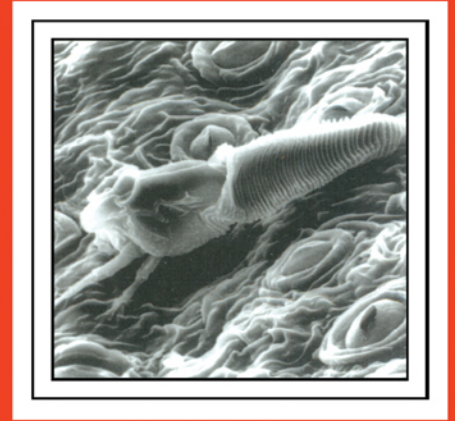
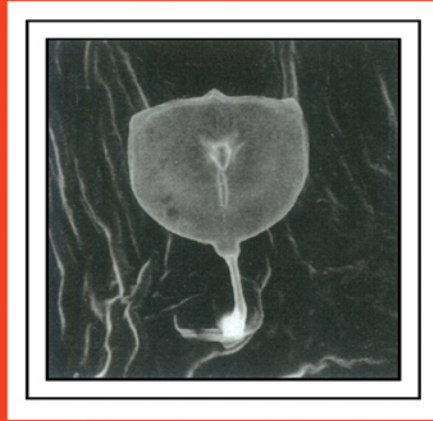
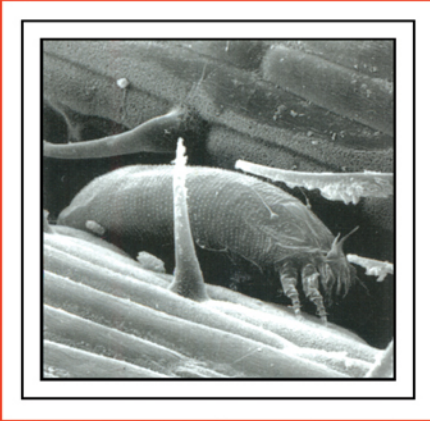


# World Crop Pests

Editor-in-Chief W.Helle



# Eriophyoid Mites

Their Biology, Natural Enemies and Control

Volume 6

Edited by

E.E. Lindquist, M.W. Sabelis and J. Bruin

Elsevier

World Crop Pests, 6

**ERIOPHYOID MITES  
THEIR BIOLOGY,  
NATURAL ENEMIES  
AND CONTROL**

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### **Editor-in-Chief**

**W. Helle**

University of Amsterdam  
Institute of Systematics and Population Biology  
Section Population Biology  
Kruislaan 320  
1098 SM Amsterdam, The Netherlands

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Edited by E.E. Lindquist, M.W. Sabelis and J. Bruin  
ISBN 0-444-88628-1

World Crop Pests, 6

# **ERIOPHYOID MITES THEIR BIOLOGY, NATURAL ENEMIES AND CONTROL**

Edited by

E.E. LINDQUIST

*Eastern Cereal & Oilseed Research Centre  
Agriculture Canada  
K.W. Neatby Building- C.E.F.  
Ottawa, ON, K1A 0C6 Canada*

M.W. SABELIS

J. BRUIN

*University of Amsterdam  
Institute of Systematics and Population Biology  
Section Population Biology  
Kruislaan 320  
1098 SM Amsterdam, The Netherlands*



1996

ELSEVIER

Amsterdam – Lausanne – New York – Oxford – Shannon – Tokyo

ELSEVIER SCIENCE B.V.  
Sara Burgerhartstraat 25  
P.O. Box 211, 1000 AE Amsterdam, The Netherlands

ISBN: 0-444-88628-1

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This book is printed on acid-free paper.

Printed in The Netherlands

## Preface



Among the Acari eriophyoid mites – the Eriophyoidea or Tetrapodili – are second only to the spider mites (Tetranychidae) in their economic importance as plant pests throughout the world. They surpass all other groups of phytophagous mites in the extent of their morphological and biological specialization for obligate phytophagy. Moreover, they surpass these other groups in the degree to which they are specialized on their host plants, making them superior in their potential as weed control agents.

Despite the reductive structural simplicity evident among even the most primitive extant members of the Eriophyoidea, the more derived subgroups have augmented their body plan secondarily in a variety of ways, either for living in closely confined spaces like sheaths, buds, erineae and galls or, moreso, for living, freely exposed, on plant surfaces. Behavioral and life cycle modifications correlated with these structural changes reflect the adaptation and evolution of this lineage into a disparity of highly host-specific forms that, to date, have bewildered any meaningful classification of them.

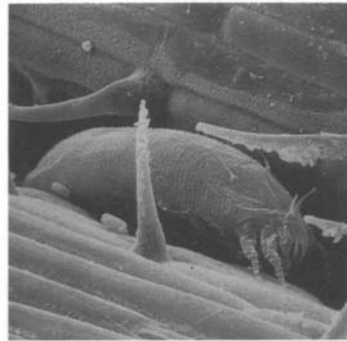
At the time of the last compilation of world knowledge about eriophyoid mites in the book *Mites Injurious to Economic Plants* by Jeppson, Keifer and Baker (1975), some 1800 species in 115 genera were known. During only the 20 years since then, approximately 1000 more species and nearly 115 more genera have been described, giving testimony to how poorly known and taxon-rich this group is. Yet, major regions of the world remain virtually untouched in surveying for these mites, such that Amrine and Stasny (1994), in their new comprehensive *Catalog of the Eriophyoidea of the World*, estimated that not more than 5 percent of the world species of Eriophyoidea have been described!

Just as the number of described taxa of Eriophyoidea has doubled during the last two decades, so has our knowledge of the biology, ecology and importance of these mites expanded. At the same time, the actual and potential economic importance of eriophyoids continues to grow worldwide, and their success in colonizing new regions makes them an ongoing quarantine threat in many parts of the world (a new case in point, as this is written, is the note in *Florida Entomologist* by Peña and Denmark (1996) on the recently confirmed presence in Florida of *Tegolophus perseae* Keifer, a neotropical pest of avocado).

Thus, this book is timely in compiling and synthesizing information that is now available on these behaviorally fascinating, economically important mites. We realize that such a book, containing updated knowledge on nearly 3000 species, will perforce be incomplete and overly generalized in some areas. However, we have asked the best specialists available concerned with the biology, ecology and control of eriophyoid mites, as well as some generalists in

acarology, to join us in contributing to the compilation of this book. The book gives much attention to fundamental aspects of eriophyoid anatomy, behavior, ecology and even systematics, as bases for understanding the ways of life of these mites and their effects on host plants; in turn, this will lead to developing the most appropriate means of regulating these mites as detrimental or beneficial organisms.

Previous general accounts of eriophyoid mites have been primarily from the perspectives of single authors – notably Nalepa during the first third, and Keifer during the middle third, of this century – followed by more regional perspectives from subsequent specialists as, for example, Boczek in Poland, Shevchenko in Russia, Mohanasundaram in India, Manson in New Zealand, and Smith Meyer in South Africa. The present book is unique in being not only the first compilation of knowledge on Eriophyoidea by a multiplicity of authors (47, including some of those just named), but also in the international aspect of its contributors (from 14 countries) and in many of them being hands-on specialists in the biology, behavior and economic importance of these mites. The book is also unique in its perspective of treating eriophyoid mites as a lineage – no matter how specialized – of acariform mites, such that standard terms and notation for structures common to other such mites are applied to them as well.



The disparity of interests and also linguistic backgrounds among authors has led to quite different, often refreshing, approaches to the subject of their chapters, such that uniformity in content and presentation has not been possible or even encouraged by the editors. Considerable latitude has also been given to authors on the subject matter presented in sections that are of a parallel nature, *e.g.*, eriophyoid pests of citrus, of apple and pear, *etc.* With an eye to the future, however, we have strongly encouraged authors to consider the needs of further research in the conclusions of each of their sections. Such a multi-authored book will have some unavoidable overlap of content, and even some discord, in various sections. On balance, we view this as advantageous in cross-referring and stimulating readers to other sections of the book.

Our book is generally organized in four parts. Part I deals with aspects of eriophyoid mites themselves, including: external anatomy, systematics (including the first illustrated key limited to genera with species of economic importance), and nomenclatural problems (Chapter 1.1); internal anatomy and physiology (Chapter 1.2); morphogenesis and cytogenetics (Chapter 1.3); biology, ecology and general accounts of eriophyoids associated with primitive vascular plants (Chapter 1.4); evolution and phylogeny (Chapter 1.5); and field and laboratory techniques for their scientific study (Chapter 1.6).

Part II treats the natural enemies of eriophyoid mites, including: predatory phytoseiid mites, potentially the most effective biological control agents of phytophagous mites (Chapter 2.1); predatory stigmaeid mites, long in need of

greater scrutiny as auxiliary biological control agents (Chapter 2.2); and other predatory arthropods (Chapter 2.3) and pathogens (Chapter 2.4).

Part III begins with an account of the nature of damage by eriophyoids and its assessment (Chapter 3.1), followed by a series of 14 sections that treat eriophyoid pest problems and their control in major world agro-ecosystems (Chapter 3.2). This part continues with presentations on host plant resistance (Chapter 3.3), pesticide resistance in eriophyoids and their associates (Chapter 3.4), and an extensive review of chemical control (Chapter 3.5).

Part IV deals with eriophyoid mites as beneficial organisms, and includes accounts of various species in the biological control of weeds (Chapter 4.1). The effects and potential impact of the presence of eriophyoid mites as competitors of other phytophagous mites and as alternative prey for the natural enemies of other phytophagous mites are also considered (Chapter 4.2).

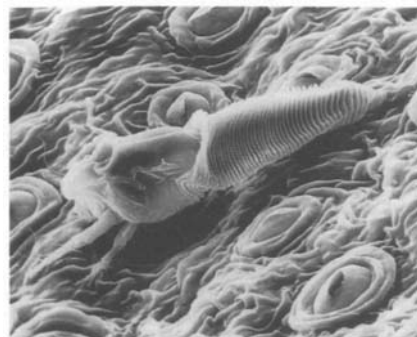
We are grateful to the contributing authors, not only for their individualistic experience and knowledge as put forward in their presentations, but also for valuable input by some of them as reviewers for various sections. Permission to reuse Fig. 1.1.2.50 was given by DSIR Plant Protection, Auckland, New Zealand; figures used with permission from other sources are acknowledged in appropriate captions. Special thanks go to Barry Flahey (Agriculture & Agri-Food Canada, Ottawa) for timely artistic support in Chapters 1.1.1 and 1.5.1, to Alice Boerrigter and Hans Bolland for their enormous support in creating a reference collection of literature on eriophyoid mites, to Simon van Mechelen for producing hundreds of glossy prints, and to Lia Out who was instrumental in constructing the indices and in giving the book its final touch.

We hope that this book meets the needs for an up-to-date compilation of the basic and applied knowledge on eriophyoid mites and their control that is otherwise scattered in a variety of languages and literature throughout the world. In doing so, it also presents new views intended to stimulate interest in eriophyoids and their enemies, and it points to areas where further research is needed. The contents are intended for students, teachers, researchers, extension workers and other clients in the areas of acarology and plant protection. They are also intended for readers having broader interests in ecology and evolutionary biology who may find eriophyoids to be rewarding experimental animals for formulating and testing biological concepts that may provide new insights about general biological phenomena. We further hope that the book stimulates readers to critically test the views presented and aimed ultimately toward environmentally safe, sustainable and economically efficient means of regulating detrimental and beneficial eriophyoid mites.

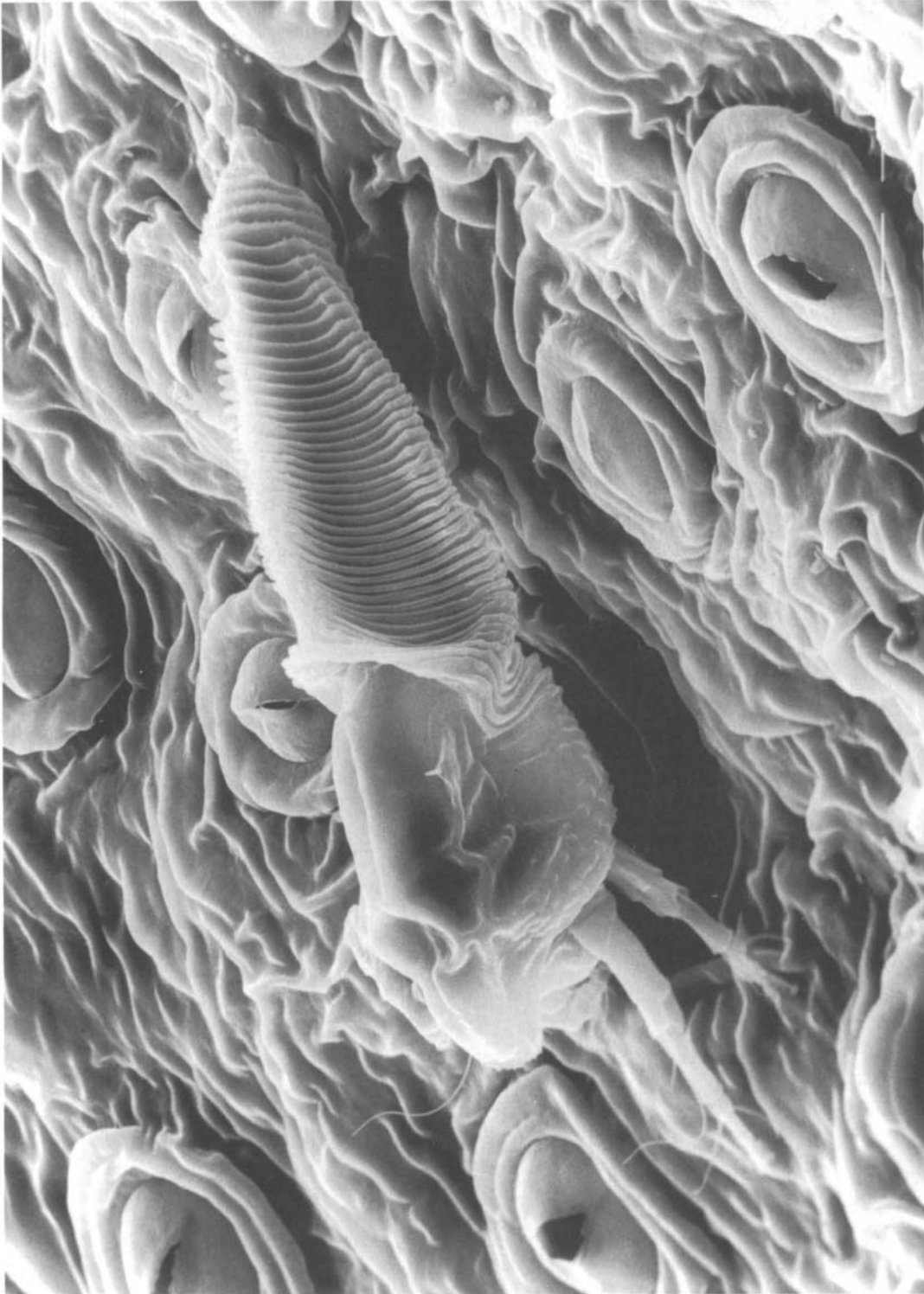
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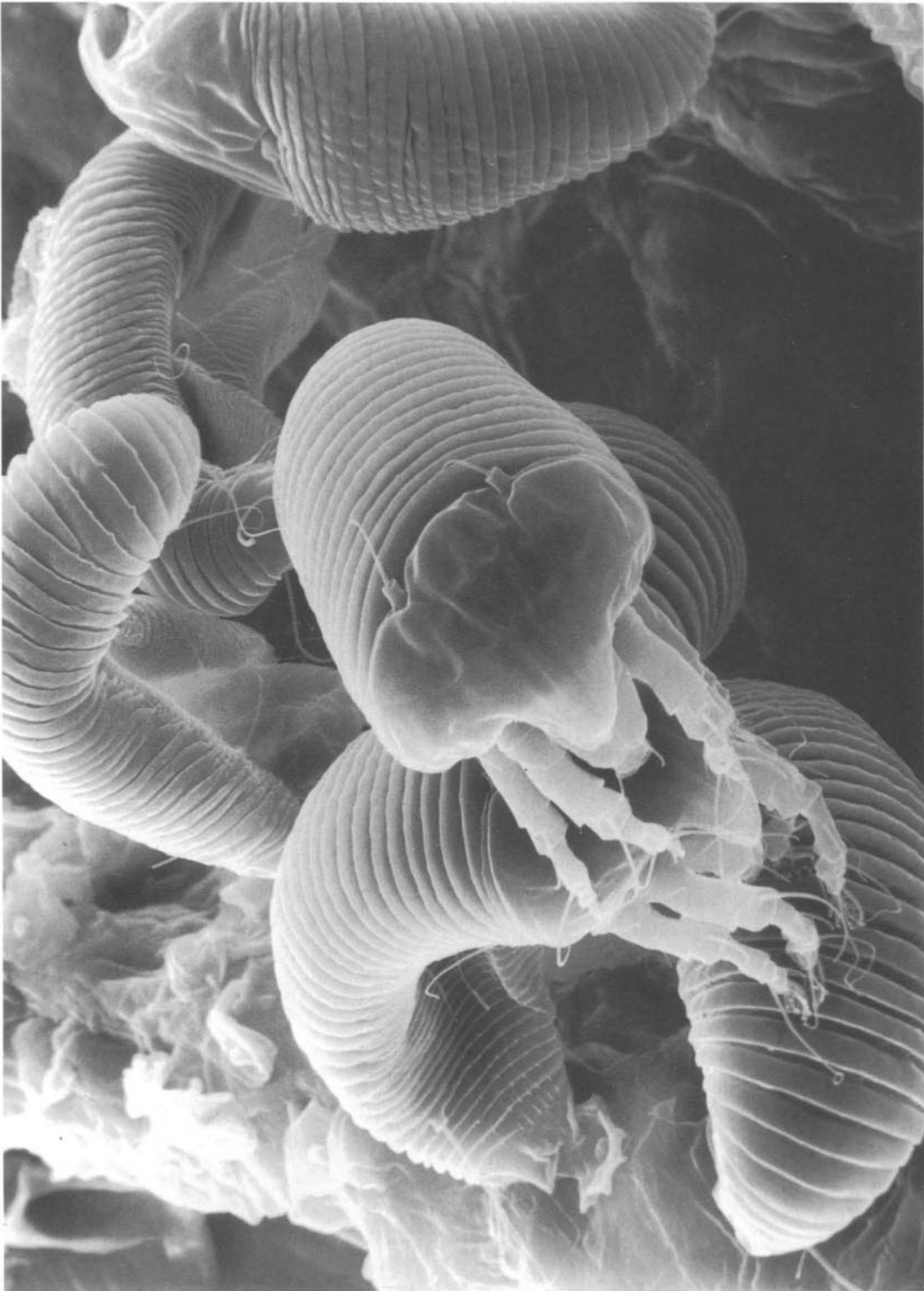
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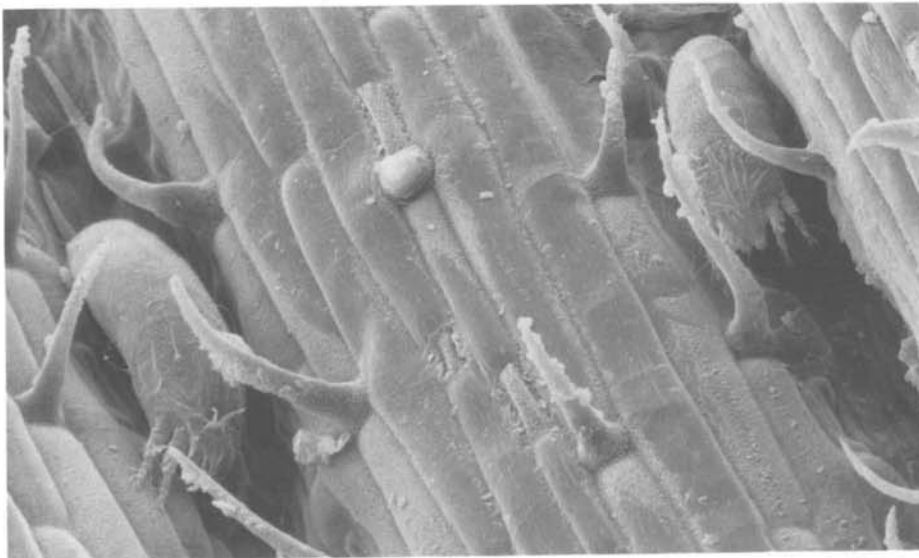
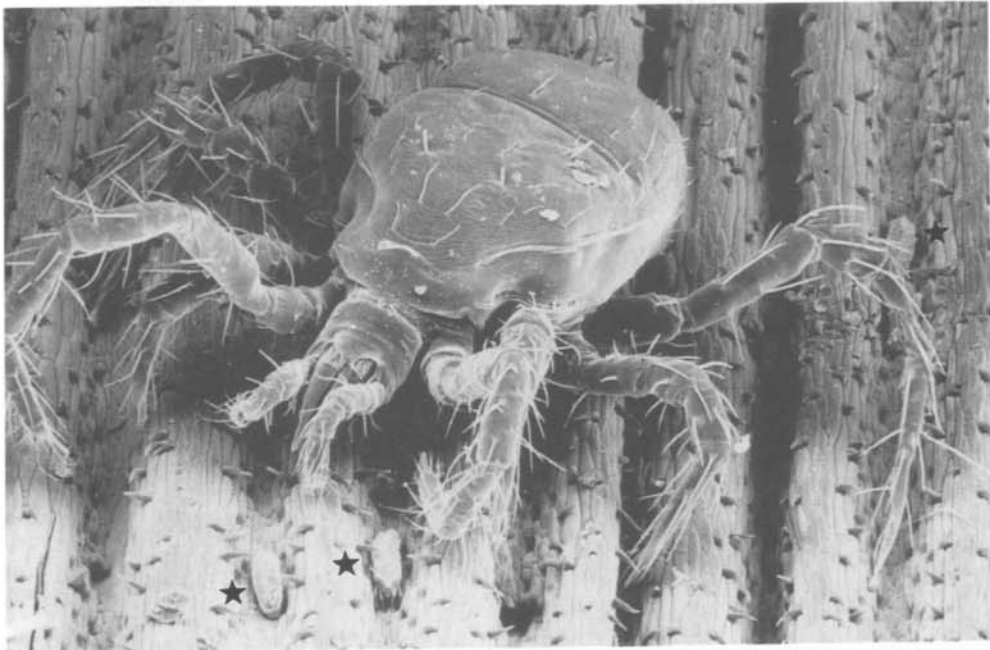
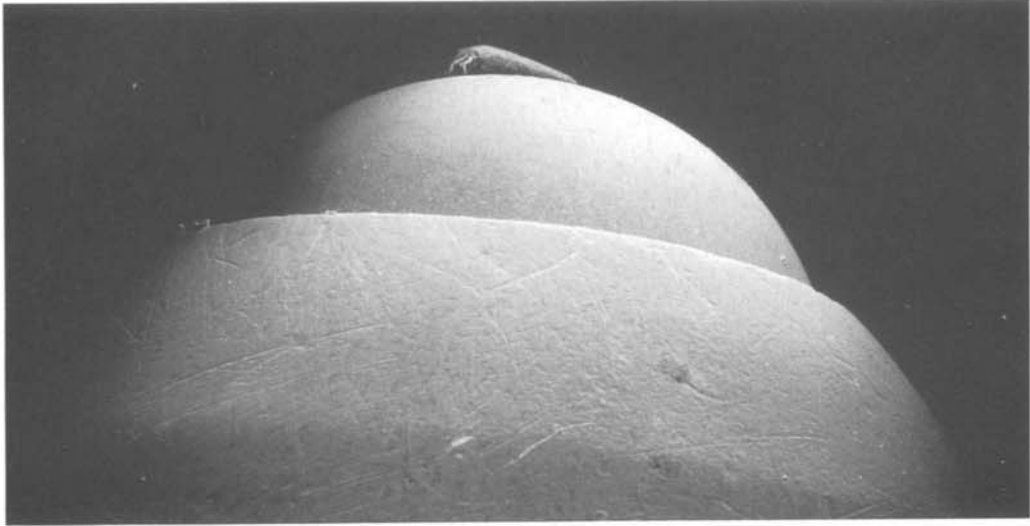


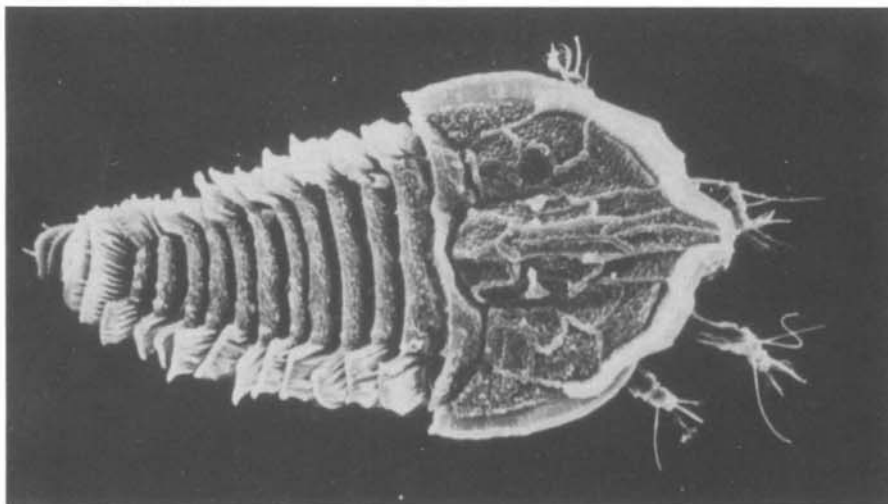
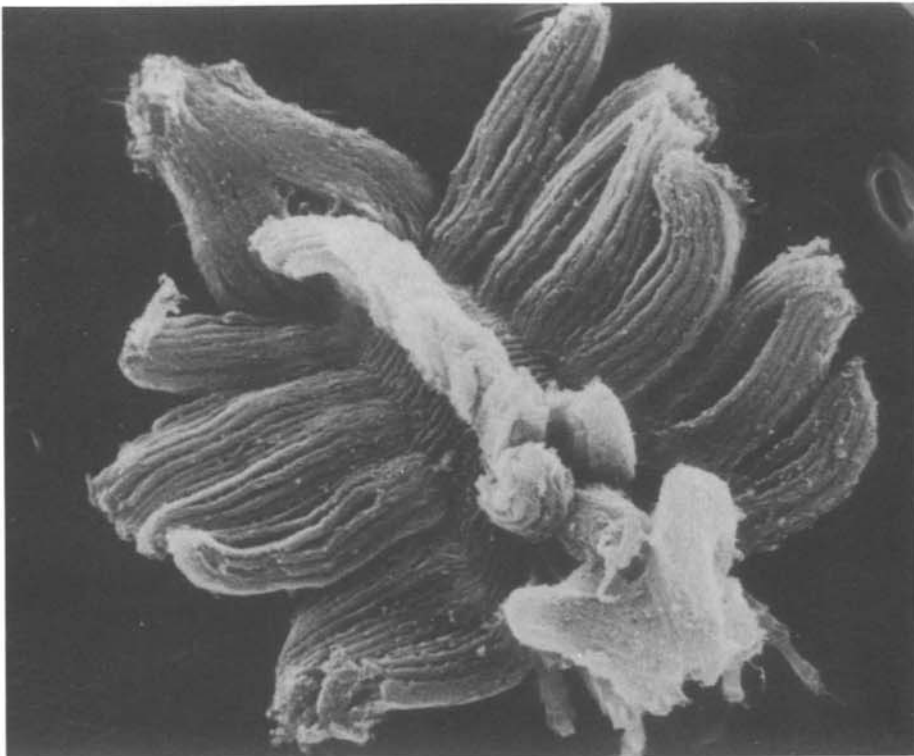
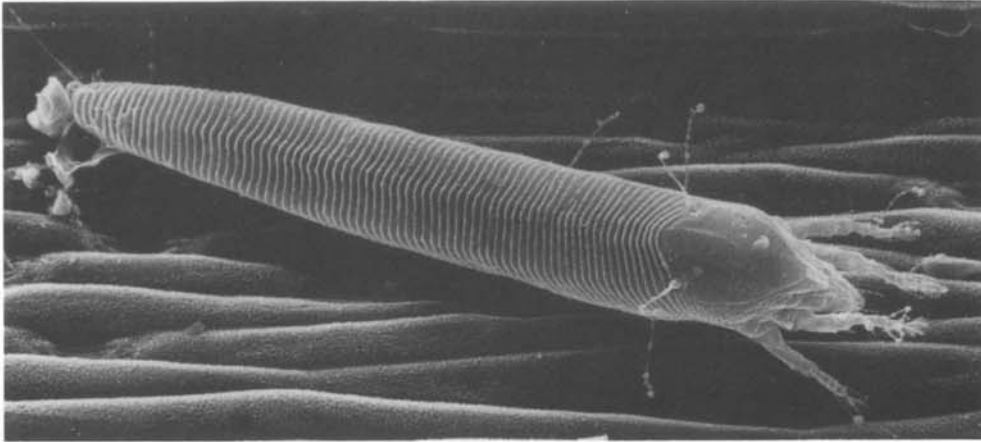


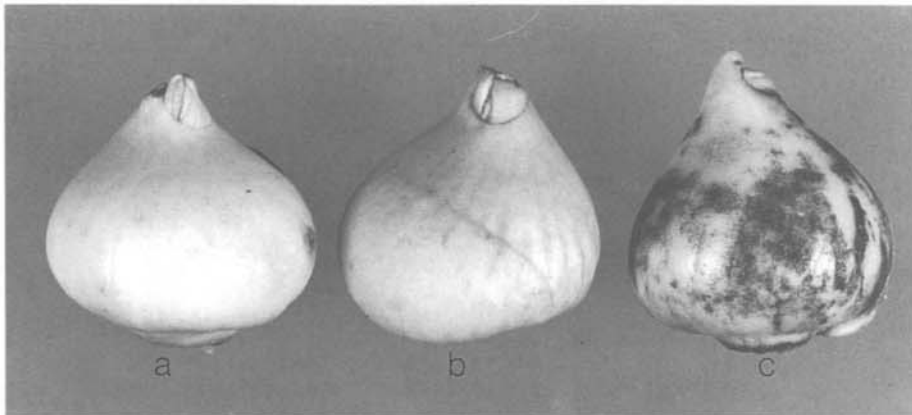
This page: *Acaricalus ilexopacae* on *Ilex opaca* leaf (photo by W.E. Styer). Opposite page, top: *Abacarus hystrix* on ball point pen; middle: *Parasitus* sp. (Mesostigmata: Parasitidae) plus three specimens of *Abacarus hystrix* (asterisks) on perennial ryegrass; bottom: *Aceria* sp. in leaf grooves of wheat (photos by W.E. Frost and P.M. Ridland).



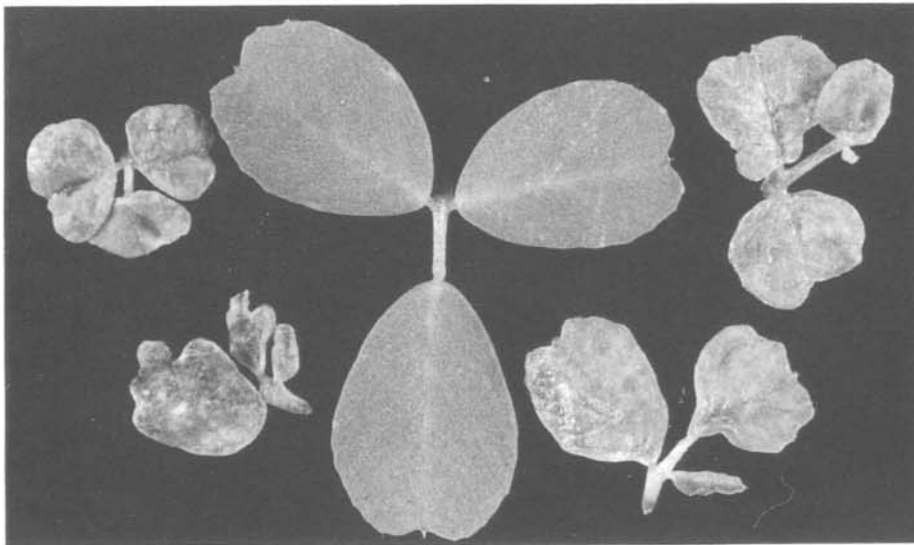
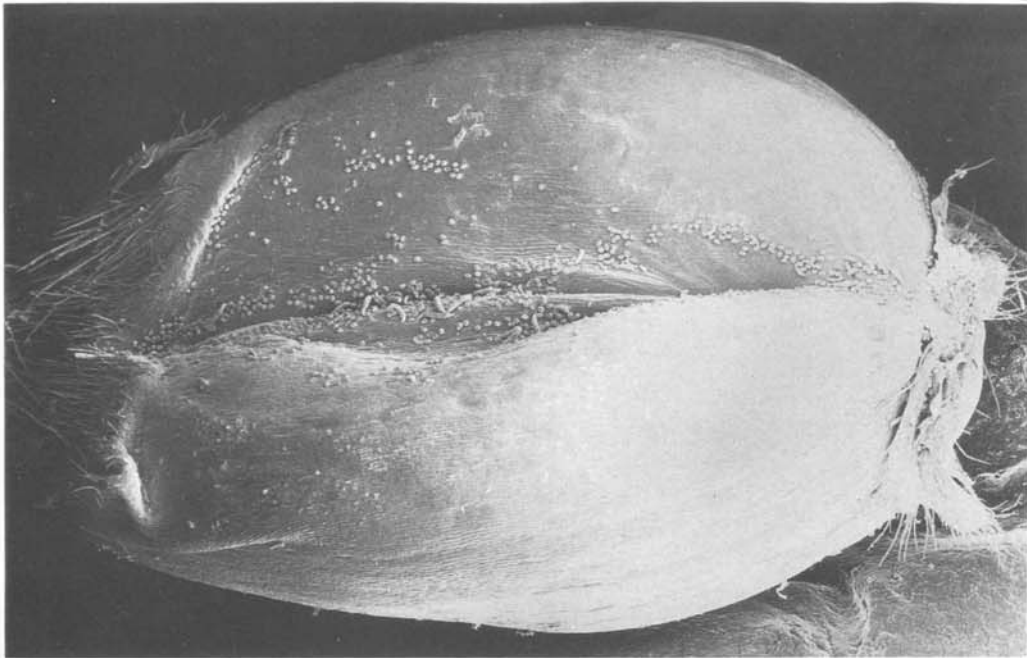
This page: *Acalitus fagerinea* in erineum on *Fagus grandifolia* (photo by W.E. Styer). Opposite page, top: *Abacarus hystrix* on perennial ryegrass (photo by W.E. Frost and P.M. Ridland); middle: wax-secreting *Trimeroptes aleyrodiformis*; bottom: *Cymeda zealandica* (photos by D.C.M. Manson).







Top: coconuts (Photo by D. Moore and F.W. Howard); middle: tulip bulbs (photo supplied by C.G.M. Conijn); bottom: apples (photo by M.A. Easterbrook).



Top: wheat grain with *Aceria tosichella* (Photo by W.E. Frost and P.M. Ridland); middle: lucerne (photo by P.M. Ridland); bottom: pear leaves with blister galls (photo by M.A. Easterbrook).

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## Contributors to this Volume

G. ALBERTI

Zoologisches Institut und Museum, Universität Greifswald, Johann-Sebastian-Bachstr. 11/12, D-17489 Greifswald, Germany

J.W. AMRINE, Jr.

Division of Plant and Soil Sciences, West Virginia University, P.O.Box 6108, Morgantown, WV 26506-6108, USA

J. BOCZEK

Department of Applied Entomology, Warsaw Agricultural University, 02-766 Warszawa, ul. Nowoursynowska 166, Poland

R. BRONNER

Laboratoire de Cécidologie, Institut de Botanique, Université Louis Pasteur, 28 rue Goethe, 67083 Strasbourg Cedex, France

J. BRUIN

Section Population Biology, Institute of Systematics and Population Biology, University of Amsterdam, Kruislaan 320, 1098 SM Amsterdam, The Netherlands

M. CASTAGNOLI

Istituto Sperimentale per la Zoologia Agraria, Via Lanciola, Cascine del Riccio, 50125 Firenze, Italy

G.P. CHANNABASAVANNA

Department of Entomology, University of Agricultural Sciences, Rajajinagar, Bangalore 560 010, India

C.C. CHILDERS

Citrus Research and Education Center, University of Florida, 700 Experiment Station Road, Lake Alfred, FL 33850-2299, USA

D.R. CLEMENTS

Department of Biology, Trinity Western University, 7600 Glover Road, Langley, British Columbia V3A 6H4, Canada

C.G.M. CONIJN

Bulb Research Centre, Vennenstraat 22, 2160 AB Lisse, The Netherlands



B.A. CROFT

Department of Entomology, Oregon State University, Corvallis, OR 97331-2907, USA

E. DE LILLO

Istituto di Entomologia Agraria, Università degli Studi di Bari, Via Amendola 165/A, 70126 Bari, Italy

F. DREGER

Laboratoire de Cécidologie, Institut de Botanique, Université Louis Pasteur, 28 rue Goethe, 67083 Strasbourg Cedex, France

J.E. DUNLEY

Tree Fruit Research and Extension Center, 1100 N. Western Avenue, Wenatche, WA 98801, USA

C. DUSO

Istituto di Entomologia Agraria, Università degli Studi di Padova, Via Gradenigo 6, 35131 Padova, Italy

M.A. EASTERBROOK

Horticultural Research International, East Malling, Kent ME19 6BJ, United Kingdom

C.A. FARRAR

Department of Entomology, University of California, Riverside, CA 92521-0314, USA

W.E. FROST

South Australian Research & Development Institute, Entomology Unit, G.P.O.Box 397, Adelaide, South Australia 5001, Australia

U. GERSON

Levi Eshkol School of Agriculture, Hebrew University of Jerusalem, P.O.Box 12, Rehovot 76-100, Israel

R. HARMSSEN

Department of Biology, Queen's University, Kingston, Ontario K7L 3N6, Canada

W. HELLE

Biesbosch 65, 1181 HX Amstelveen, The Netherlands

I. LESNA

Section Population Biology, Institute of Systematics and Population Biology, University of Amsterdam, Kruislaan 320, 1098 SM Amsterdam, The Netherlands

E.E. LINDQUIST

Eastern Cereal & Oilseed Research Centre, Agriculture Canada, K.W. Neatby Building-C.E.F., Ottawa, Ontario K1A 0C6, Canada

D.C.M. MANSON

7A MacMurray Road, Remuera, Auckland 5, New Zealand

C.W. McCOY  
Citrus Research and Education Center, University of Florida, 700 Experiment  
Station Road, Lake Alfred, FL 33850, USA

J. McMURTRY  
P.O.Box 4487, Sunriver, OR 97707, USA

R.H. MESSING  
University of Hawaii, 7370 Kuamo'o Road, Kapa'a, HI 96746, USA

K. MICHALSKA  
Department of Applied Entomology, Warsaw Agricultural University, 02-766  
Warszawa, ul. Nowoursynowska 166, Poland

D. MOORE  
International Institute of Biological Control, Silwood Park, Buckhurst Road,  
Ascot, Berks SL5 7TA, United Kingdom

L.R. NAULT  
Department of Entomology, Ohio Agricultural Research and Development  
Center, Ohio State University, 1680 Madison Avenue, Wooster, OH 44691-  
4096, USA

G. NUZZACI  
Istituto di Entomologia Agraria, Università degli Studi di Bari, Via  
Amendola 165/A, 70126 Bari, Italy

G.N. OLDFIELD  
Department of Plant Pathology, University of California, Riverside, CA  
92501, USA

T.A. PERRING  
Department of Entomology, University of California, Riverside, CA 92521-  
0314, USA

G. PROESELER  
Institut für Phytopathologie Aschersleben, Theodor-Römer-Weg 4, 432  
Aschersleben, Germany

P.M. RIDLAND  
Institute for Horticultural Development, Agriculture Victoria, Private Bag 15,  
South Eastern Mail Centre, Victoria 3176, Australia

S.S. ROSENTHAL  
Rangeland Insects Laboratory, U.S.D.A.-A.R.S., Montana State University,  
Bozeman, MT 59717-0056, USA

R.N. ROYALTY  
Rhône-Poulenc, P.O.Box 12014, 2 T.W. Alexander Drive, Research Triangle  
Park, NC 27709, USA

M.W. SABELIS  
Section Population Biology, Institute of Systematics and Population Biology,  
University of Amsterdam, Kruislaan 320, 1098 SM Amsterdam, The  
Netherlands

V.G. SHEVCHENKO

Biological Research Institute, Petersburg State University, Oranienbaumskoe  
2, Staryy Peterhof, St. Petersburg, 198904 Russia

M.K.P. SMITH MEYER

Plant Protection Research Institute, Private Bag X134, Pretoria 0001, Republic  
of South Africa

M.G. SOLOMON

Horticultural Research International, East Malling, Kent ME19 6BJ, United  
Kingdom

W.E. STYER

Department of Entomology, Ohio Agricultural Research and Development  
Center, Ohio State University, 1680 Madison Avenue, Wooster, OH 44691-  
4096, USA

H.M.A. THISTLEWOOD

Laboratoire d'Acarologie, UFR d'Ecologie Animale et de Zoologie Agricole,  
INRA-ENSA.M-ORSTOM, 2 Place Pierre Vialla, F-34060 Montpellier Cedex,  
France

J. VAN AARTRIJK

Bulb Research Centre, Vennenstraat 22, 2160 AB Lisse, The Netherlands

P.C.J. VAN RIJN

Section Population Biology, Institute of Systematics and Population Biology,  
University of Amsterdam, Kruislaan 320, 1098 SM Amsterdam, The  
Netherlands

E. WESTPHAL

Musée Zoologique, 29 Boulevard de la Victoire, F-67000 Strasbourg, France

M. WYSOKI

Department of Entomology, Institute of Plant Protection, The Volcani Center,  
P.O.Box 6, Bet-Dagan 50250, Israel

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## PART 4 BENEFICIAL EFFECTS OF ERIOPHYOID MITES

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# **PART 1**

## **THE ERIOPHYOIDEA**

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## Chapter 1.1 External Anatomy and Systematics

### 1.1.1 External Anatomy and Notation of Structures

E.E. LINDQUIST

Studies on the external structures of eriophyoid mites began with the remarkable work of Nalepa (1887) over a century ago. The accuracy and level of detail of his observations on these most minute of mites is astounding in view of the optical systems then available for microscopy. Some 65 years passed before further studies added more refined knowledge on the morphology of these mites by using phase contrast (Keifer, 1952, 1959; Krantz 1973), and scanning and transmission electron microscopy (Shevchenko and Sil'vere, 1968; Shevchenko, 1970; Keifer, 1975a; Nuzzaci, 1976a, 1979c). The descriptions by many authors of a multitude of eriophyoid taxa, which display a much greater diversity of external structure than was known in Nalepa's time, have added breadth and perspective to the external morphology of these mites.

Our current knowledge of eriophyoids as highly specialized mites with a simplified anatomy because of the loss of many structures belies the fact that our knowledge of their morphology is still limited in an important way. Their external structures have not been adequately compared with those of other groups of acariform mites to establish homologies and thereby permit the use of a standard set of terms and notation applicable to acariform mites in general. This in turn has hampered hypotheses concerning character state transformations that are prerequisite to cladistic analyses which lead to more accurate concepts concerning the classification of eriophyoid mites and their relationships with other superfamilies of Acariformes (see Chapters 1.1.2 (Lindquist and Amrine, 1996) and 1.5.2 (Lindquist, 1996)).

The present chapter attempts to resolve the aforementioned limitations regarding external structures of eriophyoid mites by introducing a system of standardized terminology and notation, most of which was developed in a series of studies on oribatid mites by Grandjean (1934, 1939, 1947). This system has potential for application to virtually all groups of acariform mites. In a similar way, this has already been done for the external anatomy of tetranychoid mites (Lindquist, 1985a) in a companion volume of this series (Helle and Sabelis, 1985).

A rationale for applying Grandjean's system to eriophyoid mites follows. (1) The eriophyoid stock is a subset (superfamily) of the mite order (or suborder) Acariformes, and as such manifests characteristics that may be homologous with those of other subsets of acariform mites (be they, *e.g.*, Tetranychoida or Nematalycoidea). (2) The basic patterns of setation on the body and appendages of acariform mites can be recognized and setal homologies hy-

pothesized; that is, setae are generally idionymous and can be denoted by a standardized notation, by study of their ontogeny and position during postembryonic development. (3) As eriophyoid mites retain three active postembryonic instars, their idiosoma is assumed to be modified from at least the larval components of the acariform idiosoma, including a six-segmented opisthosoma (counting the terminal larval, or pseudanal, segment), even though external manifestations of these segments may not be evident. (4) Eriophyoids have a very reduced, or hypotrichous, complement of body setae. As these setae are all present beginning with the first active postembryonic instar, they are regarded to be fundamental, or prototrichous, elements of the original, or primitive, set of larval setae. (5) That the eriophyoid stock, having undergone considerable reductions in setal and other structures, would develop some setae *de novo* (that is, as secondarily derived setae present beginning with the first active postembryonic instar), is implausible and not found in any other group of Acariformes (and therefore not a parsimonious hypothesis). (6) Instead, it is most probable (and parsimonious) that the setae remaining on eriophyoid mites have assumed modified positions that reflect the highly specialized body shape of these mites and the niches to which they are adapted.

The advantages of using Grandjean's system are both practical and theoretical. (1) It is potentially applicable to virtually all families of Acariformes. (2) A single system, rather than a variety of systems peculiar to each superfamily of mites, is far easier to recall by users of diverse published studies. (3) Usage is international, in any language. (4) The system reflects the segmental origins of structures. (5) The system reveals predictive patterns in the ontogeny of structures that are useful in various ways, including the diagnosis of postembryonic instars and the hypothesis of character state transformation series. It must be remembered, however, that application of this system *at once* implies hypothetical homologies of the structures denoted.

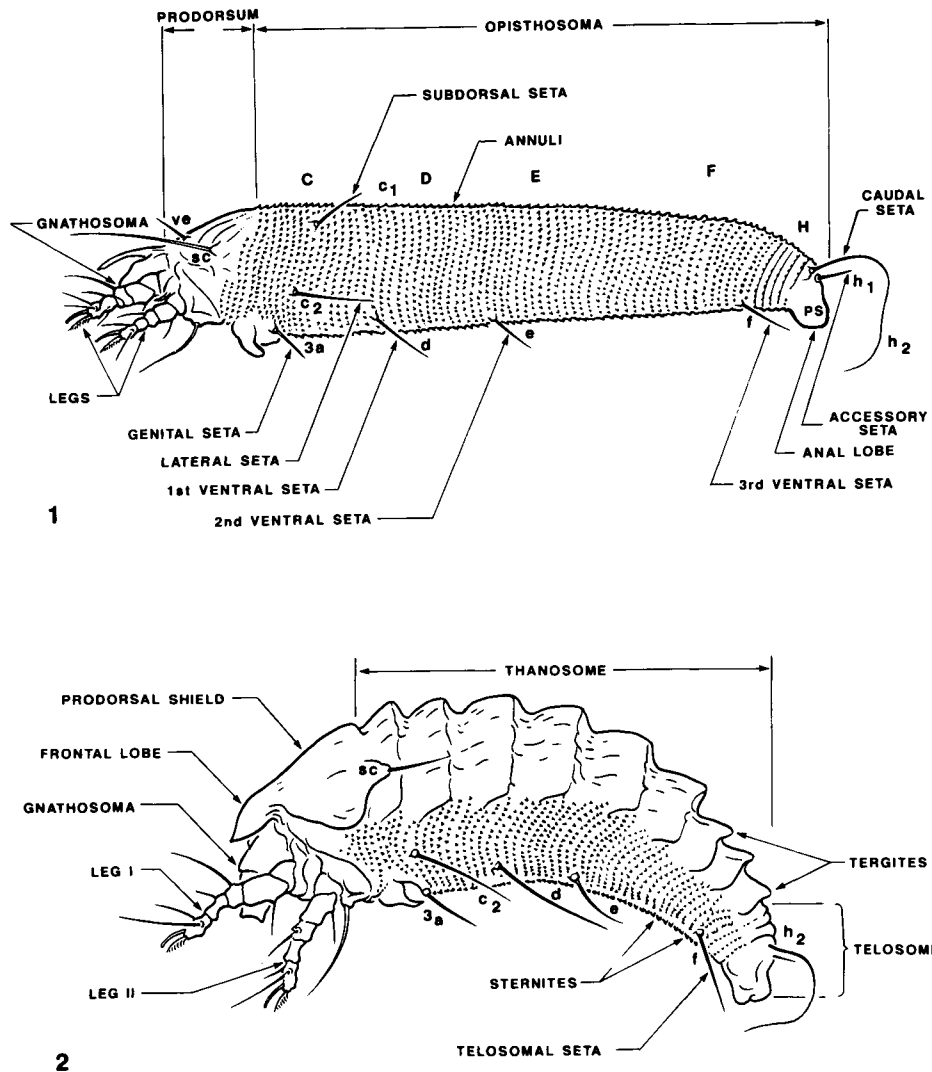
The following presentation is, therefore, based on a variety of original observations of mites representing a diversity of eriophyoid taxa, as well as on observations presented in the literature cited.<sup>1)</sup>

## HABITUS

Eriophyoid mites are of small size, the body length of adults averaging about 200  $\mu\text{m}$ , and ranging from 80 to nearly 500  $\mu\text{m}$  (Nalepa, 1887; Keifer, 1975a, 1979; Mohanasundaram, 1981; Smith, 1977, 1984). The idiosoma of larval and postlarval instars is wormlike, with an elongated and transversely annulated opisthosoma, and with only 2 pairs of legs, which lack paired claws but have an empodial featherclaw (Figs. 1.1.1.1-2). The genital opening of adults of both sexes is positioned proximally, closely behind the bases of the legs. The setae on the body and appendages are nearly always simple and tapered; rarely, a set may be spinelike, as are the prodorsal setae in *Spinacus* Keifer, or bifurcate, as are the subapical palpal setae in *Dicrothrix* Keifer, *Neodicrothrix* Mohanasundaram, *Flechtmannia* Keifer and *Porosus* Smith Meyer.

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<sup>1)</sup> Part of this presentation, on application of Grandjean's system of setal notation to the opisthosomal region of eriophyoid mites, was first given at the annual meeting of the Acarological Society of America, Reno, Nevada, Dec. 1991.



Figs. 1.1.1.1-2. Habitus of the two major body forms of eriophyoid mites in lateral view (modified from Keifer, 1975a). (1) A vermiform mite, *Phytoptus leucothonius* Keifer. (2) A fusiform mite, *Anthocoptes helianthella* Keifer. See text for setal notation.

## GNATHOSOMA

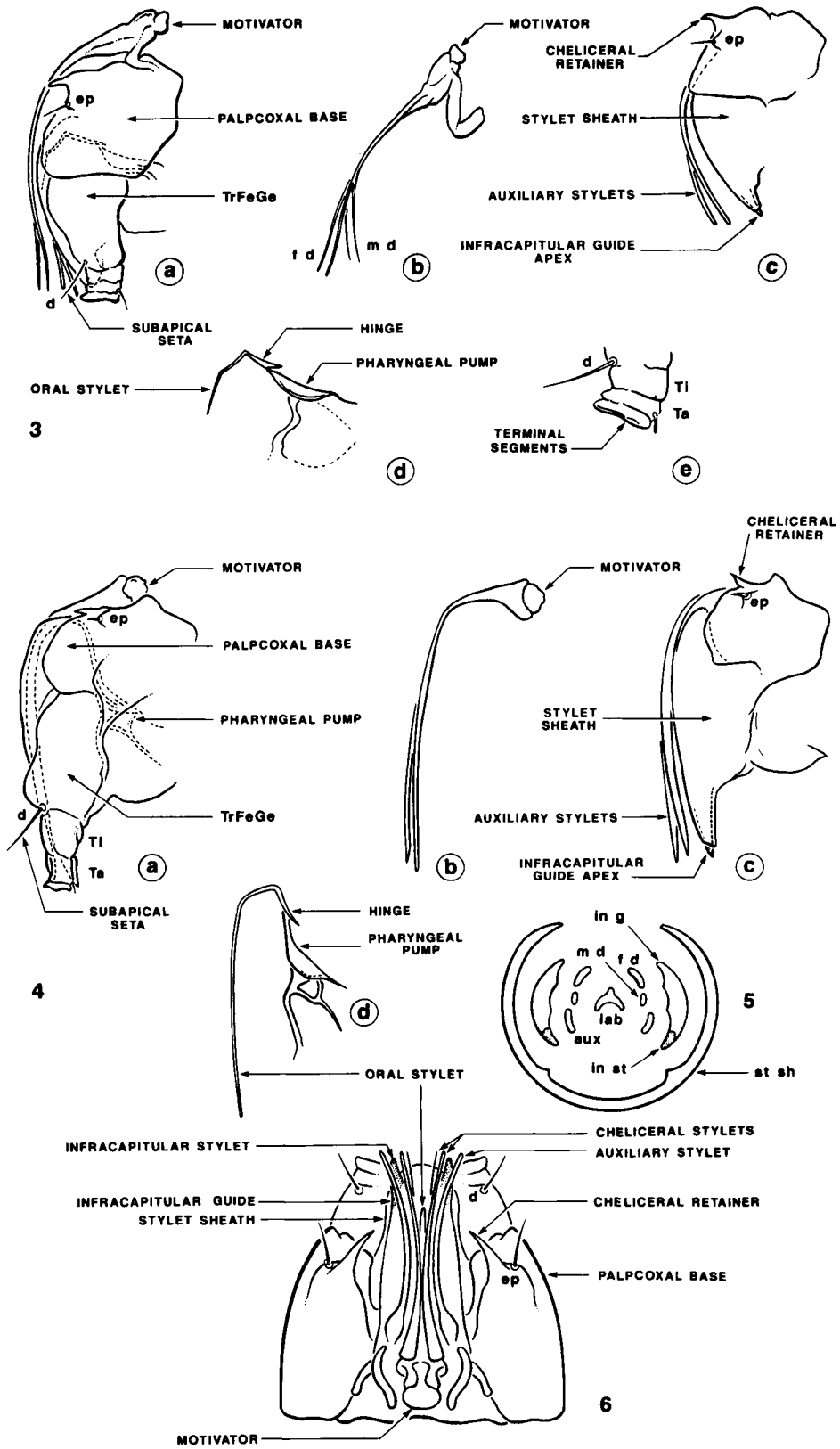
Despite the general morphological simplicity that characterizes mites of the superfamily Eriophyoidea, the gnathosoma exhibits a complex of cheliceral and associated structures (Nuzzaci, 1979c). The dorsomedial surface, or cervix, of the infracapitulum (the "rostrum" or "hypostome" in eriophyoid literature) has a longitudinal channel, or rostral gutter, called the "cheliceral sheath" by Nuzzaci (1979b, 1979c) and, more precisely, "stylet sheath" in Chapter 1.2 (Nuzzaci and Alberti, 1996). This channel is deeply U-shaped in cross section (Fig. 1.1.1.5) and ensheaths 7, or sometimes 9, styletlike structures as follows: a pair of cheliceral shafts that each divides apically into 2 fine stylets (fixed and movable digits); a single oral stylet, or labrum; a pair of

auxiliary stylets, called the "inner infracapitular stylets" in Chapter 1.2 (Nuzzaci and Alberti, 1996; also called "hypostomal outgrowths" or "hypostomal protuberances" or "inner subcapitular stylets" in the literature); and in some taxa (particularly in the Phytoptidae and Diptilomiopidae) a pair of freely projecting apices of guidelike structures, which may appear to be derived from the stylet sheath and were called the "cheliceral guides" by Keifer (1959, 1975a) but actually derive from infracapitular lamellae distinct from the stylet sheath, and are called the "outer infracapitular stylets" in Chapter 1.2 (Nuzzaci and Alberti, 1996) (Figs. 1.1.1.3-6).

The cheliceral shafts are distinguished by being the dorsalmost pair of these structures, and also by being the only ones that are optically birefringent in polarized light. These stylets are not deeply retractable; their bases are not developed as a stylophore, but they appear to be hinged and bendable by means of muscular action (Shevchenko and Sil'vere, 1968). Their movement is limited to a slight, alternate, back-and-forth, boring motion activated by a small knob, the motivator, that lies between their bases (Chapter 1.2 presents functional anatomical details of cheliceral motion (Nuzzaci and Alberti, 1996)). Motivator pulsation may not stop after the chelicerae are inserted into plant tissue, but continues throughout the feeding episode (Krantz, 1973). The cheliceral stylet shafts are tapered along their lengths, and they do not interlock apically to form a single hollow tube during feeding as is found in tetranychoid mites. A few studies (Shevchenko and Sil'vere, 1968; Krantz, 1973; Keifer, 1975a; Nuzzaci, 1979b; Thomsen, 1987) have noted that each cheliceral shaft divides towards the apex into a dorsal digit and a ventral digit, or filament (shown only in Fig. 1.1.1.3b); as these are innervated, they are thought to be modified from the fixed and movable digits, respectively, of the chelicerae (Nuzzaci, 1979c; see also Chapter 1.2 (Nuzzaci and Alberti, 1996)). Whether the cheliceral shaft divides into a dorsal and a ventral digit among diptilomiopid mites, or among eriophyoids generally, is not known. References to further subdivision of the cheliceral apices into additional "threads" in some eriophyids (Keifer, 1959) need clarification, as do those to a proximal and a distal "part" or "segment" (Shevchenko and Sil'vere, 1968; Hislop and Jeppson, 1976). The linear "groove" noted along the distal part of the cheliceral shaft by Hislop and Jeppson (1976) may simply delineate the fixed and movable digits. Within the Eriophyoidea, the cheliceral stylets are of two fundamental forms: a slightly, evenly curved form of small to moderate size is found in the Phytoptidae and Eriophyidae; a more robust form with abrupt basal curvature, correlated with a more robust infracapitulum, is found in the so-called "big-beaked" eriophyoids, the Diptilomiopidae (compare Figs. 1.1.1.3a, b and 1.1.1.4a, b).

The unpaired oral stylet is continuous basally with the dorsal anterior extremity of the pharynx; it is hinged there, allowing some independent, up-and-down flexion at the level of the mouth. The oral stylet is generally less than half as long as the cheliceral stylets in the Phytoptidae and Eriophyidae, but nearly as long in the Diptilomiopidae (*cf.* Figs. 1.1.1.3d and 1.1.1.4d).

Figs. 1.1.1.3-6. Diagrammatic views of gnathosomal structures of eriophyoid mites. (3a-e) and (4a-d) Exploded lateral views from (3) an eriophyid and (4) a diptilomiopid (modified from Keifer, 1959): (a) composite; (b) cheliceral stylets apart from other structures; (c) palpcoxal base, infracapitulum, auxiliary stylets apart from other structures; (d) labrum (= oral stylet) and pharynx apart from other structures; (e) apex of palpus. (5) Transverse section of cheliceral and associated structures at level near apices of stylets. (6) Dorsal view of gnathosoma (modified from Keifer, 1959). Abbreviations: **aux**, auxiliary stylet; **f d**, fixed digit of cheliceral stylet; **in g**, infracapitular guide; **in st**, (outer) infracapitular stylet; **lab**, labrum; **m d**, movable digit of cheliceral stylet; **st sh**, stylet sheath. See text for setal notation.





The auxiliary stylets are paraxial processes of the palpcoxal base (the "inner infracapitular stylets" in Chapter 1.2 (Nuzzaci and Alberti, 1996)) and closely flank the cheliceral stylets ventrolaterally (Figs. 1.1.1.3c, 1.1.1.4c, 1.1.1.5-6); they are about as long as the latter, but are not capable of a similar boring movement. Although these stylets may not function in penetrating leaf tissue, they appear to enter into the penetrated tissue and function in feeding, along with the oral stylet, by channeling secretions from salivary glands whose ducts appear to open near their bases (Keifer, 1975a).

A pair of infracapitular lamellae, which are distinct from – but hidden in longitudinal view by – the surrounding stylet sheath, form a set of stiffened guides alongside the stylets (Fig. 1.1.1.5). The apices of these guides are usually rounded, inconspicuous projections in the Eriophyidae (Fig. 1.1.1.3c); however, in the Phytoptidae and Diptilomiopidae (Fig. 1.1.1.4c), they may be pointed, more or less freely projecting, conspicuous processes that appear to constitute another pair of stylets, called the "outer infracapitular stylets" in Chapter 1.2 (Nuzzaci and Alberti, 1996).

Apart from the cheliceral and oral stylets, the homologies of the other styletlike structures and the motivator are problematic; the auxiliary, or inner infracapitular, stylets may be derivatives of the lateral lips that are basic to acariform mites. Further perspective on the juxtaposition and functional anatomy of the gnathosomal structures used in feeding is provided in Chapter 1.2 (Nuzzaci and Alberti, 1996).

There is no confirmed evidence of a respiratory system that opens by way of a pair of stigmata located at the bases of the chelicerae. Speculations that the motivator between the bases of the chelicerae is a modified relict of a tracheal system (Shevchenko and Sil'vere, 1968) and that a pair of structures arising just posterior to the motivator may be tracheal trunks (Krantz, 1973), have not been confirmed. Respiration in eriophyoids is cuticular, as discussed in Chapter 1.2 (Nuzzaci and Alberti, 1996). The absence of a prostigmatic respiratory system may be hypothesized either as a primitive condition or as a secondarily derived loss; these alternatives profoundly affect classificatory concepts of the Eriophyoidea as a group either inside or outside of the acariform suborder Prostigmata, as discussed in Chapter 1.5.1 (Lindquist and Oldfield, 1996).

The ventral surface of the infracapitulum is reduced in expanse because of the more or less hypognathous orientation of the gnathosoma. Subcapitular and adoral setae are absent, and oral structures such as lateral lips are not evident, unless the latter are represented by the auxiliary stylets as noted above.

The palpi are reduced in segmentation, but they remain well developed as stout, usually truncated structures flanking and supporting the infracapitulum (Figs. 1.1.1.3a, 1.1.1.4a, 1.1.1.6). The paraxial faces of the palpi are flattened and appressed to the lateral walls of the infracapitulum, such that they, along with the stylet sheath of the infracapitulum, enclose and guide the feeding structures. Each palp appears to consist of a base and three segments. The base, called the "proximal segment" or "basal palp segment" by Keifer (1959, 1975a), projects from the gnathosoma on either side of the base of the infracapitulum, and appears to be a projection of the dorsal portion of the palpcoxal base (the palpcoxa is never a free segment in the Acari). The dorsal surface of the palpal base bears 2 significant structures: a flexible spinelike process directed paraxially somewhat over the cheliceral stylets, called the "cheliceral retainer" by Keifer (1959, 1975a), and a basal seta. The homology of the basal seta has not been addressed. Based on its dorsoproximal position, it appears to represent the palpcoxal seta, *ep*. As such, the palpcoxal seta is surprisingly well developed, compared to its usually reduced size in other su-

perfamilies of trombidiform mites, when present. This may be due to its exposed position, in contrast to the condition of being more or less covered by the bases of the chelicerae in mites of these other superfamilies.

The first, or proximal, articulating palpal segment, called the "intermediate segment" by Keifer (1959, 1975a), is by far the largest segment and appears to be a consolidation of the palpal trochanter, femur and genu. In other superfamilies of Trombidiformes, reduction in number of palpal segments in general occurs first, from fusion of the femur and genu, and next, from reduction of the trochanter and consolidation of its remnant with the femorogenu. In view of this pattern, the interpretation of Shevchenko and Sil'vere (1968), that the eriophyoid palpus retains a genual segment separate from a "trochantero-femur", is improbable. The proximal palpal segment in Eriophyoidea, generally somewhat longer than wide, consistently bears only one seta, the "subapical" or "antapical" seta of Keifer (1959, 1975a), or "rostral" seta of Ramsay (1958), which is inserted dorsodistally and denoted here as *d*. Based on its distal position, this is a genual, rather than a femoral or trochanteral, seta; moreover, the palptrochanter does not retain a seta in any of the known acariform mites. The second segment, here regarded as the palptibia, is short, usually wider than long, and devoid of setae; it is sometimes indistinctly separated from either the proximal segment or the apical segment, or both. The apical segment, the palptarsus, is short like the palptibia; it bears a short setalike structure, inserted ventrally and antiaxially, called the "sensory peg" or "papilla" by authors. The small size of this structure often renders it difficult for discerning the presence or absence of birefringence in polarized light, thus leaving unresolved whether it may be a seta or solenidion. In some diptilomiopids, however, this structure is sufficiently large, *e.g.*, about 10  $\mu\text{m}$  long in *Rhyncaphytoptus constrictus* (Hodgkiss), to show a tapered shape and visible birefringence; whether it is a simple seta or a eupathidium remains problematic (see Chapter 1.2 (Nuzzaci and Alberti, 1996).

Each palptarsus has a distally truncated surface, or lip, that has an adhesive function; these apical lips are usually semicircular in cross section and fused, but they are circular and separate in diptilomiopids. During feeding, the palpi generally flank the infracapitulum, with their apices adhering to the leaf surface, and the tarsal and tibial segments telescope or buckle into one another to allow deeper penetration of the stylets into plant tissue (Fig. 1.1.1.3a; see also Chapter 1.4.6 (Westphal and Manson, 1996)). In some diptilomiopids and phyllocoptine eriophyids, however, the palptarsus is longer, more tapered, and its distal extremity has a less developed or vestigially truncated surface that may not have an adhesive function (Fig. 1.1.1.4a). In these forms, the palpi apparently do not flank the infracapitulum during feeding, and instead fold back, between the legs, to allow deeper cheliceral penetration into plant tissues (Fig. 1.1.1.9) (Keifer, 1959; Shevchenko, 1970; Krantz, 1973; Hislop and Jeppson, 1976; see also Chapter 1.2 (Nuzzaci and Alberti, 1996)). This folding back of the palpi during feeding was regarded as a characteristic of Diptilomiopidae in distinction to other Eriophyoidea by Keifer (1959); however, Nuzzaci (1976b) observed the palpal feeding posture in the diptilomiopid *Diptacus hederiphagus* Nuzzaci to be simply telescoped as in the other eriophyoid families. In other respects, the palpi vary little in form and structure among the great majority of taxa of Eriophyoidea. Correlated with other structures of the gnathosoma, they may be more elongated as in some graminivorous sheath-living taxa like *Novophytoptus* (Fig. 1.1.1.7), or more robust as in the "big-beaked" diptilomiopid taxa. The deutogyne female of the aberoptine eriophyid genus *Cisaberoptus* is exceptional in having the apices of the palpi unusually prognathous, thickened, hardened