashchenko) is working on Margarodidae. G.I. Matesova has died. **Kyrgyzstan -** N. Abdrashitova is working on scale insects of the local walnut forests. **Pakistan** - A. Latif is maintaining an interest in mealybugs and margarodids, while W.A. Gillani has just graduated from Wye College where he studied the biocontrol of mealybugs. **Philippines** - I.L.Lit and his wife, M. Caasi-Lit, are working full-time on scale insects. **Sri Lanka** - Since E.E. Green's extensive work (1886-1938) little has been done here. Kosztarab did some collecting in 1979 but, due to lack of funds, this is still waiting to be processed at the Smithsonian Institution. **Taiwan -** J-S. Hwang has expressed an interest in Kerriidae and mealybugs. Unfortunately, no information is available on the recent activities of C.C.C. Tao and C.Y. Wong.

AUSTRALIA AND NEW ZEALAND

Australia - H.M. Brookes has retired and is able to do only limited work. D.W. Cameron works on the chemistry of pigmentation at the University of Melbourne. Most of the scale insect activities are concentrated in P.J. Gullan's laboratory in Canberra at present. She has already provided graduate training to a number of past or currently active researchers, including S. Bhatti and T.K. Qin. She currently has a Ph.D. candidate, L. Cook, working on Eriococcidae, and a 4th-year honours student, H.E. Trueman, working on the

Margarodidae. She is also the external adviser for I.L. Lit's Ph.D. research on the Kerriidae at the University of Philippines. Besides systematics, her students are also doing molecular studies. J.F. Donaldson, at Brisbane, is due to retire within a few years. T.K. Qin is currently working for the Australian Quarantine and Inspection Service, Canberra. **New Zealand** - Coccidology lost a very able researcher in C.F. Butcher-Morales (Morales, 1991). R.C. Henderson works for Landcare Research, and now curates the New Zealand coccoid collection and is also working with C.J. Hodgson on a revision of the Coccidae of New Zealand; M-C. Lariviere continues to work on Hemiptera systematics. Within the Horticulture and Food Research Institute of New Zealand (HortResearch), R.H. Blank, J.G. Charles, K.J. Froud, A.R. Tomkins, C. Thompson, P. Lo, G.F. McLaren and C.H. Wearing are working on various aspects of the biology, ecology and control of coccid, diaspidid and pseudococcid pests.

CENTRAL AND SOUTH AMERICA

Little active research on scale insect systematics is currently being conducted in this vast continent: **Argentina** - M.C. Granara de Willink (Williams & Granara de Willink, 1992) is actively working in scale insect systematics (Williams & Granara de Willink, 1992; Granara de Willink, 1999) and has a Ph.D. candidate in training. Both L.E. Claps and P. Gonzalez at Tucuman are active on armoured scale biology and systematics. M.E. Haro Barba, also in Tucuman, is interested in dactylopiid biology and systematics. **Chile** - R.H. González worked in scale insect research but I have no news from him on his present activities. R. Munoz has a group of people working with her on scale insect identification. **Mexico** - After the untimely death of Raul McGregor, there is little work on scale insect systematics here, except for a fauna list by D.R. Miller of USA (Miller, 1996). S.N. Myartseva has recently moved to this country.

NORTH AMERICA

Canada - R. Foottit, an aphidologist, is in charge of coccoid work at present. G.P. Gibson is working with D.R. Miller and Y. Ben-Dov on the SCALENET, a systematic information system on scale insects (see Miller *et al*., this volume). **United States** - has the largest concentration of active coccidologists but, unfortunately, without much replacement training. J.W. Beardsley, J.A. Davidson and M. Kosztarab have recently retired but are remaining active with research activities. Other active workers are: **Alabama** -

M.L. Williams has trained a number of students in Coccidae and continues to publish, usually in co-authorship with them; he currently has a Ph.D. candidate, D.T. Kondo, from Colombia, who is working on the immature stages of the Myzolecaniinae. Williams is also interested in the scale insects of Guatemala and Honduras and works with E. Danzig on a joint project on Mexican coccids. **California** - R.J. Gill, as well as working on the whitefly and scale problems and identifications for this large state, has produced three identification manuals (Gill, 1988, 1993, 1997) and has revised some poorly known genera. He is also producing a volume on mealybugs of this state. Others interested in scale insects include: S.I. Frommer, collection curator at Riverside, R. Garrison (Los Angeles Co.), N. Nisson (Orange Co.), and J. Sorensen; the latter is an aphidologist but also works on coccoids when needed. J.B. Steinweden, now in his nineties, is in retirement. Unfortunately, when Richard Wilkey died, we lost the best expert slide maker. **Connecticut** - M.S. McClure has written some excellent papers on the biology, ecology and biocontrol of scale insects but, unfortunately, he has switched to work on the Adelgidae. **Florida** - A.B. Hamon identifies scale insects and whiteflies and is the adviser for this semi-tropical state but is due to retire in four years; he currently has a summer intern from the Florida Agricultural and Mechanical University. F.W. Howard, with a background in scale studies, works at the University of Florida on the control of *Aulacaspis yasumatsui* Takagi on cycads, while maintaining an interest in Halimococcidae. **Georgia** - R.J. Beshear and H.H. Tippins have retired and have not been replaced. J.O. Howell, although involved in administration and teaching, maintains his interest in the false pit scales and in the immature stages of armoured scales; G. Hodges is completing Ph.D. research in his laboratory. H.J. Hendricks has recently moved back to this State and will continue his work on mealybugs; his Ph.D. dissertation on legless mealybugs was printed (1999) in Germany for Das Tierreich. **Hawaii** - When J.W. Beardsley retired to California, Hawaii lost an excellent coccidologist. B. Kumashiro, Hawaii Department of Agriculture, is working on the biological control and systematics of scales. **Louisiana** - F.W. Howard worked on the armoured scales in this State, but moved to Florida a few years ago. **Maryland** - Has the largest concentration of coccidologists. W.F. Gimpel, although in an administrative position, still does some scale insect research, as does J.A. Davidson, who has retired. R.F. Denno and L.M. Hanks have studied the biology, ecology and adaptation of coccoids; Hanks is now located in a midwest State. Because the U.S. Department of Agriculture Systematic Entomology Laboratory is located in Beltsville, Maryland, D.R. Miller (Miller & Miller, 1993) and G.L. Miller and

M.B. Stoetzel (both received M.Sc. and Ph.D. degrees for scale insect studies and both now in aphid research but latter also in administration). D. Odermatt is doing scale identifications for the U.S. Quarantine. L.M. Russell, who retired a long time ago and is now in her nineties, kept up with the pit scales and aphids until recently. D.R. Miller, Y. Ben-Dov (Israel), M. Gimpel (USDA), and K. Veilleux (Virginia Tech) are compiling "SCALENET" using the database system BASIS, developed by G. Gibson and J. Read, Agriculture Canada. **Massachusetts** - X. Hu expressed an interest in evolution and systematics of coccoids. **New York** - After a productive career in scale insect genetics, U. Nur has retired without leaving a successor. Emily Morrison, in her nineties, is probably still in retirement in this State. **North Carolina** - L.L. Deitz maintains his interest in diaspidid and halimococcid systematics, although he works now on the Membracidae. **Pennsylvania** - J.F. Stimmel is in charge of coccoid work and identifications and provides reports on some of the pest species. **Tennessee** - P.L. Lambdin leads an active research group, including two graduate students in systematics: C. Stumpf working on neotropical asterolecaniids and John Nelson working on the ecology of scale insects; Lambdin's laboratory has attracted a number of foreign researchers in the past. Current work includes studies on an oak eriococcids and the wings of male scales. **Texas** - Only T.X. Liu is currently active but in his own time, as his assignment is on vegetable IPM. Both E. McDonald and A.I. Mercado are active in preventing new scale introductions at the Houston Intercontinental Airport. **Virginia** - P.B. Schultz, now an administrator, still does some work on the biology and control of scale insects on ornamentals. Karen Veilleux continues the cataloguing and indexing of the world scale literature. M. Kosztarab (Kosztarab, 1996; Kosztarab & Kozár, 1988) retired six years ago, after training 12 students in the field of coccidology (five still active) and has continued to work part-time on scale insects. Unfortunately, no systematist or "biodiversity specialist" has been employed as a replacement at Virginia Polytechnic Institute and State University.

STATISTICAL CONCLUSIONS FROM SURVEY

Of the 39 respondents, 32 were employed and seven retired; five worked for their federal government, nine for a state government, 16 for a public college or university and one for a private university. There were no private company employees or graduate students among the respondents. Some colleagues kindly provided the names and activities of additional scale insect researchers, including graduate students and retired colleagues.

Among the 39 respondents, 35 were doing some work on systematics as part of their professional workload; those who retired spent an average of 36% of their time on systematics. Ten respondents included work on morphology (average: 15% of their time); 21 on biology (average: 14% of their time); 15 on ecology (average: 9.6% of their time); nine in database preparation (average: 16% of their time); 13 on biological control (average: 21.5% of their time); and four on chemical control (average: 5.5% of their time). In addition, one person stated some work on phylogenetics, one on zoogeography (9%); one on biogeography (10%); one on faunistics (20%); one on palaeontology (10%); one on administration (70%); one on integrated pest management (11%); one on extension (5%) and on collection and curating (5%).

Twenty-two people obtained assistance through 17 graduate students (average: 36.7% (10-50%) of their time); 16 had technicians, using 56% (range 10-100%) of their time; three had stenographers, using 32% (5-50%) of their time; two had illustrators, using 5.5% (1-11%) of their time; one had a cataloguer, using 100% of his/her time; and two had computer programmers, using 5% (0.1-10%) of their time.

Many colleagues expressed dissatisfaction with the support provided for their work from their institute/office. For example, 19 received what they considered insufficient funds, 11 lacked satisfactory research space, 13 were not allowed enough time for scale research, and four were provided with unsatisfactory facilities.

Unfortunately, a number of active researchers working at universities were unable to train graduate students due to lack of funds or time, or both.

Of the 32 active researchers who responded, the average time to retirement was 11.7 (1-33) years, with 13 of them reaching retirement age within five years. Currently, 17 graduate students (including six in systematics) are in training in scale research as possible replacements for 12 retirees during the next five years. It is encouraging that 13 researchers have expressed a willingness to continue working on scale insects even if no financial support is provided after their retirement. Many other colleagues also planned to continue their research on scale insects after retirement, pending support in funding and/or space.

After the untimely retirements in Eastern and Central Europe, there are now only 23 women active in coccidology, including three in graduate training at present. Three women were trained at Virginia Tech. but, after their excellent thesis/dissertation work, none continued their scale insect studies.

It is a very unfortunate trend in a number of institutions and countries that positions vacated through retirements of 13 coccidologists were not filled with coccidologists; often not even with systematists. Apparently, this has been the case with the retirements of J.W. Beardsley, H.M. Brookes, M. Canard, J.M. Cox, J.A. Davidson, F. Lellakova-Duskova, L.R. MacGregor, B. McDaniel, G. Ördögh, A. Savescu, S. Takagi, H.H. Tippins and M. Kosztarab. It is assumed here that this is also true for the four retired colleagues from Poland and the four from the former Soviet Union.

At the same time, at least 12 colleagues who completed graduate work in scale insect research are underemployed or are working in fields other than coccidology; for example, S. Bhatti, R.G. Baer, L.L. Deitz, H.J. Hendricks, R.G. Knipscher, T-X. Liu, G.L. Miller, B.J. Muse, D. Pollet, C.H. Ray and M.B. Stoetzel.

IDEAS AND SUGGESTIONS RECEIVED THROUGH THE SURVEY

Comments received from colleagues follow in alphabetic order:

How to obtain funds for research and for graduate or postdoctoral stipends?

Davidson, J.A.: I do not see any institution hiring a coccidologist per se to just do this work, except a museum. The strategy should be to place people in applied positions (i.e., jobs such as on aspects of ornamentals), where they can work part time on scales. **Erkiliç, L.B.:** we have to include a biological control and integrated pest management approach in our projects to get reasonable funding, because basic research such as taxonomy should be considered together with applied sciences. **Gullan, P.:** although I could apply for funds for Ph.D. or postdoctoral positions from Australian Government Funding agencies, I do not have time to supervise additional people at present, and could not be guaranteed of finding suitable candidates for such positions. However, I currently do supervise three students in scale insect systematics. **Hamon, A.B.:** concentrate on the most economically important species. **Hodgson, C.J.:** concentrate on biocontrol of coccoids of important crops. Perhaps we should be dealing with taxonomy of important groups in geographical areas that are not currently well known? **Kosztarab, M.:** request funds from government funding agencies for stipends for research that includes an integrated approach, combining biology, ecology, morphology, and systematics of scale insect genera or families, and gather information on their potential biological control agents. We should publicize that institutions

could capitalize on the accumulated library, database, and facilities to save funds, by hiring replacements for retiring coccidologists, who could work in the same general area of research. **Lambdin, P.L.:** look to the agencies that are interested in biodiversity and community structure, such as NSF, Nature Conservancy, USDA conservation and biology. **Lit, I.L.:** biodiversity-documentation? UNDP? UNESCO? **Miller, D.R.:** train as many students as possible. Some may find jobs that allow them to study scales. **Panis, A.:** we could mass produce coccidiphagous insects for companies that sell beneficial insects. Seek European Economic Community Funding for multidisciplinary research programs. Bring together researchers from various European countries with companies, in the field of genetics and population biology of scales and their entomophages. **Porcelli, F.:** try for E.C. (European Community) funding. **Takagi, S.:** I do not think that emphasizing economic importance alone is sufficient to evoke an interest in scale insects, especially in systematics. In the field of systematics, classification in higher categories suffers the most from lack of theories. By 'theories', I do not mean cladistic logic and algorithms now in fashion, but biological theories applicable to and testable by observations. To be a really attractive field of biology, systematics has to be able to produce theories from its own field, which are testable in other fields of biology. This may require inter-disciplinary research rather than museum or single-laboratory work. Scale insects can be an attractive group of organisms from the viewpoint of such research. In my experience, for example, manifestations of remote ancestral phenotypic patterns are frequent in this insect group. I believe that this phenomenon is not only useful for elucidating relationships among higher taxa but also worthy of multi-disciplinary study from the viewpoint of phenotypic manifestation in the evolution of higher taxa. In my view, evolution is not merely an accumulation of DNA changes. **Williams, M.L.:** combine scale training with another area, such as urban entomology.

HOW TO IMPROVE CHANCES FOR TRAINING FUTURE COCCIDOLOGISTS?

Erkiliç, L.B.: the importance of training in special subjects should be explained by use of public communication systems such as TV, newspapers, magazines and especially to influence politicians. Maybe this is not a subject for developed countries but in countries like Turkey, we need explanation. **Gullan, P.:** coccidology training courses, especially in developing countries. **Hamon, A.B.:** if I and other current coccidologists did not do identifications for free, perhaps more organizations would support a practising coccidologist. **Kosztarab, M.:** let's get our graduate students involved in

selecting the topic for his/her research. If a foreign student, the selected project should also benefit his/her country. Resurrect summer short courses in coccidology, such as those that were so successful at the University of Maryland, and expand these to each continent where the need and interest is present. Request funding from sources such as government, NSF and FAO. **Koteja, J.:** either transform coccidology into a "modern" and profitable discipline (for the student) or, create people with real scientific interest. **Kozár, F.:** increase the interest of students in systematics and taxonomy through University courses. **Lambdin, P.L.:** the proposed federal policy statement regarding the need to catalogue the fauna and flora of the U.S. will require taxonomists to identify tens of thousands of species. **Lit, I.L.:** promotion of coccidology should be part of promoting systematics of insects as well as biodiversity conservation, especially because the latter is the "in" thing nowadays in terms of funding and student interest. **Panis, A.:** training by coccidologists who work in molecular biology or genetics and biomathematics. **Stimmel, J.:** private industry and high-level U.S. Government (i.e., SEL) lobbying with State legislature and executive branches, particularly the Secretary of Agriculture. But they might not be receptive!

How to increase public awareness of our research and its value with examples from our area?

Beardsley, J.W.: several serious new mealybug pests have appeared in Hawaii during the past 10 years; i.e., *Maconellicoccus hirsutus, Phenacoccus parvus, P. solenopsis* for which I provided initial identifications. **Erkiliç, L.B.:** we have new mealybug species on citrus near to the Syrian border in Hatay, which was not known previously from this host. **Gullan, P.:** Australia exports citrus to New Zealand and other countries, and shipments can be rejected if they contain mealybugs or other scales not known in those countries. My identifications of "suspect" species, therefore, can save the Australian industry large sums of money, especially if the importing country incorrectly rejects fruits, because their authorities have misidentified introduced insects (the latter has happened at least once in the past few years). **Hamon, A.B.:** cycads in Dade County, Florida have been severely damaged by *Aulacaspis yasumatsui* Takagi. This is an introduction (via commerce) from Asia. Little is known about the scale and it arrived without natural enemies. It will take several years of effort to conduct biological controls. It will also result in the loss of millions of dollars worth of plants (Cycads). **Kosztarab, M.:** there is a need to write more popular articles on scale insects, pointing out their

economic importance, and unique facts about them. Collect and publish records on the cost of scale prevention and control, on each major crop, and the value of losses due to their infestation. We have to become better sales people in promoting public and government awareness about the menace of new pest scale introductions, and the need for experts that provide timely species identifications. **Kozár, F.:** publicize the rapid spread of important scale pests in Europe such as *Ceroplastes japonica, Pseudaulacaspis pentagona, Pulvinaria regalis*, etc., without efficient biological control agents. **Lambdin, P.L.:** because of the explosion in international and inter-regional trade that is now occurring throughout the world, plants, building and food products often harbour exotic species that threaten the native species of the new region. With the advent of Internet purchasing of plant materials (trees, shrubs, garden plants) from nurseries from around the U.S., identification and control of plant pests will only increase in this global economy. It is imperative that the basic research be completed on the species before successful attempts at suppressing or controlling the species can be implemented. **Lit, I.L.:** in 1988-1989, I was asked to examine oranges imported from New South Wales that were supposed to have passed our plant quarantine office. I found them infested with live armoured scales (Florida red scale, etc.) on the outside as well as mealybugs (*Pseudococcus calceolariae* Maskell) on the navel. The oranges were already out in the market. **Panis, A.:** public awareness increased when I enhanced biological control of Olive black scale, of armoured scales and mealybugs on ornamentals under glasshouse. **Russo, A.:** introduction of several injurious species into Italy, e.g., *Aonidiella citrina, Unaspis yanonensis, Pseudaulacaspis cockerelli, Ceroplastes japonicus*, etc. **Schmutterer, H.J.:** two important pests have been introduced into Germany in recent years, namely: *Pulvinaria regalis* and *Unaspis euonymi*. (He will publish a paper on the latter species in 1998). **Williams, D.J.:** I do think there is a dearth of posts. It is posts that are lost, not a lack of budding coccidologists willing to fill them. There seems to be a growing emphasis on molecular taxonomy, medical entomology and anything that brings in money. Funds are available for taxonomic research on scale insects as I found out when I did the Pacific and South American works. Research must be on a fairly grand scale and on subjects that are topical and of interest for the big funding agencies. I am working on the mealybugs of southern Asia without funds, merely for something worthwhile to do. If I were to ask for funds I would be under immediate pressure, which I do not want. **Williams, M.L.:** scale insects are one of the top pest groups in the ornamental and landscape plant industry.

CONCLUSIONS

Ferris in 1957 estimated that only about 20% of the world scale insect fauna had been described. More recent estimates (Kosztarab *et al.*, 1990) put the figures at one-third to one-half of the species in the more intensively studied North American fauna as still undescribed, and about three-fourths of the species in the tropics as still undescribed (Kosztarab *et al.*, 1990). When considering the males and immature stages of all species, probably more than 90% are still undescribed.

In addition to the missing morphological descriptions, we are still lacking a substantial amount of information on the biology and ecology of the species that are already named. Now that there are so few of us left, with so little time, I would like to suggest that each of us help with a strategy to narrow this gap in scale knowledge.

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REFERENCES

Mainly family catalogues, monographs and identification manuals published between 1988 and 1997.

BEN-DOV, Y., 1993 - A Systematic Catalogue of the Soft Scale Insects of the World (Homoptera: Coccoidea: Coccidae) with Data on Geographical Distribution, Host Plants, Biology and Economic Importance. Flora & Fauna Handbook, No.9. Sandhill Crane Press, Gainesville, Florida. 536pp.

BEN-DOV, Y., 1994 - A Systematic Catalogue of the Mealybugs of the World (Insecta: Homoptera: Coccoidea: Pseudococcidae and Putoidae) with Data on Geographical Distribution, Host Plants, Biology and Economic Importance. Intercept Limited, Andover, UK. 686pp.

BEN-DOV, Y., HODGSON, C.J. (Eds.), 1997a - Soft Scale Insects – Their Biology, Natural Enemies and Control. Series: World Crop Pests, 7A. Elsevier, Amsterdam & New York. 452pp.

BEN-DOV, Y., HODGSON, C.J. (Eds.), 1997b - Soft Scale Insects – Their Biology, Natural Enemies and Control. Series: World Crop Pests, 7B. Elsevier, Amsterdam & New York. 442pp.

DANZIG, E.M., 1993 - Scale Insects: Family Phoenicoccidae and Diaspididae. Nauka Publishing House, St. Petersburg. Fauna of Russia and Neighbouring Countries: Rhynchota, 10. New Series, No. 144. 452pp. (In Russian).

FERRIS, G.F., 1957 - A Brief History of the Study of the Coccoidea. *Microentomology*, 22: 39-57.

GILL, R.J., 1988 - The Scale Insects of California: Part 1. The Soft Scales of California. California Department of Food & Agriculture, Sacramento, CA. Technical Series in Agricultural Biosystematics & Plant Pathology, No. 1. 132pp.

GILL, R.J., 1993 - The Scale Insects of California: Part 2. The Minor Families (Homoptera: Coccoidea): Margarodidae, Ortheziidae, Kerridae, Asterolecaniidae, Lecanodiaspididae, Cerococcidae, Aclerdidae, Kermesidae, Dactylopiidae, Eriococcidae, and Phoenicoccidae. California Department of Food & Agriculture, Sacramento, CA. Technical Series in Agricultural Biosystematics & Plant Pathology, No. 2. 241pp.

GILL, R.J., 1997 - The Scale Insects of California: Part 3. The Armoured Scales (Homoptera: Diaspididae). California Department of Food & Agriculture, Sacramento, CA. Technical Series in Agricultural Biosystematics and Plant Pathology No. 3. 307pp.

GRANARA DE WILLINK, M.C., 1999 - Las cochinillas blandas de la República Argentina (Homoptera: Coccoidea: Coccidae). *Contributions on Entomology, International*, 3(1): 1-183.

HODGSON, C.J., 1994 - The Scale Insect Family Coccidae: an Identification Manual to Genera. CAB International, Wallingford, Oxon, UK. 639pp.

KOSZTARAB, M., 1996 - Scale Insects of Northeastern North America. Identification, Biology, and Distribution. Virginia Museum of Natural History, Martinsville, Virginia. Special Publication No. 3. 650pp.

KOSZTARAB, M., O'BRIEN, L.B., STOETZEL, M.B., DIETZ, L.L., FREYTAG, P.H., 1990 - Problems and needs in the study of Homoptera in North America, pp 119-145 *in* Kosztarab, M., Schaefer, C.W. (eds): Systematics of the North American Insects and Arachnids: Status and Needs. Virginia Agricultural Experiment Station Information Series 90-1. Virginia Polytechnic Institute and State University, Blacksburg, Virginia. 247pp.

KOSZTARAB, M., KOZÁR, F. 1988 - Scale Insects of Central Europe. Academy Publishing Co., Budapest and Junk Publishing Co., Amsterdam. 456pp.

MILLER, D.R., 1996 - Checklist of the scale insects (Coccidae: Homoptera) of Mexico. *Proceedings of the Entomological Society of Washington*, 98: 68-86.

MILLER, D.R., MILLER, G.L., 1993 - Eriococcidae of the Eastern United States (Homoptera). Contributions of the American Entomological Institute, Gainesville, Florida, 27. 91pp.

MORALES, C.F., (Butcher), 1991 - Margarodidae (Insecta: Hemiptera). Fauna of New Zealand, No. 21. DSIR Plant Protection, Auckland, New Zealand. 123pp.

PEREZ-GUERRA, G., KOSZTARAB, M., 1992 - Biosystematics of the family Dactylopiidae (Homoptera: Coccinea) with emphasis on the life cycle of *Dactylopius coccus* Costa. Virginia Agricultural Experiment Station, Blacksburg, Virginia. Bulletin 92-1. 87pp.

ROSEN, D. (Ed.), 1990a - Armoured Scale Insects, Their Biology, Natural Enemies and Control. Elsevier, Amsterdam. World Crop Pests Series, Vol. 4A. 384pp.

ROSEN, D. (Ed.), 1990b - Armoured Scale Insects, Their Biology, Natural Enemies and Control. Elsevier, Amsterdam. World Crop Pests Series, Vol. 4B. 688pp.

TANG, FANGDE, 1991 - The Coccidae of China. Shanxi United Universities Press, Taiyuan, China. 377pp + 84 plates. (In Chinese; abstract and keys in English).

TANG, FANGDE, 1992 - The Pseudococcidae of China (Homoptera: Coccinea of Insecta). Chinese Agricultural Science Technology Press, Beijing. 768pp. (In Chinese; abstract and keys in English).

TANG, FANGDE, HAO, J.J., 1995 - The Margarodidae and Others of China (Homoptera: Coccinea of Insecta). Chinese Agricultural Science Technology Press, Beijing. 740pp. (In Chinese; with detailed summary and keys in English).

WILLIAMS, D.J., GRANARA DE WILLINK, M.C., 1992 - Mealybugs of Central and South America. CAB International, Wallingford, UK. 635pp.

WILLIAMS, D.J., WATSON, G.W., 1988a - The Scale Insects of the Tropical South Pacific Region. Part 1. The Armoured Scale (Diaspididae). CAB International, Wallingford, Oxon, UK. 290pp.

WILLIAMS, D.J., WATSON, G.W., 1988b - The Scale Insects of the Tropical South Pacific Region. Part 2. The Mealybugs (Pseudococcidae). CAB International, Wallingford, Oxon, UK. 260pp.

WILLIAMS, D.J., WATSON, G.W., 1990 - The Scale Insects of the Tropical South Pacific Region. Part 3. The Soft Scales (Coccidae) and Other Families. CAB International Institute of Entomology, London, UK. 267pp.