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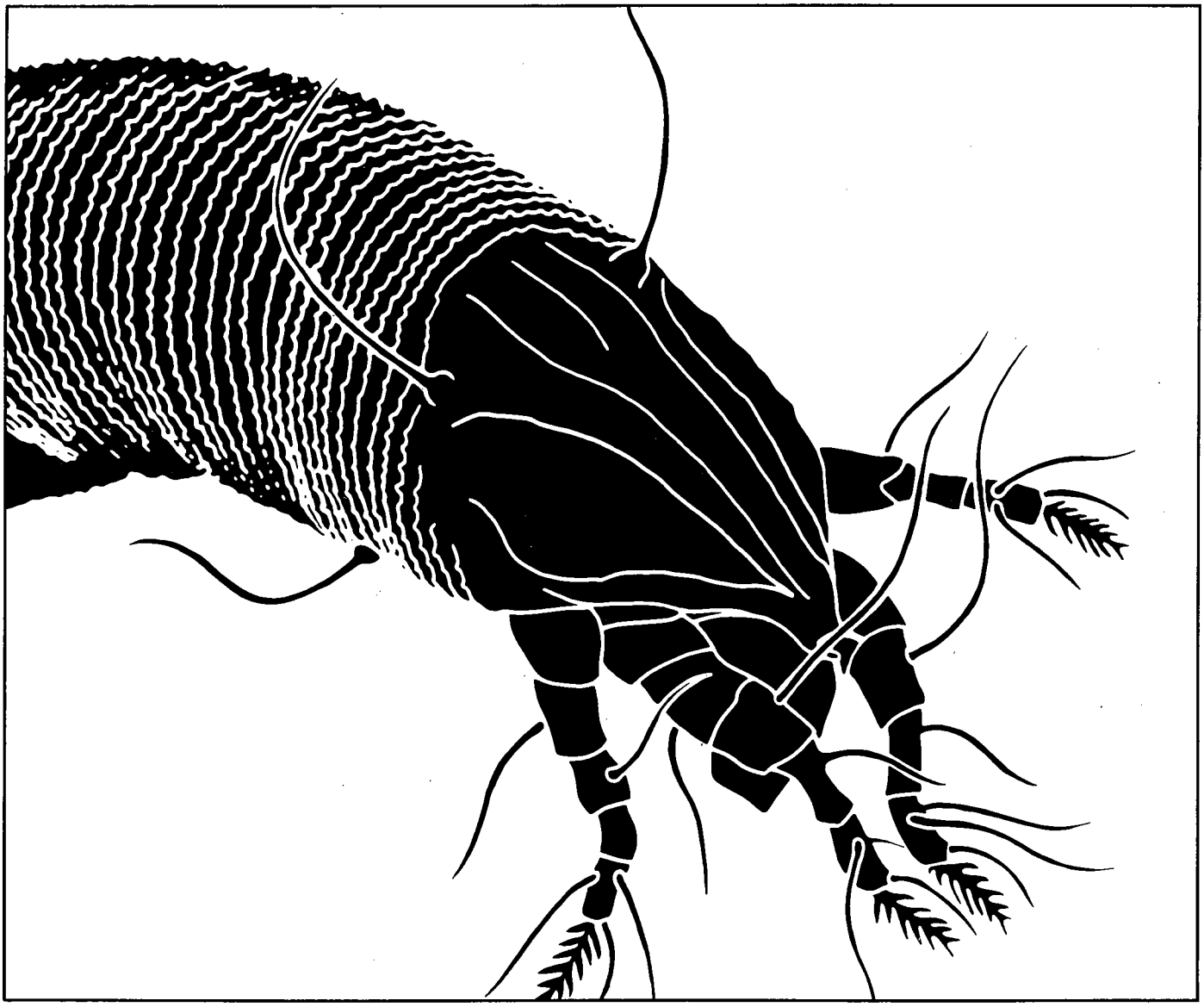
Number 573

An Illustrated Guide to Plant Abnormalities Caused by Eriophyid Mites in North America



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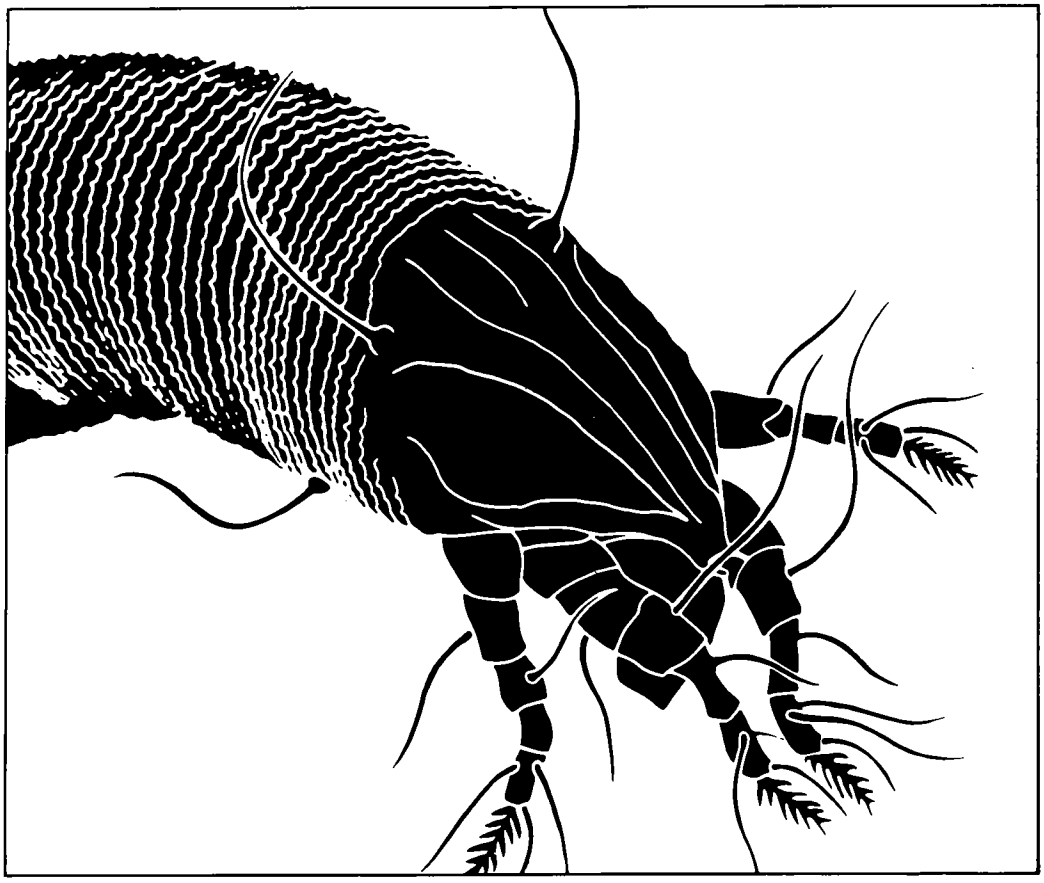
An Illustrated Guide to Plant Abnormalities Caused by Eriophyid Mites in North America

By Hartford H. Keifer, Edward W. Baker, Tokuwo Kono, Mercedes Delfinado, and William E. Styer



Abstract

Keifer, Hartford H., Baker, Edward W., Kono, Tokuwo, Delfinado, Mercedes, and Styer, William E. 1982. An illustrated guide to plant abnormalities caused by eriophyid mites in North America. U.S. Department of Agriculture, Agriculture Handbook No. 573, 178 pp.

This guide includes taxonomic descriptions of eriophyid mites (Eriophyoidea: Acari), their life histories, distribution, and host data. Characteristic plant injuries, such as galls, erineum, big bud, and witches'-broom, that are caused by these mites are illustrated with color photographs. Selected references are given. This guide will assist in mite identification and mite-induced injury. It is intended for acarologists, entomologists, horticulturists, and those who need to identify mites and to distinguish eriophyid injury from similar symptoms caused by other organisms.

KEYWORDS: Acari, Acarina, erineum, eriophyid mite biology, eriophyid mite description and taxonomy, eriophyid mite-host plant distribution, eriophyid mite-induced injuries, eriophyid mite-plant abnormalities handbook, eriophyid mite-plant galls, eriophyid mite-transmitted mosaic virus, Eriophyidae, Eriophyoidea, witches'-broom.

Acknowledgment

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The University of California Press has permitted inclusion of some gall illustrations from "Mites Injurious to Economic Plants" by Lee R. Jeppson, Hartford H. Keifer, and Edward W. Baker.

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Contents

	Page
Eriophyid mites and plant injury	6
Host symptoms of eriophyid feeding as taxonomic characters	25
Economic importance	29
Eriophyid research	29
Leaf galls	30
Bud, inflorescence, and stem galls, brooming, and rosette	74
Erineum	102
Fruit and leaf discoloration, russeting, bronzing, fruit hardening, foliage withering, and fruit and bud drop	120
Leaf and bud blisters	134
Leaf deformation, distortion, vein atrophy, and fruit, bud, and flower abnormalities	142
Leaf coating and webbing	156
Virus diseases	160
References	166
Glossary	171
Index of host plants	173
Index of eriophyid mites	177

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An Illustrated Guide to Plant Abnormalities Caused by Eriophyid Mites in North America

By Hartford H. Keifer, Edward W. Baker, Tokuwo Kono, Mercedes Delfinado, and William E. Styer[1]

Many plant abnormalities are well known to most people. Few persons, however, can recognize the innumerable injuries caused by eriophyid mites (Eriophyoidea: Acari) because no manual or guide exists for the identification and recognition of plant abnormalities and their mite causal agents. This illustrated guide is intended to fulfill this need by (1) providing essential information on plant abnormalities caused by eriophyid mites, (2) identifying these injuries from related forms caused by other organisms, and (3) presenting necessary information on the morphology, habits, and importance of the various eriophyid species that damage plants.

The text summarizes the distinguishing characteristics of both plant injury and mite species, the basic biology of the mite, and the geographical and seasonal distribution. The illustrations of the mites and color photographs of the injuries to the host plants show the characters used in identification. Each plate consists of drawings of an individual mite and certain body structures, with one or more photographs of the typical injuries to the host plants.

The guide includes the mites of the superfamily Eriophyoidea that affect plants of economic or horticultural importance in North America. Certain species occurring elsewhere are also discussed. Because the abnormalities caused by these mites are extremely diverse, it has not been possible to discuss all kinds of injuries in this manual. We have treated those examples most likely to be found in the field.

Terms referring to body structures of the eriophyid mite and certain terms commonly used in descriptive entomology, acarology, and botany are defined in the glossary. Scientific names are given for all plants and mites, and accepted common names are used wherever possible.

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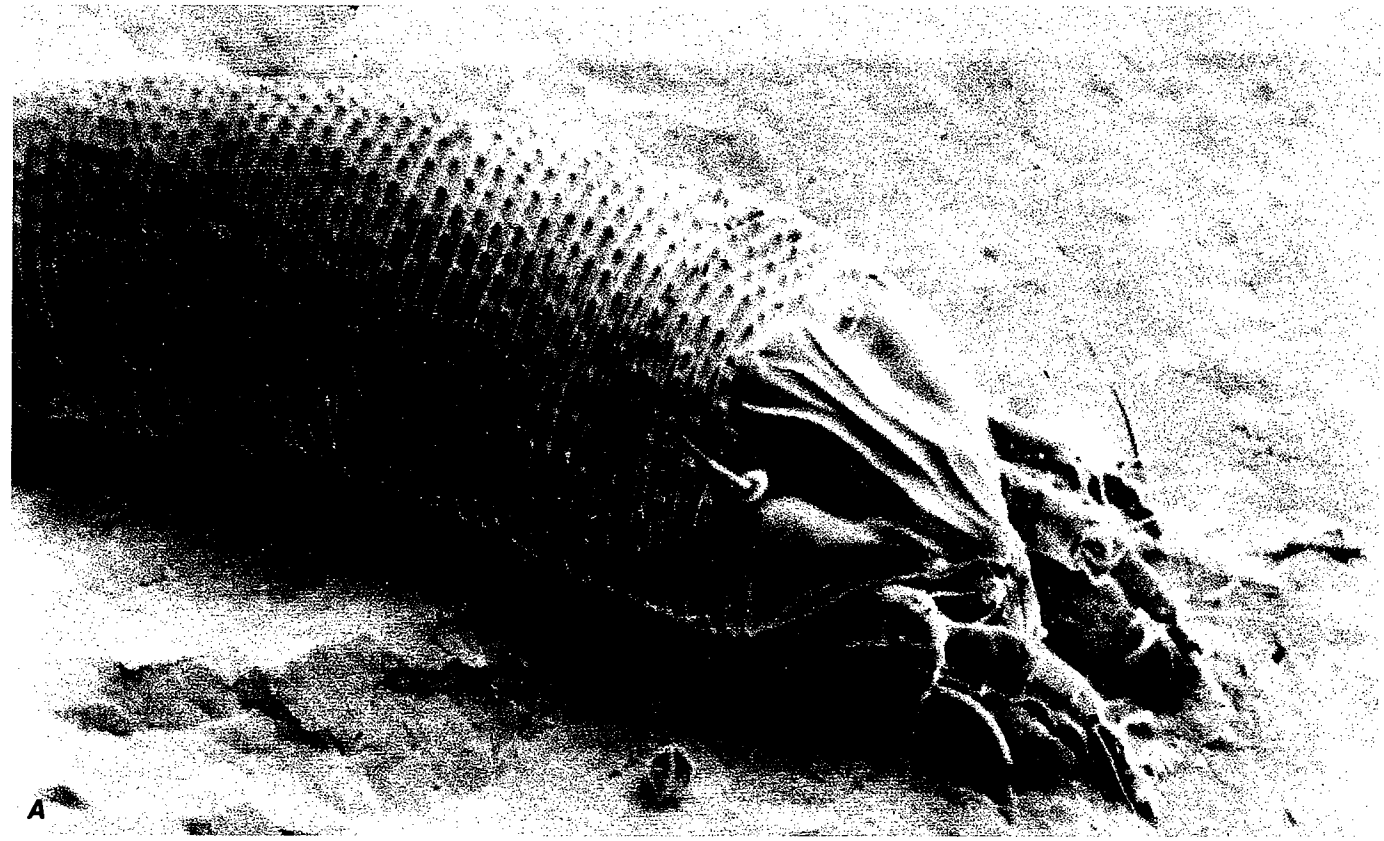
Eriophyid Mites and Plant Injury

Over 1,250 species of mites are in the superfamily Eriophyoidea; the majority belong in the family Eriophyidae and are of considerable economic importance. They are commonly known as gall, rust, bud, and blister mites or simply eriophyids. Eriophyids are so small that they are almost invisible to the unaided eye, and they are exclusively plant feeders. Members of the Eriophyoidea are soft bodied, wormlike, or spindle shaped and have two body regions, the gnathosoma (mouthparts) and the idiosoma (remainder of body). They are unique among the mites because they have only two pairs of legs. (No other mite has two pairs at any stage of its development.) Morphological development within the superfamily can be rather bizarre (see pls. 1–3).

The life cycle of most eriophyids is relatively simple, but certain species develop through a complicated cycle that includes alternation of generations. The more complex life history is predominant in species that infest deciduous plants and apparently is adapted to seasonal changes in the condition of the hosts. There are two forms, one consisting only of overwintering females called deutogynes and the other consisting of both sexes. The females of the latter are called protogynes. Deutogynes and protogynes of the same species may be conspicuously different morphologically and cause considerable taxonomic confusion. For example, in the walnut-infesting species *Eriophyes brachytarsus* Keifer, the deutogyne and protogyne have each been given a separate scientific name. This

PLATE 1.—*Eriophyes tulipae* Keifer. BN-49405



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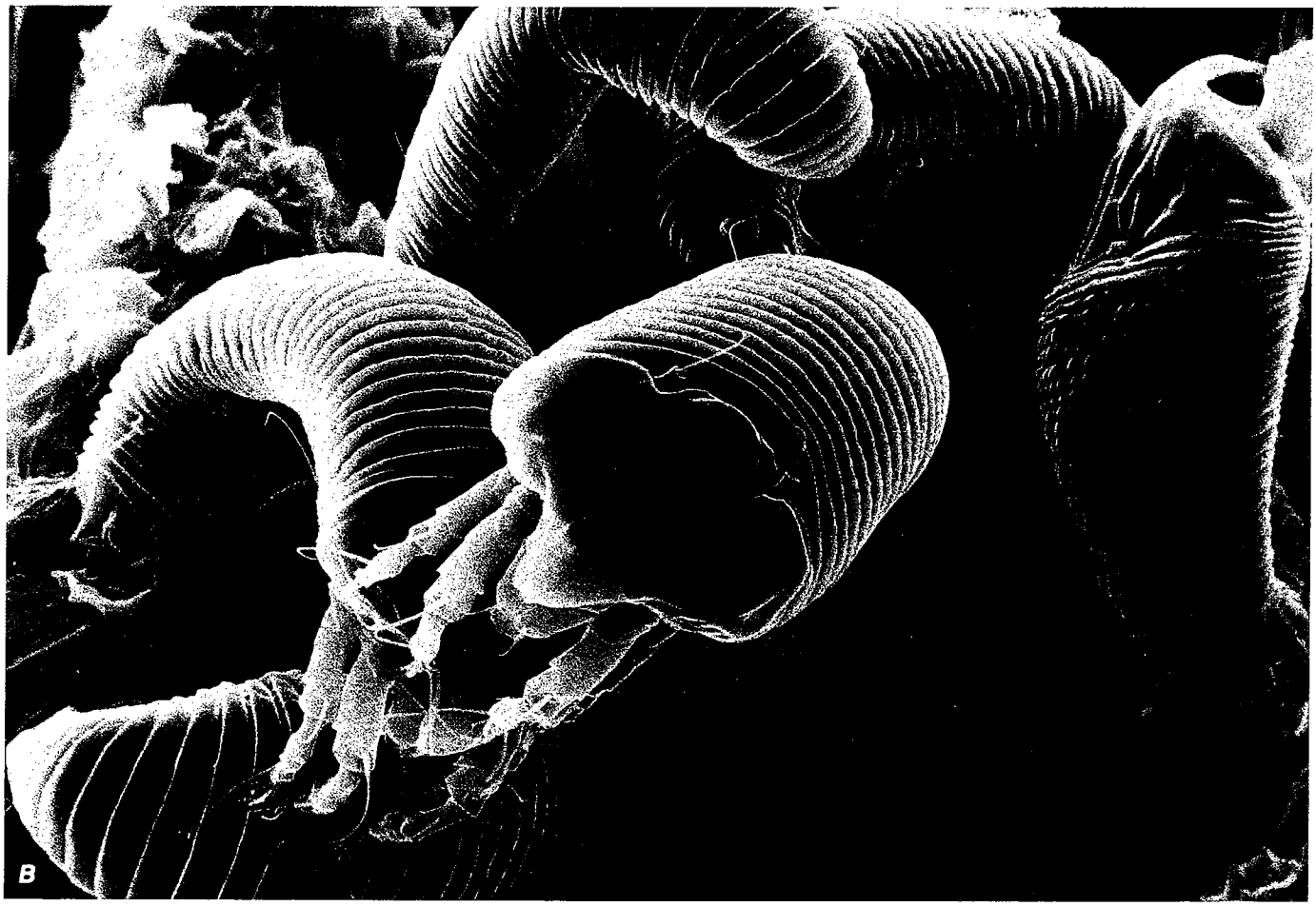

PLATE 2.—*A, Acalitus fagerinea* (Keifer); *B, Vasates aceriscrumena* (Riley): Adults.

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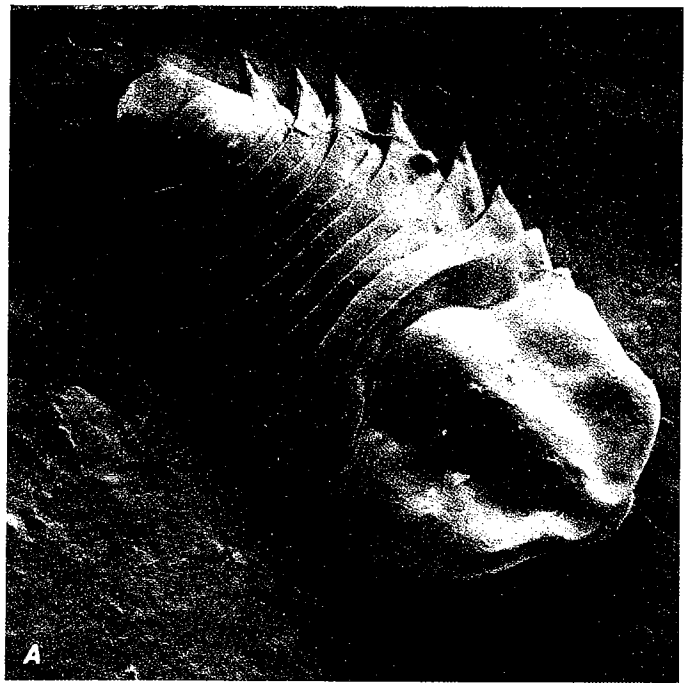

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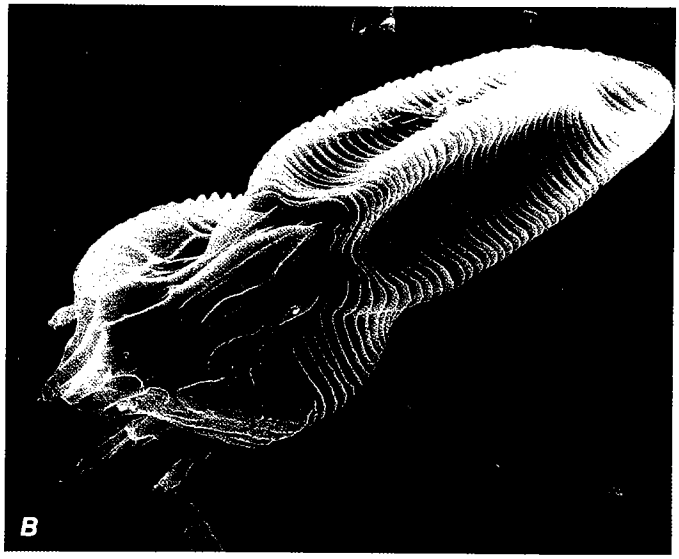

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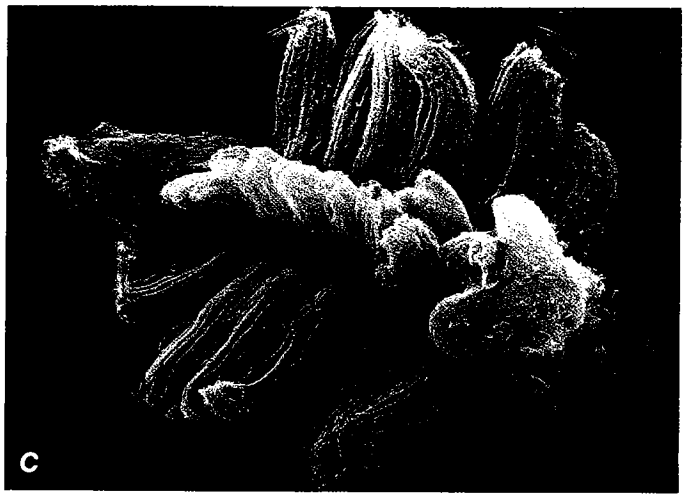

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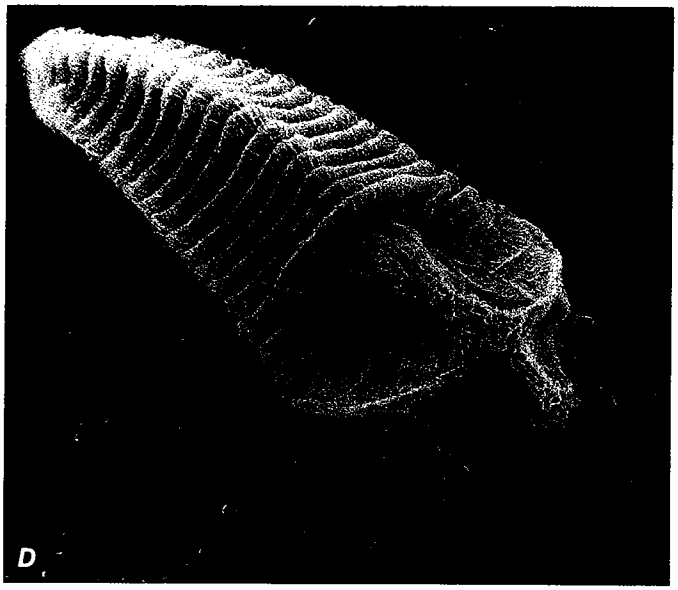

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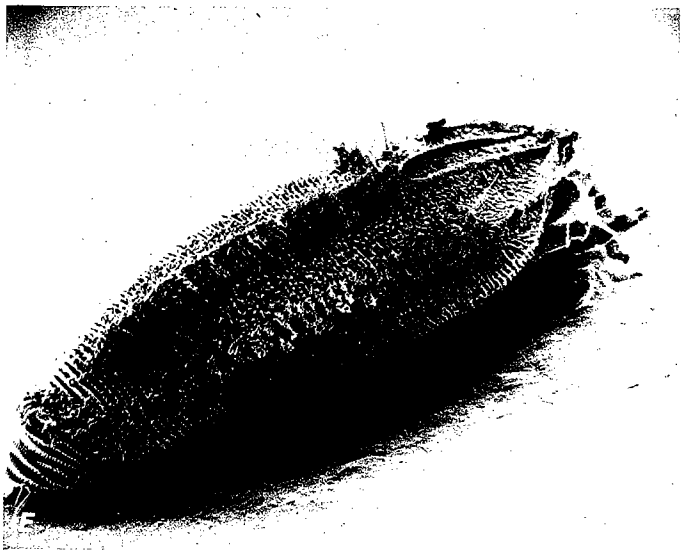

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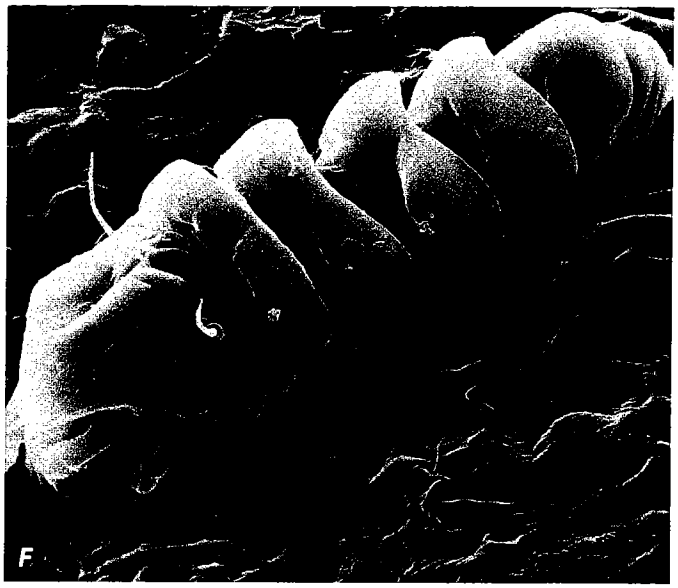

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PLATE 3.—*A, Tegonotus uranomus* (Keifer); *B, Acaricalus rhodaspris* (Keifer); *C, Trimerocoptes aleyrodiformis* (Keifer); *D, Tegolophus spongiosus* (Keifer); *E, Abacarus hystrix* (Nalepa); *F, Heterotergum* sp.

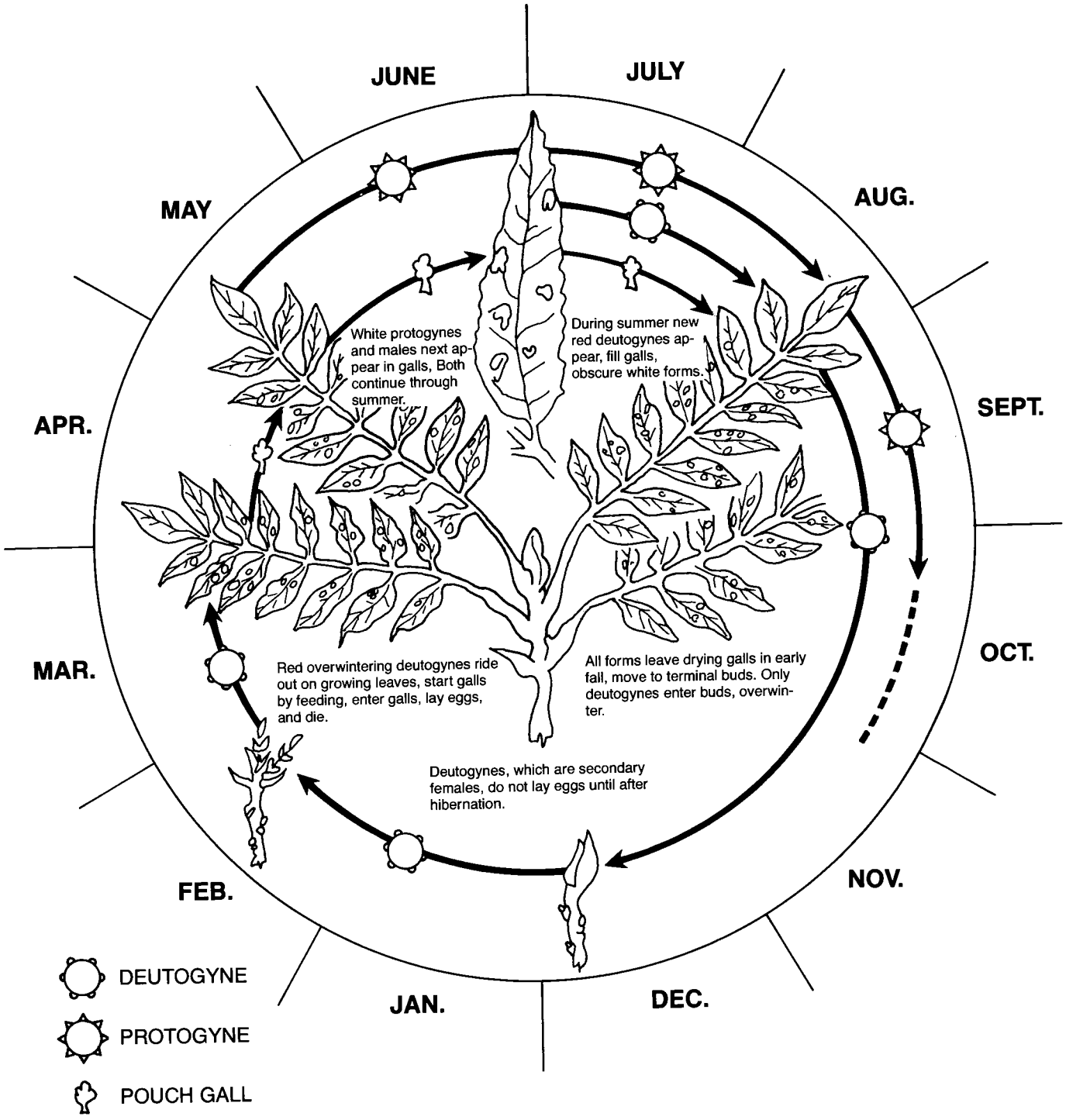


PLATE 4.—Life cycle of *Eriophyes brachytarsus* Keifer, illustrating alternation of generations.

accounts for the confusion and synonyms found for this species, as well as others with a similar life cycle. The typical life cycle of a gall-forming species in which an alternation of generations occurs is illustrated in plate 4.

Eriophyids are one of the most specialized groups of plant feeders. Although symptoms of their feeding run the gamut from simple russeting to complex gall formation, host-mite relationships often appear to be rather specific and probably reflect the high degree of specialization.

Gall formation occurs as a result of mite attack on individual plant cells; it is a localized growth reaction of the host plant to the attack. Common examples are leaf galls, bud galls, and erineum. In some plants, elongation of flower stems and lateral branches is inhibited, causing the development of contorted foliage, flowers, and branches. One of the most conspicuous examples is witches'-broom, which is a cluster of brushlike growth of stunted twigs or branches on trees. Some eriophyid species arrest shoot development, causing leaf sheaths to become enlarged, closely packed, and bunched at stem nodes. Others cause the well-known "big bud," which consists of an aggregation of swollen, thickened scale leaves. Eriophyids also cause an array of nongall abnormalities, such as leaf folding and twisting, blisters, and mosaic virus disease. Russeting and silvering of leaves and redberry disease are also induced by eriophyid feeding.

The various symptoms of injuries caused by eriophyid mites may appear on the following parts of the plant: *Buds, shoots, stems, and twigs*—bud blisters, bud and twig rosette and stunting, discolored buds and bud scales, enlarged buds, premature bud drop, galls, shoot and twig clustering or brooming, shoot, stem, and twig distortion; *flowers*—abnormal shape, blisters, discoloration, failing to open, galls, premature drop; *fruits*—abnormal shape, blisters, damaged seeds, discoloration, galls, hardening, premature drop; and *leaves*—abnormal shape or distortion, blisters, discoloration, erineum, galls, mosaic virus disease, stunting, webbing or coating, and russeting, bronzing, and withering.

The narrow range of acceptable hosts of most eriophyid species also suggests that these mites are highly specialized plant feeders. Although host data for most species are sketchy at best, a surprisingly large number appear to be confined to one species of host plants. Most other eriophyids feed on a few closely related species or genera of plants.

Table 1 includes host plants of economic or horticultural importance, symptoms of injury, and species of mites most likely to cause injury to these plants.

TABLE 1.—Host plants, symptoms of injuries, and mites

Host plant[1]		Symptom of injury	Mite
Scientific name	Common name[2]		
ACERACEAE			
Acer:			
campestre L.	Hedge maple	Leaf gall	*Eriophyes macrochelus* (Nalepa).[2]
glabrum Torr.	Rocky Mountain maple	Erineum	*Aculops glabri* (Keifer),[3] *A. paraglabri* (Keifer),[3] *Eriophyes calaceris* (Keifer) (p.102).
negundo L.	Box elder	Leaf gall	*Eriophyes negundi* Hodgkiss (p.30).
rubrum L.	Red maple	Erineum	*Eriophyes major* Hodgkiss (= *E. ornatus* Hodgkiss), *E. minutissimus* (Hodgkiss), *E. quinquilobus* (Hodgkiss) (p.32).
		Leaf gall	*Eriophyes confusus* Hodgkiss,[3] *Vasates quadripedes* Shimer (p.32).
saccharinum L.	Silver maple	Erineum	*Eriophyes aceris* Hodgkiss (p.32).
		Leaf gall	*Eriophyes confusus* Hodgkiss,[3] *Vasates quadripedes* Shimer (p.32).
saccharum Marsh.	Sugar maple	Erineum	*Aculops maculatus* (Hodgkiss),[3] *Eriophyes elongatus* Hodgkiss (= *E. regulus* Hodgkiss), *E. modestus* Hodgkiss (p.104).
		Leaf gall	*Vasates aceriscrumena* (Riley) (= *Phytoptus acericola* Garman) (p.34).
AMARYLLIDACEAE			
Allium spp.	Garlic, onion	Bulb damage	*Eriophyes tulipae* Keifer (p.160).

See footnotes at end of table.

TABLE 1.—Host plants, symptoms of injuries, and mites—Continued

Host plant[1]		Symptom of injury	Mite
Scientific name	Common name		
ANACARDIACEAE			
Mangifera indica L.	Mango	Bud gall, defoliation, inflorescence gall (?), stunted twigs.	*Eriophyes mangiferae* (Sayed) (p. 74).
		Leaf coating	*Cisaberoptus kenyae* Keifer (p. 156).
Rhus:			
diversiloba Torr. & A. Gray	Poison oak	Leaf gall	*Aculops toxicophagus* (Ewing) (p. 36).
radicans L.	Poison ivy	do	*Aculops toxicophagus* (Ewing) (p. 36).
vernix L.	Poison sumac	do	*Aculops toxicophagus* (Ewing) (p. 36).
ANNONACEAE			
Annona muricata L.	Soursop	Erineum	*Eriophyes annonae* Keifer (p. 106).
ARALIACEAE			
Hedera helix L.	English ivy	Leaf deformation, stunting	*Phytocoptella hedericola* Keifer.[2]
BERBERIDACEAE			
Mahonia dictyota (Jeps.) Fedde.	Holly grape, Oregon grape	Leaf fold, twisting	*Eriophyes caliberberis* (Keifer) (p. 142).
BETULACEAE			
Alnus:			
oregona Nutt. (= *rubra* Bong.).	Oregon alder, red alder	Leaf gall	*Phytoptus laevis* Nalepa (p. 38).
rhombifolia Nutt.	White alder	do	*Phytoptus laevis* Nalepa (p. 38).
rugosa (Du Roi) K. Spreng.	Hazel alder	do	*Phytoptus laevis* Nalepa (p. 38).
tenuifolia Nutt.	Mountain alder	do	*Phytoptus laevis* Nalepa (p. 38).

See footnotes at end of table.

TABLE 1.—Host plants, symptoms of injuries, and mites—Continued

Host plant[1]		Symptom of injury	Mite
Scientific name	Common name		
Alnus sp.	Alder	Erineum	*Acalitus brevitarsus* (Fockeu).[2]
Corylus avellana L.	Filbert, hazelnut	Big bud or bud gall	*Phytocoptella avellanae* (Nalepa) (p. 76).
		Bronzing, leaf edge roll, russeting.	*Aculus comatus* (Nalepa) (p. 76).
		Summer big bud	*Cecidophyopsis vermiformis* (Nalepa) (p. 76).
CAPRIFOLIACEAE			
Symphoricarpos rivularis Suksd.	Snowberry	Leaf roll	*Phyllocoptes triacis* Keifer (p. 144).
CARYOPHYLLACEAE			
Dianthus caryophyllus L.	Carnation	Colorless, distorted, greasy, stunted growth.	*Eriophyes paradianthi* (Keifer).[2]
COMPOSITAE			
Baccharis:			
glutinosa Pers.	Seep willow	Leaf gall	*Eriophyes baccharices* (Keifer) (p. 40).
pilularis var. *consanguinea* (D. C.) O. Kuntze.	Chaparral broom	.....do	*Eriophyes baccharipha* (Keifer) (p. 40).
viminea D. C.	Mule-fat	.....do	*Eriophyes baccharices* (Keifer) (p. 40).
Chondrilla juncea L.	Skeletonweed	Bud gall	*Eriophyes chondrillae* (Canestrini) (p. 78).
Chrysanthemum sp.	Common chrysanthemum	Brooming, bud clustering, discoloration, shortened internodes, stunting and backward curling of apical leaves.	*Paraphytoptus chrysanthemi* Keifer.[2]
Lepidospartum squamatum Gray (Gray).		Bud gall	*Eriophyes lepidosparti* (Keifer) (p. 80).

See footnotes at end of table.

TABLE 1.—Host plants, symptoms of injuries, and mites—Continued

Host plant[1]		Symptom of injury	Mite
Scientific name	Common name		
CONVOLVULACEAE			
Ipomoea batatas (L.) Lam.	Sweetpotato, yam	Leaf and stem deformation	*Eriophyes gastrotrichus* Nalepa.[2]
CUPRESSACEAE			
Juniperus:			
californica Carr.	California juniper	Berry gall, deformed, shriveled berries.	*Trisetacus quadrisetus* (Thomas) (p. 82).
occidentalis Hook.	Sierra juniper	do	*Trisetacus quadrisetus* (Thomas) (p. 82).
scopulorum Sarg.	Rocky Mountain juniper	do	*Trisetacus neoquadrisetus* Smith, *T. quadrisetus* (Thomas) (p. 82).
virginiana L.	Red cedar	do	*Trisetacus batonrougei* Smith (p. 82).
EBENACEAE			
Diospyros virginiana L.	Common persimmon	Blackened fruit surface under button and stem, premature fruit drop.	*Eriophyes diospyri* (Keifer).[2]
ERICACEAE			
Gaylussacia baccata (Wangenh.) C. Koch.	Huckleberry	Bud blister, rosette fruit deformation.	*Acalitus vaccinii* (Keifer) (p. 134).
Vaccinium spp.	Blueberry	do	*Acalitus vaccinii* (Keifer) (p. 134).
FAGACEAE			
Fagus grandifolia J. F. Ehrh.	American beech	Erineum	*Acalitus fagerinea* (Keifer) (p. 108).
Quercus:			
agrifolia Née	California live oak	Brooming at lower tree level.	*Eriophyes paramackiei* Keifer (p. 110).
		Erineum	*Eriophyes mackiei* Keifer (p. 110).
alba L.	White oak	do	*Eriophyes triplacis* (Keifer) (p. 110).

See footnotes at end of table.

TABLE 1.—Host plants, symptoms of injuries, and mites—Continued

Host plant[1]		Symptom of injury	Mite
Scientific name	Common name		
GRAMINEAE			
Agropyron sp.	Wheatgrass	Wheat streak mosaic virus disease.	*Eriophyes tulipae* Keifer (p. 160).
Avena sativa L.	Oats	....do....	*Eriophyes tulipae* Keifer (p. 160).
Cynodon dactylon (L.) Pers.	Bermuda grass	Leaf blade and terminal shoot distortion.	*Eriophyes cynodonis* (Wilson) (p. 146).
		Leaf sheath and stem gall	*Eriophyes cynodoniensis* (Sayed) (= *Aceria neocynodonis* Keifer) (p. 84).
Elymus:			
canadensis L.	Canada wild rye	Wheat streak mosaic virus disease.	*Eriophyes tulipae* Keifer (p. 160).
virginicus L.	Virginia wild rye	....do....	*Eriophyes tulipae* Keifer (p. 160).
Hordeum vulgare L.	Barley	Ryegrass mosaic virus disease.	*Abacarus hystrix* (Nalepa).[2]
		Wheat streak mosaic virus disease.	*Eriophyes tulipae* Keifer (p. 160).
Lolium sp.	Ryegrass	Ryegrass mosaic virus disease.	*Abacarus hystrix* (Nalepa).[2]
Oryza sativa L.	Rice	....do....	*Abacarus hystrix* (Nalepa).[2]
Oryzopsis hymenoides (Roem. & Schult.) Ricker.	Indian ricegrass	Wheat streak mosaic virus disease.	*Eriophyes tulipae* Keifer (p. 160).
Phleum sp.	Timothy	Ryegrass mosaic virus disease.	*Abacarus hystrix* (Nalepa).[2]
Poa compressa L.	Canada bluegrass	Wheat streak mosaic virus disease.	*Eriophyes tulipae* Keifer (p. 160).
Secale cereale L.	Rye	....do....	*Eriophyes tulipae* Keifer (p. 160).
Triticum aestivum L.	Wheat	Ryegrass mosaic virus desease.	*Abacarus hystrix* (Nalepa).[2]
		Trapped leaves, wheat spot mosaic virus disease, wheat streak mosaic virus disease.	*Eriophyes tulipae* Keifer (p. 160).

See footnotes at end of table.

TABLE 1.—Host plants, symptoms of injuries, and mites—Continued

Host plant[1]		Symptom of injury	Mite
Scientific name	Common name		
GRAMINEAE (con.)			
Zea mays L.	Corn	Distorted, stunted growth of corn in southern greenhouses.	*Eriophyes zeasinis* (Keifer).[2]
		Kernel red streak, leaf curling or rolling, wheat spot mosaic virus disease, wheat streak mosaic virus disease.	*Eriophyes tulipae* Keifer (p. 160).
JUGLANDACEAE			
Carya illinoinensis (Wangenh.) C. Koch (= *C. pecan* (Marsh.) Engl. & Graebn.).	Pecan	Leaf edge, spotting	*Eriophyes caryae* Keifer.[2]
Juglans:			
californica S. Wats.	California walnut	Catkin gall	*Eriophyes neobeevori* Keifer (p. 86).
		Leaf gall	*Eriophyes brachytarsus* Keifer (= *E. amiculus* Keifer, *E. brevitarsus* Keifer) (p. 42).
cinerea L.	Butternut	Erineum	*Eriophyes cinereae* Keifer (p. 112).
hindsii (Jeps.) Jeps.	Hind's walnut	Catkin gall	*Eriophyes spermaphaga* Keifer (p. 86).
		Leaf gall	*Eriophyes brachytarsus* Keifer (= *E. amiculus* Keifer, *E. brevitarsus* Keifer) (p. 42).
major (Torr.) A. Heller	Arizona walnut	.....do.....	*Eriophyes microcarpae* Keifer (p. 42).
microcarpa Berland	Little walnut	.....do.....	*Eriophyes microcarpae* Keifer (p. 42).
nigra L.	Black walnut	Petiole gall	*Eriophyes caulis* Cook (p. 44).
regia L.	English walnut	Erineum	*Eriophyes erineus* (Nalepa), *E. tristriatus* (Nalepa) (p. 114).

See footnotes at end of table.

TABLE 1.—Host plants, symptoms of injuries, and mites—Continued

Host plant[1]		Symptom of injury	Mite
Scientific name	Common name		
LEGUMINOSAE			
Medicago sativa L.	Alfalfa	Witches'-broom	*Eriophyes medicaginis* Keifer.[2]
LILIACEAE			
Aloe:			
nobilis Haw.	Golden-tooth aloe	Leaf and inflorescence gall	*Eriophyes aloinis* Keifer (p. 46).
spinosissima Hort. ex A. Berger.	Spider aloe	do	*Eriophyes aloinis* Keifer (p. 46).
Haworthia sp.	Star cactus, wart plant	do	*Eriophyes aloinis* Keifer (p. 46).
Tulipa sp.	Tulip	Bulb damage	*Eriophyes tulipae* Keifer (p. 160).
MALVACEAE			
Gossypium spp.	Cultivated and wild cotton	Bud injury, foliage deformation, leaf blister.	*Acalitus gossypii* (Banks) (p. 136).
MELIACEAE			
Sandoricum koetjape (Burm. F.) Merr.	Santol	Leaf gall	*Eriophyes sandorici* Nalepa (p. 48).
MORACEAE			
Ficus carica L.	Fig	Mosaic virus disease	*Eriophyes ficus* Cotte (p. 162).
NYSSACEAE			
Nyssa sylvatica Marsh.	Pepperidge, sour-gum, tupelo.	Leaf edge roll	*Eriophyes dinus* Styer & Keifer (p. 148).
		Leaf gall	*Cenalox conyssae* Styer & Keifer, *C. nyssae* Keifer, *Eriophyes nyssae* Trotter (p. 148).
OLEACEAE			
Fraxinus:			
americana L.	White ash	do	*Eriophyes chondriphora* (Keifer) (p. 50).

See footnotes at end of table.

TABLE 1.—Host plants, symptoms of injuries, and mites—Continued

Host plant[1]		Symptom of injury	Mite
Scientific name	Common name		
OLEACEAE (con.)			
excelsior L.	European ash	Leaf gall	*Eriophyes fraxinicola* (Nalepa) (p. 50).
latifolia Benth.	Oregon ash	.....do	*Eriophyes chondriphora* (Keifer) (p. 50).
pennsylvanica var. *lanceolata* Bork.	Green ash, red ash	.....do	*Eriophyes chondriphora* (Keifer) (p. 50).
Fraxinus sp.	Ash	Inflorescence gall	*Eriophyes fraxinivorus* Nalepa (p. 88).
PALMAE			
Chamaedorea sp.	Ornamental palm	Black blotches on underside of leaf, waxy secretion.	*Retracrus johnstoni* Keifer.[2]
Cocos nucifera L.	Coconut	Flower and fruit injury, premature fruit drop.	*Eriophyes guerreronis* (Keifer) (p. 120).
Elaeis guineensis Jacq.	African oil palm	Black and yellow leaves, leaf blade speckling.	*Retracrus elaeis* Keifer (p. 122).
PINACEAE			
Pinus:			
clausa (Chapm.) Vasey	Sand pine	Aborted buds, rosette gall, stunted needles.	*Trisetacus floridanus* Keifer (p. 90).
elliottii Engelm.	Slash pine	.....do	*Trisetacus floridanus* Keifer (p. 90).
glabra Walt.	Cedar pine	.....do	*Trisetacus floridanus* Keifer (p. 90).
lambertiana Dougl.	Sugar pine	.....do	*Trisetacus alborum* Keifer (p. 90).
monticola Dougl. ex D. Don	Western white pine	.....do	*Trisetacus alborum* Keifer (p. 90).
strobus L.	Eastern white pine, white pine.	.....do	*Setoptus strobacus* Keifer.[2]
sylvestris L.	Scotch pine	.....do	*Trisetacus campnodus* Keifer & Saunders, *T. gemmavitians* Styer, Nielsen, & Balderston (p. 90).

See footnotes at end of table.

TABLE 1.—Host plants, symptoms of injuries, and mites—Continued

Host plant[1]		Symptom of injury	Mite
Scientific name	Common name		
Pseudotsuga menziesii (Mirb.) Franco.	Douglas fir	.....do.....	*Trisetacus pseudotsugae* Keifer (p. 90).
POLYPODIACEAE			
Pteridium aquilinum var.:			
lanuginosum (Bong.) Fern.	Bracken	Pinnule gall	*Phytoptus helicantyx* (Keifer) (p. 52).
latiusculum (Desv.) Underwood.	.....do.....	.....do.....	*Phytoptus helicantyx* (Keifer) (p. 52).
PUNICACEAE			
Punica granatum L.	Pomegranate	Leaf roll	*Eriophyes granati* (Canestrini & Massalongo) (p. 150).
RHAMNACEAE			
Ceanothus velutinus Dougl.	Redroot	Leaf gall	*Eriophyes ceanothi* Keifer (p. 54).
Rhamnus californica Eschsch.	Coffeeberry	Atrophied, coalesced veins, deformed leaves.	*Thamnacus rhamnicola* (Keifer) (p. 152).
ROSACEAE			
Adenostoma fasciculatum Hook. & Arn.	Greasewood	Leaf gall	*Phytoptus adenostomae* Keifer (p. 56).
Malus pumila Mill.	Apple	Browning underside of leaves.	*Calepitrimerus baileyi* Keifer.[2]
		Injured terminal growth, leaf curl lengthwise, russeting.	*Aculus schlechtendali* (Nalepa).[2]
Prunus:			
americana Marsh.	Wild plum	Leaf gall	*Phytoptus emarginatae* (Keifer) (p. 58).
domestica L.	Common or European plum.	Bud gall	*Acalitus phloeocoptes* (Nalepa) (p. 92).
		Leaf gall	*Phytoptus emarginatae* (Keifer) (p. 58).

See footnotes at end of table.

TABLE 1.—Host plants, symptoms of injuries, and mites—Continued

Host plant[1]		Symptom of injury	Mite
Scientific name	Common name		
ROSACEAE (con.)			
dulcis var. *dulcis* (Mill.) D. A. Webb.	Almond	Bud gall	*Acalitus phloeocoptes* (Nalepa) (p. 92).
		Leaf silvering, yellow spot.	*Aculus cornutus* (Banks) (p. 124).
emarginata (Dougl. ex Hook.) Walp.	Bitter cherry	Leaf gall	*Phytoptus emarginatae* (Keifer) (p. 58).
munsoniana Wight & Hedr..	Wild-goose plum	.....do.....	*Phytoptus emarginatae* (Keifer) (p. 58).
persica (L.) Batsch	Peach	Leaf silvering, yellow spot.	*Aculus cornutus* (Banks) (p. 124).
		Mosaic virus disease	*Phytoptus insidiosus* (Wilson & Keifer).[2]
persica var. *nucipersica* (Suckow) C. K. Schneid.	Nectarine	Leaf silvering, yellow spot	*Aculus cornutus* (Banks) (p. 124).
serotina J. F. Ehrh.	Blackcherry	Leaf gall	*Phytoptus cerasicrumena* Walsh (p. 60).
subcordata Benth.	Sierra plum	.....do.....	*Phytoptus emarginatae* (Keifer) (p. 58).
virginiana var. *demissa* (Nutt.) Sarg.	Chokecherry	.....do.....	*Phytoptus emarginatae* (Keifer) (p. 58).
Prunus spp.	Cherries, plums	Abnormal leaves, asteroid spots, chlorotic flecks on leaves, rosette shoots.	*Aculus fockeui* (Nalepa & Trouessart).[2]
Pyrus communis L.	Common pear, pear	Leaf blister	*Phytoptus pseudoinsidiosus* (Wilson), *P. pyri* Pagenstecher (p. 138).
Rosa spp.	Cultivated and wild roses	Rose rosette virus disease	*Phyllocoptes fructiphilus* Keifer (p. 164).
Rubus:			
procerus P. J. Muell.	Himalaya berry	Delayed drupelet ripening, redberry disease.	*Acalitus essigi* (Hassan) (p. 126).
vitifolius Cham. & Schlectend.	Blackberry	.....do.....	*Acalitus essigi* (Hassan) (p. 126).

See footnotes at end of table.

TABLE 1.—Host plants, symptoms of injuries, and mites—Continued

Host plant[1]		Symptom of injury	Mite
Scientific name	Common name		
Rubus spp.	Boysenberry, dewberry, native blackberry.	Bud distortion, shoot stunting.	*Acalitus orthomera* (Keifer) (p. 126).
Sorbus:			
californica Greene	Mountain ash	Erineum	*Phyllocoptes calisorbi* Keifer (p. 140).
scopulina Greene	do	Leaf blister	*Phytoptus sorbi* Canestrini (p. 140).
Spiraea densiflora Nutt. ex Rydb.	Bridal-wreath	Inflorescence gall	*Phytoptus paraspiraeae* Keifer (p. 92).
Spiraea sp.	do	do	*Phytoptus spiraeae* Nalepa (p. 92).
RUBIACEAE			
Cephalanthus occidentalis L.	Buttonbush	Leaf gall	*Eriophyes cephalanthi* Cook (= *E. newkirki* Keifer) (p. 62).
RUTACEAE			
Citrus spp.	Grapefruit, lemon, lime, orange, other citrus.	Bronzing and russeting of fruit, leaves, twigs.	*Phyllocoptruta oleivora* (Ashmead) (p. 128).
		Deformed buds, flowers, fruit, leaves.	*Eriophyes sheldoni* Ewing (p. 154).
SALICACEAE			
Populus:			
fremontii S. Wats.	Fremont cottonwood	Catkin gall	*Aceria populinquis* Keifer,[3] *Eriophyes neoessigi* Keifer (p. 94).
tremuloides Michx.	Quaking aspen	do	*Eriophyes neoessigi* Keifer (p. 94).
		Leaf gall	*Aculus dormitor* (Keifer),[3] *Phyllocoptes didelphis* Keifer (p. 64).

See footnotes at end of table.

TABLE 1.—Host plants, symptoms of injuries, and mites—Continued

Host plant[1]		Symptom of injury	Mite
Scientific name	Common name		
SALICACEAE (con.)			
Populus sp.	Poplar	Bud gall	*Eriophyes parapopuli* Keifer (p. 96).
		Catkin gall	*Eriophyes neoessigi* Keifer (p. 94).
Salix spp.	Willow	.....do	*Aculops aenigma* (Walsh) (p. 66).
		Leaf gall	*Aculops tetanothrix* (Nalepa) (p. 66).
SAPINDACEAE			
Erioglossum rubiginosum (Roxb.) Blume.		Leaf webbing	*Aculops knorri* Keifer (p. 158).
Litchi chinensis Sonn.	Litchi, lychee	Erineum	*Eriophyes litchii* Keifer (p. 116).
SAXIFRAGACEAE			
Ribes:			
americanum Mill.	American black currant	Abnormal flowers, bud gall, distorted foliage, short twiggy side shoots, virus disease.	*Cecidophyopsis ribis* (Westwood).[2]
divaricatum Dougl.	Coastal black gooseberry	Leaf gall	*Eriophyes breakeyi* (Keifer) (p. 68).
roezlii Regel	Sierra gooseberry	.....do	*Eriophyes breakeyi* (Keifer) (p. 68).
SOLANACEAE			
Datura inoxia Mill.	Datura	Foliage browning and withering, fruit russeting.	*Aculops lycopersici* (Massee) (= *Phyllocoptes destructor* Keifer) (p. 130).
Lycopersicon lycopersicum (L.) Karst. ex Farw.	Tomato	.....do	*Aculops lycopersici* (Massee) (= *Phyllocoptes destructor* Keifer) (p. 130).
Petunia sp.	Petunia	.....do	*Aculops lycopersici* (Massee) (= *Phyllocoptes destructor* Keifer) (p. 130).

See footnotes at end of table.

TABLE 1.—Host plants, symptoms of injuries, and mites—Continued

Host plant[1]		Symptom of injury	Mite
Scientific name	Common name		
Solanum:			
nigrum L.	Common nightshade	do	*Aculops lycopersici* (Massee) (= *Phyllocoptes destructor* Keifer) (p. 130).
sodomeum L.	Popolo	do	*Aculops lycopersici* (Massee) (= *Phyllocoptes destructor* Keifer) (p. 130).
tuberosum L.	Potato	do	*Aculops lycopersici* (Massee) (= *Phyllocoptes destructor* Keifer) (p. 130).
TAXODIACEAE			
Sequoia sempervirens (D. Don) Endl.	Redwood	Bud and terminal shoot injury.	*Trisetacus sequoiae* Keifer (p. 98).
THEACEAE			
Camellia japonica L.	Common camellia	Discoloration of bud scales, floral parts, and leaves.	*Acaphylla steinwedeni* Keifer, *Calacarus carinatus* (Green) (= *"Epitrimerus" adornatus* Keifer), *Cosetacus camelliae* (Keifer) (p. 132).
TILIACEAE			
Tilia americana L.	American linden, basswood	Leaf gall	*Phytocoptella abnormis* (Garman).[2]
Tilia spp.	Basswood, lime tree, linden	do	*Phytoptus tiliae* Pagenstecher (p. 70).
ULMACEAE			
Celtis occidentalis L.	Hackberry	Bud gall, witches'-broom	*Eriophyes celtis* Kendall (= *Aceria snetsingeri* Keifer) (p. 100).
Ulmus americana L.	American elm	Leaf gall	*Eriophyes parulmi* (Keifer), *E. ulmi* (Garman) (p. 72).

See footnotes at end of table.

TABLE 1.—Host plants, symptoms of injuries, and mites—Continued

Host plant[1]		Symptom of injury	Mite
Scientific name	Common name		
UMBELLIFERAE			
Daucus carota var. *sativus* Hoffm.	Carrot	Deformed leaves and umbels, greenish dwarfed plant, mosaic appearance, seed failure, undersize root.	*Eriophyes peucedani* (Canestrini).[2]
VERBENACEAE			
Lantana camera L.	Yellow sage	Deformed flowers, mass of small leaflike outgrowths.	*Eriophyes lantanae* Cook.[2]
VITACEAE			
Vitis spp.	Grape	Abnormal growth, bunched foliage, injured flowers, shortened internodes.	*Calepitrimerus vitis* (Nalepa).[2]
		Deformation of bud clusters and leaves, erineum.	*Colomerus vitis* (Pagenstecher) (p. 118).

[1]Source for botanical names: Bailey, L. H., and Bailey, E. Z., "Hortus Third, a Concise Dictionary of Plants Cultivated in the United States and Canada," Macmillan Pub. Co., Inc., New York, 1976.
[2]From Jeppson et al. (*1975*). These species are not discussed or illustrated in the text.
[3]Inquiline in gall or erineum.

Host Symptoms of Eriophyid Feeding as Taxonomic Characters

The taxonomic value of host-mite data is considerable. The kind of host plant, the part that is infested, and the characteristics of the resultant injury are useful in making identifications. However, we urge caution when employing eriophyid injury as a diagnostic character because similar plant injury may be induced by other organisms. It is important that all relevant field data be analyzed before attempting to determine the mite taxon in question. Also knowing the correct identity of the host plant is useful since most eriophyid species are relatively host specific. Proper determination of the plant will limit the identity of the mite to a small group of species that occurs on the host.

Symptoms of mite feeding generally are rather specific and have diagnostic merit. For example, general appearance, such as shape, size, color, and position of galls on the host plant, can be very useful. The greatest diversity of galls occurs on leaves. Galls may be elongate, clavate, hemispherical, rounded, or beadlike; they may be scattered haphazardly over the leaf blade, or they may be restricted in the angles between the veins; they may be solitary, coalesced, or in clusters; they may be visible on the upper surface of the leaf, on both surfaces, or on the undersurface only. Galls are also formed on other parts of the plant, including leaf petioles, catkin flowers, flower buds, leaf buds, and leaf axils. Interior gall structures also may provide important characters. Examples of diagnostic differences are illustrated in plates 5–7; others are discussed in Jeppson et al. (*1975*).[2]

Injury symptoms, such as silvering, blistering, leaf coating and webbing, russeting, erineum, and big bud, also are useful taxonomically. Erineum structure has several diagnostic aspects, including position on the leaves, density of hairs, and color; hairs may be elongate, clavate, capitate, unicellular, or multicellular.

[2]The year in italic after authors' names indicates the reference listed on pp. 166–170.

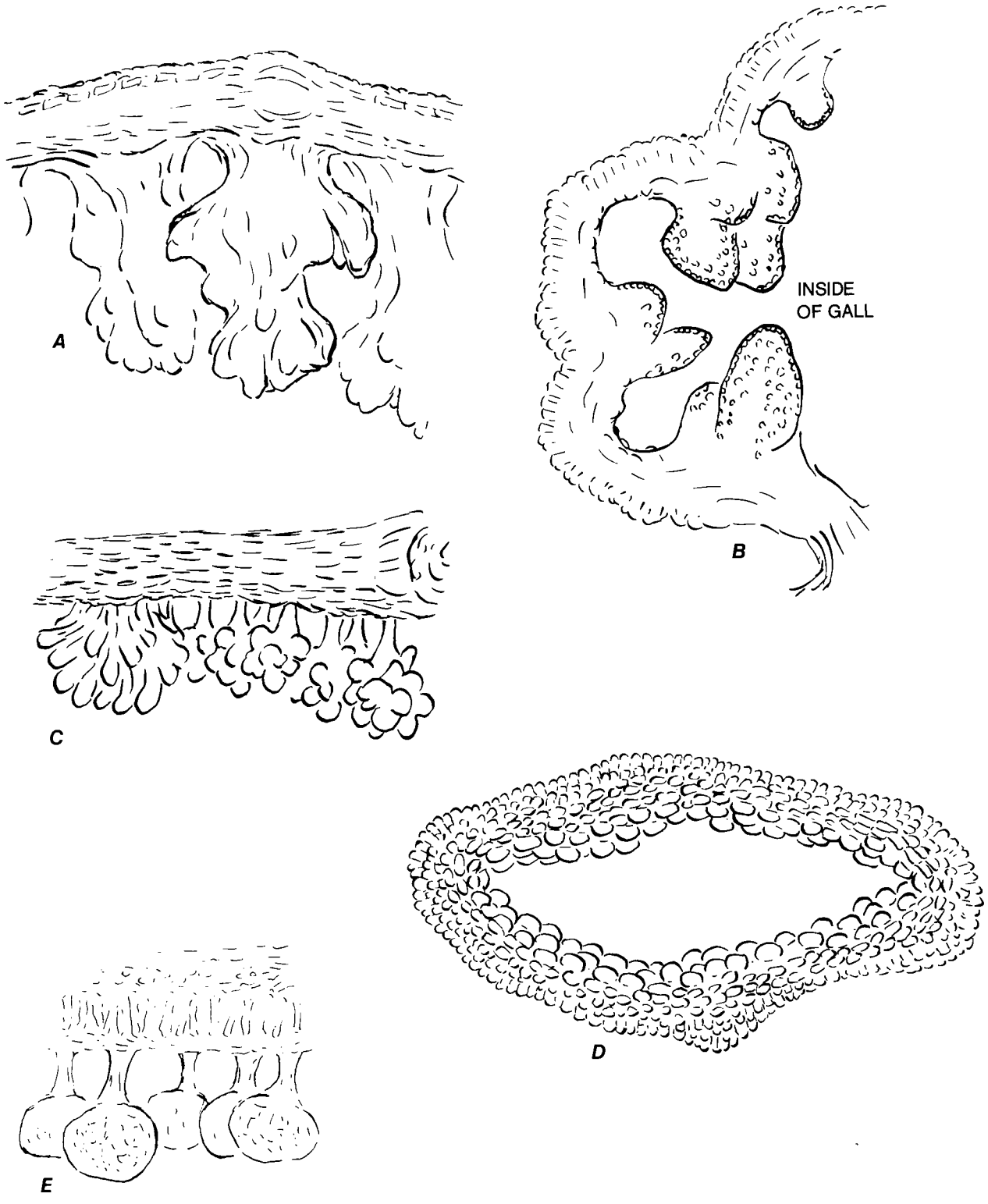


PLATE 5.—Structures of galls and erineum: *A,* Interior of leaf gall on aspen caused by *Phyllocoptes didelphis* Keifer; *B,* interior of bladder gall on silver maple caused by *Vasates quadripedes* Shimer; *C,* compound capitate erineum on fern caused by *Eriophyes* sp.; *D,* cross section of finger gall on plum caused by *Phytoptus padi* Nalepa; *E,* simple capitate erineum on sugar maple caused by *Eriophyes elongatus* Hodgkiss.

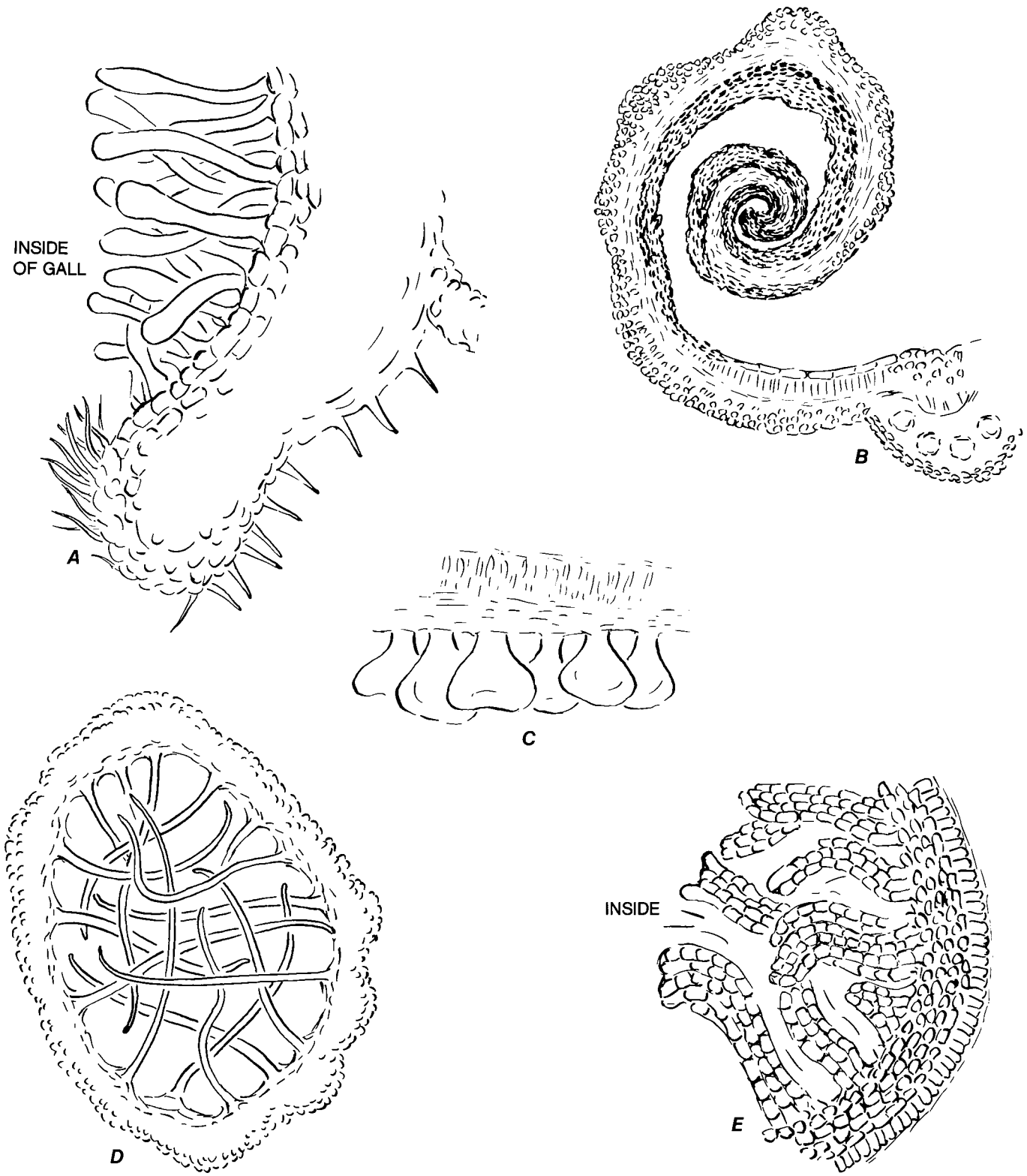


PLATE 6.—Structures of galls and erineum: *A,* Interior of leaf gall on *Prunus* sp. caused by *Eriophyes similis* (Nalepa); *B,* cross section of leaf roll gall on pistachio caused by *E. stefanii* Nalepa; *C,* simple capitate erineum on sugar maple caused by *E. modestus* Hodgkiss; *D,* cross section of nail gall on linden caused by *Phytoptus tiliae* Pagenstecher; *E,* interior of pouch gall on walnut caused by *E. brachytarsus* Keifer.

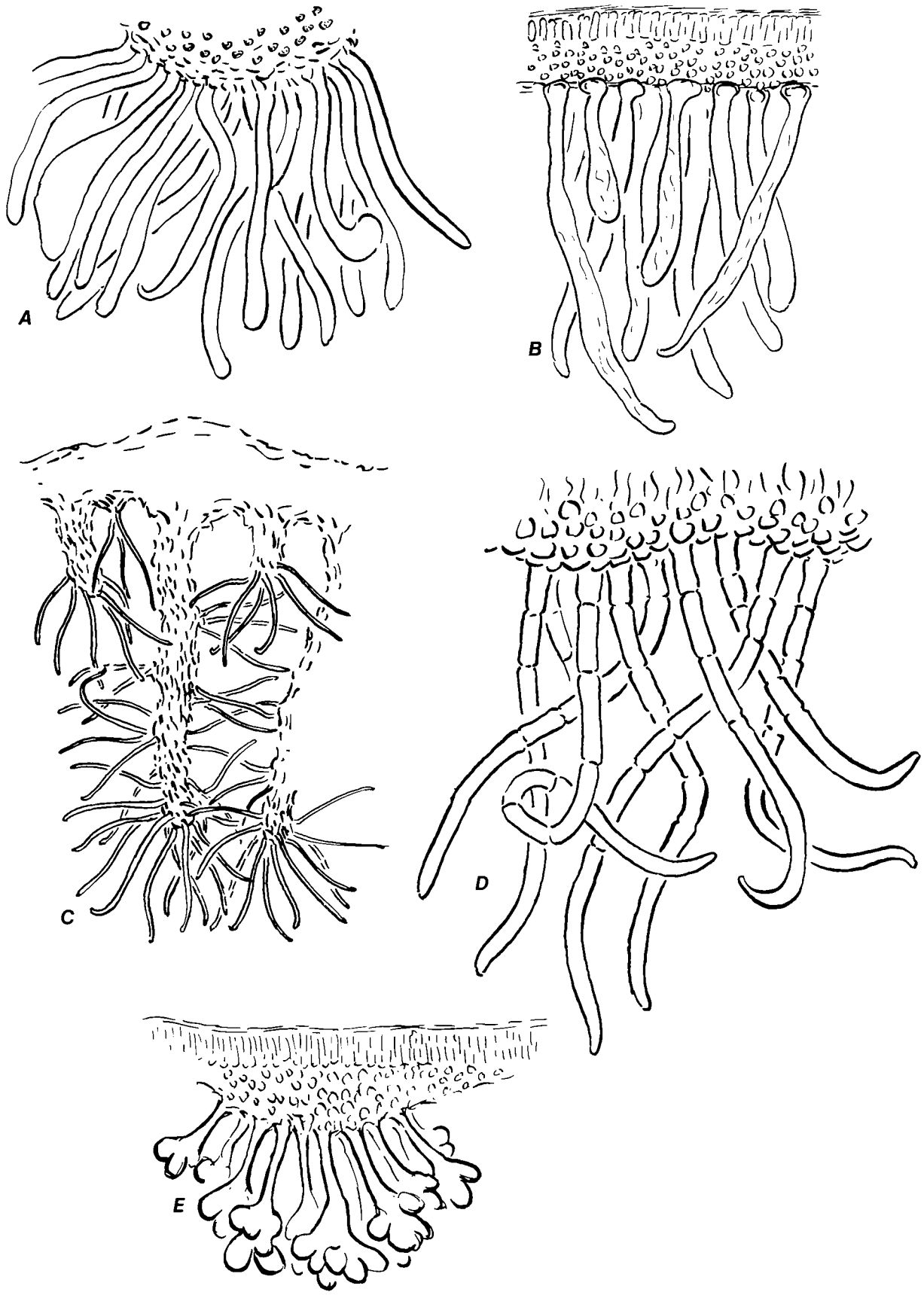


PLATE 7.—Structures of erineum: *A*, Unicellular hairlike erineum of petiole gall on black walnut caused by *Eriophyes caulis* Cook; *B*, unicellular erineum on mountain ash leaf caused by *Phyllocoptes calisorbi* Keifer; *C*, erineum on English walnut caused by *E. erineus* (Nalepa); *D*, multicellular hairlike erineum on litchi leaf caused by *E. litchii* Keifer; *E*, compound capitate erineum on alder leaf caused by *Acalitus brevitarsus* (Fockeu).

Economic Importance

Eriophyid mites are important pests of such diverse crops as wheat, citrus, and pomegranates. They have been incriminated as vectors of mosaic viruses on such important crops as wheat, corn, and figs. Injury and disfigurement are commonplace on ornamental trees and shrubs in urban areas.

This manual will aid field workers to recognize eriophyid injury so that control procedures can be undertaken before problems become serious. It should help field personnel make accurate species determinations and thus eliminate misidentifications that often lead to incorrect or ineffective applications of pesticides.

Eriophyid Research

Eriophyid systematic research is a surprisingly neglected area considering the group's economic importance. The works of H. H. Keifer essentially are the only comprehensive studies of North American eriophyids, but even their emphasis is on California fauna. Because of the enormity of the group, Keifer, of necessity, has had to restrict his efforts almost entirely to descriptions of new species. Very little is known about the biology of eriophyids. Investigations on mite-host interactions are urgently needed. For example, little is known about the mechanisms by which eriophyid feeding provokes proliferation of plant tissues and produces such complex structures as leaf galls, erineum, leaf rolls, and witches'-brooms. Westphal (*1977*) published an excellent paper on the morphogenesis, ultrastructure, and etiology of some eriophyid galls in Europe. This study illustrates the complex organization and wide range of morphogenetic patterns of plant galls caused by eriophyid mites.

Literature on the eriophyids is generally scattered and often fragmented. Information on plant injury is especially difficult to locate. It is often included in general publications on gall morphology and biology (Kendall, *1930;* Felt, *1940;* Shevchenco, *1958;* Buhr, *1964;* Mani, *1964;* Farkas, *1965;* Darlington, *1968*) and may not be seen by most acarologists. Selected eriophyid references are given in Nalepa (*1929*), Jeppson et al. (*1975*), and Westphal (*1977*).

Leaf Galls

Aceraceae

Acer negundo **L. Box Elder**

Leaf gall caused by *Eriophyes negundi* Hodgkiss (pl. 8)

The galls are large, rounded, and peculiarly pouchtype. They develop on the underside of the leaf blade as thickened cavities filled with a dense mass of felty, whitish, unicellular hairs. They protrude on the upper side and have slightly wrinkled domes. Their dimensions are variable. The galls are solitary and widespread on the leaf blade but are not on the veins.

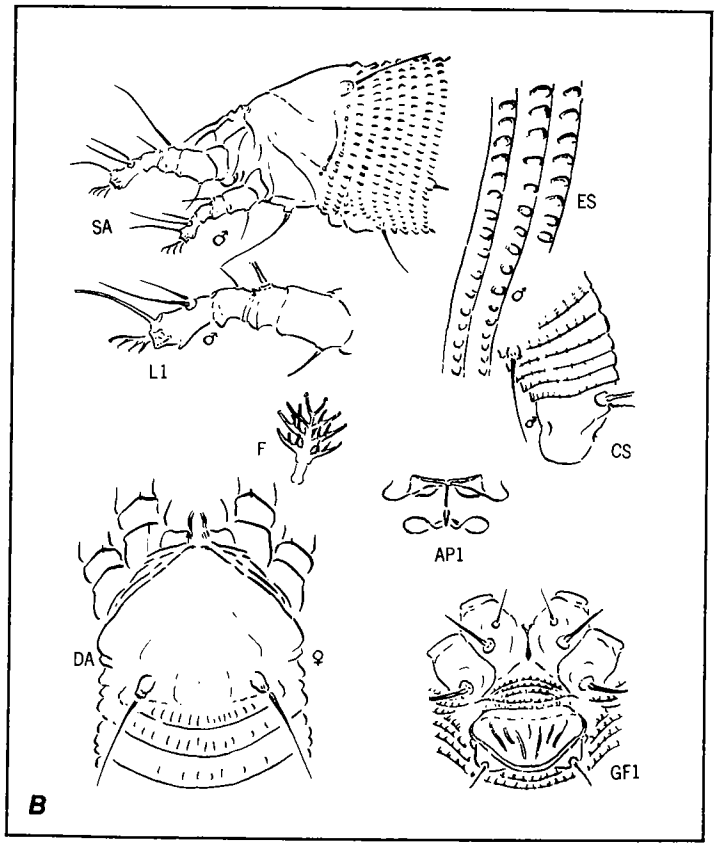
Eriophyes negundi is a slender, spindle-shaped, whitish mite; the female measures about 220 microns long and the male 200 microns. The featherclaws are four-rayed; the dorsal shield is marked with longitudinal ridges; the hysterosoma of the male and female (protogyne) is entirely covered with microtubercles, whereas that of the overwintering female (deutogyne) has microtubercles only on the ventral side; and the coverflap of the female genitalia has longitudinal ribs. The life cycle apparently involves alternation of generations. The mites usually are found in the galls until the leaves mature.

Specimens were collected in galls on box elder in New York, Illinois, and Canada and recently in Ohio. Hodgkiss (*1930*) reported two species of *Phyllocoptes* in galls of box elder in New York; they should not be confused with *E. negundi.*

References: Hodgkiss, *1913: 423; 1930: 35–37.*

PLATE 8.—*A,* Leaf galls on box elder: Left, undersurface; right, upper surface. *B, Eriophyes negundi* Hodgkiss. (AP1, internal female genitalia; CS, hysterosoma, posterior lateral view; DA, propodosoma and anterior of hysterosoma, dorsal view; ES, lateral microtubercles; F, featherclaw; GF1, female external genitalia and coxae; L1, left leg I; SA, propodosoma and anterior hysterosoma, lateral view.)

A


SA
♂
L1
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ES
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Aceraceae

***Acer rubrum* L. Red Maple**

***Acer saccharinum* L. Silver Maple**

Leaf gall caused by *Vasates quadripedes* Shimer (pl. 9)

The mite causes a pouch gall type known as bladder gall, which is periodically common and abundant on the upper leaf surface of red and silver maples. The galls on the latter are variable in shape, rounded or elongate. Each has a slender short stem or neck. The length varies from 1.5 to 5 mm. They are solitary and are usually crowded and numerous at the basal part of the leaf blade in the angles between the larger veins. The exterior of the galls appears wrinkled and glossy. They change from yellowish green or dark green to pink, to brown, to black. The interior is hollow, and the exit hole, which is on the underside of the leaf, is lined with unicellular whitish hairs. In heavy infestations, the leaves become curled, form cylindrical rolls, and drop prematurely. The galls on red maple differ in size and form. They are smaller, 1 to 2 mm, somewhat beadlike, and without a basal constriction or neck.

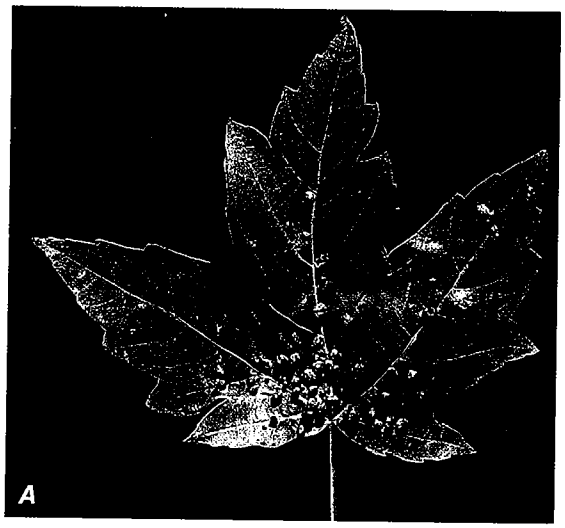
Vasates quadripedes is a spindle-shaped, whitish mite, measuring 170-220 microns long. The dorsal shield is produced anteriorly, and the dorsal setae are directed backward. The overwintering female differs by having a smooth dorsal shield and genital coverflap; it also lacks microtubercles on the dorsum of the hysterosoma; and the featherclaws are palmate and five-rayed. The male and female (protogyne) have a design on the dorsal shield, and microtubercles are over the entire hysterosoma; the featherclaws of the male are four-rayed; those of the protogyne are five-rayed and are not palmate; and the coverflap of the female genitalia is ribbed.

The life history apparently involves alternation of generations. The mites inhabit the galls throughout the summer and begin to migrate to trunk and branches as the galls become discolored. They overwinter under bark scales. An inquiline in the galls, *Eriophyes confusus* Hodgkiss, is probably the protogyne of *V. quadripedes*.

Vasates quadripedes is found on red and silver maples in the United States and Canada. In addition to bladder galls, Hodgkiss (*1913*) described four species of eriophyids that are associated with erineum on leaves of red maple in New York. They are *Eriophyes major* Hodgkiss, *E. minutissimus* (Hodgkiss), *E. ornatus* Hodgkiss (now a synonym of *E. major*), and *E. quinquilobus* (Hodgkiss). And in erineum on leaves of silver maple, *E. aceris* Hodgkiss is abundant. The erineum patches, which are on the undersurface of the leaves, are pale greenish or greenish yellow, often with a reddish tint, and later red. In July most of the erineum turns brown and becomes dry.

References: Hodgkiss, *1913: 421–424; 1930: 18, 19, 31;* Jeppson et al., *1975: 459, 498;* Keifer, *1944: 25; 1959c: 5;* Shimer, *1869: 319.*

PLATE 9.—*A,* Galls on silver maple leaf; *B,* close up of galls; *C,* galls on red maple leaf; *D,* close up of galls. *Vasates quadripedes* Shimer: *E,* Protogyne; *F,* deutogyne. (S, adult, lateral view.)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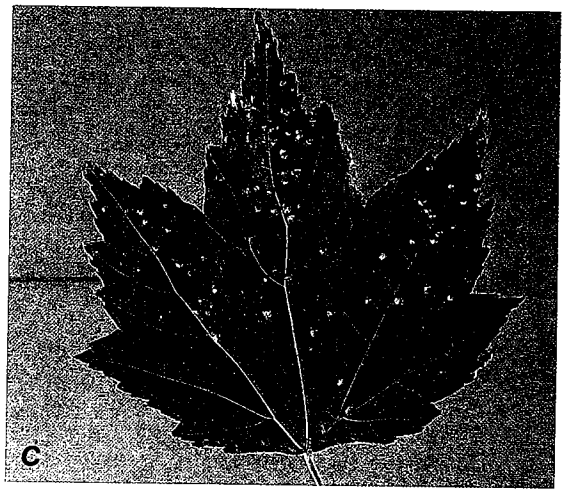
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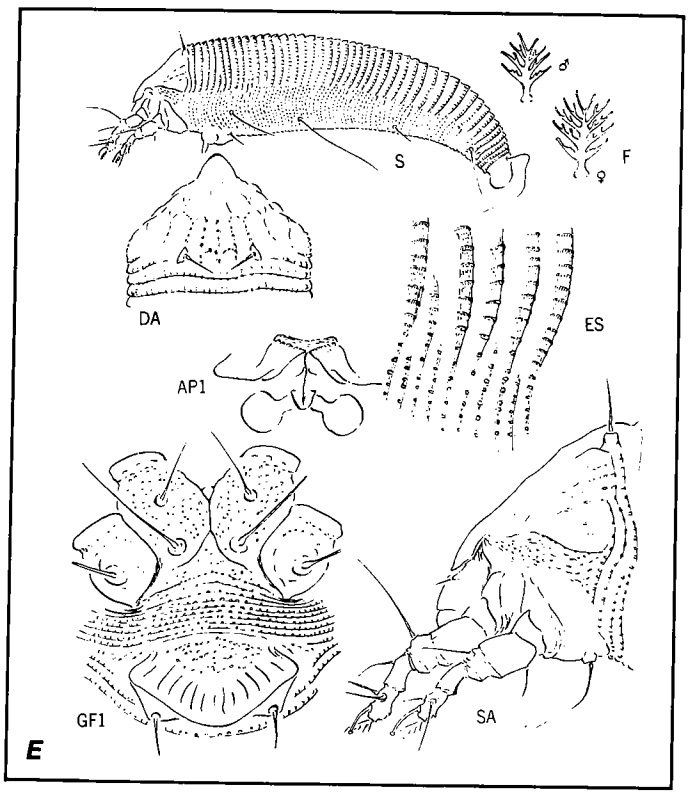
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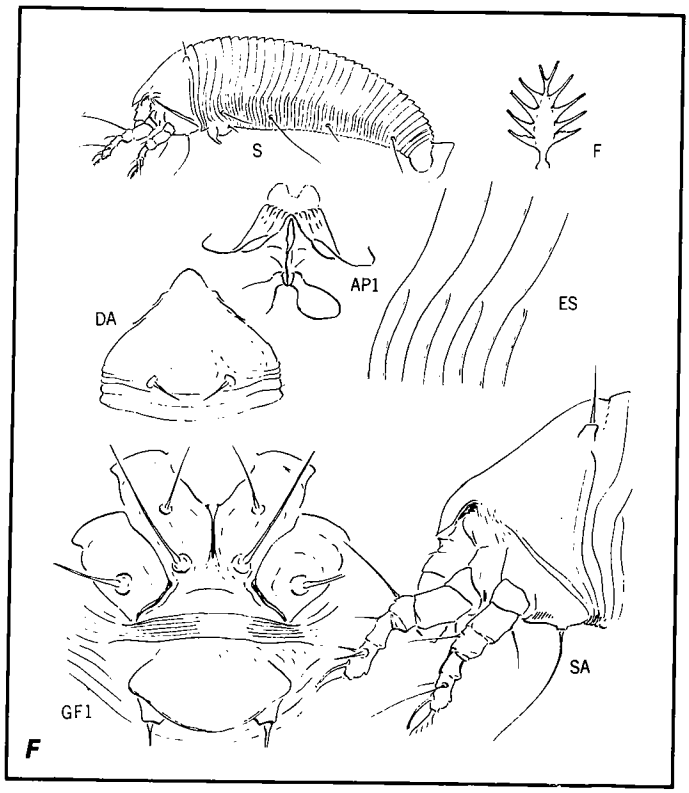
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Aceraceae

***Acer saccharum* Marsh. Sugar Maple**

Leaf gall caused by *Vasates aceriscrumena* (Riley) (= *Phytoptus acericola* Garman) (pl. 10)

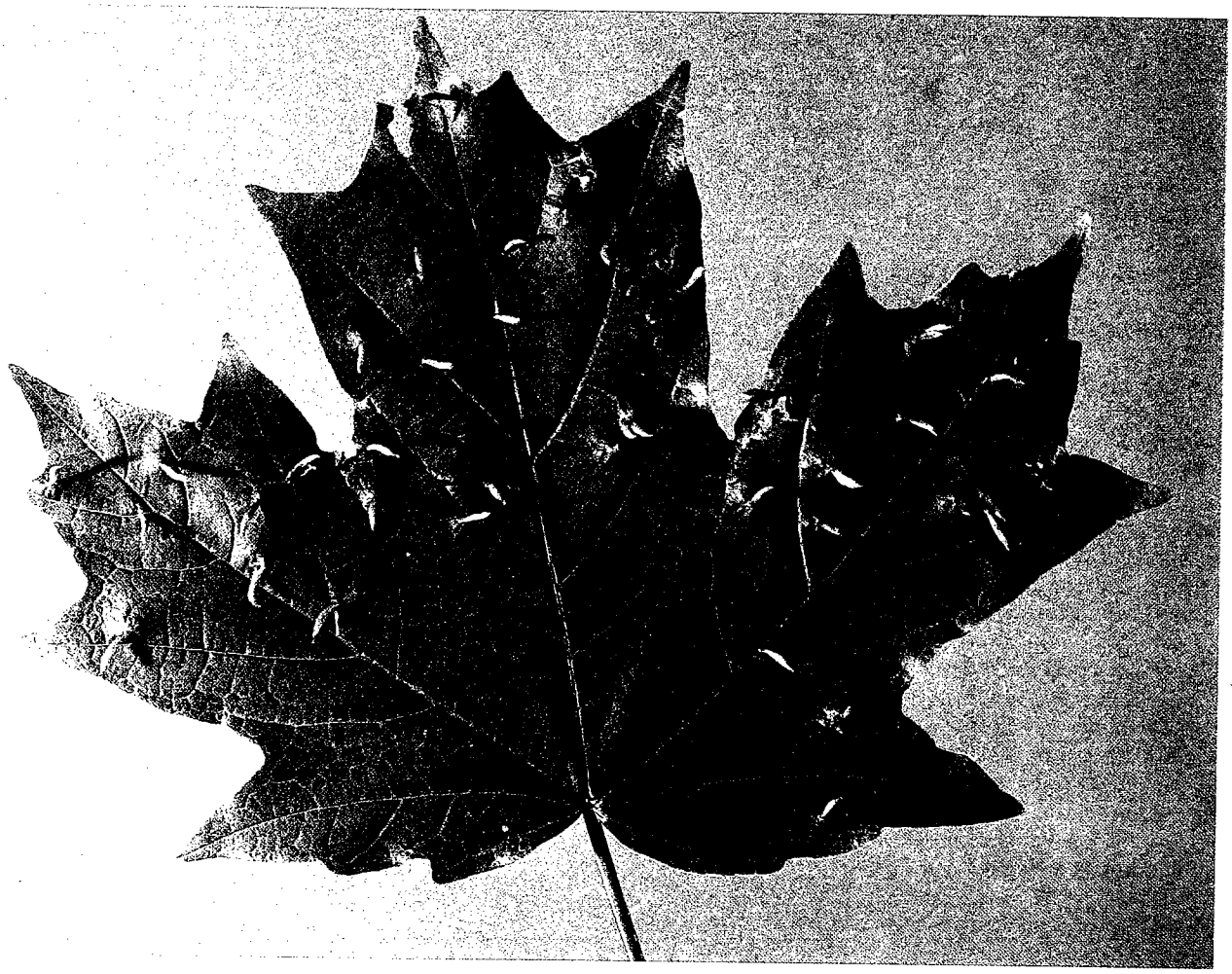
Another common and abundant pouch gall that develops on the upper surface of sugar maple leaves is the spindle or finger gall, which is caused by *Vasates aceriscrumena*. The gall is distinguished from that of *V. quadripedes* Shimer by its form, position, color, and texture. The galls are solitary, elongate, with pointed or truncate apices, or spindle shaped. They are variable in size, up to 5 mm in length, and tend to crowd at the apical half of the leaf blade. They vary from greenish tinged with yellow to pink, to crimson. The exit hole on the underside of the leaf has a tuft of unicellular hairs, but the interior of the gall is thin walled and lacks hairs.

Vasates aceriscrumena is similar to *V. quadripedes*. It is recognized by having two spinules on the anterior lobe of the dorsal shield, by the forward-centrad direction of the dorsal setae, and by the well-pronounced design of the dorsal shield. The life history of both species is similar.

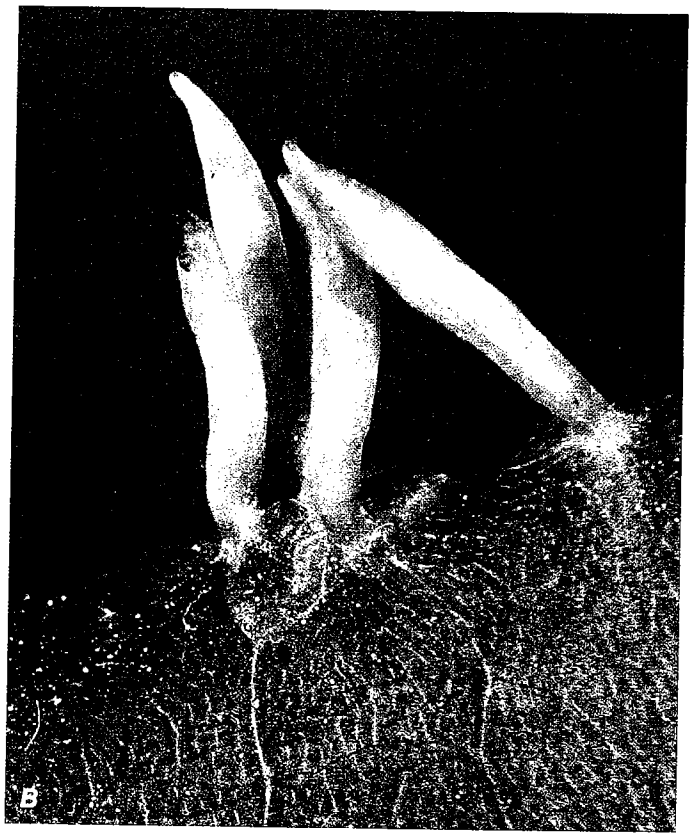
Specimens are found in galls through July on sugar maple in the Eastern United States and Canada. This mite was described in 1883 as *Phytoptus acericola* by Garman, who reported that it caused galls on maple in Illinois. It is a synonym of *V. aceriscrumena*.

References: Garman, *1883: 135;* Hodgkiss, *1930: 21;* Jeppson et al., *1975: 459, 498;* Riley, *1870: 339.*

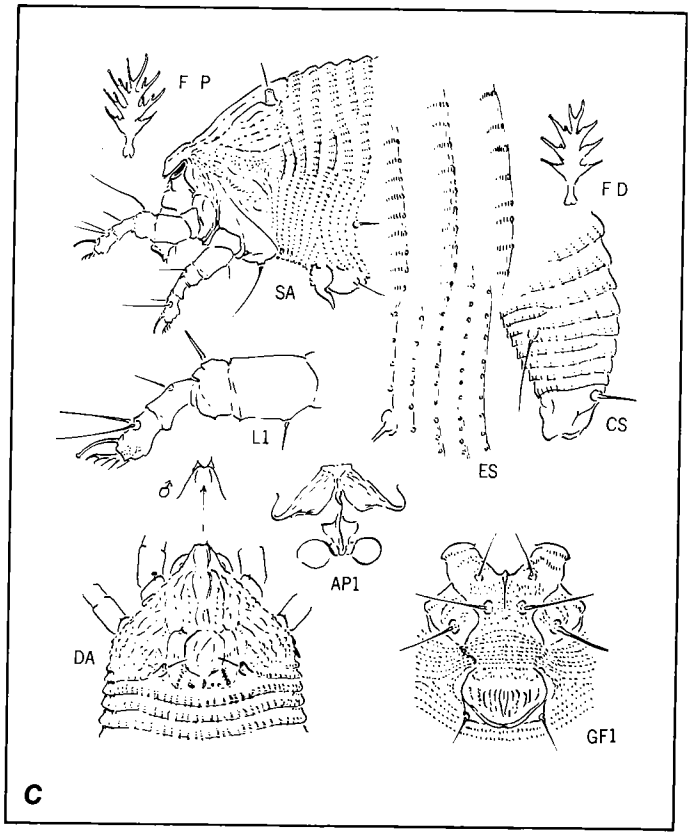
PLATE 10.—*A*, Galls on sugar maple leaf; *B*, close up of spindle-shape or fingerlike galls; *C*, *Vasates aceriscrumena* (Riley). (FD, featherclaw, deutogyne; FP, featherclaw, protogyne.)



A



B



C

Anacardiaceae

***Rhus diversiloba* Torr. & A. Gray Poison Oak**

***Rhus radicans* L. Poison Ivy**

Leaf gall caused by *Aculops toxicophagus* (Ewing) (pl. 11)

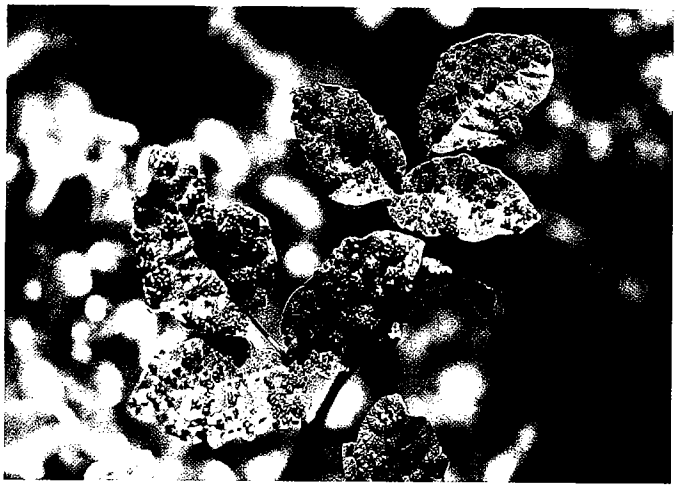
Infestation is common and typical of the leaf galls. It consists of puckered, irregular, rounded, or wartlike pouches affecting both upper and lower surfaces of the leaves. The galls are usually scattered about indiscriminately on the leaf blade. They range from green to pinkish, to red brown. Poison oak leaves are often so heavily attacked that they become visibly crinkled and distorted.

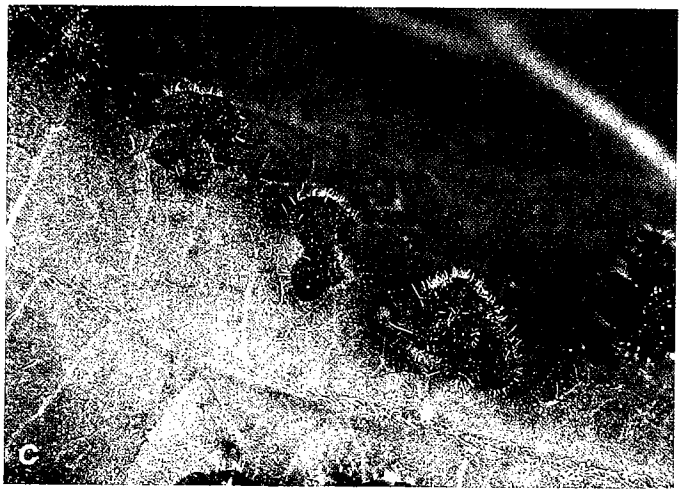
Aculops toxicophagus is a brownish, slender, spindle-shaped mite. The female measures 145-155 microns long and the male 120-130 microns. The featherclaws are four-rayed; the dorsal shield is slightly produced anteriorly and marked with a design; the microtubercles are larger and more rounded dorsally than ventrally; and the coverflap of the female genitalia has eight to nine longitudinal ribs. Nothing is known of this mite's seasonal history.

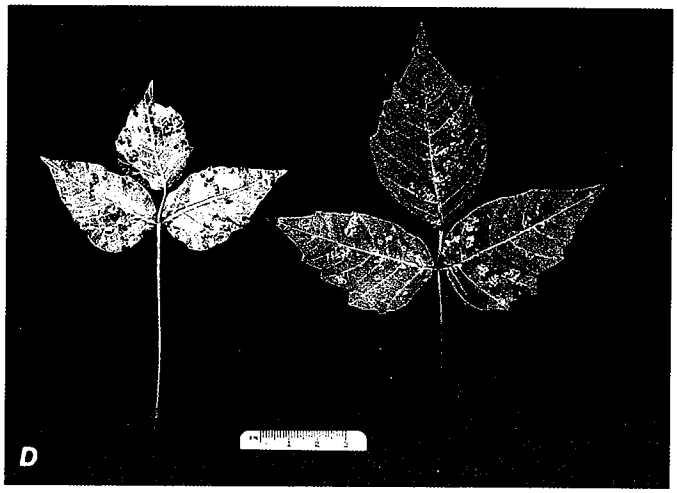
Specimens were collected on poison oak in Oregon and California and on poison ivy in Ohio and Maryland. It has also been found on poison sumac (*Rhus vernix* L.) in Ohio. The mite is probably present throughout its host range.

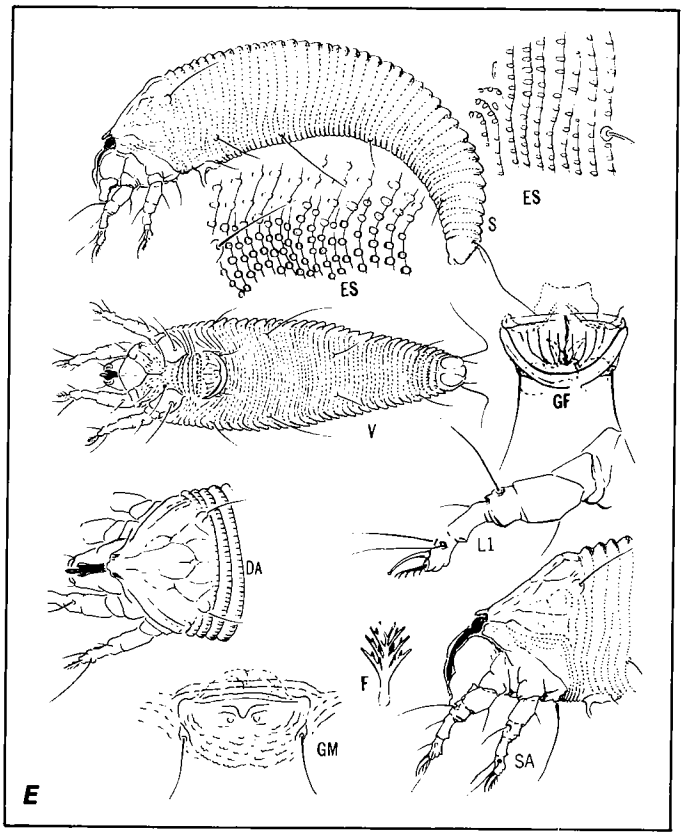
References: Ewing, *1917: 323;* Keifer, *1938a: 191.*

PLATE 11.—*A, B,* Galls on poison oak leaves; *C,* close up of galls; note wartlike or puckered appearance; *D,* galls on poison ivy leaves; *E, Aculops toxicophagus* (Ewing). (GF, female external genitalia; GM, male external genitalia; V, ventral view.)




C


D


ES
S
ES
GF
V
L1
DA
F
GM
SA
E

Betulaceae

***Alnus oregona* Nutt. (= *rubra* Bong.) Oregon Alder, Red Alder**

***Alnus rhombifolia* Nutt. White Alder**

***Alnus rugosa* (Du Roi) K. Spreng. Hazel Alder**

***Alnus tenuifolia* Nutt. Mountain Alder**

Leaf gall caused by *Phytoptus laevis* Nalepa (pl. 12)

These beadlike galls are particularly striking because they appear on both surfaces of the leaves. They are small, hemispherical, of variable size and are scattered singly or crowded alongside the midrib. The galls are firmly attached, with the exit holes on the underside. They are shiny externally and the interior contains fleshy tissue. They range from green to yellowish, to red, to reddish brown as they mature. A single leaf may carry numerous galls so that it becomes distorted and its growth inhibited.

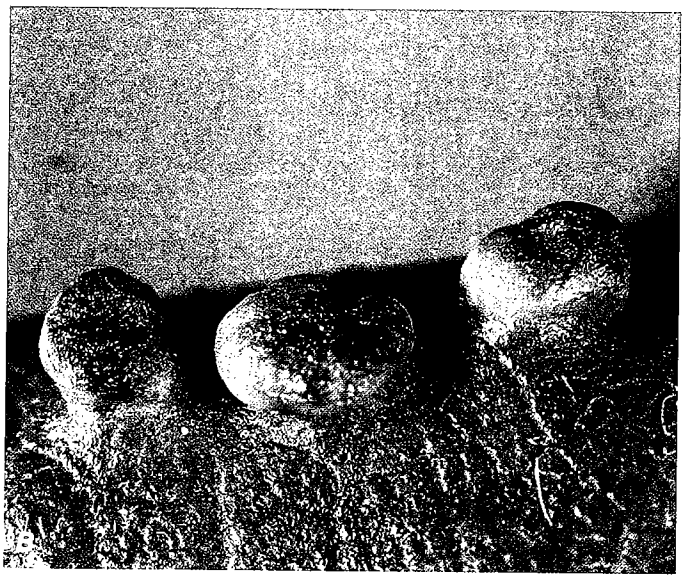
Phytoptus laevis is a yellowish, wormlike eriophyid, measuring about 190 microns long. The featherclaws are four-rayed; the dorsal shield of the male and female (protogyne) may be marked with ridges; the microtubercles are few and acuminate; those posteriorly on the ventral side are elongate. The overwintering female (deutogyne) has a smooth dorsal shield and fewer microtubercles confined to the ventral side of the hysterosoma; the dorsal setae are directed forward or dorsocentrad; and the coverflap of the female genitalia is smooth and lacks ribs. The life history involves alternation of generations. Although *P. laevis* is a common species on alder, little is known of its seasonal history and habits. Specimens were abundant in August.

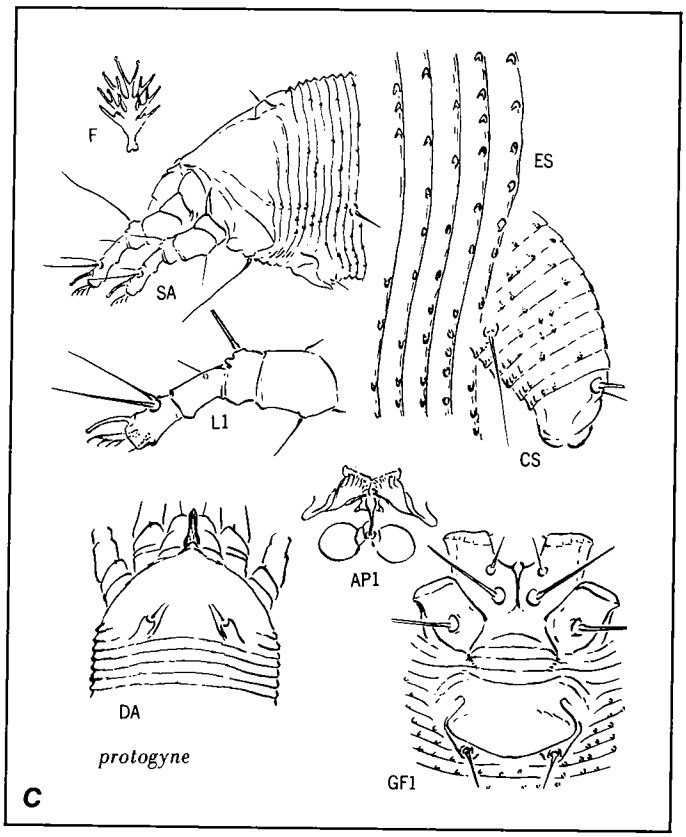
The hosts are Oregon or red alder, white alder, and mountain alder in California and hazel alder in Ohio and Georgia.

References: Barke and Davis, *1971: 160;* Keifer, *1952d: 6, 15, 37;* Nalepa, *1889: 132.*

PLATE 12.—*A,* Leaf galls on alder, upper surface; *B,* close up of galls; *C, Phytoptus laevis* Nalepa.

A




F
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protogyne
GF1
C

Compositae

***Baccharis pilularis* var. *consanguinea* (D. C.) O. Kuntze**
Chaparral Broom

Leaf gall caused by *Eriophyes baccharipha* (Keifer) (pl. 13)

This gall is known as *Baccharis* leaf blister, a pimplelike swelling that develops on both sides of the leaf blade, with the exit hole on the underside. Generally an infestation gives the leaf a pimply, blistered appearance. The galls vary in size and from greenish to yellow, to brown.

Eriophyes baccharipha is a wormlike, yellowish mite, measuring 165-215 microns long. The featherclaws are six-rayed; the dorsal shield is produced anteriorly and marked with two strong, long, median and a few short, submedian ridges; the microtubercles on the hysterosoma are slightly pointed; and the coverflap of the female genitalia has two rows of ribs. The mites occur among the fleshy tissue in the galls and presumably leave the galls and migrate to the buds during unfavorable weather. Nothing is known of the life cycle of this species.

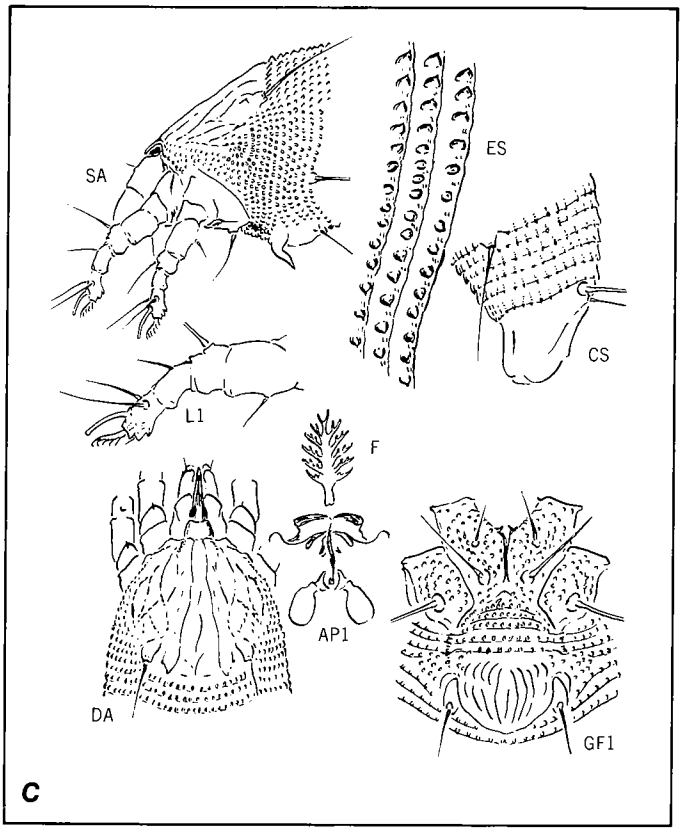
The host plant is locally known as chaparral broom, a spreading evergreen shrub that occurs in coastal and inland hills in California and southern Oregon. The mite specimens were first collected in California in April. *Eriophyes baccharipha* should not be confused with two other eriophyids that infest *Baccharis* in California. They are *Eriophyes calibaccharis* Keifer, which occurs in the terminal buds of chaparral broom, and *E. baccharices* (Keifer), which causes irregular, wartlike, rough-looking galls on the upper surface of the leaves of seep willow (*Baccharis glutinosa* Pers.) and mule-fat (*B. viminea* D. C.).

References: Keifer, *1939c: 331; 1945: 139; 1970: 9.*

PLATE 13.—*A, B,* Leaf galls on chaparral broom; *C, Eriophyes baccharipha* (Keifer).

A

B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C

Juglandaceae

***Juglans californica* S. Wats. California Walnut**

***Juglans hindsii* (Jeps.) Jeps. Hind's Walnut**

Leaf gall caused by *Eriophyes brachytarsus* Keifer (= *E. amiculus* Keifer and *E. brevitarsus* Keifer) (pl. 14)

The pouch galls induced by this mite on the upper surface of the leaves invariably appear at random between the lateral veins and on the midrib. The galls are often solitary, 3-6 mm in dimension, irregularly globular, and shiny with roughened surface. They range from green to yellowish green with reddish or brown tinge. The interior of the gall, which becomes red as it matures, consists of multicellular structures, as shown in plate 6, *E.* Galls at times are numerous on some trees, causing considerable distortion to the foliage.

Eriophyes brachytarsus is a slender, wormlike mite, measuring 195-210 microns long. The male and female (protogyne) are yellowish, whereas the overwintering female (deutogyne) is reddish. The featherclaws are three-rayed; the dorsal shield has an obscure design; the coverflap of the female genitalia is smooth; the setal bearing tubercles are not produced; and the microtubercles of the protogyne and male are pointed, and those of the overwintering female are simple and rounded. The life history involves alternation of generations (see Jeppson et al. (*1975*)). Overwintering females are found in the terminal buds in late winter and in new galls in April. The males and protogynes appear in May, inhabiting the galls through August. Both forms are found in the galls during this period.

Specimens were collected in the galls on California and Hind's walnuts in California. *Eriophyes brachytarsus* is similar to *E. microcarpae* Keifer, which causes similar pouch galls on little walnut (*Juglans microcarpa* Berland) and Arizona walnut (*J. major* (Torr.) A. Heller) in Texas, New Mexico, and Mexico. *Eriophyes amiculus* was subsequently observed to be the bisexual form (male and protogyne) of *E. brachytarsus* and is therefore a synonym. *Eriophyes brevitarsus* is a preoccupied name.

References: Jeppson et al., *1975: 377, 433;* Johnson and Lyon, *1976: 430, 432;* Keifer, *1939b: 224; 1939c: 328; 1969: 15; 1974: 7.*

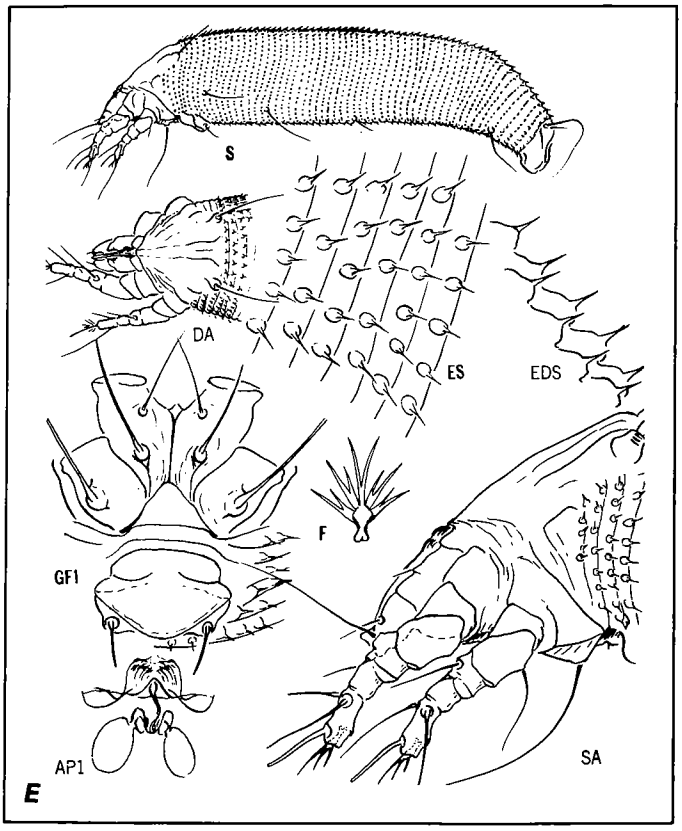
PLATE 14.—*A,* Leaf galls on walnut; *B,* close up of galls; note position between lateral veins and midrib; *C,* opened gall, showing mites and interior structure; *D,* infested walnut buds with overwintering mites. *Eriophyes brachytarsus* Keifer: *E,* Protogyne; *F,* deutogyne. (EDS, dorsal microtubercles, lateral view.)

A

B

C

D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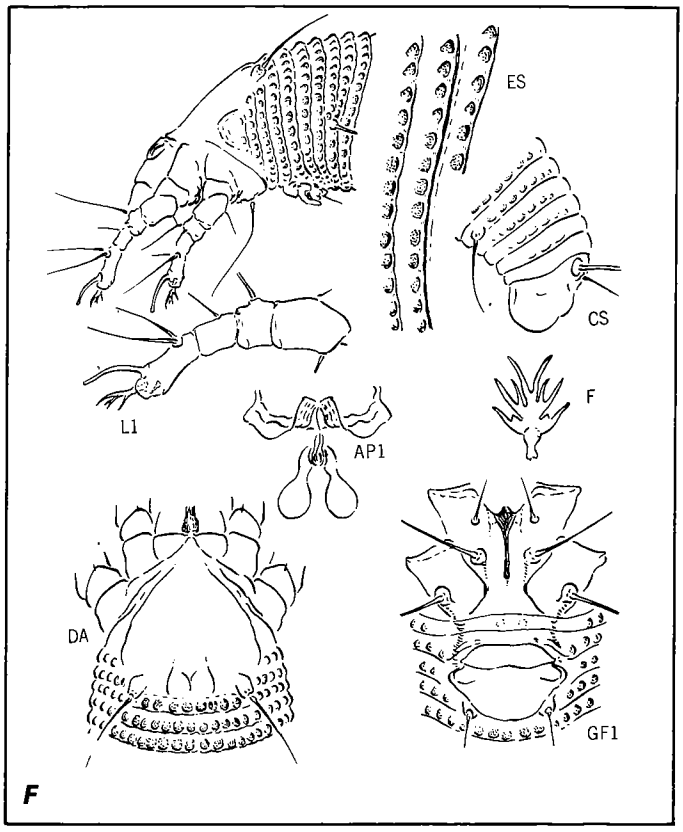
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Juglandaceae

***Juglans nigra* L. Black Walnut**

Petiole gall caused by *Eriophyes caulis* Cook (pl. 15)

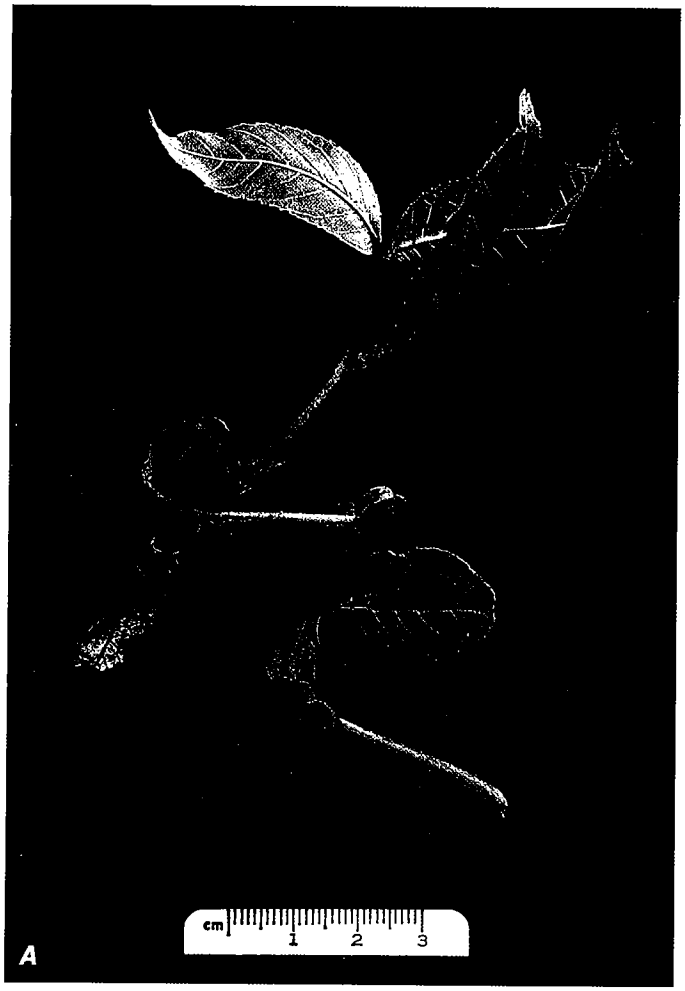
This is an exceptionally interesting and beautiful pubescent gall, often brightly colored, passing from greenish through pink and crimson to reddish brown. The gall most frequently develops as an irregular, solid, hard mass on the leaf petiole. It is often solitary and variable in size. The exterior is covered with a dense mass of silky, unicellular, erineumlike hairs (see pl. 7, *A*). The gall tends to be large and to spread to and partly envelop the stem and leaf. The affected structure is greatly distorted and twisted, and leaflets fail to develop.

Eriophyes caulis is a slender, wormlike mite, measuring 150-210 microns long. Deutogynes, or overwintering females, are reddish. The featherclaws are three-rayed; the dorsal shield has two distinct parallel ridges at the middle; the coverflap of the female genitalia is smooth; and the microtubercles of the males and protogynes are pointed, and those of the deutogynes are rounded and thickened posteriorly. The life history involves alternation of generations; only the deutogynes overwinter in the buds. Both forms may be found among the dense mass of erineum hairs during the summer.

This mite was found infesting black walnut in New Jersey and Pennsylvania in July-August. It is probably distributed throughout the range of its host from Ontario to Massachusetts and south to Florida and eastern Texas. *Eriophyes caulis* is similar to and may be confused with *E. brachytarsus* Keifer, which causes pouch galls on leaves of California walnut.

References: Cook, *1904: 859;* Jeppson et al., *1975: 434;* Johnson and Lyon, *1976: 430;* Keifer, *1940a: 24.*

PLATE 15.—*A, B,* Petiole galls on black walnut; note gall partly envelops stem and leaf; *C, Eriophyes caulis* Cook. (L, left legs I and II.)


cm
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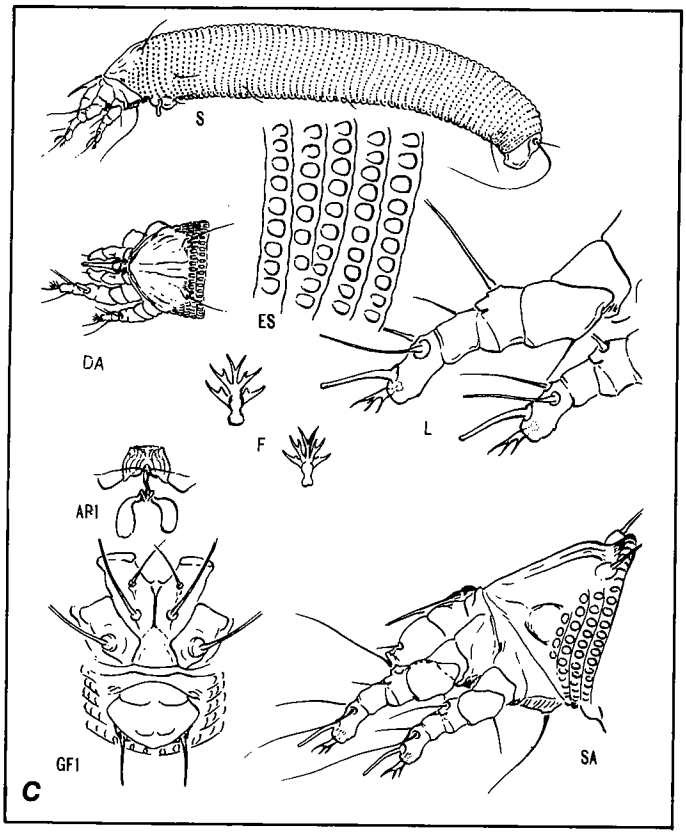
A

B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Liliaceae

***Aloe nobilis* Haw. Golden-Tooth Aloe**

***Aloe spinosissima* Hort. ex A. Berger Spider Aloe**

***Haworthia* sp. Star Cactus, Wart Plant**

Leaf and inflorescence gall caused by *Eriophyes aloinis* Keifer (pl. 16)

An affected plant shows a remarkable proliferation of unsightly, irregular outgrowth, clustered densely on the surface of the leaf blades or in leaf axils. The infestation may be confined to the base in the leaf axils as bunched, greenish, tiny-to-large globular sprouts or as a lumpy, rough-looking thickening in the form of wartlike growths from the base of the leaf blade extending to the tip. The longitudinal pattern of growth follows that of the lanceolate shape of the leaf. It ranges from yellowish to brownish, to green tinged with yellow. The mites also attack the inflorescence and cause galled blooms.

Eriophyes aloinis is a purplish, slender, wormlike mite, measuring 190-220 microns long. The featherclaws are six-rayed; the dorsal shield is marked with median ridges flanked by branching lines; the microtubercles are elliptical, each with a tiny point; the coxae have fewer granules; and the coverflap of the female genitalia has seven to nine ribs. The mites live in crevices among the various growths and were collected in November.

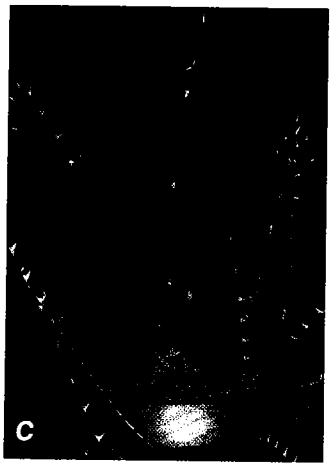
This eriophyid attacks golden-tooth aloe, spider aloe, and star cactus or wart plant in southern California and Florida. It is probably found wherever these plants are grown.

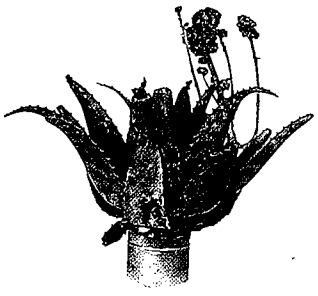
References: Denmark and Keifer, *1979: 1-2;* Keifer, *1941: 205.*

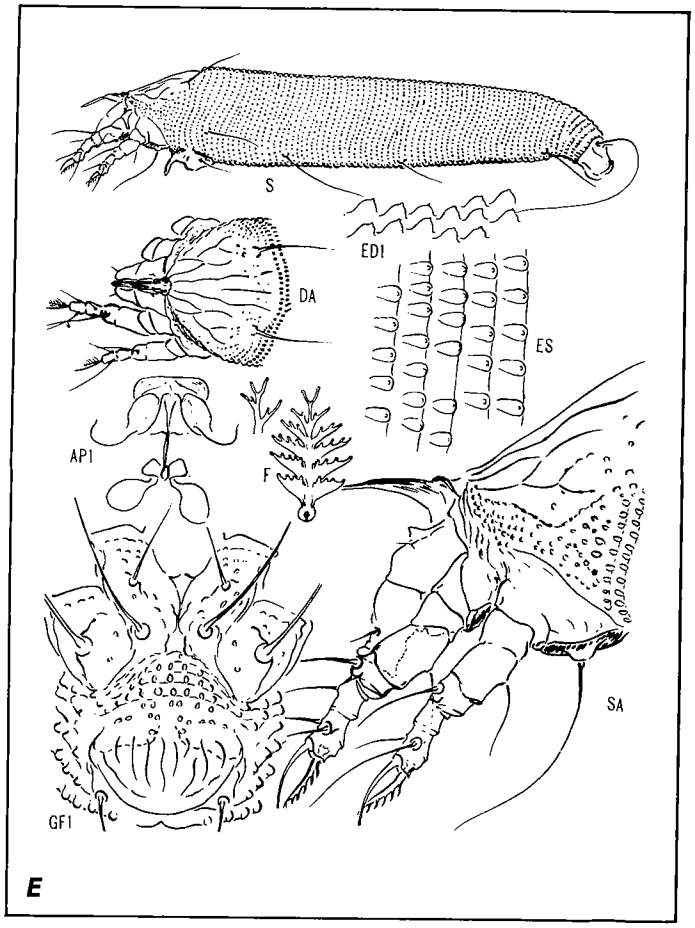
PLATE 16.—*A,* Galls in leaf axil of aloe; *B,* close up of *A; C,* wartlike galls in axil and base of leaf blades; *D,* aloe plant with galled inflorescence; *E, Eriophyes aloinis* Keifer. (ED1, dorsal microtubercles, lateral view.)

A

B


C

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E

Meliaceae

***Sandoricum koetjape* (Burm. F.) Merr. Santol**

Leaf gall caused by *Eriophyes sandorici* Nalepa (pl. 17)

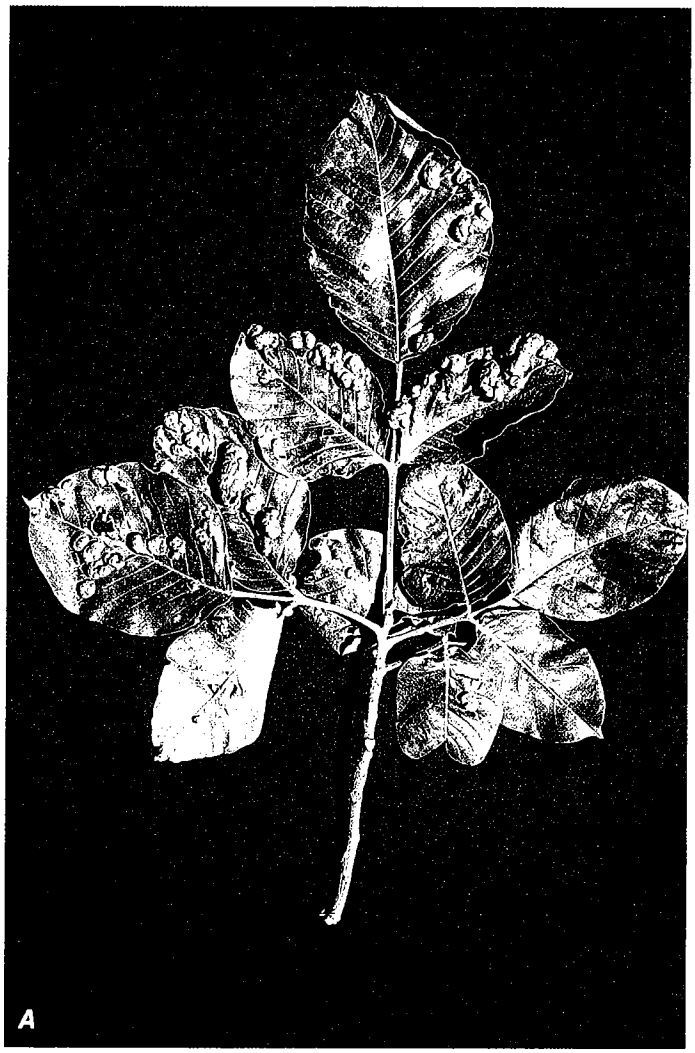
This is an unsightly pouch gall that develops on the underside of the leaf blade as a concavity filled with erineum and on the upper side as a rounded outpocketing with irregular puckered domes. The pouch is greenish, becoming blackish, and the erineum turns brownish at maturity. The galls are variable in size and are frequently coalesced and crowded, giving a lumpy appearance to the leaf blade.

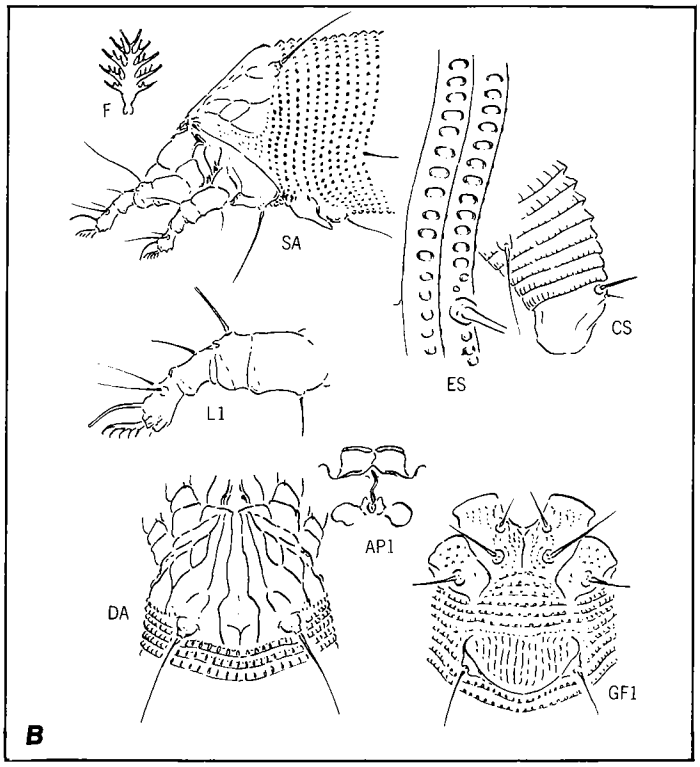
The mite is robust and wormlike, measuring about 180 microns long. The featherclaws are five-rayed; the dorsal shield is marked with a design; the microtubercles are elliptical dorsally, rounded ventrally, and usually anterior to the ring margins; and the coverflap of the female genitalia has long ribs. The life cycle and seasonal distribution are unknown.

Eriophyes sandorici has been found only on santol of the mahogany family Meliaceae, a tropical tree with edible fruit from the Indomalayan region and Mauritius.

Reference: Nalepa, *1914: 66.*

PLATE 17.—*A,* Galls on leaves of *Sandoricum koetjape* (Burm. F.) Merr.; note irregular puckered domes on upper surface; *B, Eriophyes sandorici* Nalepa.


A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B

Oleaceae

Fraxinus americana **L. White Ash**

Fraxinus latifolia **Benth. Oregon Ash**

Fraxinus pennsylvanica **var.** *lanceolata* **Bork. Green Ash, Red Ash**

Leaf gall caused by *Eriophyes chondriphora* **(Keifer) (pl. 18)**

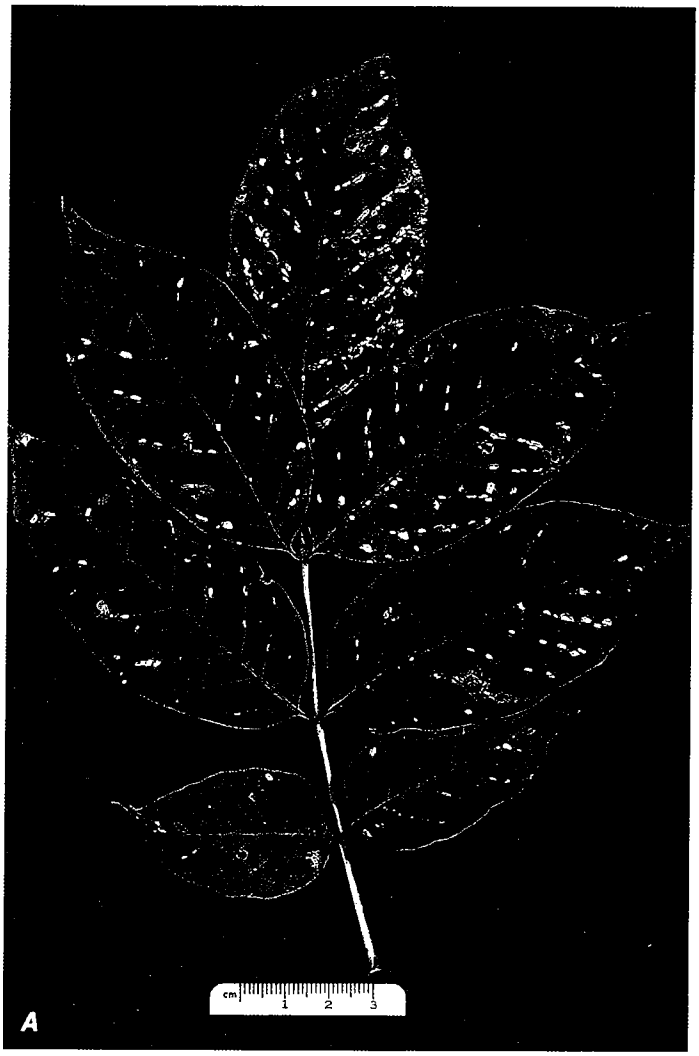
The galls on the upper surface of ash leaves are unmistakable and often particularly numerous on the terminal leaves. They are small and solitary, somewhat reniform in shape, and generally scattered at random on the lateral veins. Their greenish-yellow color and shape give a striking effect on an infested leaf.

Eriophyes chondriphora is a robust, spindle-shaped, yellowish mite, measuring 210-260 microns long; the protogyne female is larger than the deutogyne. The featherclaws are three-rayed; the dorsal shield of the protogyne and male is marked with granules and faint ridges; the hysterosoma is covered with rounded microtubercles, and that of the deutogyne is unmarked and has no microtubercles; and the coverflap of the female genitalia is smooth. The mites inhabit the galls until the leaves mature in late summer. The life history apparently involves alternation of generations.

Specimens were found in galls on leaves of white, Oregon, and green or red ash in California, Wisconsin, Virginia, New York, Vermont, and Canada. In Europe, *Eriophyes fraxinicola* (Nalepa), a closely related species of *E. chondriphora,* makes similar galls on leaves of European ash (*Fraxinus excelsior* L.).

Reference: Keifer, *1965a: 5.*

PLATE 18.—*A,* Galls on *Fraxinus* leaves; note position of galls on lateral veins; *B, Eriophyes chondriphora* (Keifer).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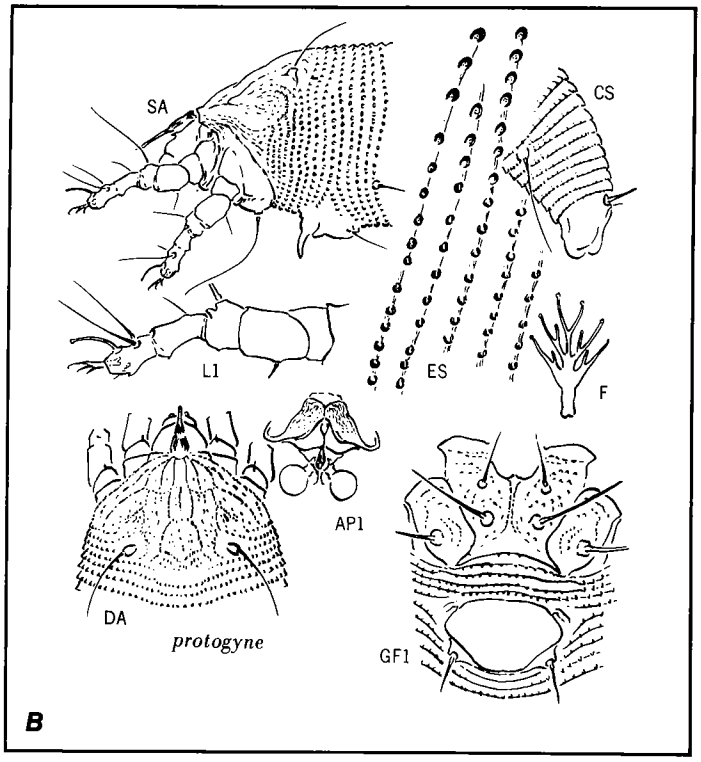
SA
L1
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protogyne
GF1
B

Polypodiaceae

***Pteridium aquilinum* var. *lanuginosum* (Bong.) Fern. and *P. aquilinum* var. *latiusculum* (Desv.) Underwood Bracken**

Pinnule gall caused by *Phytoptus helicantyx* (Keifer) (pl. 19)

This is a beautiful marginal roll gall of bracken. When seen under a microscope, it looks like a delicate, pale, lime-green lace border on the underside of the pinnule. The first indication of infestation is a characteristic discoloration and distortion of the pinna. The affected pinna is generally yellowish, later turning brown. The galled pinnules are abnormally small and distorted, with a thickening of reflexed margins. The indusium, which becomes enlarged, contains mites and lime-green erineumlike hairs. The infestation occurs in June-July.

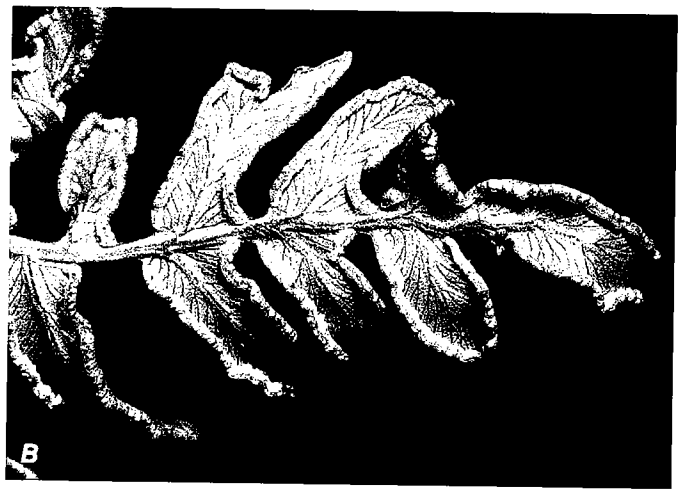
Phytoptus helicantyx is a wormlike, yellowish-white mite, measuring 250-320 microns long. The featherclaws are 3-rayed; the dorsal shield is marked with broken lines made up of short dashes and does not project anteriorly over the rostrum; the microtubercles on the hysterosoma are elongate dorsally, becoming pointed ventrally; there are granules on the coxae; and the coverflap of the female genitalia has 11–12 longitudinal ribs. The mites live among the erineum hairs in the gall.

This species was first collected in Massachusetts on bracken (*Pteridium aquilinum* var. *lanuginosum*). It was recently found in Maryland on another variety of bracken (*P. aquilinum* var. *latiusculum*). Keifer (*1966b*) mentioned an undescribed species associated with *Phytoptus helicantyx* that has four-rayed featherclaws. These two species should not be confused with one another. In Europe, *Phytoptus pteridis* Mollard has been described as causing leaf edge roll on bracken, and *Eriophyes pteridis* Nalepa, according to Darlington (*1968*), causes roll gall on bracken somewhat similar to that formed by a gall midge.

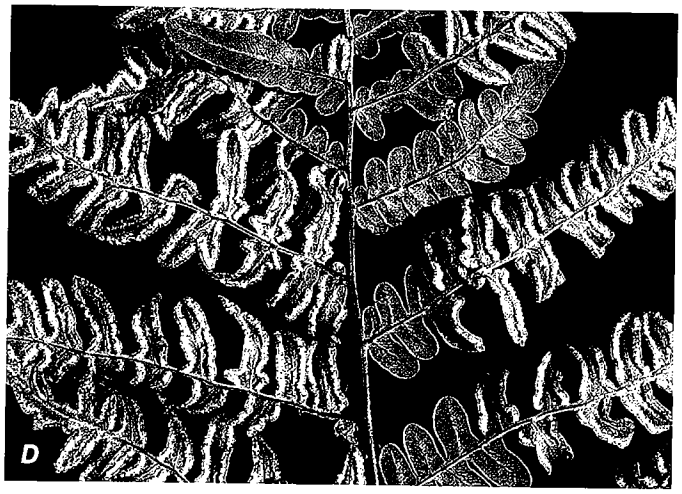
References: Darlington, *1968: 113;* Keifer, *1966b: 17.*

PLATE 19.—*A,* Infested bracken in field; *B, C,* undersurface of pinnules; note thickening of reflexed margins; *D,* close up of galled pinna; *E, Phytoptus helicantyx* (Keifer).

A


B

C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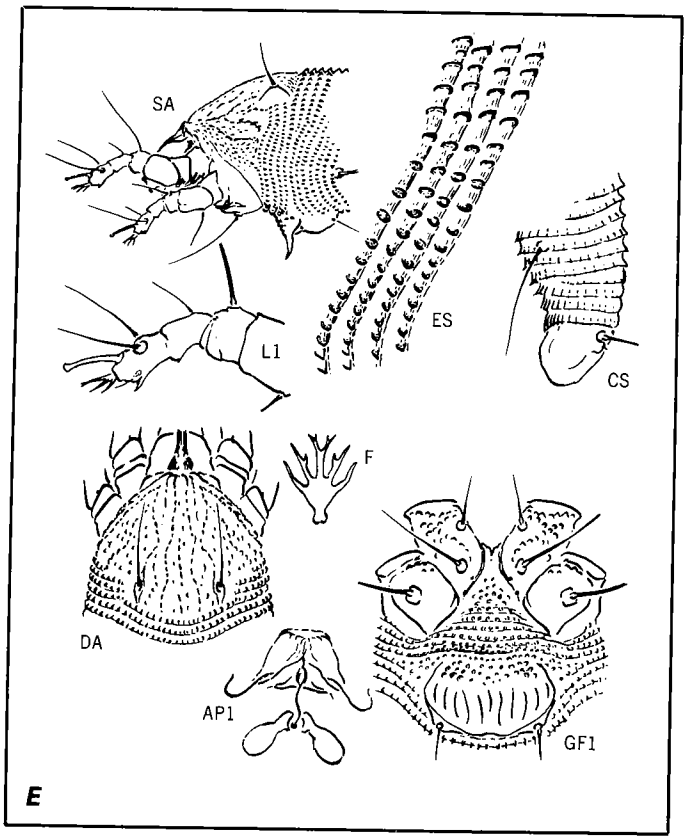
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Rhamnaceae

Ceanothus velutinus **Dougl. Redroot**

Leaf gall caused by *Eriophyes ceanothi* Keifer (pl. 20)

These are unique galls that develop on the underside of leaves. They are small, rounded, solitary, or clustered, and they are scattered haphazardly over the leaf blade and along the leaf margin. Their positions are marked on the upper surface by small, white spots, each with a tiny escape hole. The presence of white spots against the green background of the upper leaf blade makes the galls striking and easily recognizable. The galls are of the same whiteness as the underside of the leaf blade. Frequently the plant is heavily galled. These interesting and beautiful galls are caused by *Eriophyes ceanothi.*

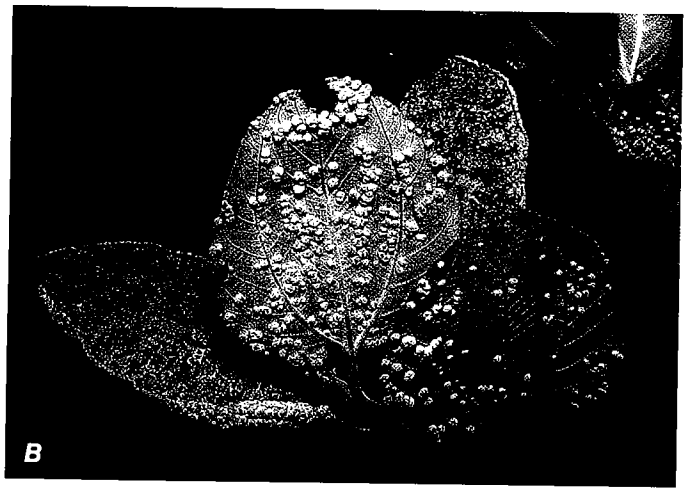
This mite is robust, wormlike, yellow or orange and measures 120–145 microns long. The featherclaws are 5-rayed; the microtubercles on the hysterosoma are elliptical; the dorsal shield has a design formed by granules, and the dorsal setae are directed backward; the coxae have a few minute granules; and the coverflap of the female genitalia has 11 ribs. The mites are found colonizing the galls. Although the galls are abundant on the leaf, most of those examined in July-October did not contain mites.

Eriophyes ceanothi occurs on redroot, an evergreen shrub found from British Columbia to Colorado and California. Specimens of mites were first collected in Oregon and subsequently in California.

Reference: Keifer, *1939c: 330.*

PLATE 20.—*A, B,* Galls on *Ceanothus* leaves; note galls prominent on undersurface of leaves; *C, Eriophyes ceanothi* Keifer.

A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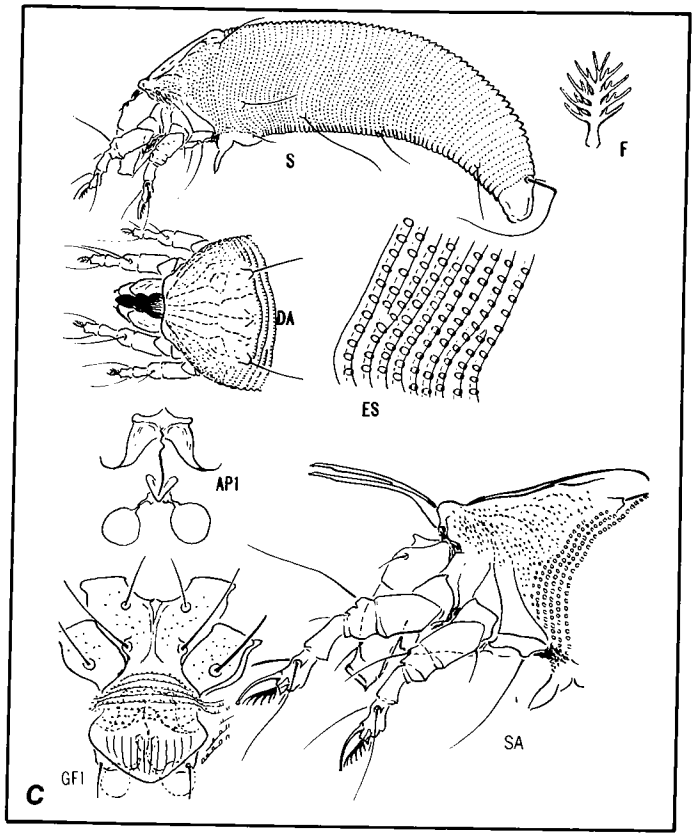
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Rosaceae

***Adenostoma fasciculatum* Hook. & Arn. Greasewood**

Leaf gall caused by *Phytoptus adenostomae* Keifer (pl. 21)

This typical pouch gall, which is distinctive and attractive, occurs on a tiny, narrow, elongate leaf blade of a rosaceous plant. The galls are hemispherical with roughened, puckered domes; they are solitary and rarely coalescent. There are seldom more than two pouches on one leaf. Initially the galls are the same color as the rest of the leaf blade, becoming brown as they mature. Infested leaves tend to be those under shady areas or where they are less exposed to sunlight. Heavily infested plants have malformed leaves that are noticeable at a distance.

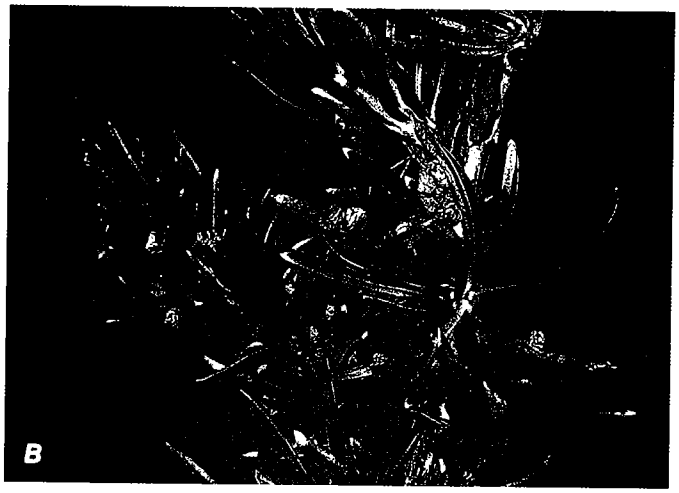
Phytoptus adenostomae is a yellowish-white, wormlike mite, measuring 90-140 microns long. The featherclaws are 4-rayed; the dorsal shield is smooth anteriorly and has 3 short ridges posteriorly between the setal bases; the coxae have fewer granules; and the coverflap of the female genitalia has 10 ribs of uneven length. The microtubercles of the overwintering females (deutogynes) are large and subelliptical; those of the protogynes and males are slightly pointed and smaller. An accessory seta is present. The life history involves alternation of generations.

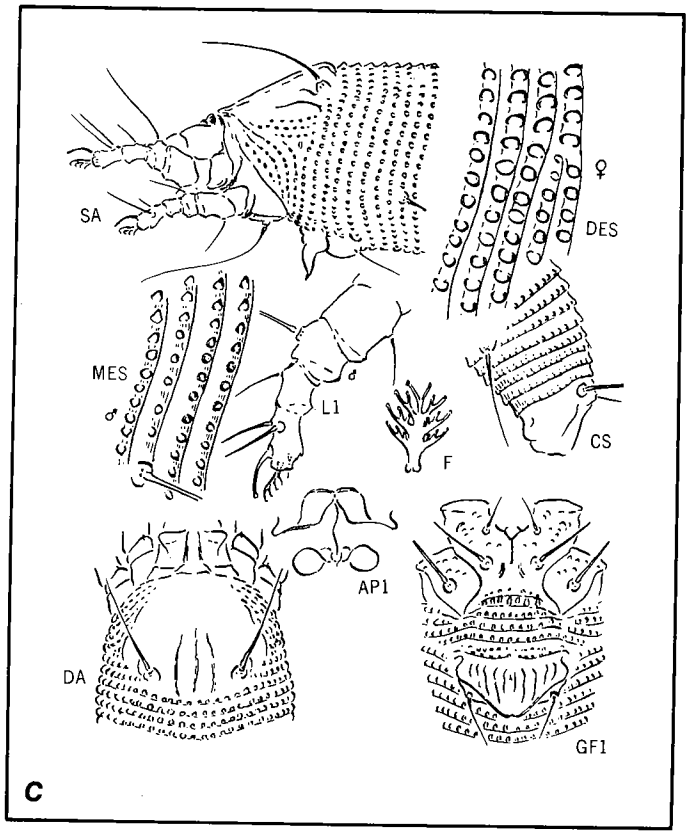
The host plant is locally known as greasewood, an evergreen shrub of the Rosaceae family; it grows in the chaparral area in California.

Reference: Keifer, *1976: 19.*

PLATE 21.—*A, B,* Galls on greasewood leaves; note large puckered domes on upper surface; *C, Phytoptus adenostomae* Keifer. (DES, deutogyne microtubercles, lateral view; MES, male microtubercles, lateral view.)

A


B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Rosaceae

***Prunus americana* Marsh. Wild Plum**

***Prunus domestica* L. Common or European Plum**

***Prunus emarginata* (Dougl. ex Hook.) Walp. Bitter Cherry**

***Prunus munsoniana* Wight & Hedr. Wild-Goose Plum**

***Prunus subcordata* Benth. Sierra Plum**

***Prunus virginiana* var. *demissa* (Nutt.) Sarg. Chokecherry**

Leaf gall caused by *Phytoptus emarginatae* (Keifer) (pl. 22)

The galls induced by *Phytoptus emarginatae* are familiar and typically pouch type. They are scattered at random over the surface of the leaves. Each gall is elongate, clavate or finger-like, of variable length, and erect or oblique. It protrudes through the upper surface of the blade; occasionally two galls are coalesced. Generally the galls are most conspicuous when yellowish and beginning to turn light brown.

The mite is robust, wormlike, and whitish or yellowish brown; it measures about 240 microns long. The featherclaws are four-rayed; the female dorsal shield has no markings, and the dorsal setae are directed forward or dorsocentrad; the coxae are smooth; there are more ventral than dorsal rings; the microtubercles are absent; also some of the posterior ventral rings have ridges arranged similarly to microtubercles; and the coverflap of the female genitalia lacks ribs. The male differs by having ridges on the dorsal shield and microtubercles on the hysterosoma. It also possesses more rings than the female.

The interesting biology of this mite has been studied by Oldfield (*1969*). The life cycle involves one generation each year. The females overwinter in crevices of old buds near the base of branches and move to newly developing leaves in the spring. *Phytoptus emarginatae* is associated with *P. prunidemissae* (Keifer), which normally inhabits the young buds near the tips of branches and later invades the galls caused by *P. emarginatae*. By late summer the latter species is outnumbered by *P. prunidemissae*.

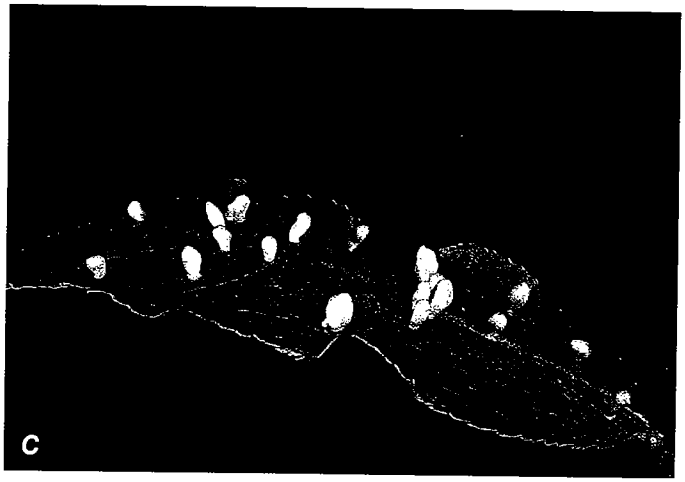
Phytoptus emarginatae appears to be widespread on several species of *Prunus*. It was first collected in galls on bitter cherry in California and subsequently in galls with *Phytoptus prunidemissae* on chokecherry in many areas of the Western United States. Other hosts include wild, common or European, wild-goose, and Sierra plums.

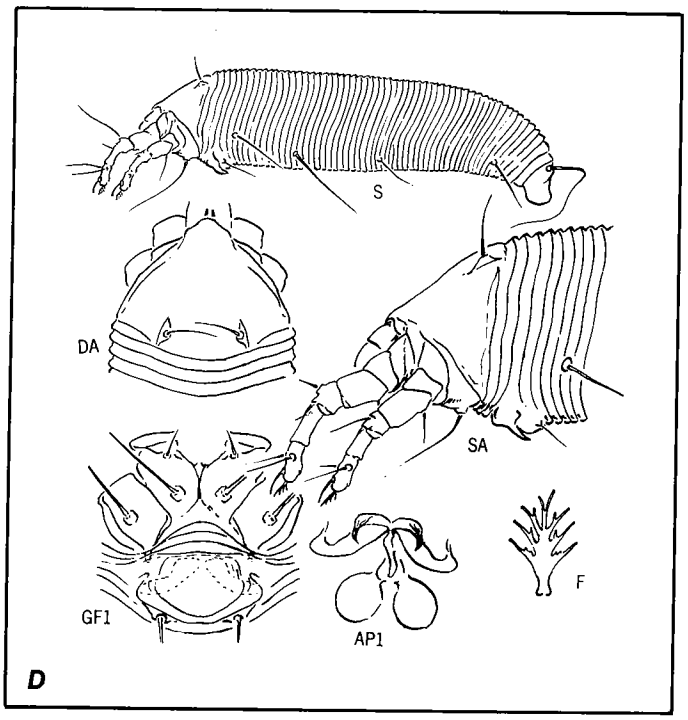
References: Keifer, *1939a: 3, 4;* Oldfield, *1969: 269.*

PLATE 22.—*A,* Galls on *Prunus* leaves; *B, C,* close up of galls on upper surface of leaves; *D, Phytoptus emarginatae* (Keifer).

A

B


C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Rosaceae

***Prunus serotina* J. F. Ehrh. Blackcherry**

Leaf gall caused by *Phytoptus cerasicrumena* Walsh (pl. 23)

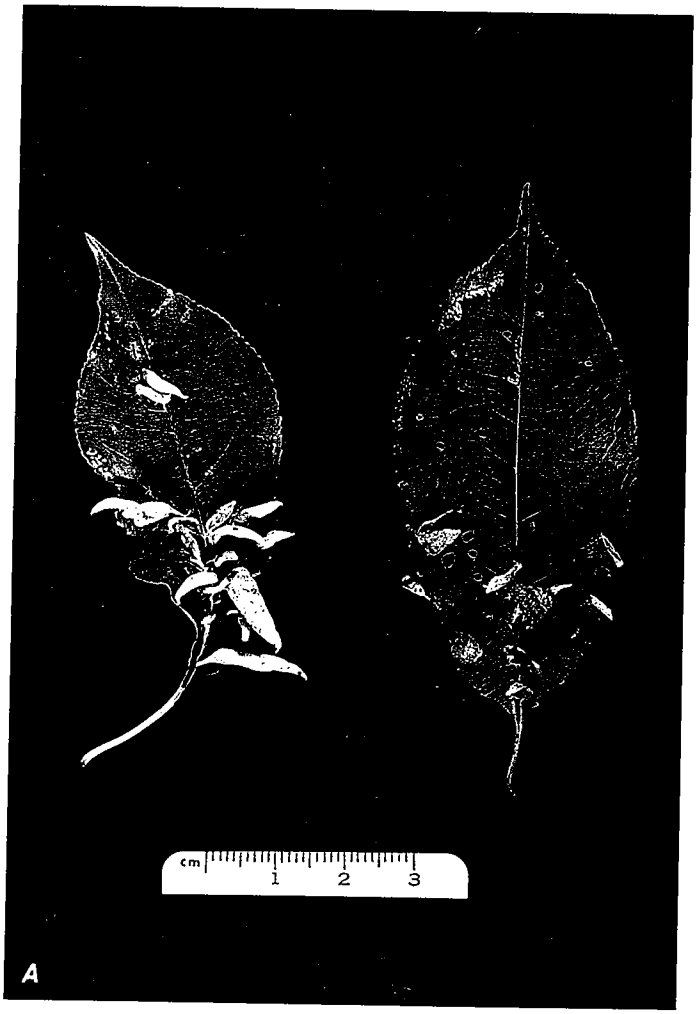
This is a striking and impressive pouchtype gall that appears on the upper surface of the leaf. Each gall is elongate, spindle shaped, about 4-8 mm long, with a pointed or attenuate tip, and is attached to the leaf blade by a slender stalk. The galls are solitary and tend to crowd, often particularly on the basal part of the leaf, mostly near the midrib. They vary from yellowish green to brownish, to reddish. The interior of the gall, where the mites are found, is hollow, with fleshy, turgid tissue. When mature, the galls split open longitudinally, dispersing the mites.

Phytoptus cerasicrumena is wormlike and yellowish. The featherclaws are palmate and five-rayed; the dorsal shield of the males and protogynes is marked with a design, and the dorsal setae are short, directed upward; the entire hysterosoma is covered with microtubercles, which are rounded ventrally and elongate dorsally; deutogynes, or overwintering females, lack microtubercles dorsally; and the coverflap of the female genitalia has laterally directed curved ribs. The life history involves alternation of generations. Protogynes and males can be found in the galls during May-June, after which overwintering females appear during July-August. In September no mites are left in the galls.

Specimens have been found only on blackcherry in the Eastern United States. *Phytoptus cerasicrumena* is not likely to be confused with other species that infest *Prunus*. The galls induced by this mite are distinctive.

Reference: Walsh, *1868: 55.*

PLATE 23.—*A,* Galls on cherry leaves; note crowding at basal part of leaf; *B,* close up of a cherry gall; *C, Phytoptus cerasicrumena* Walsh.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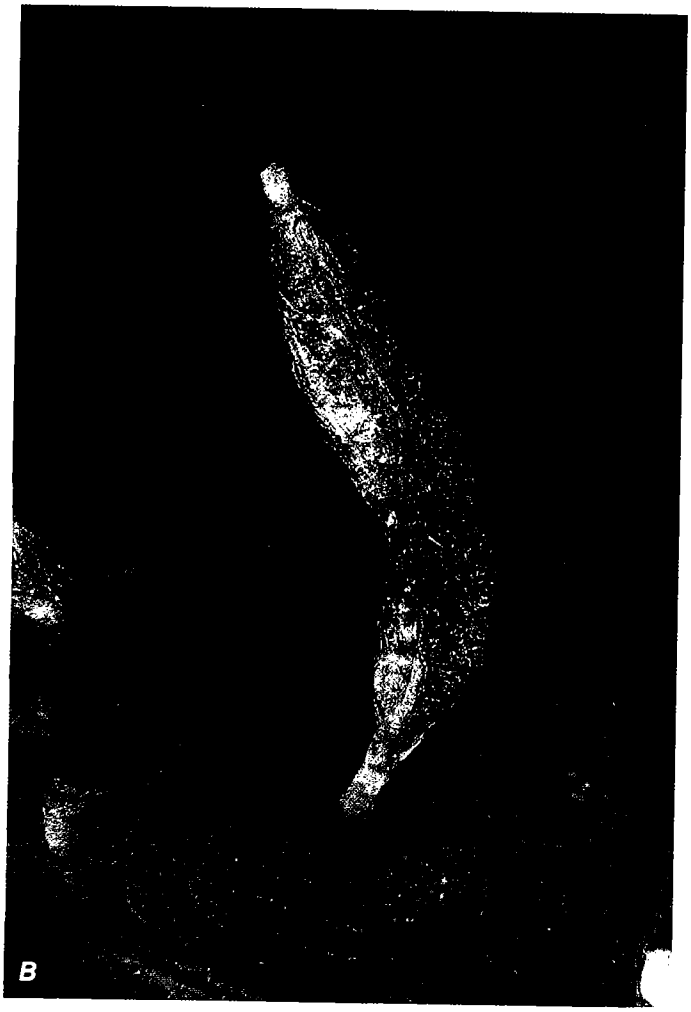
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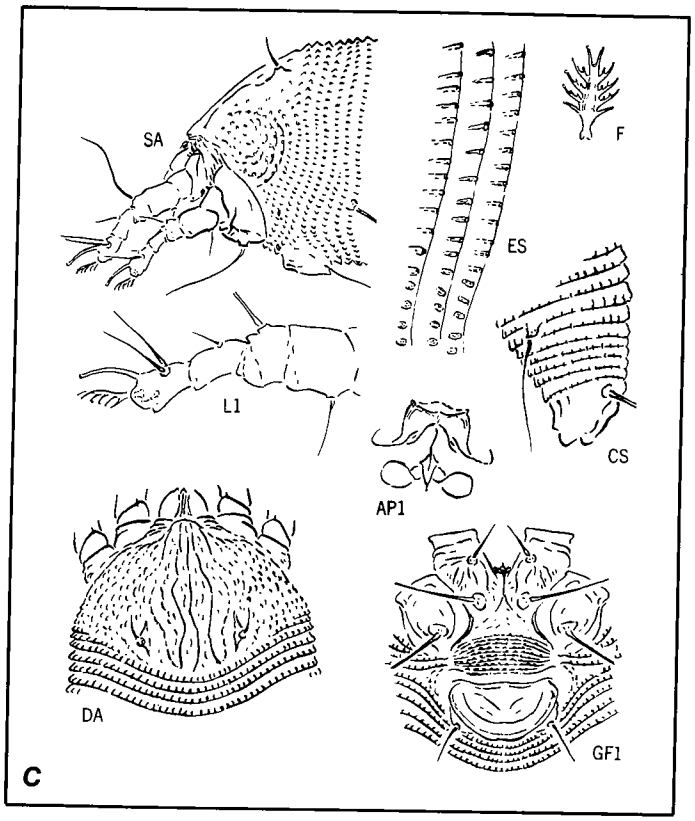
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Rubiaceae

Cephalanthus occidentalis **L. Buttonbush**

Leaf gall caused by *Eriophyes cephalanthi* Cook (= *E. newkirki* Keifer) (pl. 24)

The galls induced by this mite are easily distinguished by their position on the leaves. Either they occur on the lateral veins, or, when numerous, they are haphazardly scattered singly or in clusters on the upper surface of the leaf blade. The galls are small, variable in size, with hemispherical domes widely open on the underside. They range from yellow to yellowish tinged with red or pink, later becoming brown. The outer surface of the gall is covered with short, white hairs, and the interior is filled with erineumlike hairs, some of which project through the wide exit hole. A young leaf may have so many galls that its growth appears to be inhibited.

Eriophyes cephalanthi is a robust, spindle-shaped, yellowish-white mite, measuring 163-232 microns long. The featherclaws are 4-rayed; the dorsal shield is marked with parallel ridges, the median being longest, and laterally above the coxae these ridges are interspersed with granules; the microtubercles are elongate and slightly acuminate posteriorly; and the coverflap of the female genitalia has 8–10 short, weak ribs. The life history of this mite is unknown. The mites were found among the hairs in the galls.

The host is buttonbush, a shrub that grows along streams and swamps in the Eastern and Western United States. Specimens were collected in Washington, D.C., and Florida. *Eriophyes newkirki* Keifer is a synonym of *E. cephalanthi.*

References: Cook, *1906: 250;* Keifer, *1973: 1.*

PLATE 24.—*A,* Galls on leaves of buttonbush; *B,* close up of galls covered with short white hairs; *C, Eriophyes cephalanthi* Cook.

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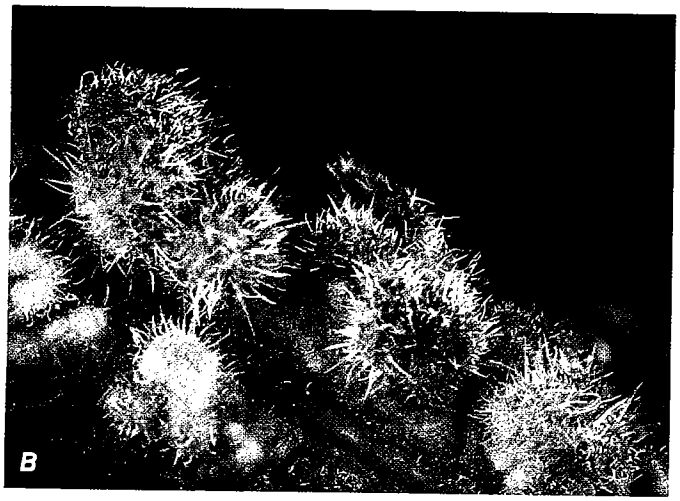
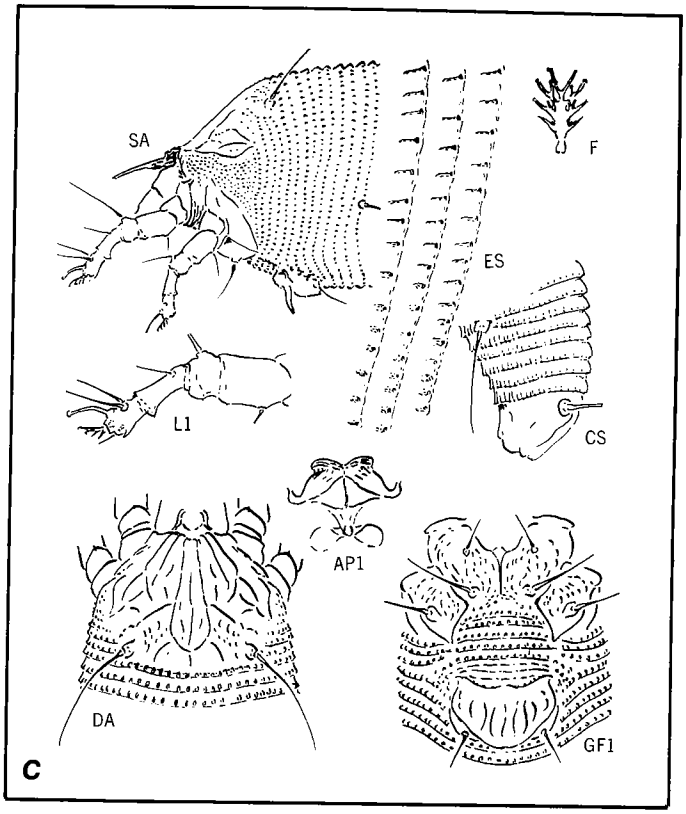

B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Salicaceae

***Populus tremuloides* Michx. Quaking Aspen**

Leaf gall caused by *Phyllocoptes didelphis* Keifer (pl. 25)

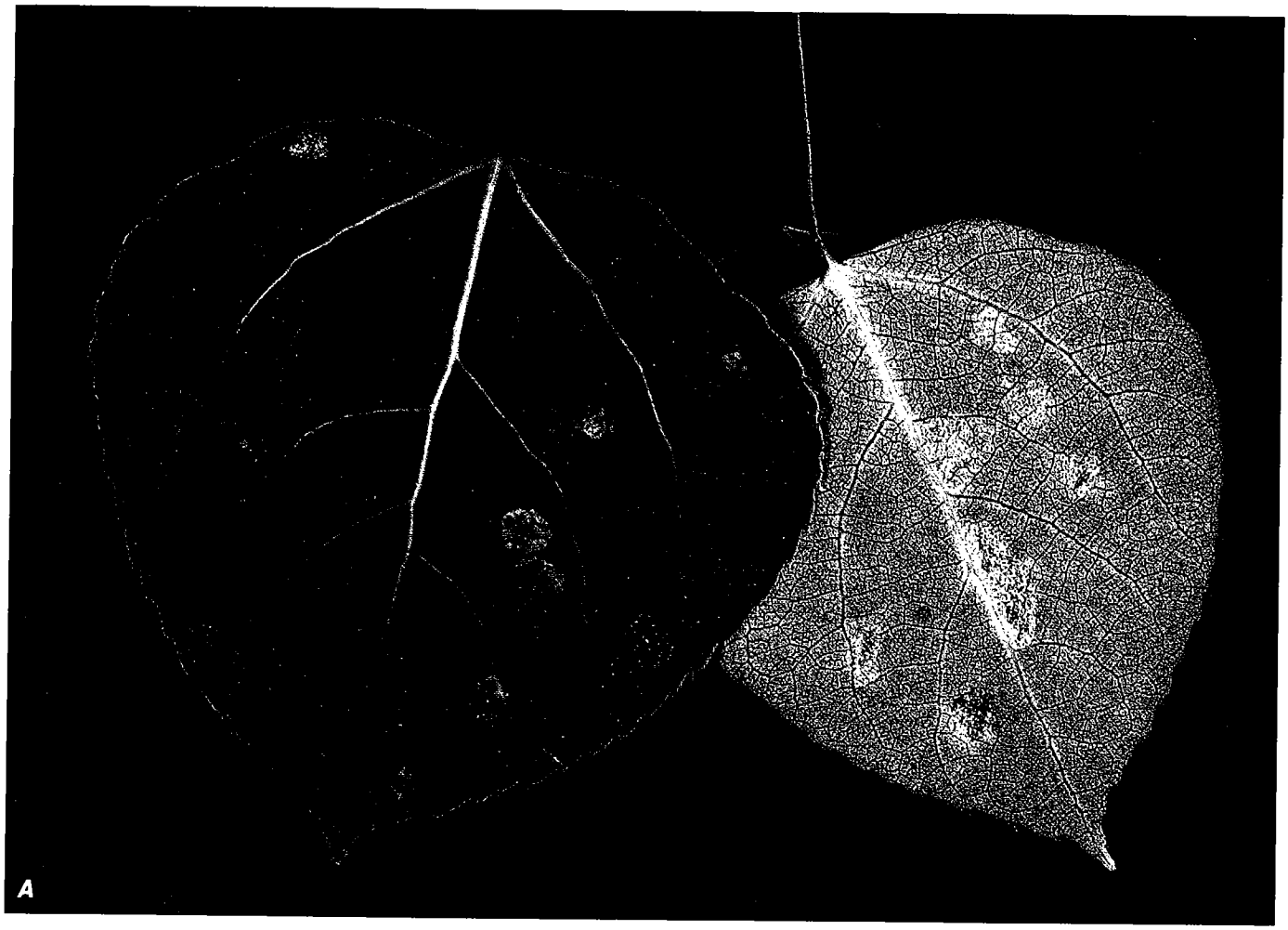
The mite induces circular, shallow galls, 5-15 mm in diameter, outpocketed from the upper surface of the leaf blade. The underside is open and filled with firm, yellowish, irregular epidermal growth (see pl. 5, *A*). The mites live within the recesses of the growth or partly exposed to the surface, and when disturbed they remain motionless. The infestation seems particularly to affect the lower shaded branches of the tree.

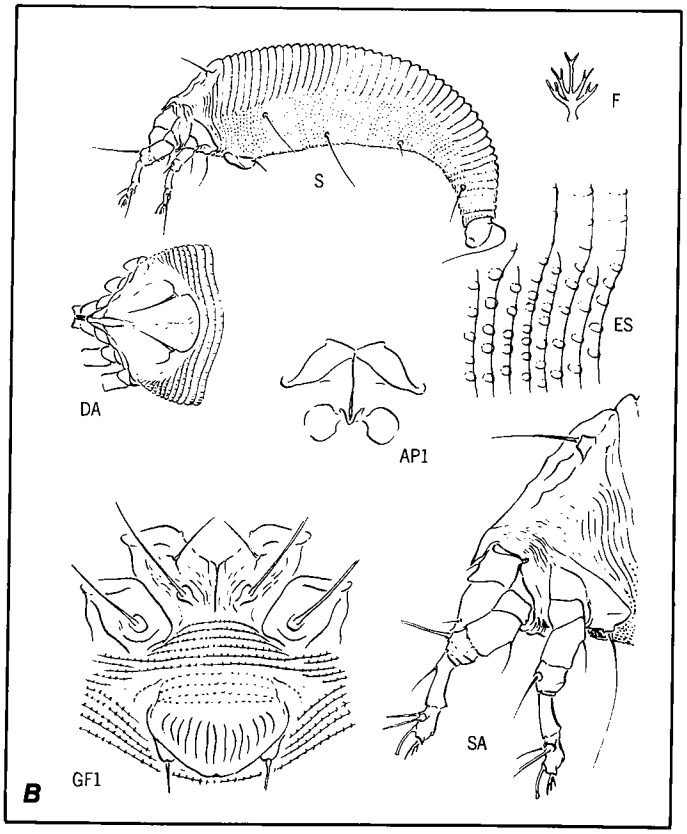
Phyllocoptes didelphis is spindle shaped, measures 230-250 microns long, and varies from creamy to reddish depending on age. The featherclaws are 3-rayed; the dorsal shield has a ridge over the anterior lobe and a longitudinal median ridge; the dorsal setae are directed forward; the hysterosomal microtubercles are elongate dorsally and rounded ventrally; the female coverflap has 12–14 ribs; and small accessory setae are present. The life cycle is unknown. Specimens were found in July.

The host is quaking aspen from California. *Aculus dormitor* (Keifer) is an inquiline in the gall.

Reference: Keifer, *1954: 125, 126.*

PLATE 25.—*A*, Galls on quaking aspen leaves: Left, upper surface; right, lower surface. *B*, *Phyllocoptes didelphis* Keifer.


A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Salicaceae

***Salix* spp. Willow**

Leaf gall caused by *Aculops tetanothrix* (Nalepa) (pl. 26)

Various willows are commonly infested by eriophyids. The situation is rather complex because the taxonomy of both the mites and the galls is uncertain. The galls on different willows are usually distinguished by form, color, position, density, and texture. *Aculops tetanothrix* belongs to a complex of gall-forming eriophyid species that induce galls on different willows; consequently, the galls are varied. The galls caused by *A. tetanothrix* are 2–3 mm in diameter, beadlike, and irregularly rounded. They are often coalesced and scattered randomly or clustered alongside the midrib and in between lateral veins on the upper surface of the leaf blade. They vary from yellowish green to pinkish or reddish brown and purple. The exterior of the gall may appear roughened and shiny or covered with fuzzy fine hairs as on pussy willow leaves. Galls may be so numerous that they cover the entire leaf blade.

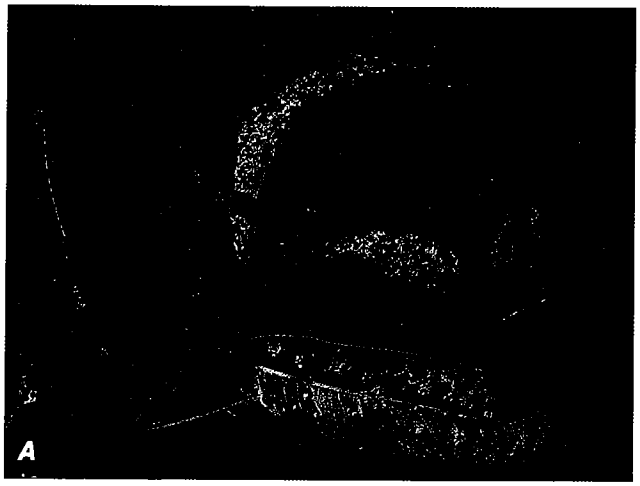
Aculops tetanothrix is a robust, yellowish-to-brownish, spindle-shaped mite, measuring about 190 microns long. The featherclaws are four-rayed; the dorsal shield is produced anteriorly, with a prominent sculptured design; and the cover-flap of the female genitalia is ribbed.

The protogynes and males differ by having microtubercles over the entire hysterosoma, whereas the overwintering females (deutogynes) have microtubercles only ventrally. The life history involves alternation of generations. The mites live in the fleshy interior of the galls, but when the galls become hard, they migrate to bark crevices and lateral buds. Only the secondary females overwinter in the lateral buds.

Aculops tetanothrix infests leaves of many willows in California, east to Utah and Arizona, and in the Eastern United States. This mite should not be confused with *A. aenigma* (Walsh), which recently has been found in galled inflorescences of willow in Maryland, Ohio, and Pennsylvania (see pl. 26). *Aculops aenigma* was previously reported from Europe.

References: Jeppson et al., *1975: 331;* Keifer, *1966c: 13;* Nalepa, *1889: 145;* Walsh, *1864: 576.*

PLATE 26.—*A–C,* Galls on leaves of willow; *D–F,* close up of different willow galls; *G,* galled catkins of willow; *H,* *Aculops tetanothrix* (Nalepa).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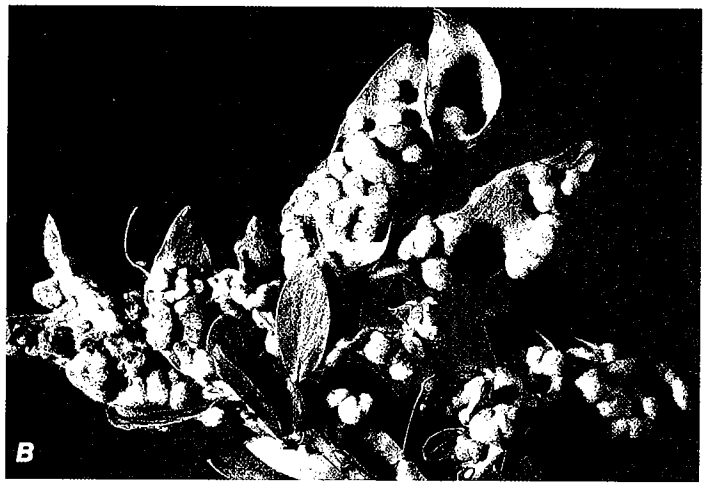
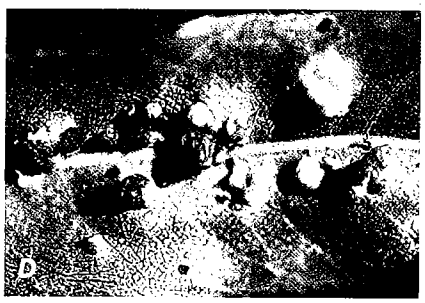

B

C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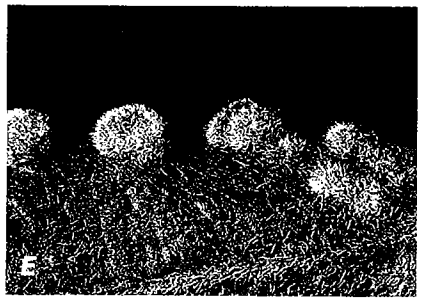
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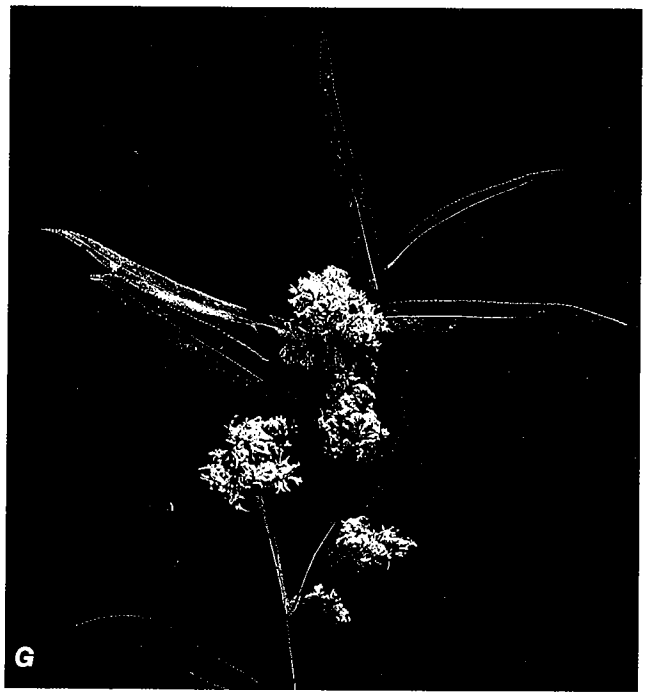
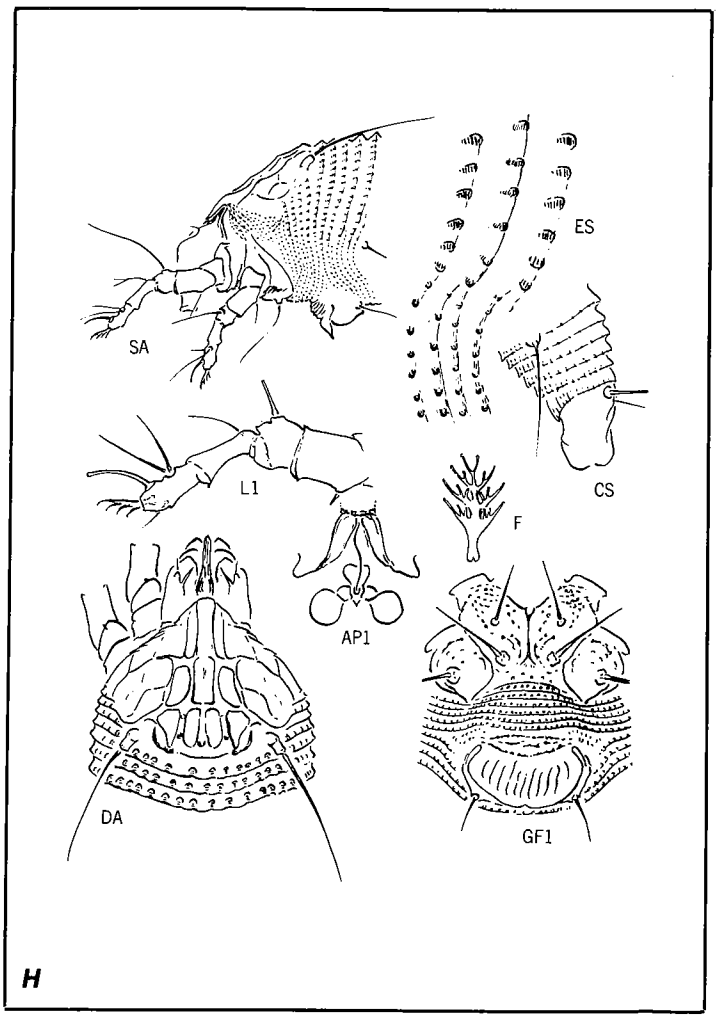

G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Saxifragaceae

***Ribes divaricatum* Dougl. Coastal Black Gooseberry**

***Ribes roezlii* Regel Sierra Gooseberry**

Leaf gall caused by *Eriophyes breakeyi* (Keifer) (pl. 27)

The infestation caused by this mite results in the formation of peculiar galls involving the midrib and lateral veins of the upper surface of the leaves. The galls consist of pouchlike swellings arising from the leaf surface around the midrib and lateral veins, with the edges meeting over the veins to form "globular chambers." The galls coalesce and are covered with whitish hairs, which make them conspicuous and unmistakable. Galled leaves are considerably deformed.

Eriophyes breakeyi is a robust, reddish, wormlike mite, measuring 220–240 microns long. The featherclaws are three-rayed; the dorsal shield is smooth anteriorly, with two median ridges posteriorly; the microtubercles are rounded, covering the entire hysterosoma except the dorsal posterior end; the coverflap of the female genitalia is smooth; and setal tubercles are spurlike.

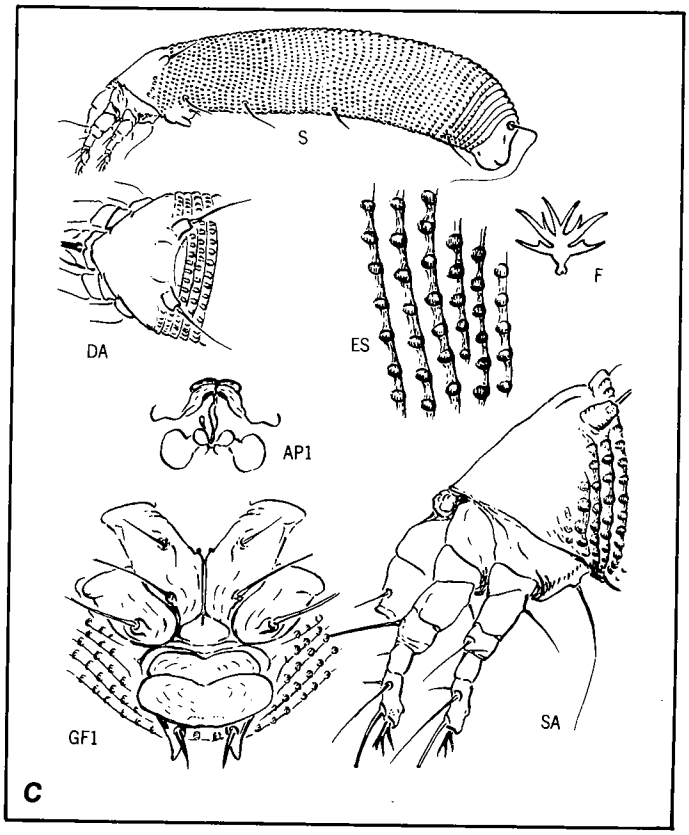
Specimens were found in the galls on Sierra gooseberry in California and on coastal black gooseberry on Orcas Island, Wash., in September. Nearly every leaf of a plant was reported to be galled.

Reference: Keifer, *1959a: 272.*

PLATE 27.—*A, B,* Galls on Sierra gooseberry leaves; note cluster of whitish galls on upper surface around midrib and lateral veins; *C, Eriophyes breakeyi* (Keifer).

A

B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Tiliaceae

***Tilia* spp. Basswood, Lime Tree, Linden**

Leaf gall caused by *Phytoptus tiliae* Pagenstecher (pl. 28)

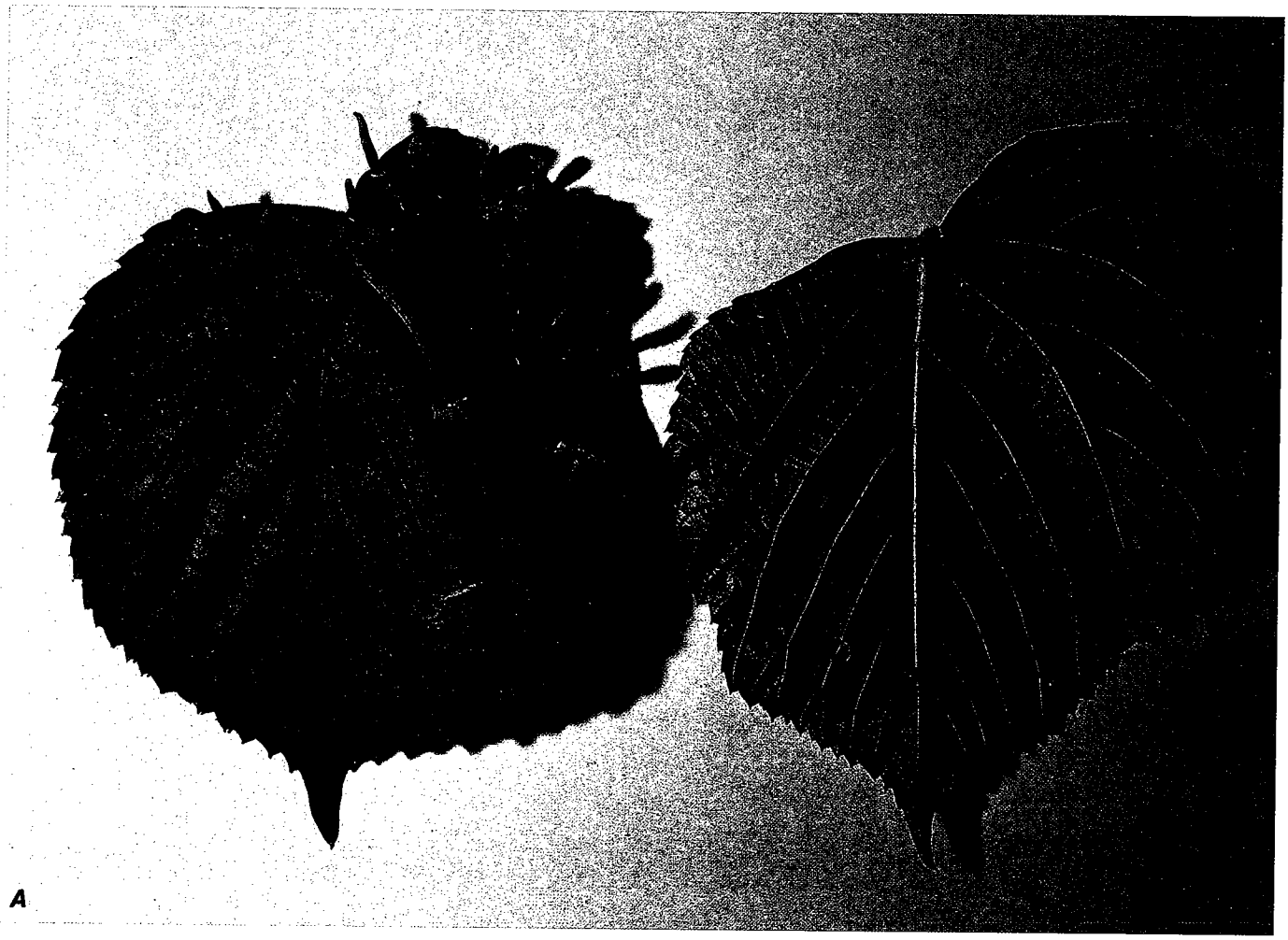
The nail galls on linden leaves induced by *Phytoptus tiliae* are a familiar and striking foliage injury. They are usually numerous and are scattered at random over the leaf surface, generally missing the veins. Each gall is an elongate structure, attenuate distally, with a rounded or pointed tip, measuring 5–12 mm long, which may be erect, oblique, or curved, protruding through the upper surface of the leaf blade. Sometimes two galls are coalesced at the base but form separate apices. The interior of the gall is filled with long, simple hairs near the base or opening (see pl. 6, *D*). The galls vary from greenish yellow to pinkish, to red and brown. They appear in June, maturing in July-August.

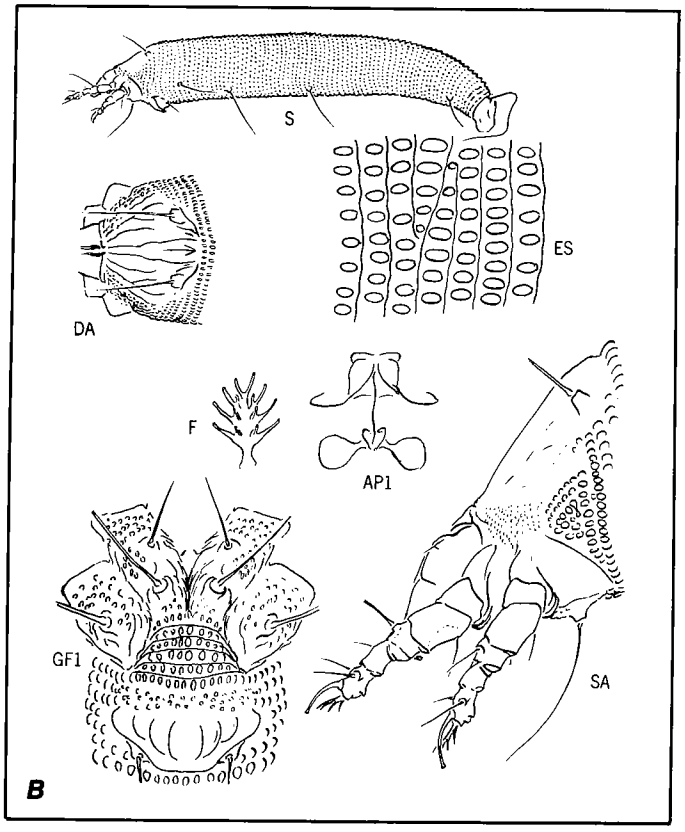
Phytoptus tiliae is a slender, wormlike eriophyid, measuring 150–170 microns long. The featherclaws are four-rayed; distinguishing characteristics are dorsal setae directed forward and elliptical microtubercles; the coxae are granular; and the coverflap of the female genitalia has six ribs. Although a common species, nothing is known of its life history. It is one of the many eriophyids that attack the linden family Tiliaceae and cause galls to form.

Phytoptus tiliae is apparently widely distributed.

References: Keifer, *1952d: 38;* Pagenstecher, *1857: 46.*

PLATE 28.—*A*, Galls on linden leaves: Left, upper surface; right, lower surface. *B, Phytoptus tiliae* Pagenstecher.


A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Ulmaceae

***Ulmus americana* L. American Elm**

Leaf gall caused by *Eriophyes parulmi* (Keifer) and *E. ulmi* (Garman) (pl. 29)

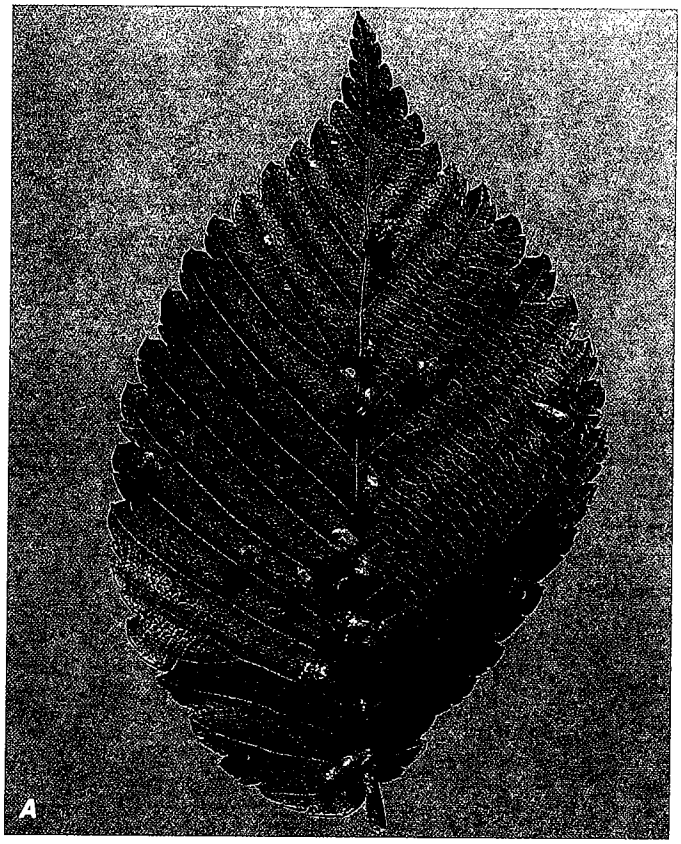
Two kinds of eriophyid galls are easily recognized on elm leaves. *Eriophyes parulmi* causes small, elongate, fingerlike galls that project from the upper surface of the leaf blade. They are randomly arranged, solitary, rarely coalesced and tend to crowd in the angles between the midrib and lateral veins. Specimens were found in July from Wisconsin westward.

Eriophyes ulmi causes the formation of small, variable, beadlike galls on the upper surface of leaves. Their exterior is rough, irregular and is covered with a few hairs like the rest of the leaf surface. They are the least impressive of the two galls. Specimens were collected in Canada and the Eastern United States on American elm and in England and Cyprus on elm.

The mites have typical *Eriophyes* characters. *Eriophyes ulmi* may be readily identified by having two-rayed featherclaws, whereas *E. parulmi* has five-rayed featherclaws. The life history of both species is unknown.

References: Garman, *1883: 137;* Keifer, *1965a: 9.*

PLATE 29.—*A*, Galls on American elm leaf; note crowding of galls between midrib and lateral veins; *B*, close up of galls; *C*, *Eriophyes parulmi* (Keifer).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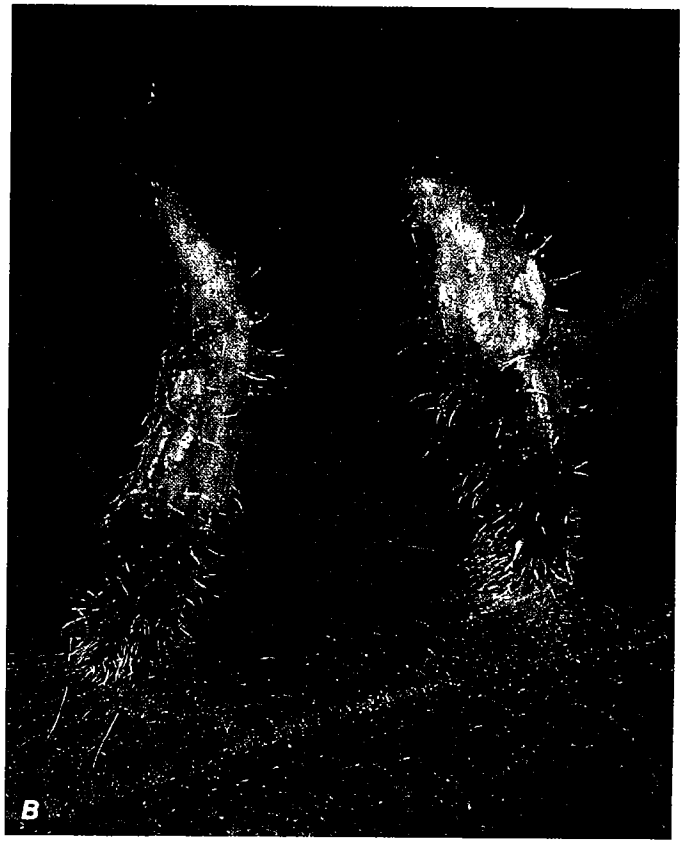
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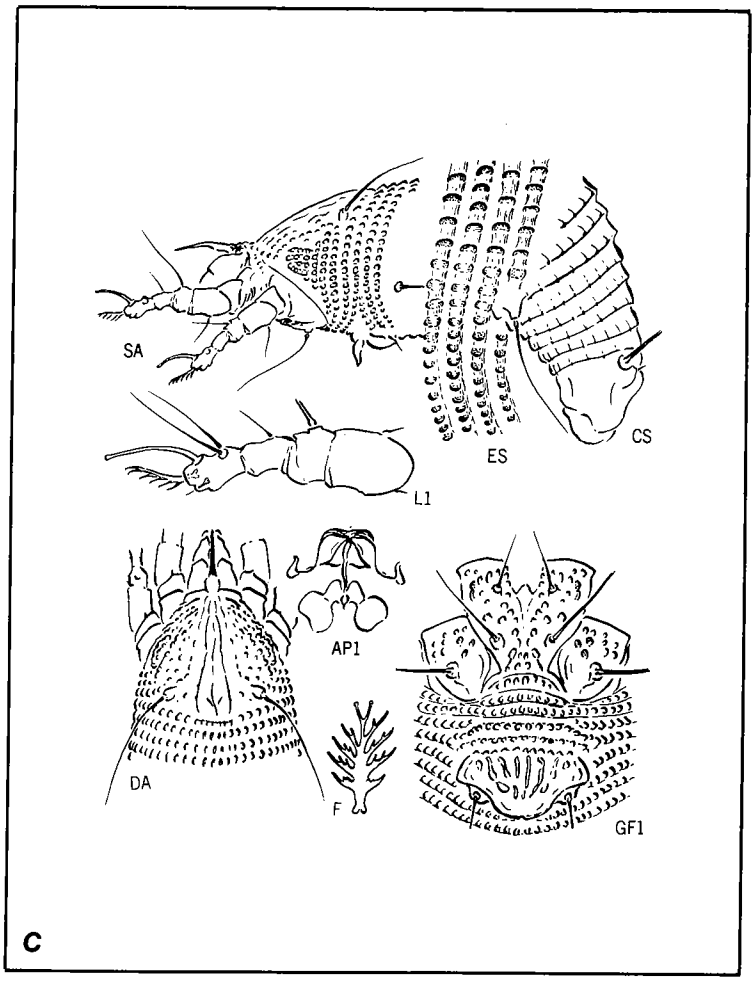
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Bud, Inflorescence, and Stem Galls, Brooming, and Rosette

Anacardiaceae

Mangifera indica **L. Mango**

Bud gall, stunted twigs, and defoliation caused by *Eriophyes mangiferae* (Sayed) (pl. 30)

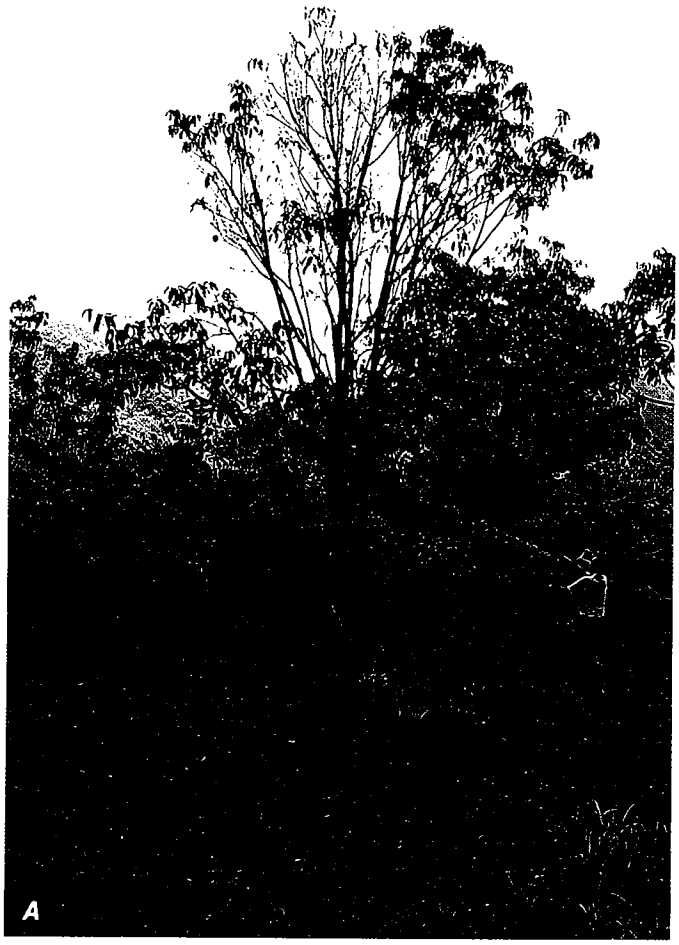
Infestation of the buds results in arrested growth, with the stunted, short, young stems close together at the terminal branch. When the leaves fall, the overall effect is scant growth of twiggy bunches, with a few stubby, short branchlets and discolored buds. Young trees are most seriously affected.

Eriophyes mangiferae is a wormlike, yellowish mite, measuring up to 225 microns long. The female has six- and the male five-rayed featherclaws; the dorsal shield is marked with a design of strong longitudinal ridges confined to the area between the dorsal tubercles; the more easily recognizable features are the hysterosomal microtubercles, which are elongate dorsally and rounded ventrally; and the coverflap of the female genitalia has longitudinal ribs of two uneven ranks. The mites are found in the buds.

This species was discovered in Egypt on mango. It has been reported in Brazil, Mexico, India, Venezuela, and Florida. *Eriophyes mangiferae* was recently collected on galled inflorescences of mango trees in India. However, it is not known whether this mite causes the injury.

References: Jeppson et al., *1975: 441;* Sayed, *1946a: 7.*

PLATE 30.—*A,* Mango tree, showing mite damage; note lack of leaves and twiggy terminal branches; *B,* damaged young mango stems; *C, Eriophyes mangiferae* (Sayed).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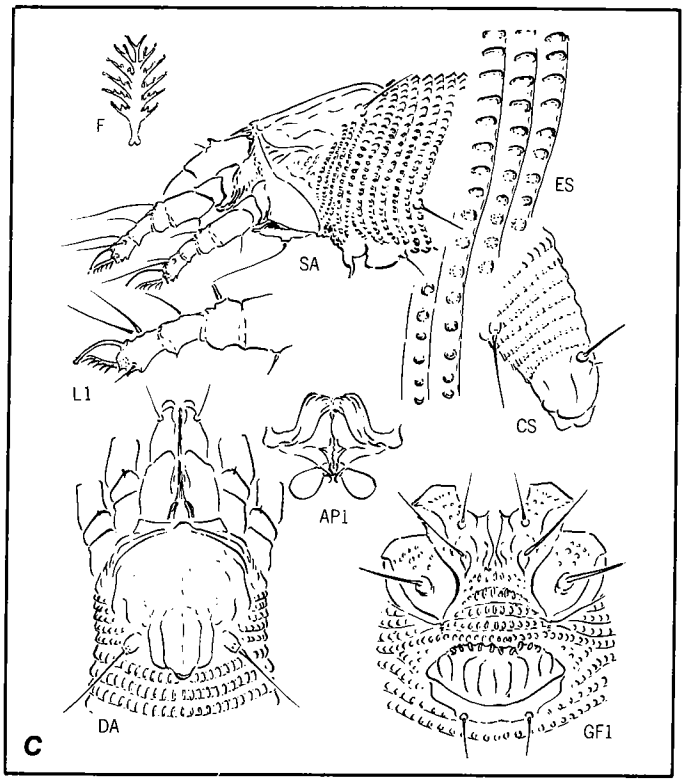
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Betulaceae

***Corylus avellana* L. Filbert, Hazelnut**

Big bud or bud gall caused by *Phytocoptella avellanae* (Nalepa) (pl. 31)

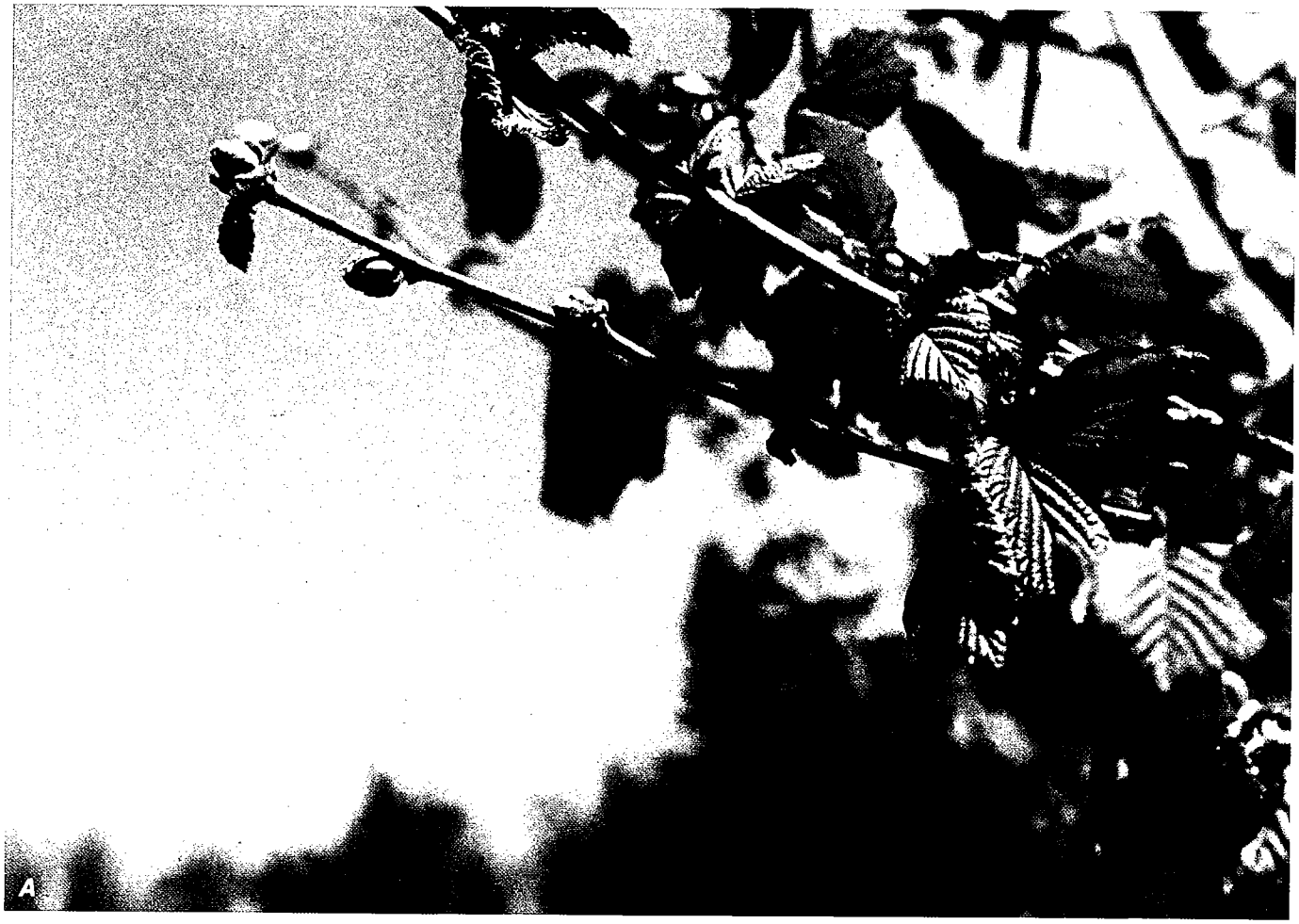
The bud gall, known as big bud, consists of an aggregation of swollen, thickened scale leaves, often containing hundreds of mites. Their feeding activities suppress the developing young leaves or inflorescences enclosed within the scales. Eventually the enlarged buds become dark and reddish brown as they mature.

Phytocoptella avellanae is an unusual eriophyid in that it has two pairs of setae on the dorsal shield and a pair of subdorsal setae on the hysterosoma. It is yellowish and wormlike, measuring 220–260 microns long. The featherclaws are asymmetrical, 4- to 5-rayed; the microtubercles are slightly pointed and lacking on the posterior 8–10 rings of the hysterosoma; the coxae are smooth; and the coverflap of the female genitalia lacks ribs. The nymphs are remarkably different from the adults. They are flattened dorsoventrally and found lying along the veins on the underside of the leaves. Adult mites may be found in the buds throughout the summer. Another eriophyid, *Cecidophyopsis vermiformis* (Nalepa), which causes crinkly leaves in Europe and summer big bud in this country, probably also occurs as an inquiline.

The mite infests filbert or hazelnut in this country and in Europe. Another pest of filbert found in Oregon is *Aculus comatus* (Nalepa). Its feeding causes bronzing or russeting on the leaves and leaf edge rolling when the infestation is severe.

References: Keifer, *1940b: 112;* Krantz, *1973: 709;* Nalepa, *1889: 128.*

PLATE 31.—*A,* Filbert branches, showing mite damage known as "big bud"; *B, Phytocoptella avellanae* (Nalepa). (AP, anterior genital apodeme.)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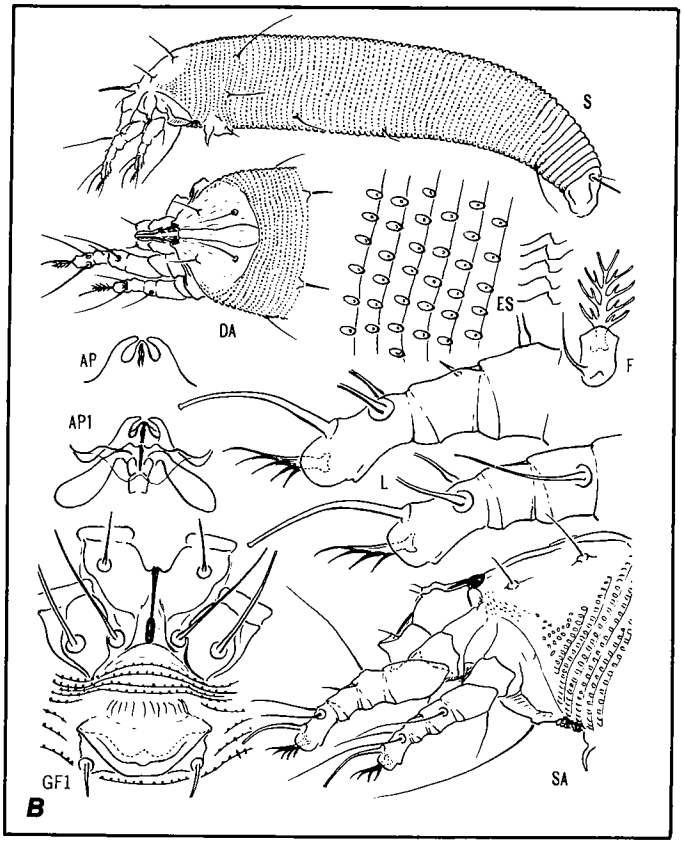
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Compositae

***Chondrilla juncea* L. Skeletonweed**

Bud gall caused by *Eriophyes chondrillae* (Canestrini) (pl. 32)

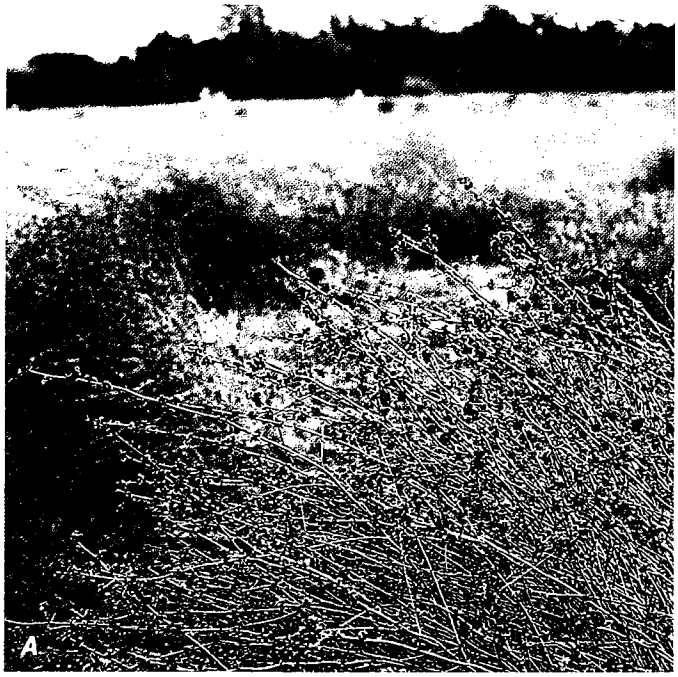
Mite infestation of the flower buds inhibits elongation of the flowering stems and lateral branches. There is considerable distortion of the galled structure, which appears cauliflower-like and of variable size or which forms clusters of aborted and contorted lateral branches, foliage, and flower heads. Since the flower stems fail to produce flowers, the reproductive capacity of the plant is greatly reduced.

Eriophyes chondrillae is one of the many eriophyids that infest various plants of the family Compositae. The feather-claws are six-rayed; the dorsal shield has distinct forked ridges anterior to each of the dorsal setal bases; the microtubercles are elliptical, but they are lacking dorsally toward the posterior end of the hysterosoma; and the coverflap of the female genitalia has longitudinal ribs. The mites inhabit both the galled structures and buds.

The host is skeletonweed, an introduced plant. It is a serious pest of cereal crops in Australia. Skeletonweed is a rapidly growing perennial and may be found in orchards, vineyards, grainlands, and pasturelands in this country. *Eriophyes chondrillae* was introduced into California as a biological control agent of skeletonweed.

References: Canestrini, *1891: 54;* Fuller, *1966: 20.*

PLATE 32.—*A,* Flower bud galls of skeletonweed infested in field; *B, C,* close up of galls; *D, Eriophyes chondrillae* (Canestrini).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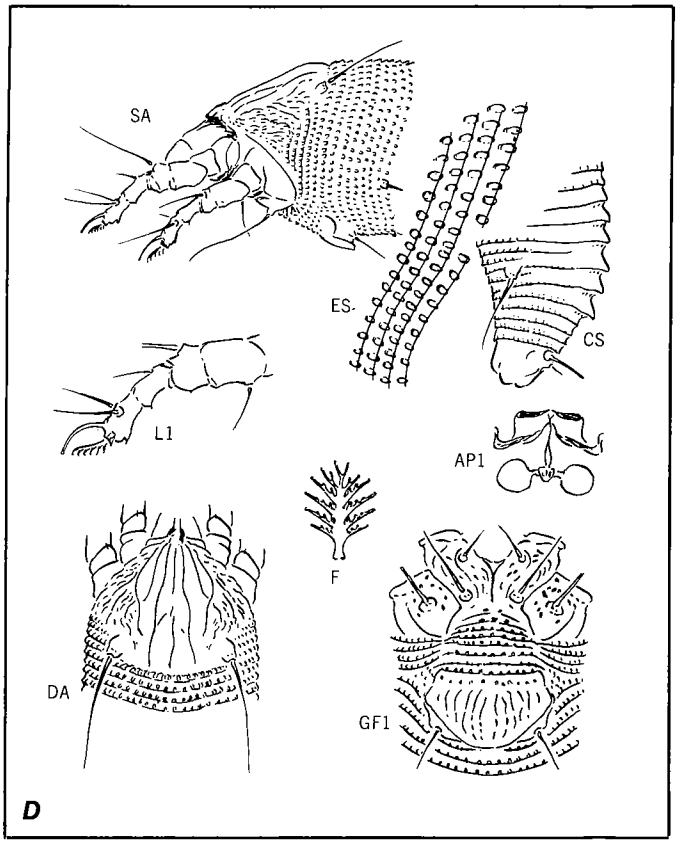
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Compositae

Lepidospartum squamatum **(Gray) Gray**

Bud gall caused by *Eriophyes lepidosparti* (Keifer) (pl. 33)

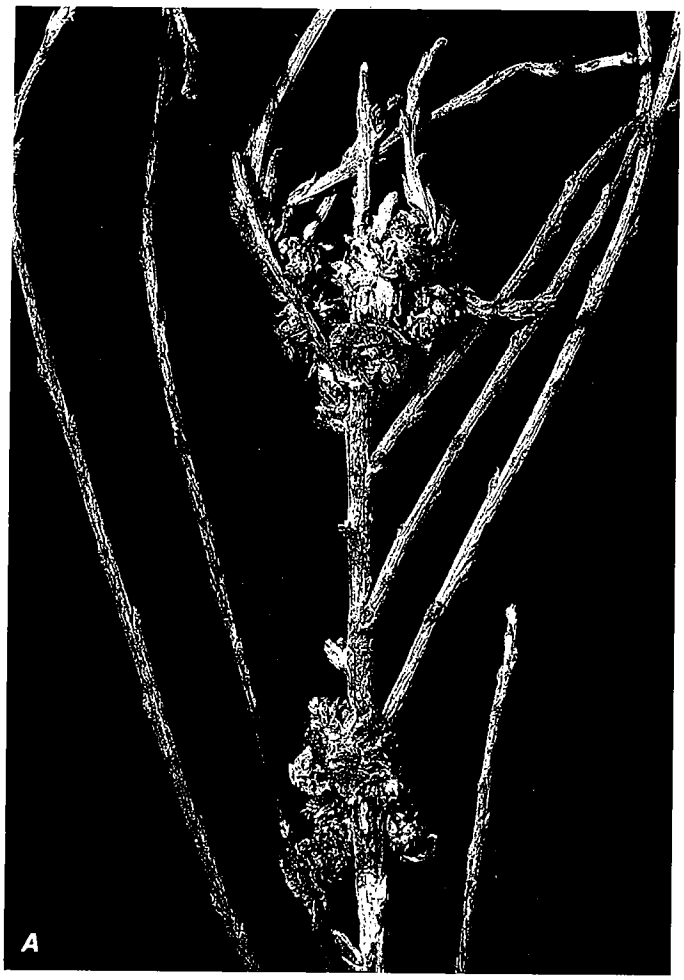
The mites attack the buds and inhibit elongation of the shoot; the result is a visible configuration of the affected structure somewhat similar to a rosette. There is considerable crowding and bunching together of malformed, stunted, thickened shoots and aborted buds with short outgrowths.

This wormlike, pinkish mite measures 170–180 microns long. The featherclaws are 5-rayed; the dorsal shield has numerous short, weak lines scattered at the middle and enclosed by 2 longitudinal, parallel ridges; the hysterosoma is completely covered with rounded microtubercles; the coxae are abundantly granular; and the coverflap of the female genitalia has 14 radiating ribs. This last characteristic is particularly distinctive.

The mites inhabit the buds. They were found in June on *Lepidospartum squamatum,* a rigid broomlike shrub common in washes and gravelly places in California.

Reference: Keifer, *1951: 95.*

PLATE 33.—*A, B,* Bud galls of *Lepidospartum squamatum* (Gray) Gray; note malformed, stunted shoots and aborted buds; *C, Eriophyes lepidosparti* (Keifer).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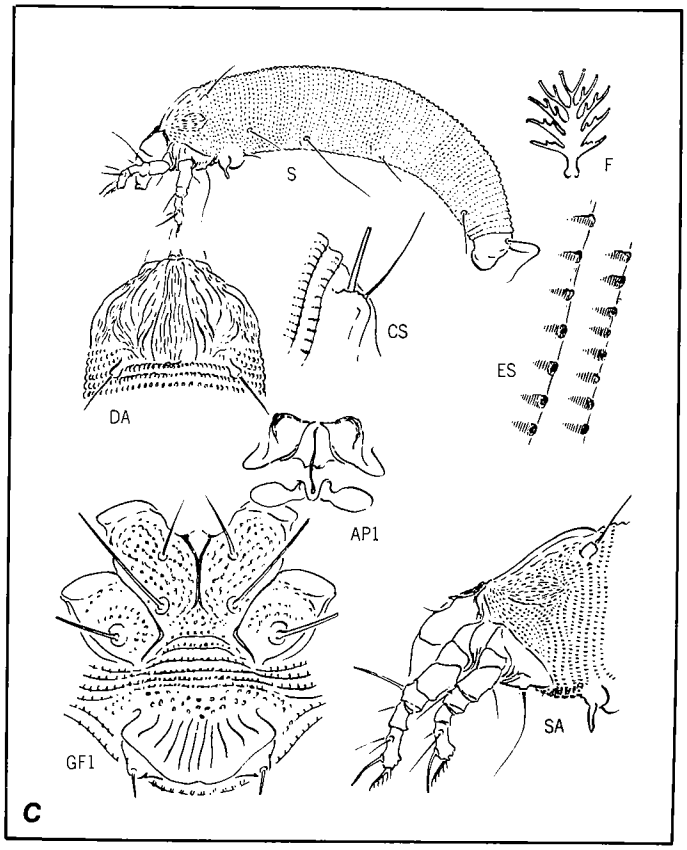
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Cupressaceae

***Juniperus californica* Carr. California Juniper**

***Juniperus occidentalis* Hook. Sierra Juniper**

***Juniperus scopulorum* Sarg. Rocky Mountain Juniper**

***Juniperus virginiana* L. Red Cedar**

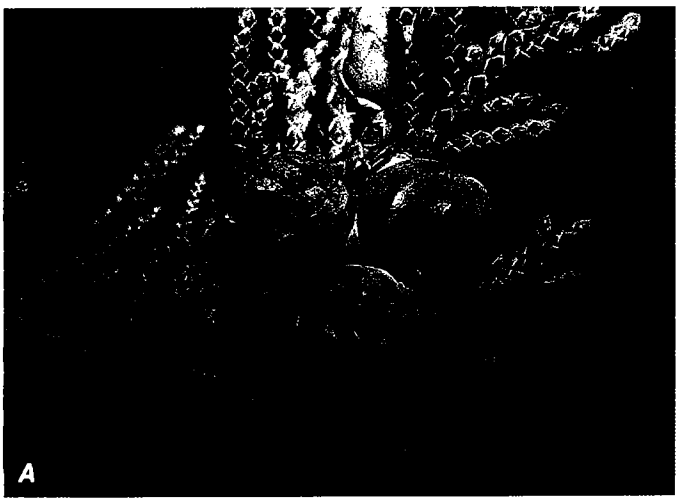
Berry gall and deformed, shriveled berries caused by *Trisetacus batonrougei* Smith, *T. neoquadrisetus* Smith, and *T. quadrisetus* (Thomas) (pl. 34)

There are a few mites that infest juniper and red cedar berries, transforming them to gall-like structures that contain mites in all stages of development. Five species of *Trisetacus* have now been reported inhabiting Cupressaceae berries or cones in the Holarctic Region (Smith, *1978b*). Three are mentioned here. *Trisetacus quadrisetus* was first collected from berries of common juniper (*Juniperus communis* L.) in Europe. This mite was subsequently reported by Keifer (*1957*) from California and Sierra junipers in California. Smith (*1978a*) described *T. neoquadrisetus* from berries of Rocky Mountain juniper in British Columbia and *T. batonrougei* from red cedar in Ontario. The mites were found in berries that were characteristically deformed, shriveled, and dark. This characteristic injury was described by Morgan and Hedlin (*1960*), who also reported the biology of *T. quadrisetus* infesting Rocky Mountain juniper in British Columbia. Infested berries of junipers in California are shown in plate 34, *A* and *B*.

We did not attempt to diagnose the *Trisetacus* species mentioned here. Smith (*1977*) published a key to the species. For identity of those that infest juniper and cedar berries in North America, we suggest that specimens should be sent to specialists for proper determination. The characteristic symptoms of injury by each *Trisetacus* species appear similar to one another.

References: Keifer, *1957: 242;* Morgan and Hedlin, *1960: 608;* Smith, *1977: 843; 1978a: 1157; 1978b: 1161;* Thomas, *1890, in* Massalongo, *1890: 460.*

PLATE 34.—*A, B,* Infested berries of junipers; mites transform berries to galls; *C, Trisetacus quadrisetus* (Thomas).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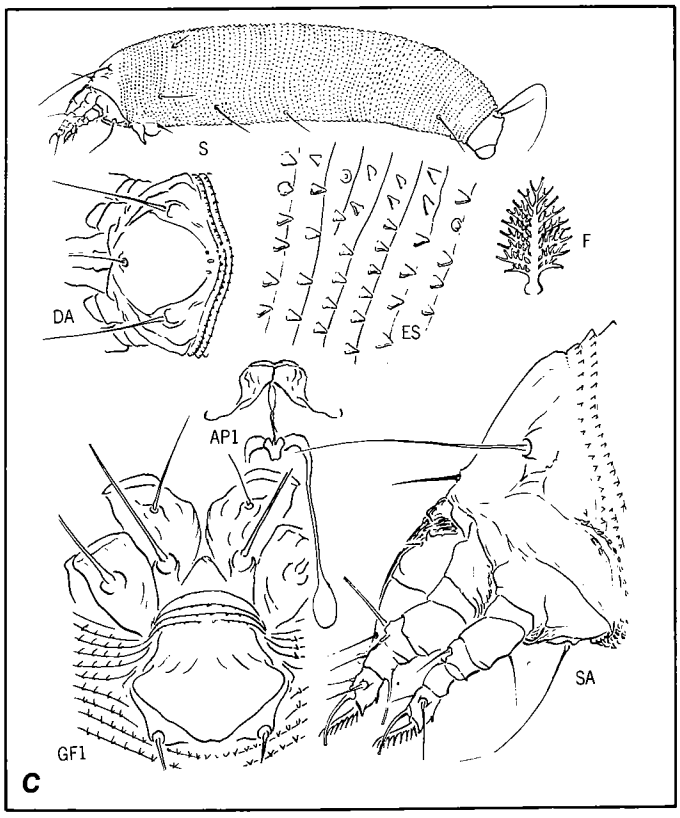
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Gramineae

***Cynodon dactylon* (L.) Pers. Bermuda Grass**

Leaf sheath and stem gall caused by *Eriophyes cynodoniensis* (Sayed) (= *Aceria neocynodonis* Keifer) (pl. 35)

Infested grass exhibits a rosette symptom. Mite feeding apparently inhibits plant growth, in which the leaf sheaths become swollen, closely packed, thickened, and bunched at the stem node, and the leaf blades become stunted. Affected stems have greatly deformed and enlarged nodes and shortened internodes. The infestation showing the characteristic injury becomes evident in the spring on Bermuda grass in lawns and on golf courses; browning and thinning out of the grass follow.

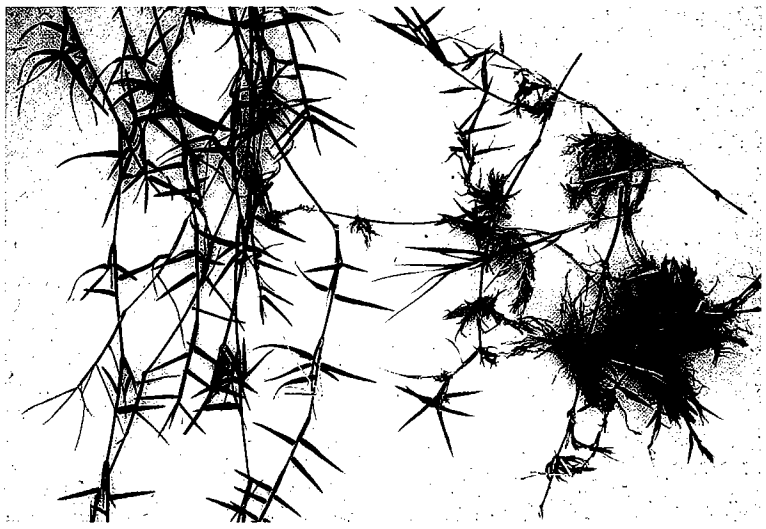
Eriophyes cynodoniensis is a slender, wormlike, yellowish mite, measuring 170–210 microns long. The female has 6- and the male 5-rayed featherclaws; the dorsal shield is marked with a distinctive design of 2 scalloped, parallel ridges running the full length of the shield, with a straight, short ridge in between; the microtubercles are elliptical; and the coverflap of the female genitalia has 11–12 ribs, with the median ribs twice as long as the lateral ones. The mites feed and seek shelter in the leaf sheaths. They vary from a few to a hundred or more in a single sheath. They are less abundant in lawns where flood irrigation is used.

Previously this mite was known in Arizona, Georgia, California, and Florida as *Aceria neocynodonis,* a synonym of *E. cynodoniensis,* which was found on grass in Egypt.

References: Denmark, *1964:* [*1*]; Jeppson et al., *1975: 449;* Keifer, *1960: 2;* Sayed, *1946b: 150;* Tuttle and Butler, *1961: 836.*

PLATE 35.—*A–C,* Bermuda grass rosette; note closely packed swollen stem nodes; *D, Eriophyes cynodoniensis* (Sayed).

A



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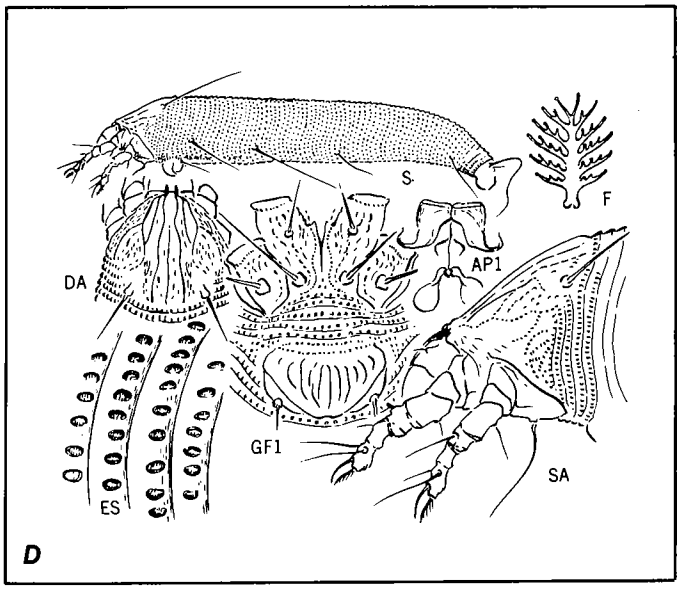
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Juglandaceae

***Juglans hindsii* (Jeps.) Jeps. Hind's Walnut**

Catkin gall caused by *Eriophyes spermaphaga* Keifer (pl. 36)

The mites infest almost every male flower in the drooping catkins. There is considerable malformation with excessive development of individual flowers, each resembling a miniature cauliflower head. Galled catkins on a tree are conspicuous from the ground as a green or dirty brown, blackish, lumpy mass. They begin to deteriorate in July, becoming heavily infested by the mildew fungus. Infested catkins often remain attached to the tree so that galls can be seen throughout the season. The mites seem to have the effect of prolonging the life of the catkin. Although female flowers are heavily infested with mites, they do not show signs of malformation. Infestations vary at two localities in California, with great numbers of galled male catkins observed developing on walnut trees at the type locality.

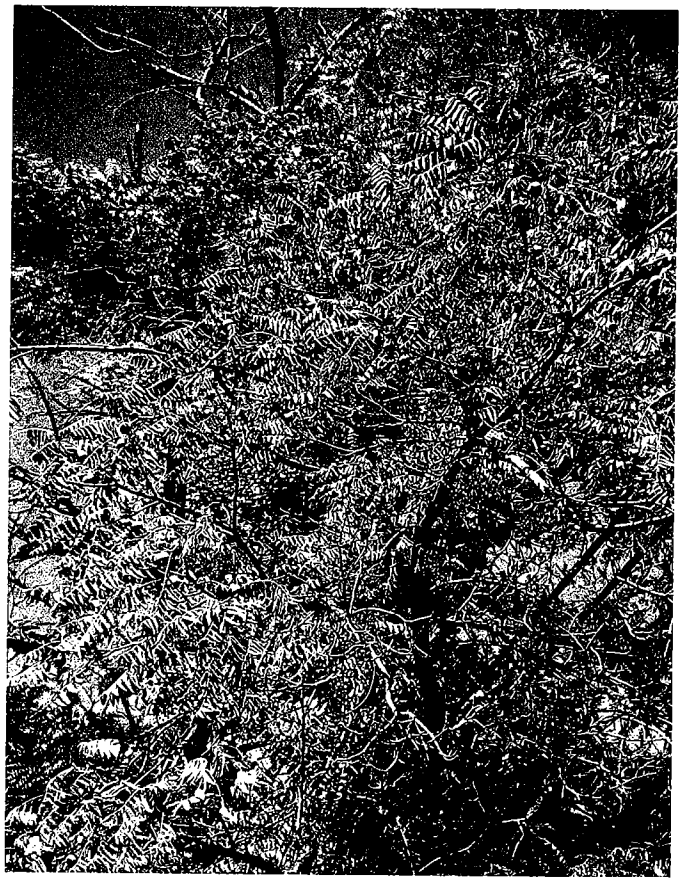
Eriophyes spermaphaga is a slender, yellowish-white, wormlike mite. The protogyne and deutogyne females measure 180–220 microns long; the male is about 188 microns long. The featherclaws are three-rayed; the dorsal shield is almost devoid of markings; there are short weak lines between the dorsal tubercles and above the second coxae; the dorsal setae are directed backward and divergent; the coxae and sternal areas are smooth; the microtubercles of the protogyne and male are pointed, and those of the deutogyne are not; the coverflap of the female genitalia is faintly marked posteriorly; and the setal bearing tubercles are produced, constricted, and pointed posteriorly. The male, protogyne, and deutogyne were found inhabiting galled male catkins and female flowers during June-July. The life cycle of this mite has not been observed.

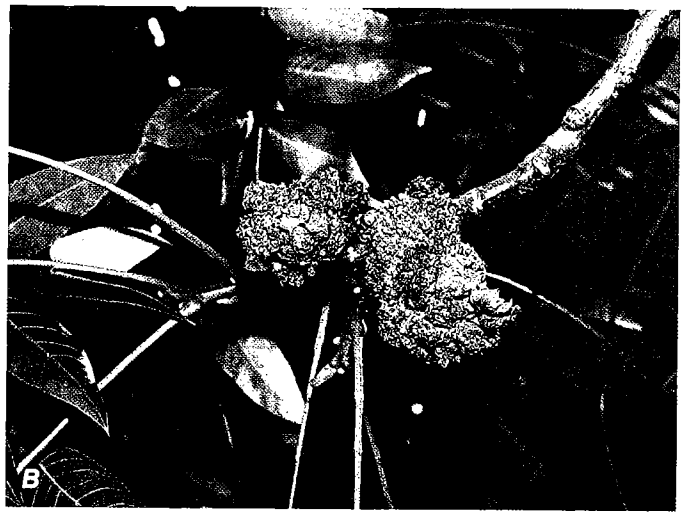
Eriophyes spermaphaga was recently discovered on catkins of Hind's walnut from California. No collection has been made in other areas.

This species should not be confused with *Eriophyes neobeevori* Keifer, which causes similar injury to catkins in California walnut (*Juglans californica* S. Wats.) in southern California.

References: Keifer, *1952c: 148; 1979: 15.*

PLATE 36.—*A,* Infested Hind's walnut tree; *B, C,* galled catkins; *D,* mites in galled catkin; *E, Eriophyes spermaphaga* Keifer. (ESD, dorsal microtubercles.)

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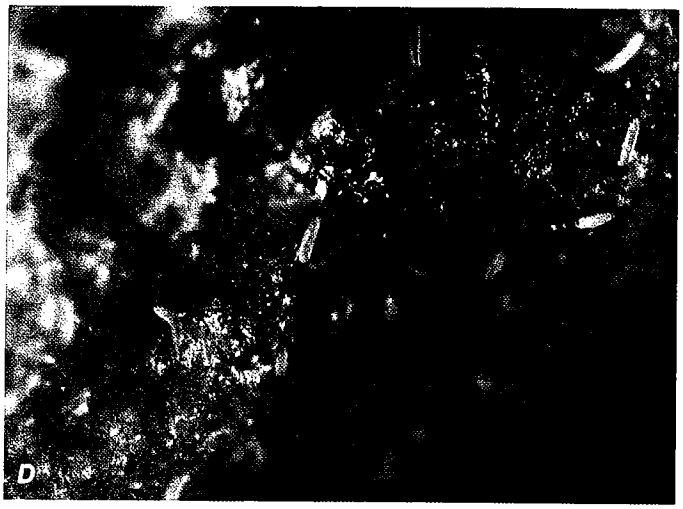
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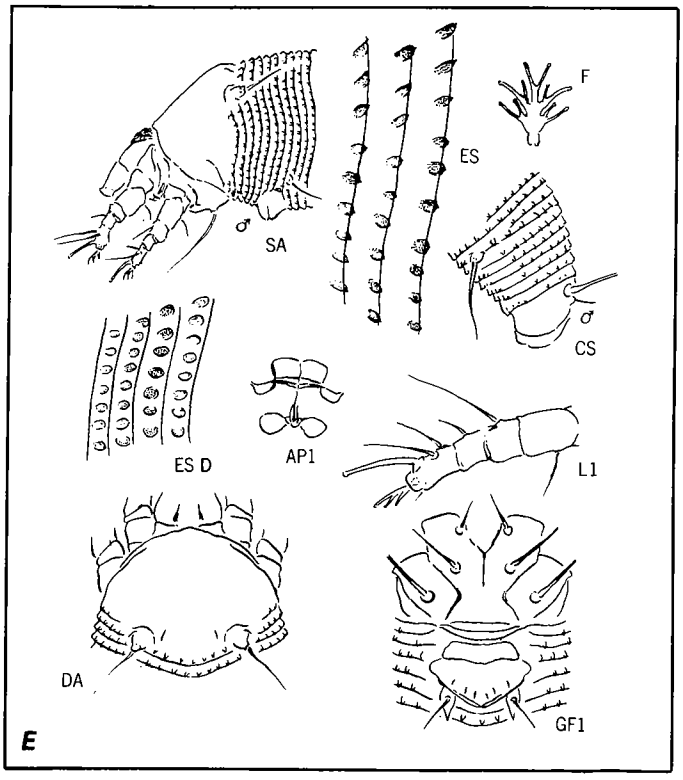
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Oleaceae

***Fraxinus* sp. Ash**

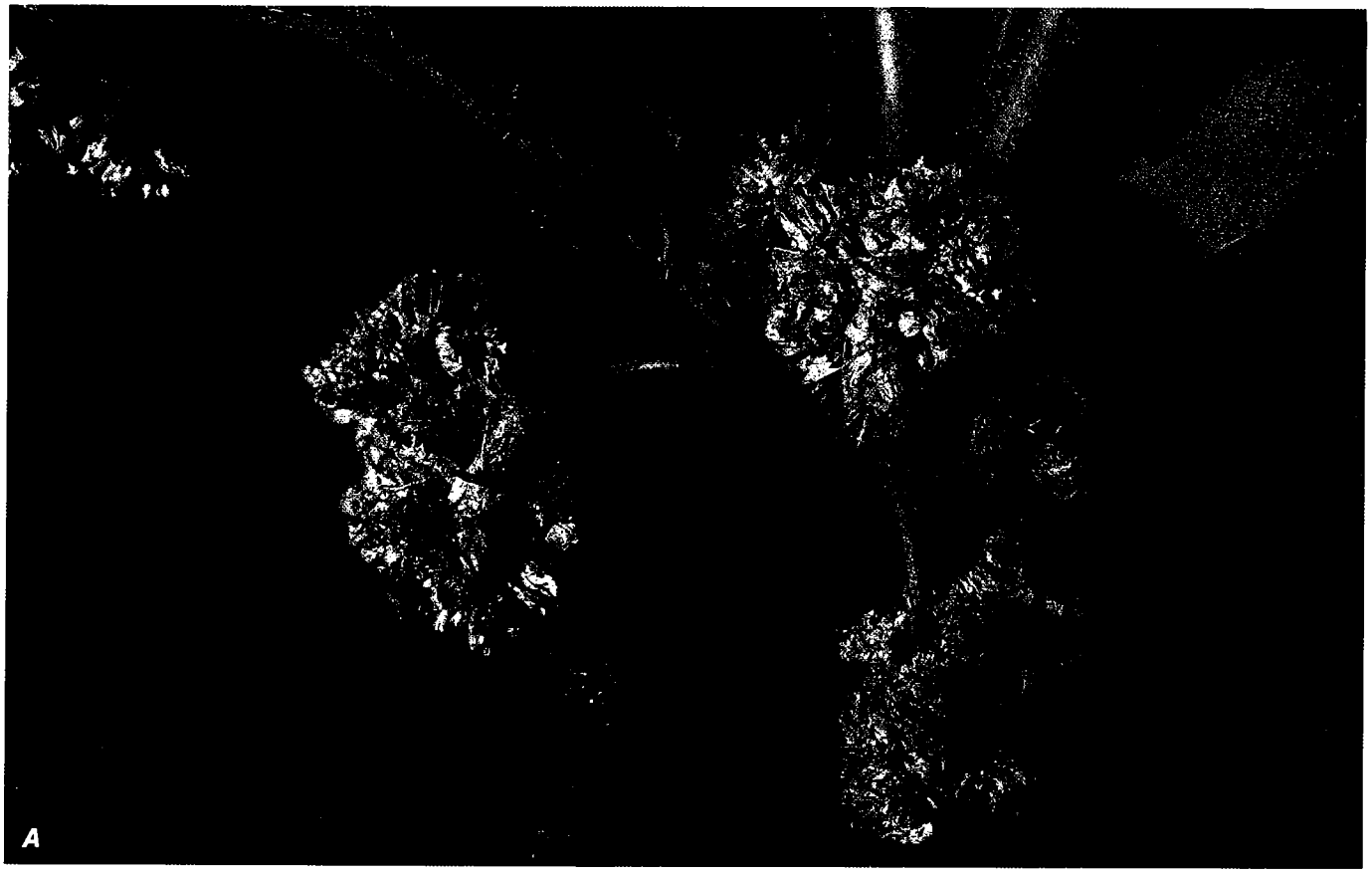
Inflorescence gall caused by *Eriophyes fraxinivorus* Nalepa (pl. 37)

This is an interesting and distinctive gall. The infested inflorescence shows swollen and fused pedicels of individual flowers, often involving the peduncle or stalk. There is considerable distortion, and when the infestation is severe, every inflorescence is galled. Fully developed galls are conspicuously brownish, lumpy, and unsightly, usually remaining attached to the twigs from one season to the next. Galled inflorescences can be found throughout the year and are locally abundant.

Eriophyes fraxinivorus, a widespread European species, may be recognized by its four-rayed featherclaws and smooth dorsal shield with a short median ridge posteriorly. Specimens have been collected on galled inflorescences of an unidentified ash from New York and on Oregon ash (*Fraxinus latifolia* Benth.) in California.

Reference: Nalepa, *1909: 117.*

PLATE 37.—*A,* Damaged inflorescence of *Fraxinus; B,* close up of *A; C,* vertical section of galled inflorescence; *D, Eriophyes fraxinivorus* Nalepa.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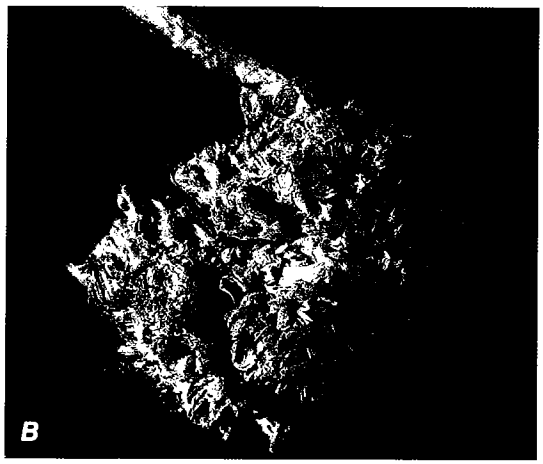
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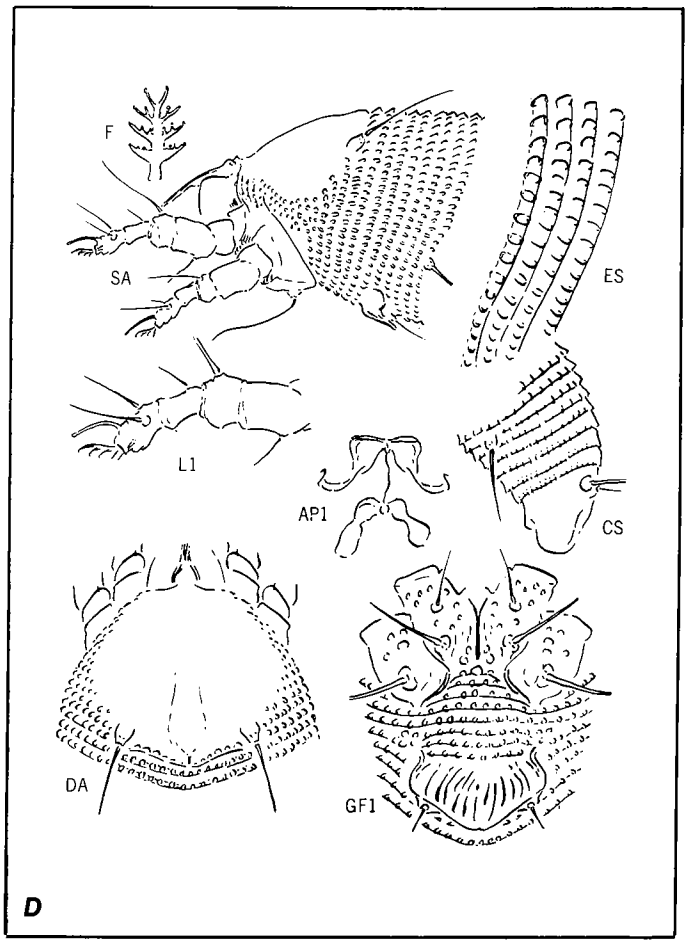
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Pinaceae

***Pinus clausa* (Chapm.) Vasey Sand Pine**

***Pinus elliottii* Engelm. Slash Pine**

***Pinus glabra* Walt. Cedar Pine**

***Pinus lambertiana* Dougl. Sugar Pine**

***Pinus monticola* Dougl. ex D. Don Western White Pine**

***Pinus sylvestris* L. Scotch Pine**

***Pseudotsuga menziesii* (Mirb.) Franco Douglas Fir**

Rosette galls, stunted needles, and aborted buds caused by *Trisetacus alborum* Keifer, *T. campnodus* Keifer & Saunders, *T. floridanus* Keifer, *T. gemmavitians* Styer, Nielsen, & Balderston, and *T. pseudotsugae* Keifer (pl. 38)

Several species of *Trisetacus* mites infest conifers. Some of the symptoms of injury caused by these five species are shown in plate 38. Rosette or clustering of numerous aborted buds and stunted needles is the typical injury. Because of the similarity of the injuries on various pines, the taxonomy becomes complex. Distinction of the injury may be based on the part of the plant attacked and on accurate identification of the mites by a specialist.

Trisetacus gemmavitians and *T. campnodus* attack Scotch pine. The former mite causes a peculiar gall, which essentially is a conspicuous, beautiful rosette easily seen on pine trees. Each rosette consists of a cluster of aborted buds or stunted needles. Typically the shoots become infested, and the elongation of the growing point is inhibited. Numerous buds are clustered at the tip, and the needles that develop from these buds are stunted. When rosettes are numerous, the value of cut pine trees is greatly reduced. Infestations occur at the base of the needle beneath the sheath. The mites have been collected in the sheaths of stunted needles and in new buds. *Trisetacus gemmavitians* has been reported from Ohio and California.

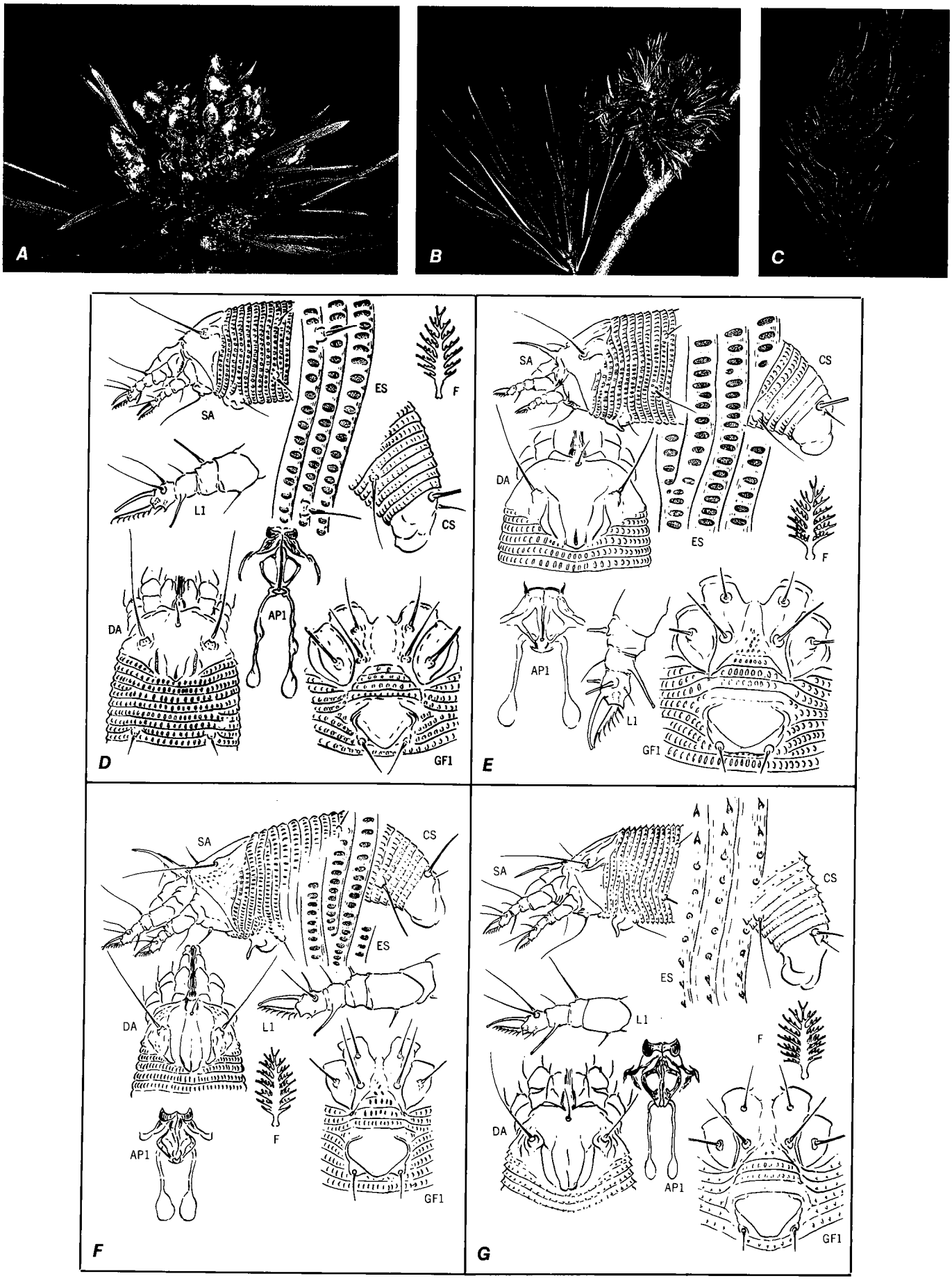
Trisetacus campnodus causes yellowing and stunting of Scotch pine needles. The mites colonize the needle base beneath the sheath. This area becomes necrotic and brown, at times calloused, and eventually the needles turn yellow and stunted, often distorted. Infested pine trees are chlorotic and generally appear unthrifty. This mite species was collected in Washington State.

The injuries on other conifers caused by the following species of *Trisetacus* are not unlike the rosette gall on Scotch pine. *Trisetacus floridanus* has been reported attacking terminal shoots and causing galls, aborted buds, and stunted needles on four species of pines in Florida: Sand, slash, and cedar pines and an unidentified pine species. Specimens have been collected in growing terminal shoots from January through August. *Trisetacus alborum* at times causes the formation of clusters of stunted needles on sugar and western white pines in California. Similar injury is caused on Douglas fir by *T. pseudotsugae*. The mites were found in Oregon infesting nursery seedlings, in which the growing tips form clusters of aborted needles. The infested seedlings are stunted and deformed.

Trisetacus mites are distinctive in having three setae on the dorsal shield; all are directed forward. The featherclaws vary from seven to nine rays and the body from 280 to 410 microns long; and the coverflap of the female genitalia is smooth. The species mentioned here share many similar morphological characters that make specific identification difficult. They may be separated, however, by the type of microtubercles on the hysterosoma and by the design on the dorsal shield.

References: Denmark, *1971:* [*1–2*]; Keifer, *1963: 5; 1964: 19;* Keifer and Saunders, *1972: 46;* Lavender et al., *1967: 621;* Styer et al., *1972: 1089.*

PLATE 38.—*A–C,* Damage to conifers by *Trisetacus* mites; *D, Trisetacus gemmavitians* Styer, Nielsen, & Balderston; *E, T. alborum* Keifer; *F, T. floridanus* Keifer; *G, T. pseudotsugae* Keifer.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Rosaceae

Prunus domestica **L. Plum**

Prunus dulcis **var.** *dulcis* **(Mill.) D. A. Webb Almond**

Bud gall caused by *Acalitus phloeocoptes* **(Nalepa)**

This is an interesting example of a rosaceous bud galled by an *Acalitus* mite. Unfortunately we have no color photograph to illustrate the injury. *Acalitus phloeocoptes* causes permanent irregular galls of various sizes around the buds and deforms the fruit of almond. Infested trees fail to form fruit buds and lose vigor, and the damage appears to be progressive and irreversible. This results in the trees dying in 3 to 6 years. On plum, the mites form small, irregular, subspherical galls, 1.3–1.8 mm in diameter, surrounding the buds and also deforming the fruit. The galls may appear singly or clustered around the buds and become woody. Unlike almond, infested plum trees often recover from mite attack and do not show permanent injury.

Acalitus phloeocoptes is wormlike and whitish, measuring 135–150 microns long. The overwintering females are more slender than the mites during the summer. This mite can be easily separated from other species of *Acalitus* by its five-rayed featherclaws, smooth dorsal shield, strong sternal and coxal apodemes, and granular coverflap of the female genitalia. Details of the life cycle are summarized in Jeppson et al. (*1975*). The females overwinter in the hardened galls. When the galls crack in early spring, the mites migrate to newly developing buds.

This mite is distributed throughout southern and central Europe on almond and plum. It has been found in the Eastern United States on the same host plants.

References: Jeppson et al., *1975: 468;* Nalepa, *1926: 80.*

Rosaceae

Spiraea densiflora **Nutt. ex Rydb. Bridal-Wreath**

Inflorescence gall caused by *Phytoptus paraspiraeae* **Keifer (pl. 39)**

The umbellike inflorescence of infested bridal-wreath plants has oval or pear-shaped, greenish and whitish, unopened buds in a cluster of red flowers. Feeding activities of the mites abort the growth of flower buds, preventing the sepals and petals from opening, and the stamens, pistils, and other floral parts are distorted. These galls are induced by *Phytoptus paraspiraeae.*

This mite is robust, wormlike, and yellowish white; the female measures 155–175 microns long and the male 130 microns. The featherclaws are 6-rayed; the surface of the dorsal shield is rough, with numerous short, broken ridges; the dorsal setae are directed forward; the microtubercles are rounded and widely spaced on the rings; the coxae have few granules; and the coverflap of the female genitalia has 10 ribs.

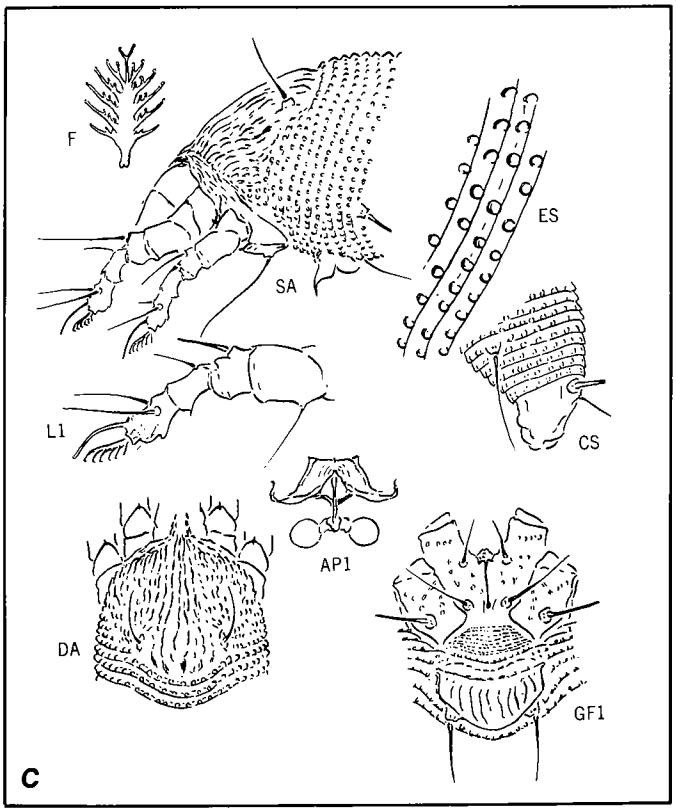
The mites in the galled flower buds were found in California at 1,800 meters in August. The host plant, bridal-wreath, is found from California to British Columbia. In Europe, a closely related species, *Phytoptus spiraeae* Nalepa, also causes similar galls in *Spiraea* flowers.

Reference: Keifer, *1977: 17.*

PLATE 39.—*A,* Infested inflorescence of bridal-wreath in field; *B,* close up of galled flower buds; *C, Phytoptus paraspiraeae* Keifer.

A

B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Salicaceae

***Populus fremontii* S. Wats. Fremont Cottonwood**

***Populus* sp. Poplar**

Catkin gall probably caused by *Eriophyes neoessigi* Keifer (pl. 40)

The mites colonize catkin flowers, which become enlarged, malformed, and bunched tightly together. The affected floral parts are wrinkled and curled, often containing numerous mites. The elongate, pendulous catkin hangs like a bunch of grapes, its diameter varying from 7.6 to 12.7 cm and length from 15.2 to 25.4 cm. Unlike normal catkins that drop in the spring, infested catkins hang until summer.

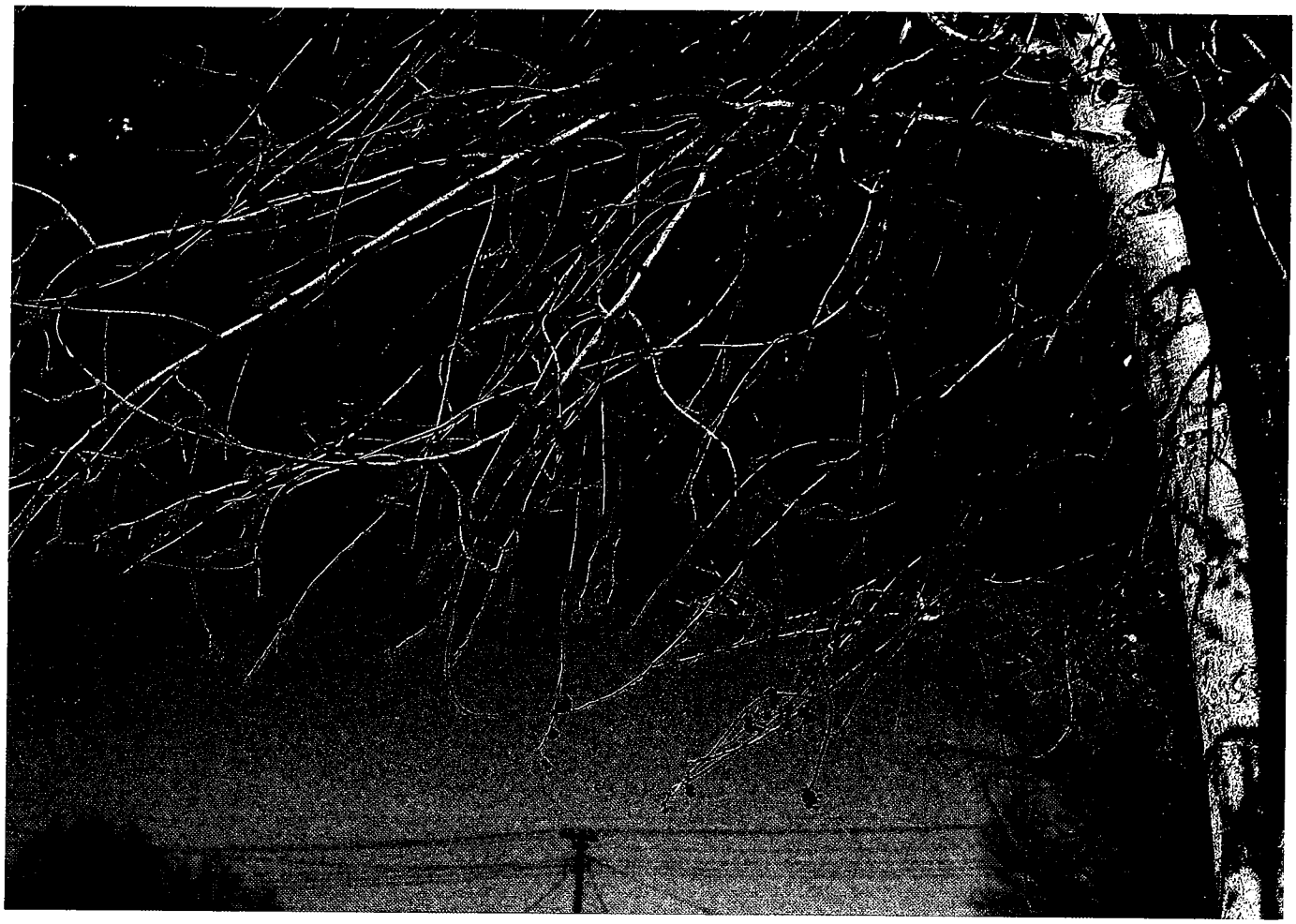
It is not certain that *Eriophyes neoessigi* causes the injury. A similar situation is also found on catkins of willow (*Salix*) in Europe (Rack, *1958;* Westphal, *1977*). According to Westphal (*1977*), "Wirrzope" or catkin galls of *Salix* are not induced by eriophyid mites. The pathological tissues have been found to contain bacilliform particles resembling rhabdoviruses and suggesting a viral origin of catkin galls.

Eriophyes neoessigi is a slender, wormlike, yellowish mite, measuring 170–200 microns long. The featherclaws are 6-rayed; the distinctive dorsal shield design consists of 3 longitudinal median ridges flanked by 2 pairs of short curved ridges; the microtubercles are elliptical; the coxae are heavily granular; and the coverflap of the female genitalia has 10 ribs in a single row. This mite has a simple life cycle, with reproduction taking place in the infested catkin. It overwinters in the buds, becoming active in the following spring.

Specimens of *E. neoessigi* were first collected on malformed catkins of an unknown poplar in Utah and subsequently on Fremont cottonwood in California. Wilson and Oldfield (*1966*) reported *E. neoessigi* "producing large pendant gall of fasciated outgrowths on staminate catkins of *Populus fremontii* and *P. tremuloides* Michx., quaking aspen." They also listed *Aceria populinquis* Keifer as an inquiline in galls infested by *E. neoessigi* on Fremont cottonwood.

References: Jeppson et al., *1975: 362;* Keifer, *1940a: 22;* Rack, *1958: 31;* Westphal, *1977: 193;* Wilson and Oldfield, *1966: 590.*

PLATE 40.—*A*, Damaged catkin of poplar; *B*, *Eriophyes neoessigi* Keifer. (L2, left leg.)



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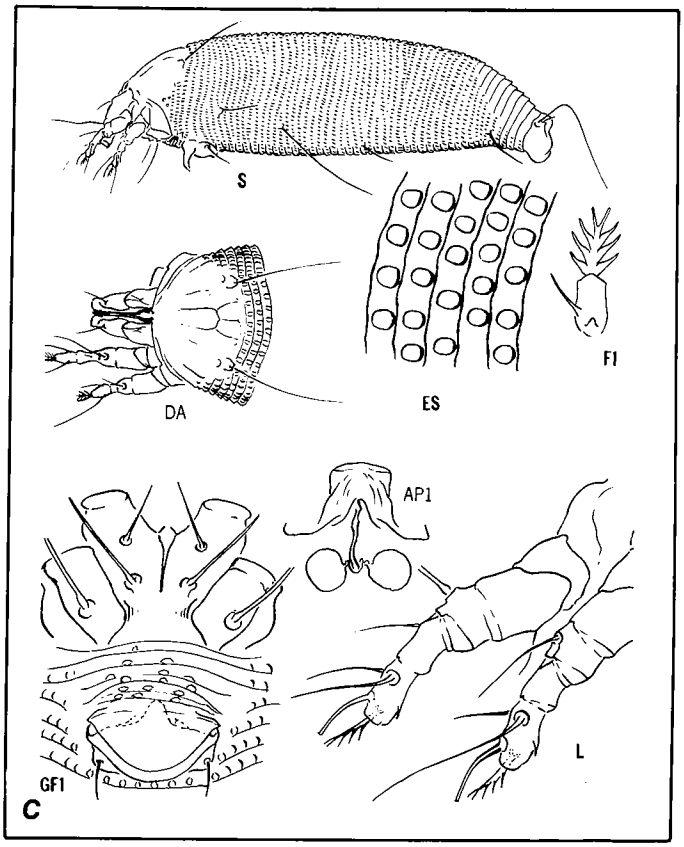
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Taxodiaceae

***Sequoia sempervirens* (D. Don) Endl. Redwood**

Bud and terminal shoot injury caused by *Trisetacus sequoiae* Keifer (pl. 42)

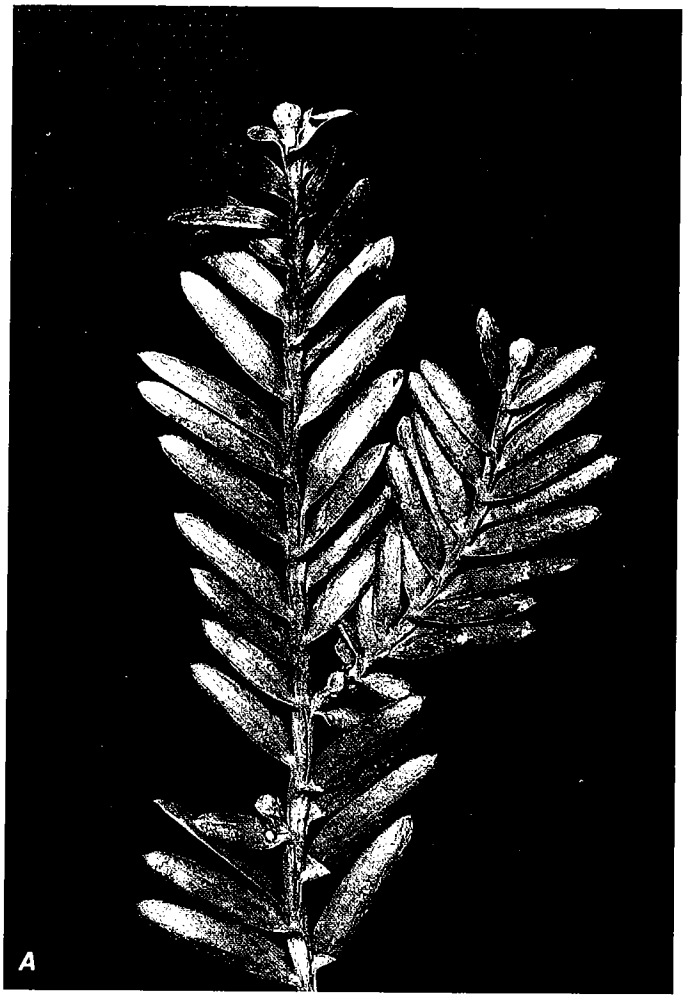
Although this mite is confined locally to California and is perhaps uncommon, it is included here because its host is a well-known conifer. It colonizes and damages the buds, causing browning of the scales and some of the leaves behind the growing point and preventing further growth of lateral buds. As long as the buds or terminal shoots are infested, no new growth develops.

Trisetacus sequoiae is a slender, yellowish-white mite; the female measures 205–225 microns long and the male 180 microns. This species is distinguished from other members of the genus by having eight-rayed featherclaws; the dorsal shield has no defined markings, but it has a median indentation posteriorly; the microtubercles are rounded and dense, with fewer dorsally toward the posterior end of the hysterosoma; and the coverflap of the female genitalia, as in other members of the genus, is smooth.

Specimens were collected in buds of redwood during September along the northern California coast.

References: Jeppson et al., *1975: 403;* Keifer, *1970: 2.*

PLATE 42.—*A, B,* Injured terminal buds, stems, and shoots of redwood; *C, Trisetacus sequoiae* Keifer.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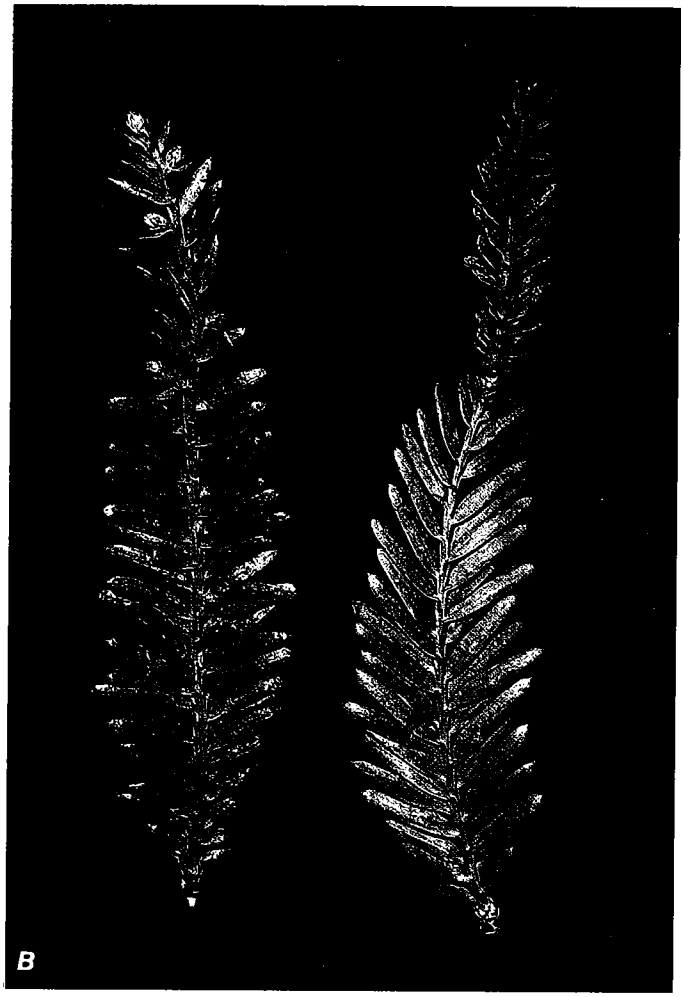
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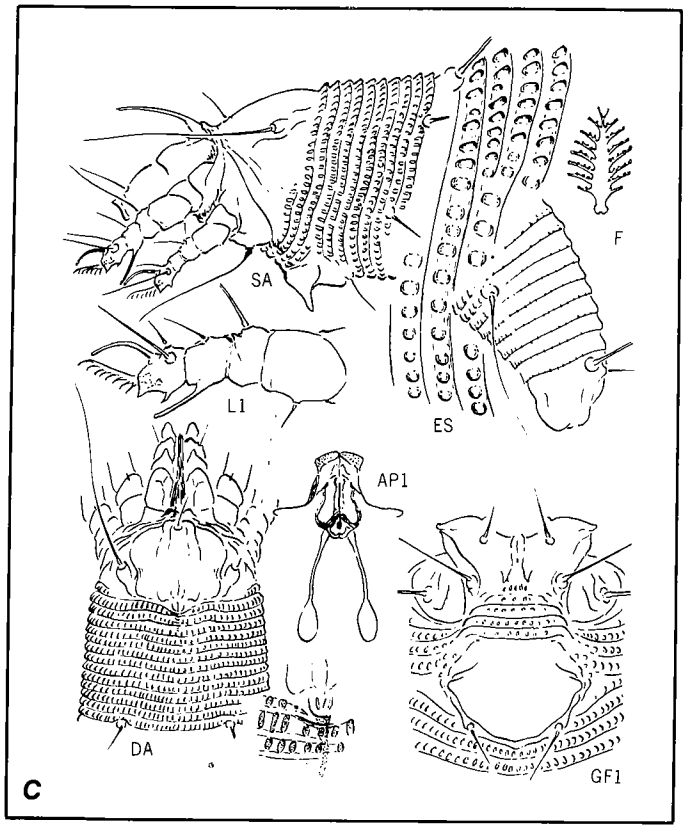
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Ulmaceae

***Celtis occidentalis* L. Hackberry**

Bud gall and witches'-broom caused by *Eriophyes celtis* Kendall (= *Aceria snetsingeri* Keifer) (pl. 43)

Witches'-broom is the most conspicuous symptom of tree injury and is used by laymen to identify hackberry trees. *Eriophyes celtis* causes the brooms on this tree. Infestation of the buds prevents normal growth, and as a result numerous buds are clustered together on the side of the stem. Eventually the buds develop and produce thin, short, stunted, and tightly bunched twigs. The twigs bear large buds with open scales and tend to dieback after a year's growth. Usually the brooms are numerous and contribute to the undesirability of hackberry as a shade tree.

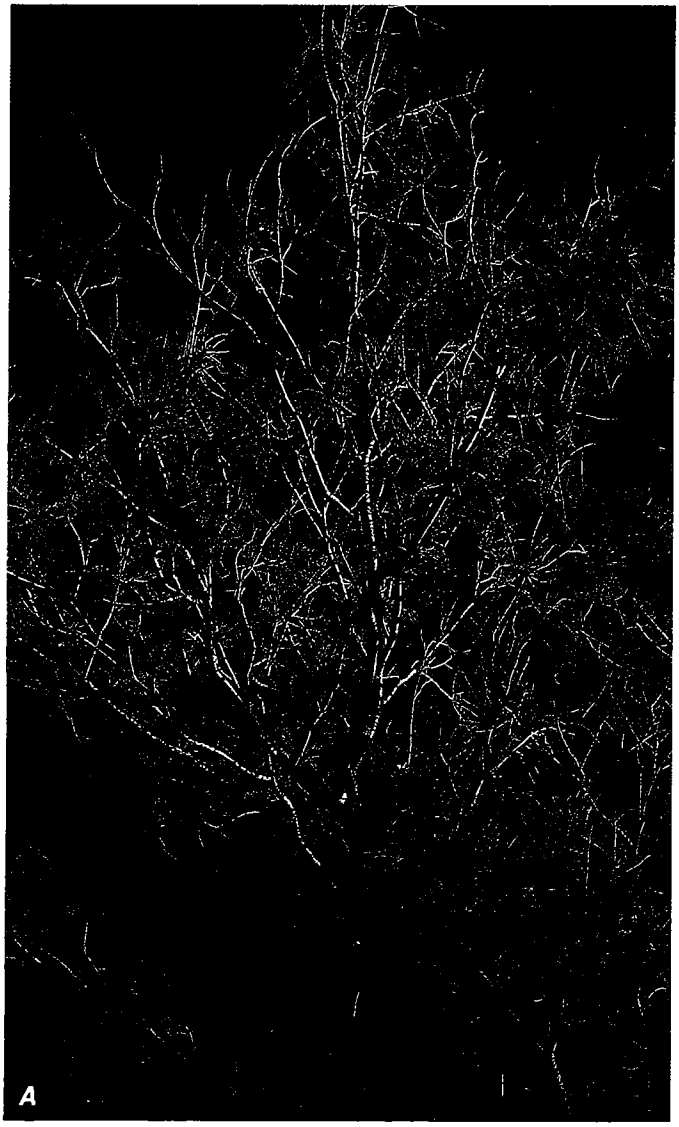
A powdery mildew, *Sphaerotheca phytoptophila* Kellerm. & Swingle (Erysiphaceae), was found intimately associated with the mites. It occurs only on hackberry that has been attacked by the mites, and it thrives on the infested branches or distortions caused by the mites (Salmon, *1900*). This symbiotic relationship between the two organisms was also suggested by L. R. Batra (plant pathologist, U.S. Dept. Agr., Beltsville, Md.). In England, witches'-broom (trunk or branch galls) on birch trees (*Betula*) is induced by fungi belonging to three genera: *Taphrina, Puccinia,* and *Melampsorella.* Another mite, *Eriophyes rudis* (Canestrini), frequently occurs in large numbers as an inquiline in the galls (Darlington, *1968*).

Eriophyes celtis is a wormlike mite, measuring about 200 microns long. The featherclaws are five-rayed; the dorsal shield is unmarked except for a short median ridge posteriorly; the microtubercles are irregular and somewhat thickened posteriorly; and the coverflap of the female genitalia is smooth. Little is known of the life history. Eggs are laid in May and colonies develop throughout the spring, summer, and fall. The mites are found in large numbers in the buds, 2,000 or more per bud.

Eriophyes celtis has been found on *Celtis occidentalis,* locally known as hackberry, in Ohio, Illinois, and Mississippi. It probably occurs throughout its host range from Quebec to North Carolina and Alabama. *Aceria snetsingeri* Keifer from Illinois is a synonym.

References: Keifer, *1957: 244;* Kendall, *1929: 296;* Snetsinger and Himelick, *1957: 541.*

PLATE 43.—*A,* Infested hackberry tree with witches'-brooms; *B,* close up of witches'-brooms; *C, Eriophyes celtis* Kendall.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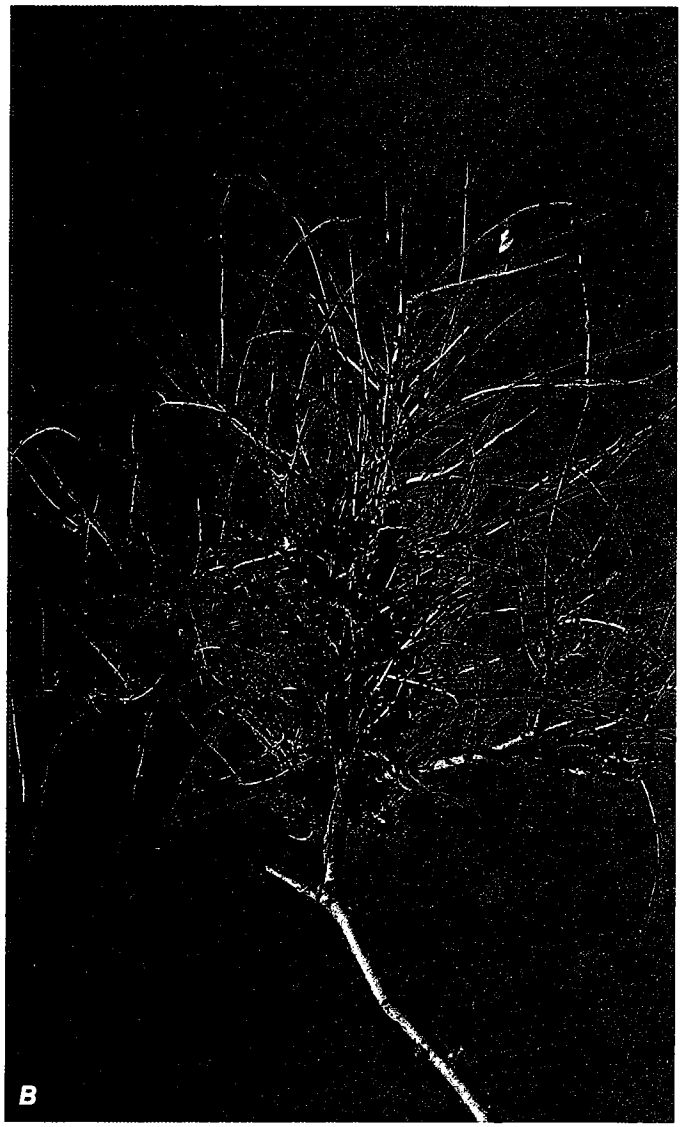
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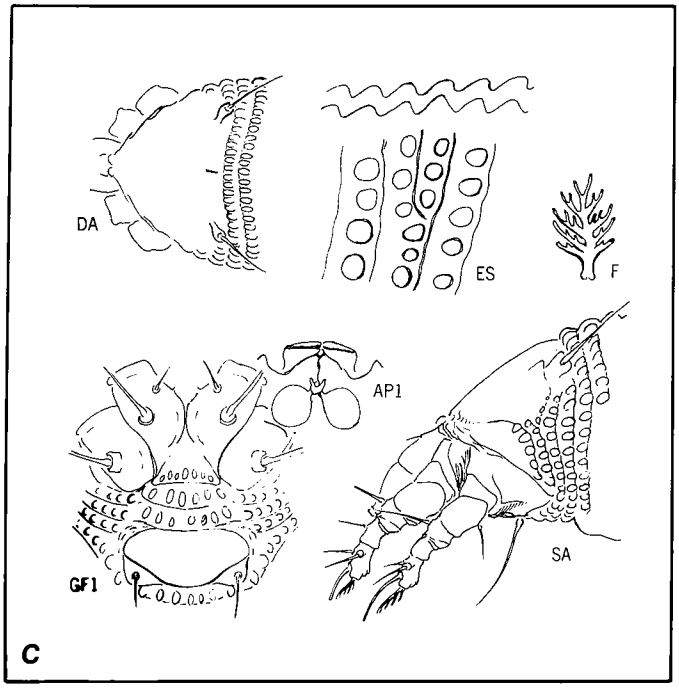
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Erineum

Aceraceae

Acer glabrum **Torr. Rocky Mountain Maple**

Erineum caused by *Eriophyes calaceris* (Keifer) (pl. 44)

This is a colorful and impressive erineum on maple leaves caused by *Eriophyes calaceris* in the Western United States. The erineum growth is pustulelike, consisting of a brightly colored aggregation of tiny papillae. Each papilla is filled with colored fluid, and when magnified it has a rounded or capitate tip. The erineum appears on the upper surface of the leaf and is thickest from the apical half to the edge of the blade, missing the larger veins. It ranges from greenish yellow to pink, crimson, and purplish red. The infestation may be widespread on some trees.

Eriophyes calaceris is a robust, wormlike, yellowish mite, measuring 180–190 microns long. The featherclaws are 4-rayed; the dorsal shield is unmarked and smooth; and the coverflap of the female genitalia has 8–10 longitudinal ribs. The males and protogynes possess microtubercles over the entire hysterosoma, whereas the overwintering females, or deutogynes, have microtubercles confined ventrally. The life history involves alternation of generations. The mites continue to colonize the erineum until September and then migrate to stems or twigs and bark crevices. Deutogynes overwinter in bark crevices and then move to newly developing buds in the spring. The inquiline eriophyids *Aculops glabri* (Keifer) and *A. paraglabri* (Keifer) are frequently in the erineum. *Aculops paraglabri* was recently found to be the overwintering form (deutogyne) of *A. glabri* and is therefore a synonym.

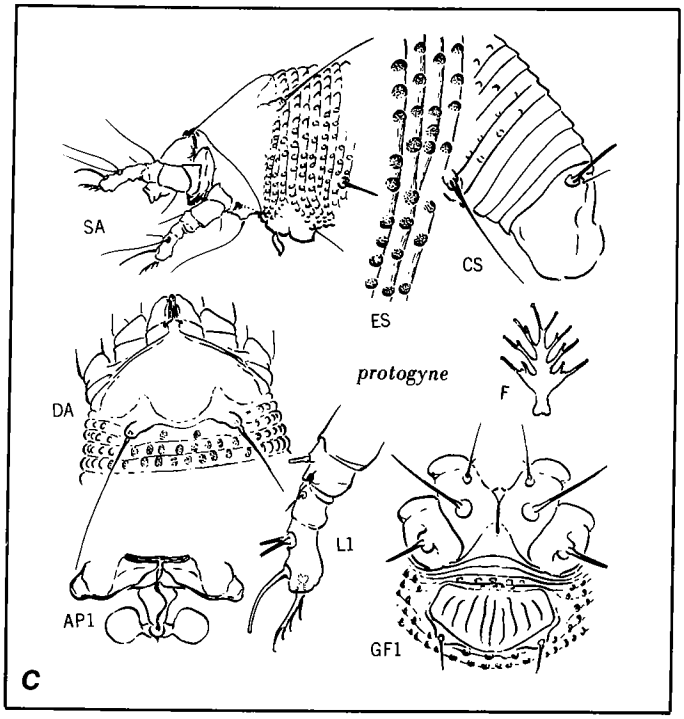
This mite was found abundant on Rocky Mountain maple in September in California. It is probably generally distributed throughout the range of the host plant from Alaska to California and east to South Dakota and New Mexico. *Eriophyes calaceris* may be confused with *E. elongatus* Hodgkiss, which commonly infests sugar maple (*Acer saccharum* Marsh.) in the Eastern United States. In addition to the differences in morphological structures, the erineum growths caused by each species are distinguished by their position, form, color, and density.

References: Jeppson et al., *1975: 376;* Keifer, *1952a: 33, 34.*

PLATE 44.—*A,* Erineum on Rocky Mountain maple leaves; *B,* patches of erineum on upper surface of leaf; *C, Eriophyes calaceris* (Keifer).

A

B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Aceraceae

***Acer saccharum* Marsh. Sugar Maple**

Erineum caused by *Eriophyes elongatus* Hodgkiss (= *E. regulus* Hodgkiss) (pl. 45)

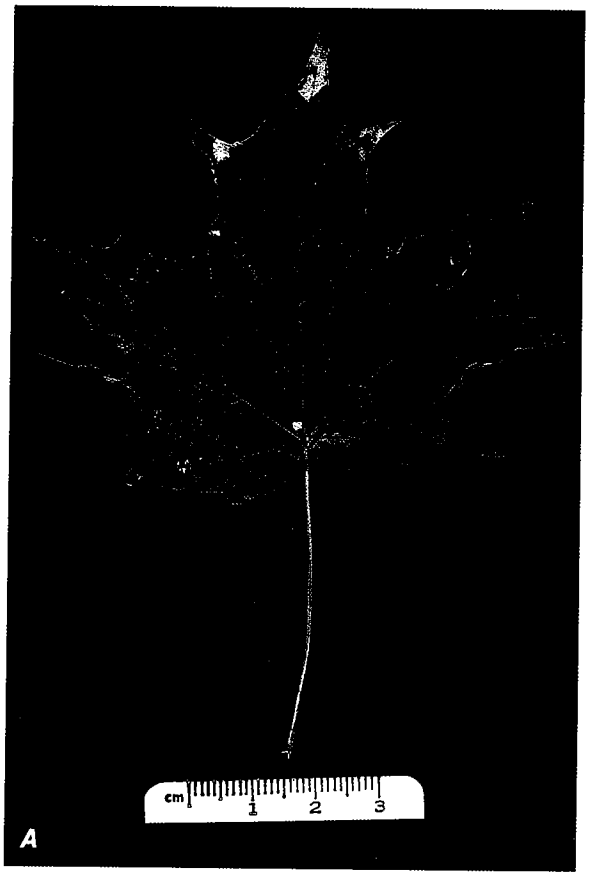
Hodgkiss (*1913*) distinguished *Eriophyes elongatus* and *E. regulus,* which cause the familiar glossy crimson erineum on the leaves of sugar maple. According to Jeppson et al. (*1975*), the latter mite species is a synonym of *E. elongatus.* The colorful erineum on sugar maple is remarkably similar to that produced by *Eriophyes calaceris* (Keifer) on Rocky Mountain maple (*Acer glabrum* Torr.). It is one of the most attractive and brilliant growths on the leaf surface. The pustulelike patches, at first greenish white and later becoming crimson or purplish, are generally scattered on the upper surface of the leaves. Close examination of the erineum patch shows an aggregation of tiny, rounded, capitate papillae that contain red fluid. The density of the erineum is variable. Occasionally the growth becomes extremely abundant and causes leaf distortion and premature leaf drop.

Eriophyes elongatus is a slender, yellowish, wormlike mite, measuring 150–216 microns long. The featherclaws are 4-rayed; the dorsal shield is almost unmarked except for an inverted V anterior to each of the dorsal setal bases; the hysterosoma of the overwintering female lacks microtubercles dorsally but has more rings ventrally; the male and protogyne are distinguished by the irregularly placed, coarse, rounded microtubercles of the hysterosoma; and the coverflap of the female genitalia has 10 longitudinal ribs. The life history involves alternation of generations. The mite population reaches its peak in the summer, when the erineum growth is most noticeable and abundant.

Specimens are common on sugar maple in the Eastern United States and Canada. In New York, Hodgkiss (*1930*) reported an uncommon greenish erineum on the underside of sugar maple leaves caused by *Eriophyes modestus* Hodgkiss. The erineum later changes to brownish or blackish. *Aculops maculatus* (Hodgkiss) occurs as an inquiline in the crimson erineum or as a leaf vagrant.

References: Hodgkiss, *1913: 421; 1930: 25, 29;* Jeppson et al., *1975: 457, 459.*

PLATE 45.—*A,* Erineum on sugar maple leaves; *B,* close up of erineum patch on maple leaf; *C,* erineum caused by *Eriophyes modestus* Hodgkiss; *D, E. elongatus* Hodgkiss. (GM1, male external genitalia and coxae.)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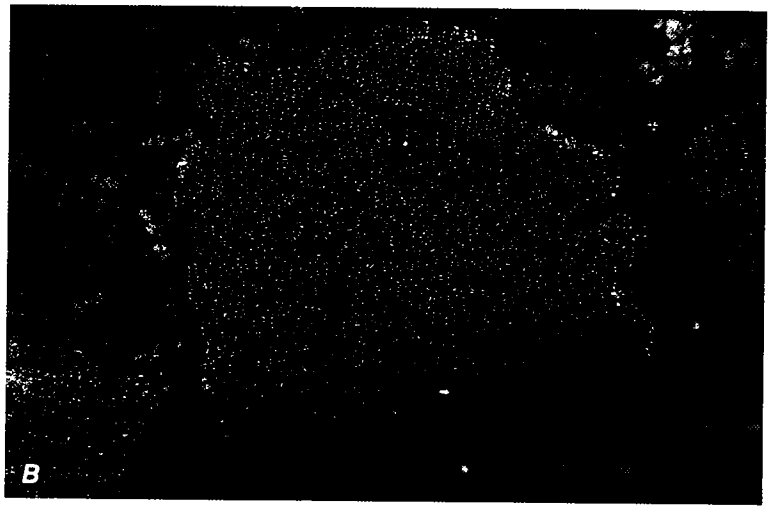
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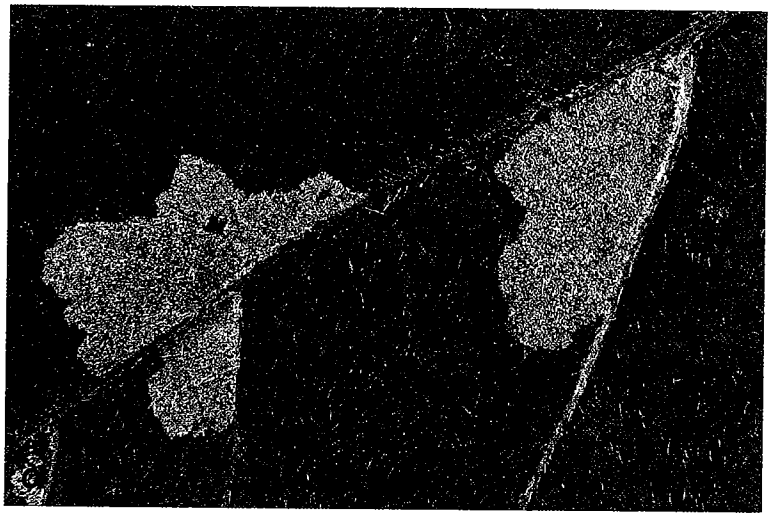

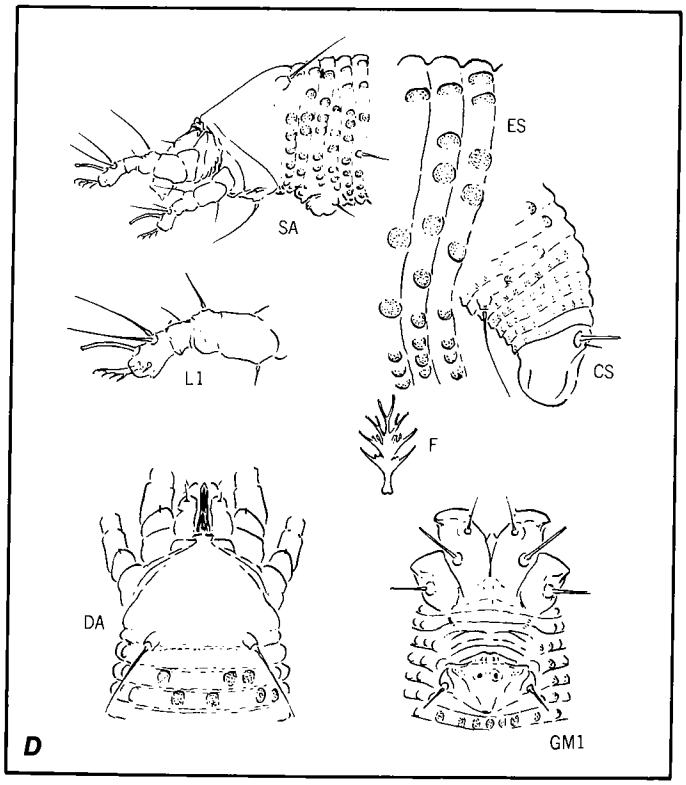
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Annonaceae

Annona muricata **L. Soursop**

Erineum caused by *Eriophyes annonae* Keifer (pl. 46)

The erineum on the leaves of soursop may be so widespread on the tree that nearly every leaf is affected. The leaves fail to develop normally, and distortion and stunting are considerable. The position of the erineum on the leaf is interesting. It develops as thick, irregular ridges or strips of tufted hairs on the underside, lying in a ropelike pattern along the midrib, and it may extend beyond the midrib to include the bases of lateral veins. Small blotches of tufts may be seen scattered on the leaf blade. Swellings may appear in the same position on the upper side of the leaf blade. In the early stages of development the hairs are whitish, later turning brownish.

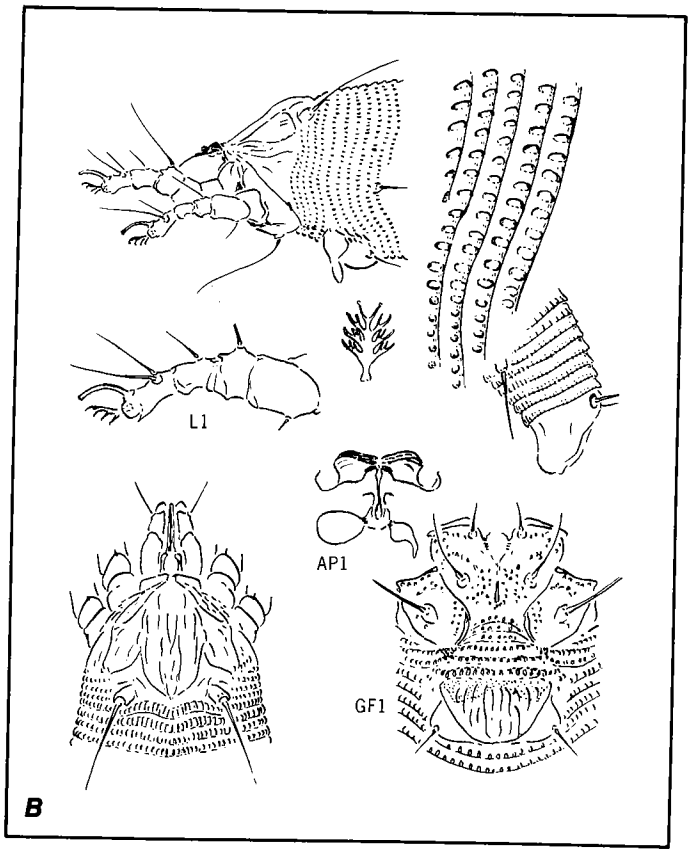
Eriophyes annonae is a yellowish-white, wormlike, slender mite, measuring 165–185 microns long. The featherclaws are four-rayed; the dorsal shield has a series of short ridges scattered over the dorsum; the hysterosoma is completely covered with rounded or elliptical microtubercles; the coxae are minutely granular; the coverflap of the female genitalia has two rows of ribs; and the setal tubercles are large and rounded.

Eriophyes annonae is a neotropical species. Specimens were found among the erineum hairs in March–July on soursop in Venezuela.

Reference: Keifer, *1973: 3.*

PLATE 46.—*A,* Erineum on *Annona* leaves; note ridges of tufted hairs along midrib; *B, Eriophyes annonae* Keifer.

A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Fagaceae

***Fagus grandifolia* J. F. Ehrh. American Beech**

Erineum caused by *Acalitus fagerinea* (Keifer) (pl. 47)

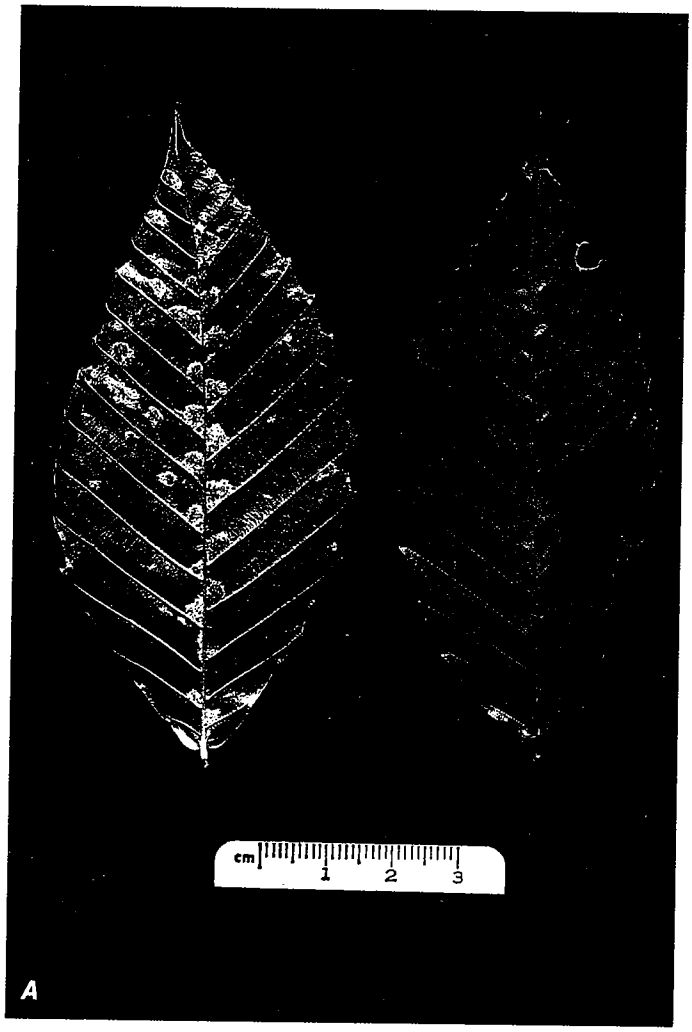
The yellow, common, attractive erineum patches on the leaves of American beech occur in the angles between the midrib and lateral veins on the upper surface of the leaf. They are regularly arranged, lying alternately, and extending from the petiole to near the apex of the blade. A few patches may occur between the lateral veins near the leaf margin. The erineum consists of thick, felty hairs, which are pale green in the early stages of development, later turning yellow and brownish. The patches are most noticeable at the yellow stage. Under high magnification, the tip of each erineum hair is lobed or compound capitate. This type of erineum is caused by *Acalitus fagerinea.*

The mite is yellowish and wormlike, measuring 220–250 microns long. The featherclaws are four-rayed; the tibia of leg I lacks seta; the dorsal shield has parallel median and submedian ridges interspersed with granules; the microtubercles are rounded and well spaced; and the coverflap of the female genitalia lacks ribs. In late summer when the erineum starts to dry, the mites migrate to the buds. They overwinter in the buds, becoming active in the following spring.

Acalitus fagerinea was first collected in July on American beech in Pennsylvania. It is probably present throughout much of the Eastern United States.

References: Jeppson et al., *1975: 367;* Johnson and Lyon, *1976: 428;* Keifer, *1959b: 650.*

PLATE 47.—*A,* Erineum patches on American beech leaves: Left, lower surface; right, upper surface; note position of erineum patches in angles between midrib and lateral veins. *B, Acalitus fagerinea* (Keifer). (GF1 D, genital and coxal apodemes, deutogyne; GF1 P, genital and coxal apodemes, protogyne; SAD, deutogyne, lateral view.)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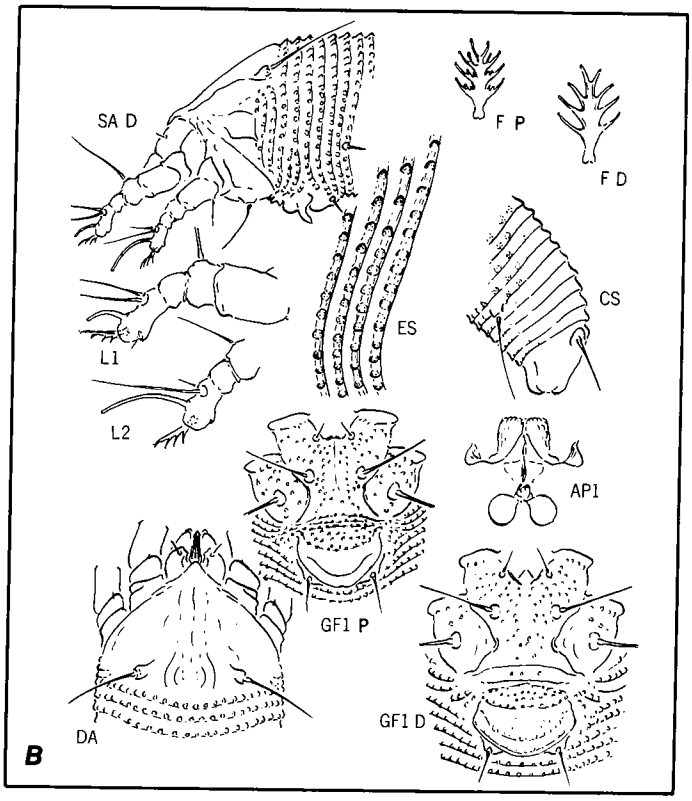
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Fagaceae

***Quercus agrifolia* Née California Live Oak**

Erineum caused by *Eriophyes mackiei* Keifer (pl. 48)

Eriophyes mackiei infests California live oak and causes shallow pockets or concavities filled with dense erineum on the underside of the leaves. The erineum pockets appear singly and scattered at random over the leaf blade, generally missing the veins. On the upper surface, the erineum growth is noticeable at first as a green, glossy, rounded swelling, later becoming brown.

The mite is whitish or yellowish, slender, and wormlike, measuring about 230 microns long. The featherclaws are three-rayed; the dorsal shield is marked with a design of two ridges flanked anteriorly and diagonally by short, wavy ridges; the microtubercles are rounded, each with a tiny spine; the coxae are smooth; and the coverflap of the female genitalia has about eight weak longitudinal ribs. Specimens were collected from erinuem pockets in June.

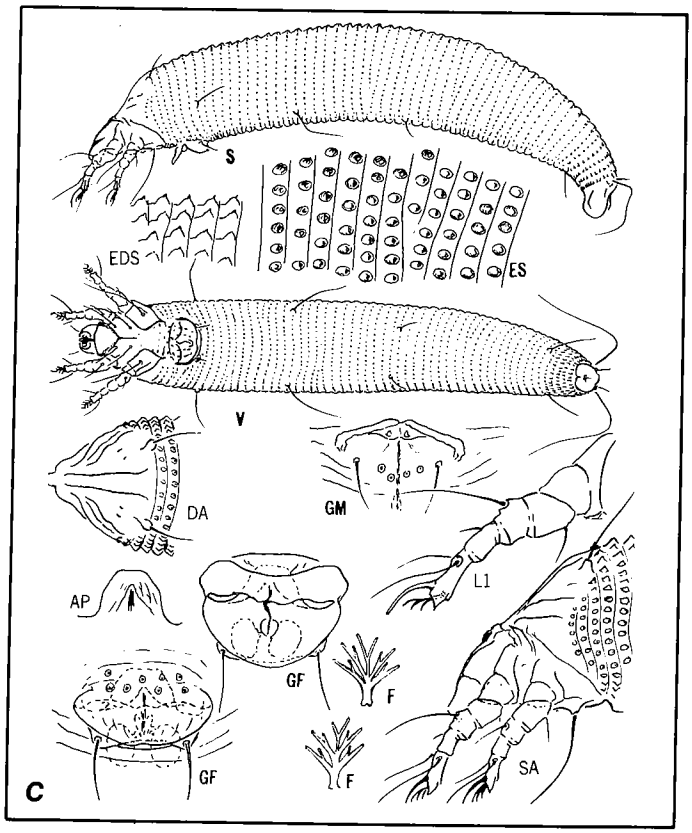
Eriophyes mackiei is known only from California. Similar erineum growths on several evergreen oaks (*Quercus*), also in California, are most probably caused by this mite. In the Eastern United States, white oak (*Q. alba* L.) is infested by *Eriophyes triplacis* (Keifer), which causes similarly shallow erineum pockets on the leaves. A closely related species of *E. mackiei, Eriophyes paramackiei* Keifer, also infests California live oak and causes a broom effect of densely clustered, stunted twigs on one side of the stem. The twiggy bunches are stubby, with short, somewhat thickened branchlets, each crowded with numerous buds that contain mites. The tree infested with *E. paramackiei* shows the broom growths at the lower level of the tree, whereas the upper section does not look thrifty.

References: Jeppson et al., *1975: 366;* Keifer, *1938b: 302; 1941: 204.*

PLATE 48.—*A,* Infested leaves of California live oak; *B,* left, upper surface of leaf, and middle and right, lower surface of leaves, showing dense erineum; *C, Eriophyes mackiei* Keifer.

A

B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Juglandaceae

***Juglans cinerea* L. Butternut**

Erineum caused by *Eriophyes cinereae* Keifer (pl. 49)

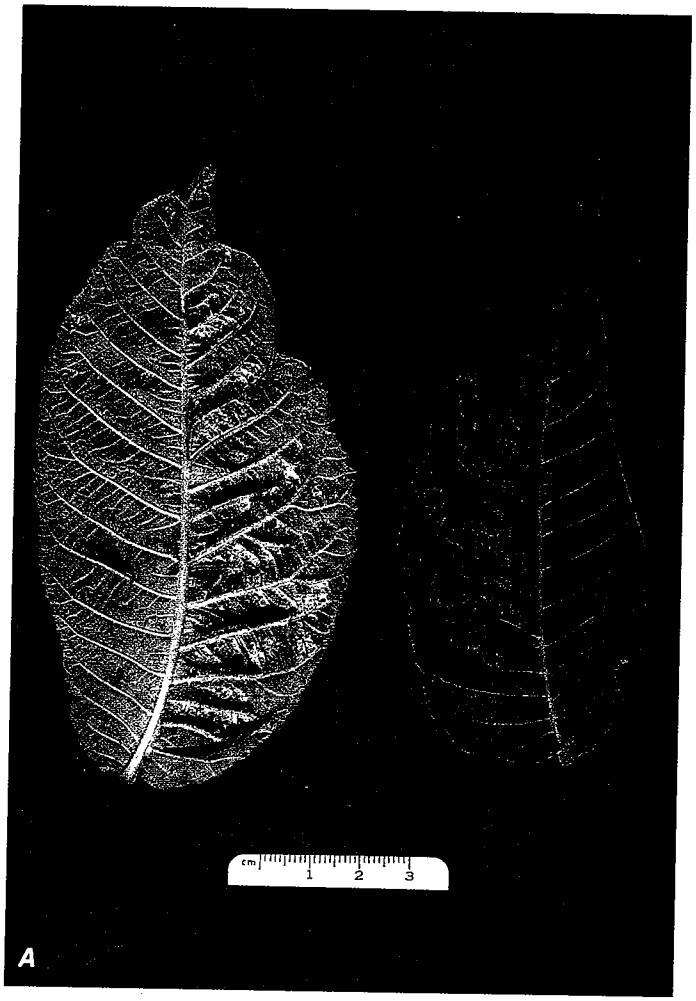
Leaves of butternut are often seen with large patches of erineum, similar in general appearance to that caused by *Eriophyes erineus* (Nalepa) on leaves of English walnut (*Juglans regia* L.). The erineum growths are conspicuous on the underside of the leaf blade, consisting of coalesced patches of dense felted hairs lying alongside the midrib, usually filling the area between the lateral veins. On the upper side, the leaf blade with erineum patches appears swollen and puckered. The growth ranges from light brown to reddish brown.

Eriophyes cinereae is morphologically similar to *E. erineus*. It is yellowish, slender, and wormlike, measuring 140–240 microns long. The featherclaws are three-rayed; the dorsal shield is unmarked and smooth; the microtubercles are rounded or subtriangular, and the coxae are smooth; and the female genitalia have a smooth coverflap and strongly produced setal bearing tubercles.

Specimens were collected in New York among erineum hairs on heavily infested butternut leaves. The mite's distribution range is probably that of the host, extending from New Brunswick to Arkansas.

Reference: Keifer, *1940a: 23.*

PLATE 49.—*A*, Erineum patches on butternut leaves: Left, lower surface; right, upper surface. *B, Eriophyes cinereae* Keifer.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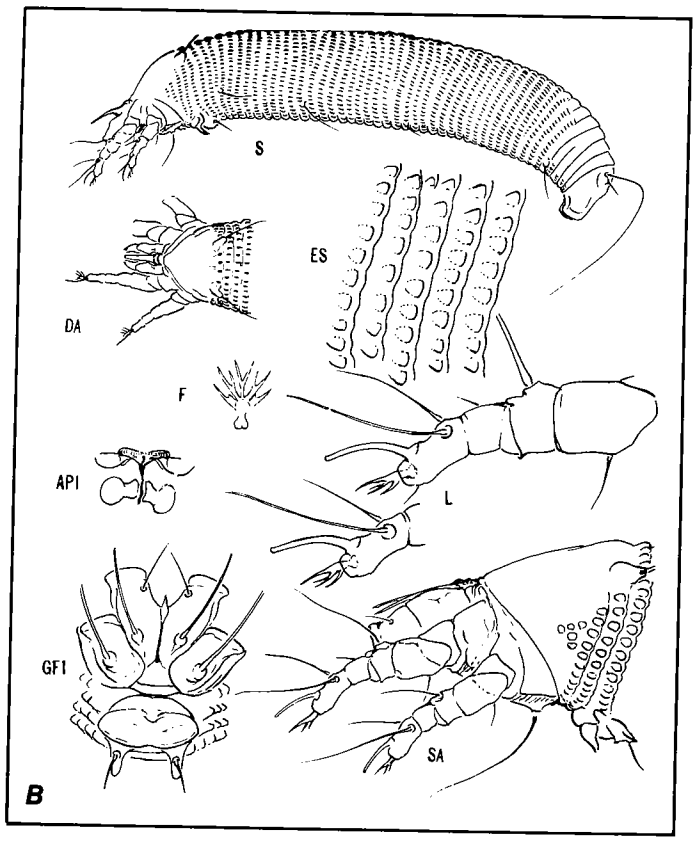
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Juglandaceae

***Juglans regia* L. English Walnut**

Erineum caused by *Eriophyes erineus* (Nalepa) (pl. 50)

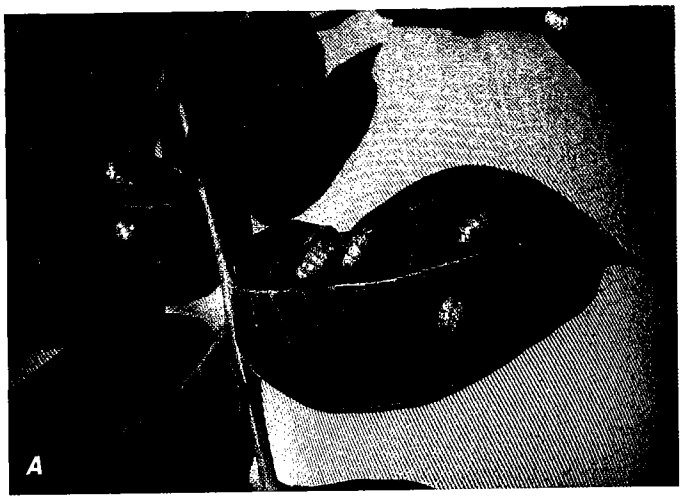
The infestation caused by this mite is most noticeable as shiny, convex swellings on the upper surface of the leaf blade and on the underside as patches of shallow, large, solitary concavities lined with felty, yellowish hairs, among which the mites are to be found. These patches have well-defined edges and lie to the side of the midrib between the lateral veins; the erineum growths miss the small secondary veins and appear as thickened partitions. The erineum is particularly characteristic in that each structure is covered with short, minute, unicellular hairs (see pl. 7, *C*). Although erineum patches are fewer on the leaves, they are easily recognized because of their size and color.

Eriophyes erineus is a yellowish-white, slender, wormlike mite, measuring about 225 microns long. The featherclaws are three-rayed; the dorsal shield is smooth anteriorly, with two short ridges posteriorly; the microtubercles are elongate; the coverflap of the female genitalia is smooth; and the setal bearing tubercles are produced and have rounded apices. Unlike other walnut-infesting eriophyids, this mite has a simple life history. During the summer the females migrate from the erineum to the terminal buds, where they overwinter. It is not uncommon to find mites in both the buds and the erineum in the fall.

Eriophyes erineus was found on English walnut in California. In Europe and the Near East, this walnut is infested by *Eriophyes tristriatus* (Nalepa), which causes similar erineum galls on the leaves.

References: Jeppson et al., *1975: 434;* Keifer, *1938a: 184;* Nalepa, *1891: 875, 884.*

PLATE 50.—*A,* Erineum patches on English walnut leaves, upper surface; *B,* close up of erineum patch, lower surface; *C, Eriophyes erineus* (Nalepa). (LT, tarsus, leg I; SP, hysterosoma, posterior lateral view (see CS on plate 8).)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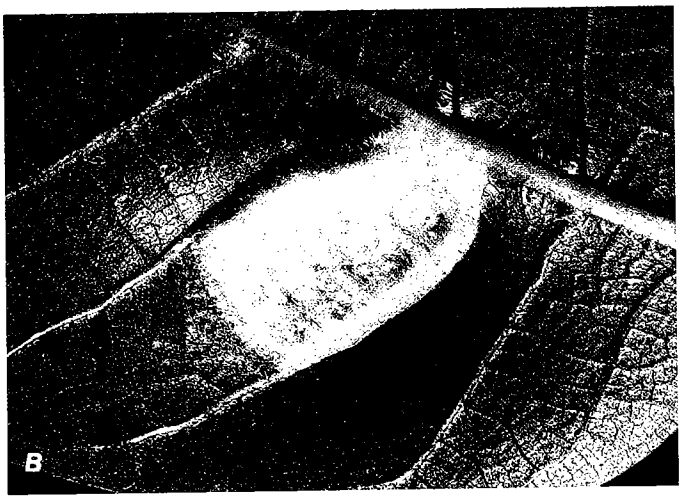
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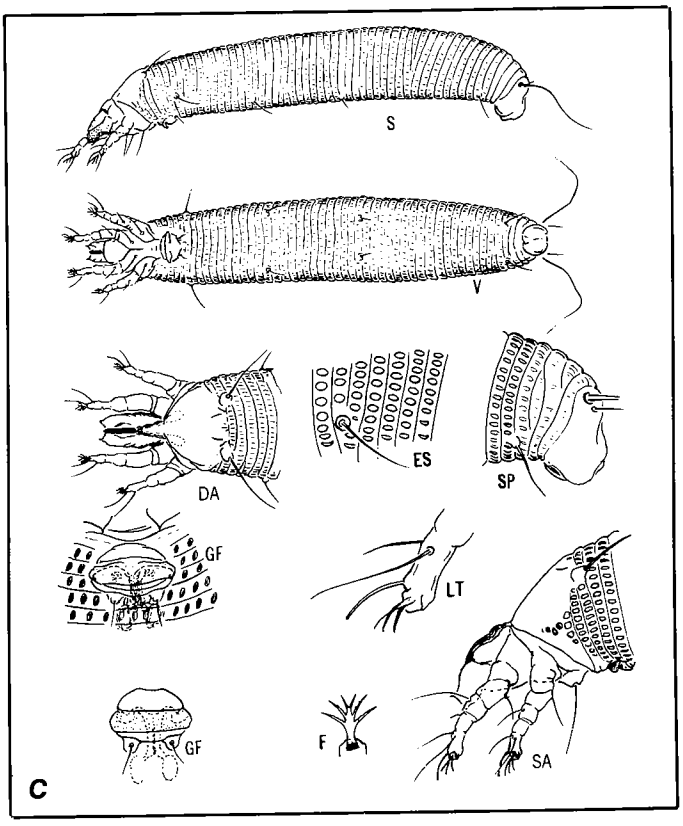
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Sapindaceae

***Litchi chinensis* Sonn. Litchi, Lychee**

Erineum caused by *Eriophyes litchii* Keifer (pl. 51)

The felty patches of erineum are usually extensive and numerous on a plant and are easily found on the underside of the leaves. They are noticeable as pale-green, convex swellings on the upper side. The erineum in the early stages of development is yellowish, later turning red to dark brown, when it is then most conspicuous. The affected leaves eventually become distorted or curled. For erineum structure, see plate 7, *D*.

Eriophyes litchii is a robust, yellowish-to-reddish, wormlike mite; the female measures 110–135 microns long. The featherclaws are 5-rayed; the dorsal shield is marked with a design of various ridges; the coxae have large granules; the hysterosoma is completely covered with elliptical microtubercles; and the coverflap of the female genitalia has about 16 longitudinal ribs filling most of the area. This last feature would readily identify the mite.

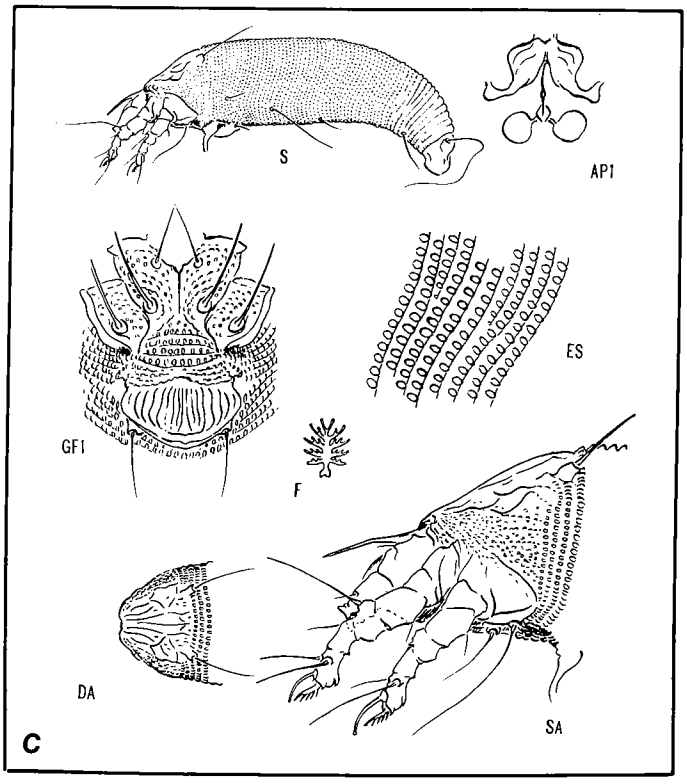
The mites inhabit the erineum, and specimens were collected in November on litchi in Hawaii and recently in Canton, China. Litchi or lychee is widely grown in Southeast Asia and elsewhere in the Tropics and Subtropics for its edible fresh and dried fruit.

References: Keifer, *1943: 212;* Nishida and Holdaway, *1955: 1.*

PLATE 51.—*A*, Erineum patches on litchi leaves, upper surface; *B*, erineum patches, lower surface; *C*, *Eriophyes litchii* Keifer.

A

B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Vitaceae

***Vitis* spp. Grape**

Erineum and deformation of bud clusters and leaves caused by *Colomerus vitis* (Pagenstecher) (pl. 52)

Three forms of *Colomerus vitis* have been reported to cause different types of injury to grapevines. One form feeds on the leaves and causes the appearance of patches of felty erineum on the lower surface, followed by blisterlike swellings on the upper surface. The erineum patches are whitish at first, then yellow, and finally reddish brown. At times they are abundant in early spring in commercial vineyards or throughout the season on abandoned and backyard vines. Another form of *C. vitis* attacks grape buds, causing such injury as deformation of the primordial bud clusters, distortion of the basal leaves, stunting of the main growing point, and often death of the overwintering buds. This form does not produce erineum on the leaves. The third form produces leaf curl and abnormal plant hairs at the colony sites. For further discussion of the mite injuries on grapes, refer to Jeppson et al. (*1975*).

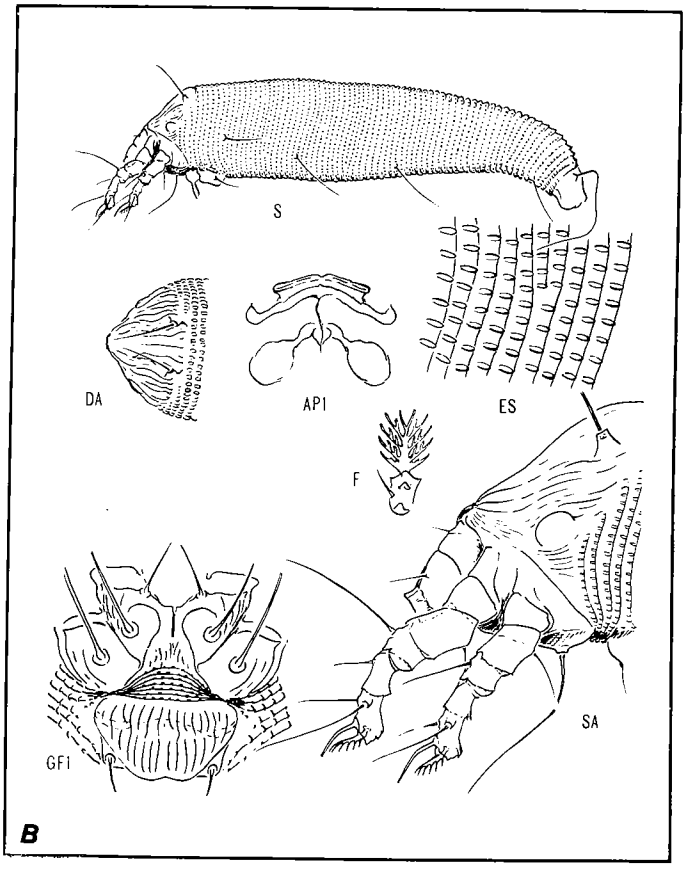
Colomerus vitis is a yellowish, slender, wormlike mite, measuring 160–200 microns long. The featherclaws are five-rayed; the dorsal shield has numerous longitudinal ridges, an ocellar spot near the lateral shield angle, and the dorsal setae are directed forward; the microtubercles are elliptical; and the coverflap of the female genitalia has two rows of ribs. The mites live among the erineum hairs and feed on the lower leaf epidermis between the hairs. Adults overwinter in bud scales on dormant buds, and as soon as the buds open in the spring, the mites migrate to the unfolding leaves. Literature on the biology and habits of this mite is extensive; a summary is given in Jeppson et al. (*1975*).

Colomerus vitis attacks various species and hybrids of grapes and is probably widespread. It should not be confused with *Calepitrimerus vitis* (Nalepa), another pest of grapevines (see Jeppson et al. (*1975*)).

References: Jeppson et al., *1975: 415;* Keifer, *1944: 21;* Kido and Stafford, *1955: 119;* Pagenstecher, *1857: 46;* Smith and Stafford, *1948: 317.*

PLATE 52.—*A*, Erineum on grape leaves: Left, upper surface; right, lower surface. *B, Colomerus vitis* (Pagenstecher).

A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Fruit and Leaf Discoloration, Russeting, Bronzing, Fruit Hardening, Foliage Withering, and Fruit and Bud Drop

Palmae

Cocos nucifera **L. Coconut**

Flower and fruit injury and premature fruit drop caused by *Eriophyes guerreronis* (Keifer) (pl. 53)

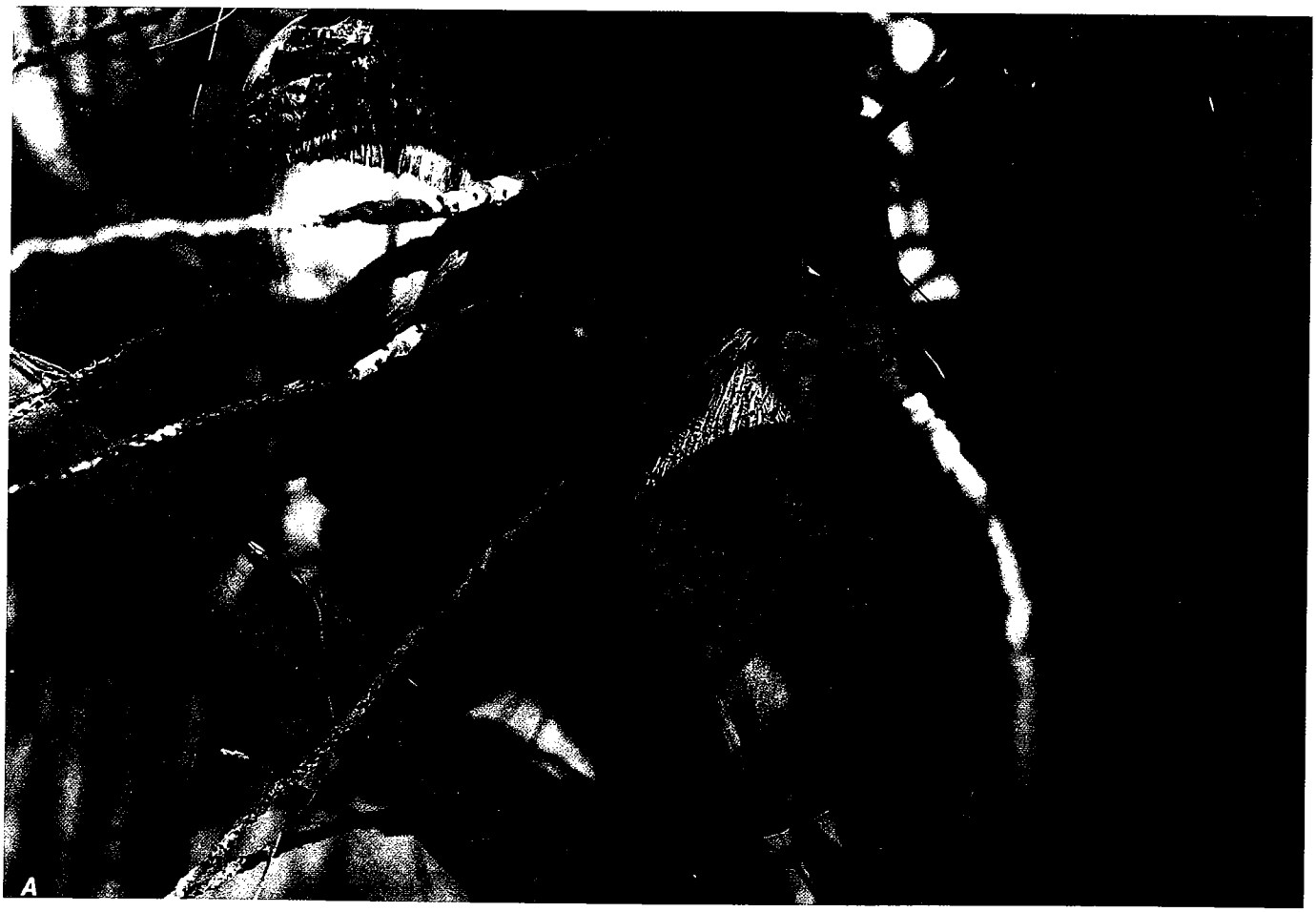
This tropical mite injury is an interesting and a serious malady of coconuts. An infestation of female flowers results in hardening and drying of the surface of developing fruit. The injury begins around the floral bracts and extends down to the inner husks or fibers. The injured area becomes shriveled, brown, and scattered. Colonization is at times so dense as to cause considerable damage to infested fruit, and fruit drop may occur.

Eriophyes guerreronis is a slender, yellowish, wormlike mite, measuring 205–255 microns long. The featherclaws are 6-rayed; the dorsal shield is marked with longitudinal ridges; the microtubercles are much more elongate dorsally than ventrally; and the coverflap of the female genitalia has 9–12 longitudinal ribs.

The mites were found in coconut flowers and developing fruit in March in Mexico. Additional specimens were collected in Venezuela, Brazil, and West Africa. At times *E. guerreronis* is a serious pest of coconuts.

References: Jeppson et al., *1975: 447;* Keifer, *1965b: 7.*

PLATE 53.—*A*, Injured coconuts; *B*, *Eriophyes guerreronis* (Keifer).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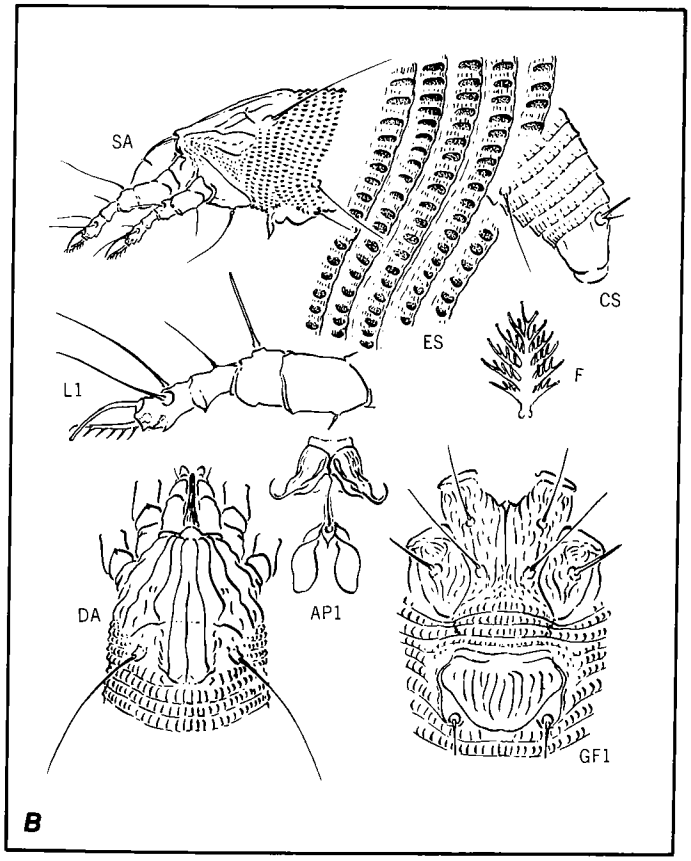
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Palmae

***Elaeis guineensis* Jacq. African Oil Palm**

Leaf blade speckling and black and yellow leaves caused by *Retracrus elaeis* Keifer (pl. 54)

Leaf discoloration caused by *Retracrus elaeis* represents a spectacular reaction of the plant to mite feeding. This discoloration forms a remarkable contrast on the fronds of the African oil palm. Many small dark spots first appear, speckling most of the leaf blade. Later, affected fronds become black and spotted with yellow and orange and completely yellow and orange with age. Colonization may be so dense as to cause extensive discoloration and loss of chlorophyll.

Retracrus elaeis is particularly easy to recognize. The body is white with wax, spindle shaped, somewhat flattened dorsoventrally, and broadest anteriorly; it measures about 160 microns long. The featherclaws are forked or divided, with a small two-rayed lobe arising at the middle; the dorsal shield has five small pointed lobes on each side; in addition to the dorsal setae, a pair of anterior setae is present; both pairs of setae are borne on elongate, bulbous tubercles; the hysterosoma has broad dorsal rings and lacks microtubercles; the ventral rings are narrow; and the coverflap of the female genitalia has a row of short longitudinal ridges confined to the base. The mites are leaf vagrants.

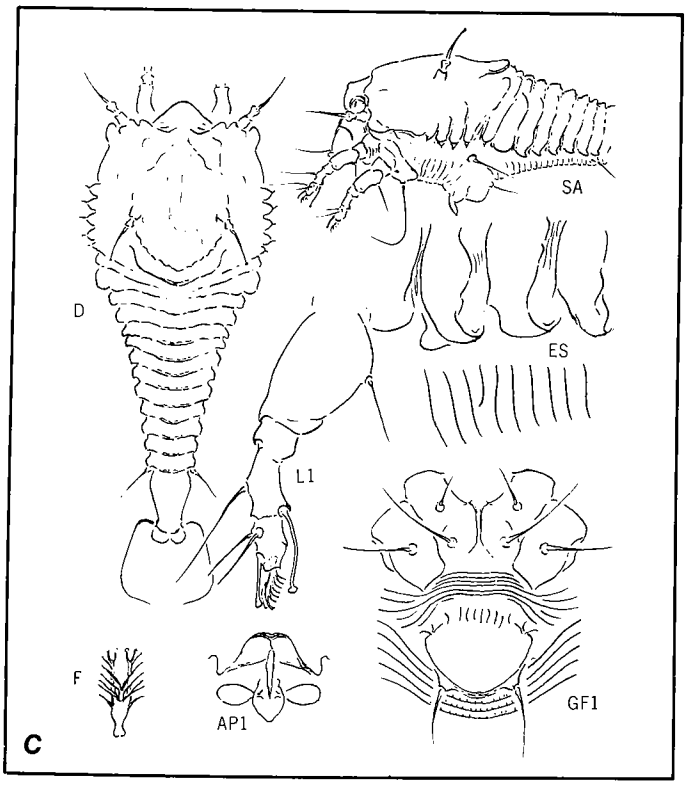
The host is the African oil palm, which is cultivated extensively on plantations in the Tropics for palm oil. *Retracrus elaeis* was found in Colombia, South America, in June.

Reference: Keifer, *1975: 3.*

PLATE 54.—*A,* Infested palm tree; note yellow and orange fronds; *B,* close up of discolored fronds; *C, Retracrus elaeis* Keifer. (D, female, dorsal view.)

A

B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Rosaceae

***Prunus dulcis* var. *dulcis* (Mill.) D. A. Webb Almond**

***Prunus persica* (L.) Batsch Peach**

***Prunus persica* var. *nucipersica* (Suckow) C. K. Schneid. Nectarine**

Leaf silvering and yellow spot caused by *Aculus cornutus* (Banks) (pl. 55)

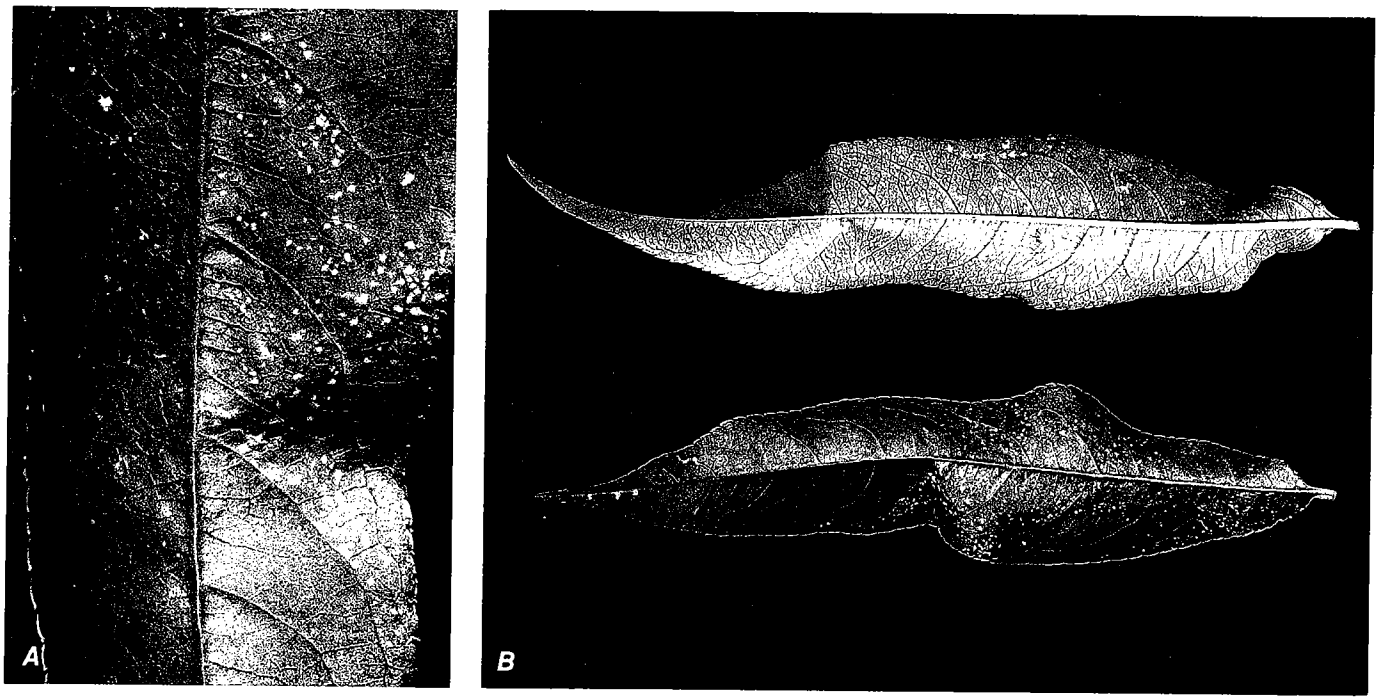
Feeding of the peach silver mite, *Aculus cornutus,* produces the well-known silvering of peach foliage that develops late in the season just before the leaves drop. Another result of the mite's feeding has been termed "yellow spot," which is characterized by yellow spotting and chlorosis alongside the veins, accompanied by upward longitudinal folding of the leaf margin into a troughlike structure. The spots range from pinpoint to more than a millimeter in diameter and are usually circular. In severe infestations, spots coalesce, producing a mottled effect. Transverse sections of affected areas of the leaf blade show disorganization of cell contents and hypertrophy of parenchyma cells. Spots and chlorosis alongside the veins appear to be the result of mite infestation of very young leaves. Mature leaves are not affected by yellow spot. For detailed information, see Wilson and Cochran (*1952*).

Aculus cornutus is a robust, light amber or yellow, spindle-shaped mite, measuring 185–205 microns long. The feather-claws are 4-rayed; the dorsal shield is produced anteriorly and marked with a design; and the coverflap of the female genitalia has 12 ribs in a single row. The males and protogynes are distinguished by having strong dorsal microtubercles and a pair of small anterior spines on the dorsal shield. The overwintering females (deutogynes) lack the anterior spines on the dorsal shield and microtubercles on the dorsum of the hysterosoma. The life history involves alternation of generations. The mites feed on both surfaces of the leaf blade. Deutogynes overwinter in the buds and bud scales.

Besides peach, *A. cornutus* attacks nectarine and almond. It is probably present throughout the range of its host plants.

References: Banks, *1905: 141;* Jeppson et al., *1975: 503;* Keifer, *1938b: 306;* Wilson and Cochran, *1952: 443.*

PLATE 55.—*A, B,* Yellow spots on peach leaves caused by mite feeding. *Aculus cornutus* (Banks): *C,* Protogyne; *D,* deutogyne. (DS, dorsal shield.)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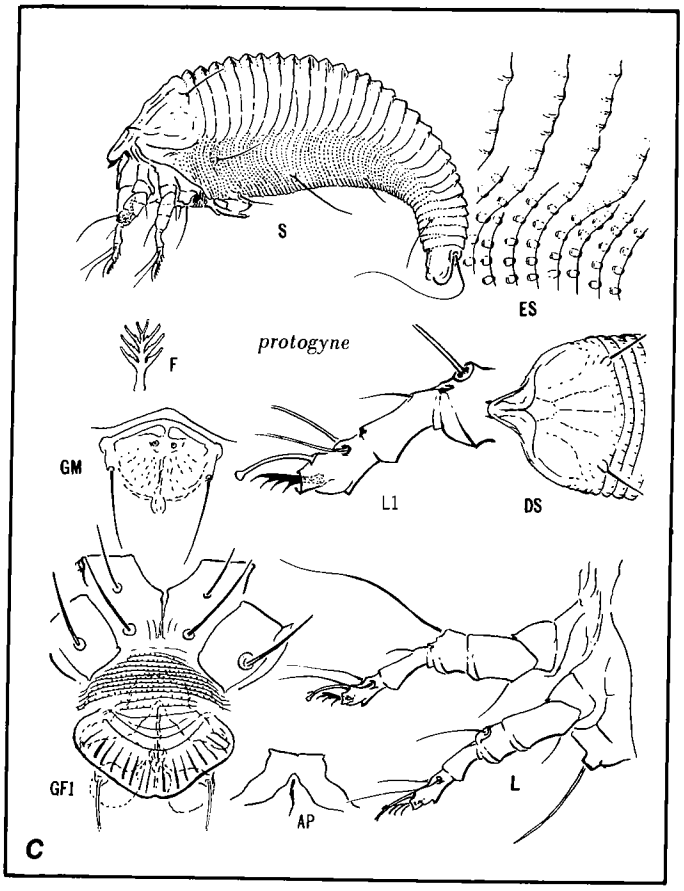
B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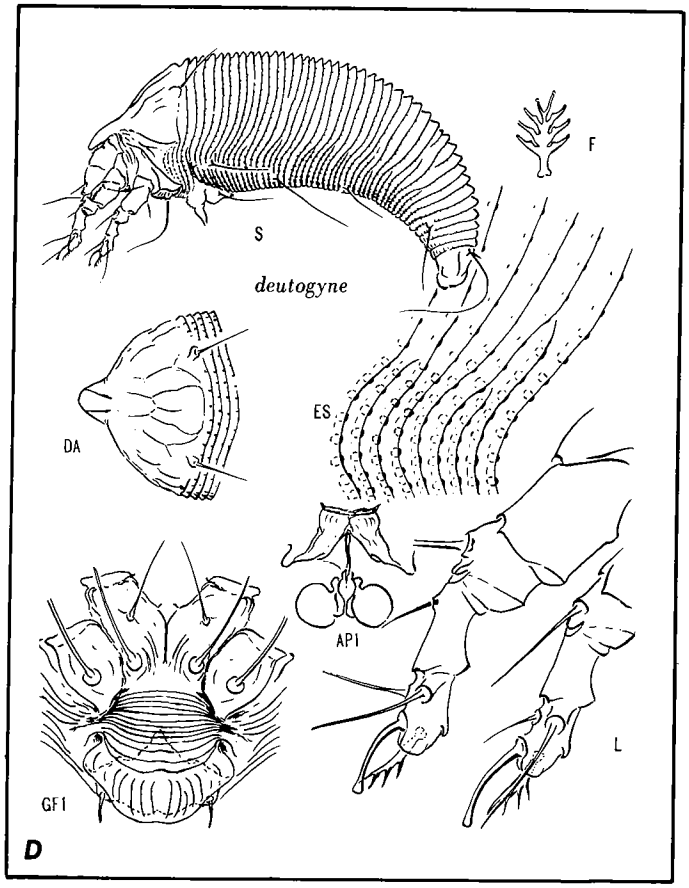
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Rosaceae

***Rubus procerus* P. J. Muell. Himalaya Berry**

***Rubus vitifolius* Cham. & Schlectend. Blackberry**

Redberry disease and delayed drupelet ripening caused by *Acalitus essigi* (Hassan) (pl. 56)

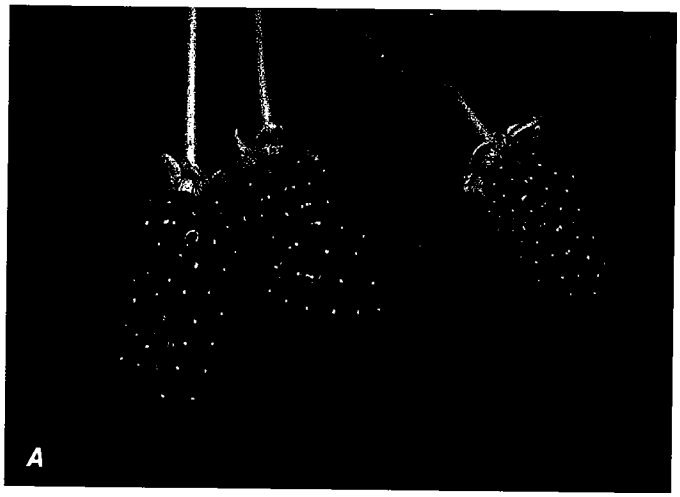
The redberry mite, *Acalitus essigi,* was found on Himalaya berry in California in 1921. It was subsequently reported on blackberry in California and Washington. It causes the well-known redberry disease, which forms an interesting and attractive contrast as a result of the mite feeding on the fruit between the drupelets and around the core. Infested berries show swollen, brilliant red or pink and greenish drupelets among unaffected purple or maroon drupelets. Some berries have entirely red drupelets. Affected berries remain red or green and do not ripen normally. Often berries of late maturing varieties are seriously infested.

This is a yellowish or colorless, spindle-shaped mite, measuring about 140 microns long. The featherclaws are four-rayed; the tibia of leg I lacks setae; the dorsal shield has a somewhat lyre-shaped design with long and short median ridges; the hysterosoma is completely covered with pointed microtubercles; and the coverflap of the female genitalia has curved, broken, transverse ridges and granules. The mites migrate from the cane buds to developing flowers or from bud scales to green berries. Oviposition occurs in the buds in early March. The mite population reaches a peak in September and decreases in the fall and winter. The mites can be found in the buds or in between old bud scales throughout the year.

Redberry disease is known primarily in California, Washington, Oregon, and Texas. The redberry mite, *A. essigi,* may be confused with *Acalitus orthomera* (Keifer), a bud mite pest of boysenberry (*Rubus ursinus* var. *loganobaccus* (L. H. Bailey) L. H. Bailey), native blackberry (*Rubus* sp.), and dewberry (*Rubus macropetalus* Dougl. ex Hook.) in California. Infestation of dewberry by *A. orthomera* causes bud distortion and shoot stunting that often result in killing of the buds. Recently specimens of *A. orthomera* were found in the buds of blackberry (*Rubus* sp.) from Maryland that show symptoms of redberry disease.

References: Hanson, *1933: 3;* Hassan, *1928: 380;* Jeppson et al., *1975: 463, 465;* Keifer, *1941: 205.*

PLATE 56.—*A, B,* Redberry disease of *Rubus;* note infested red and green drupelets; *C, Acalitus essigi* (Hassan). (GFC, variations in female genital plate.)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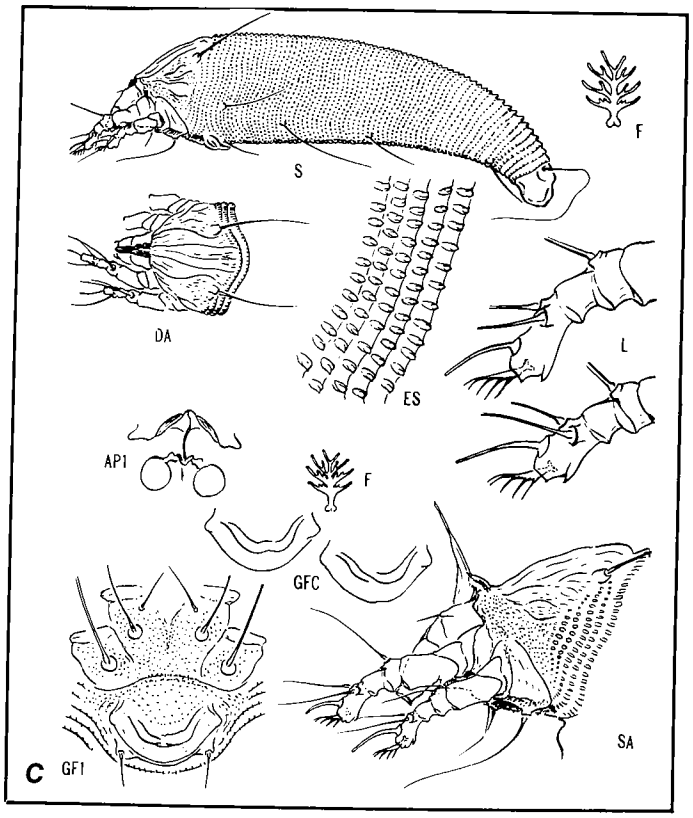
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Rutaceae

***Citrus* spp. Grapefruit, Lemon, Lime, Orange**

Russeting and bronzing of leaves, twigs, and fruit caused by *Phyllocoptruta oleivora* (Ashmead) (pl. 57)

The citrus rust mite, *Phyllocoptruta oleivora,* has been known in Florida since 1879. It is now found in most of the citrus-growing areas of the world. Although this mite causes russeting of the rind of oranges and grapefruit, it appears to be more of a serious pest of lemons in California. Its feeding destroys the epidermal cells of the rind, producing silvering or russet effects. The rind of the affected fruit is thicker than normal, and the fruit tends to be smaller. Another result of the infestations on lemons and grapefruit is a condition known as "sharkskin," in which the outer layer of the skin can be peeled. Heavy populations of mites feeding on leaves and twigs can also cause bronzing.

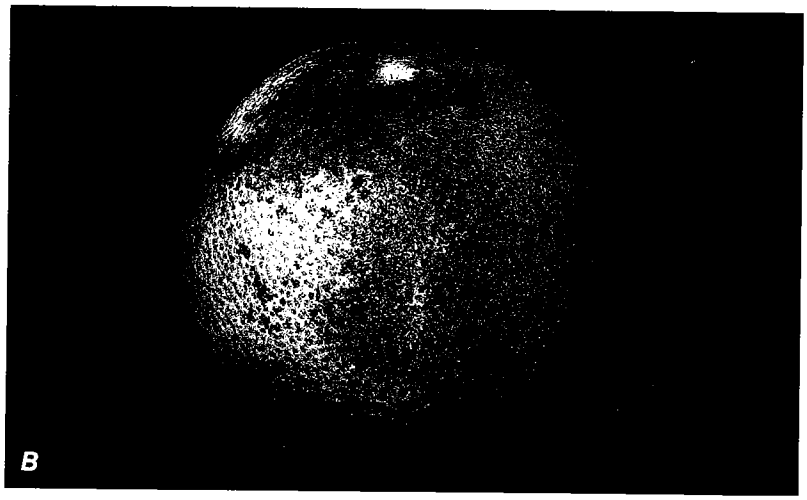
Phyllocoptruta oleivora is a robust, spindle-shaped, yellow-to-brownish mite, measuring 150–165 microns. The featherclaws are five-rayed; the dorsal shield is produced anteriorly, with a well-defined longitudinal curved ridge at the middle; and the dorsal setae are directed inward. An outstanding feature of this mite is the presence of a broad trough on the dorsum of the opisthosoma. The microtubercles are present only ventrally, and the coverflap of the female genitalia has 14–16 ribs in a single row. The mites do not overwinter. They are found on the underside of the leaves, on stems, and in protected areas of the fruit. Development from egg to adult takes 7–10 days in the summer and 14 or more days in the winter. The biology and control of *P. oleivora* have been the subject of considerable study. Jeppson et al. (*1975*) give a useful summary.

Phyllocoptruta oleivora is one of the most injurious pests of oranges and grapefruit in Florida and Texas and of lemons in California. It has been eradicated in Arizona.

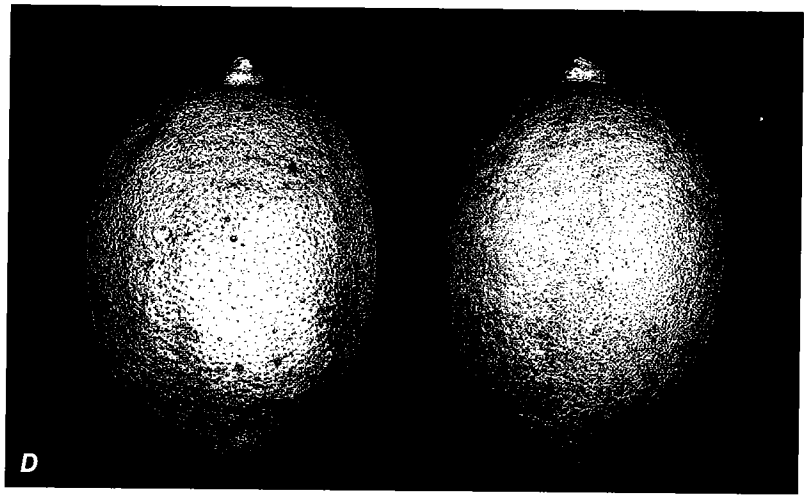
References: Ashmead, *1879: 160;* Jeppson et al., *1975: 485;* Keifer, *1938a: 193;* Yothers and Mason, *1930: 1–56.*

PLATE 57.—*A, B,* Russeting of oranges; *C, D,* russeting of lemons; *E, Phyllocoptruta oleivora* (Ashmead).

A


B

C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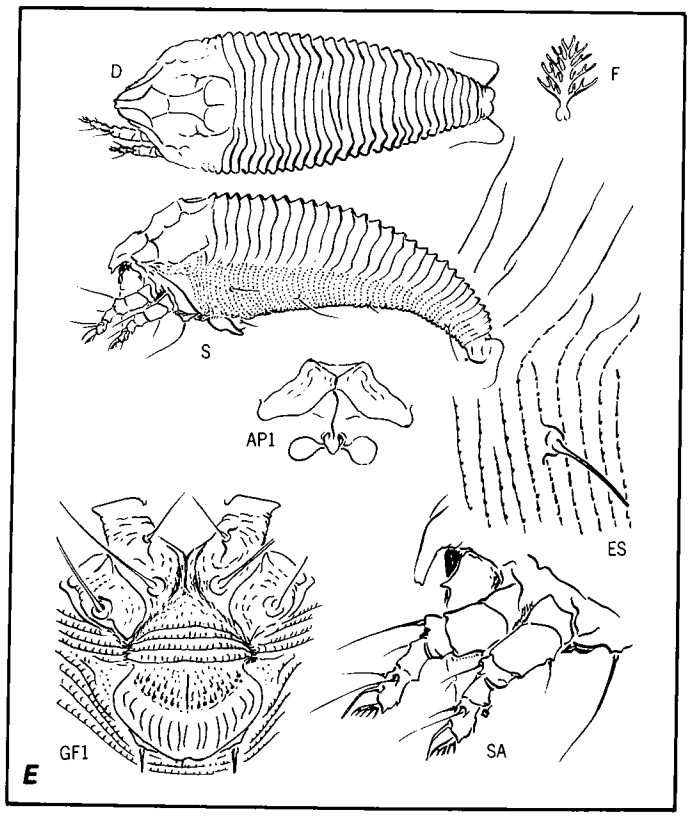
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Solanaceae

***Lycopersicon lycopersicum* (L.) Karst. ex Farw. Tomato**

Browning and withering of foliage and russeting of fruit caused by *Aculops lycopersici* (Massee) (= *Phyllocoptes destructor* Keifer) (pl. 58)

The tomato russet mite, *Aculops lycopersici,* is a serious pest of tomato plants. The first signs of infestations are noticed on the lower stem and leaves, which turn brown; later the leaves wither. Heavy mite attacks may affect the fruit, with the skin becoming russet and roughened. If the infestation is not prevented, the plants eventually wither and die; usually about one-half of the crop is lost.

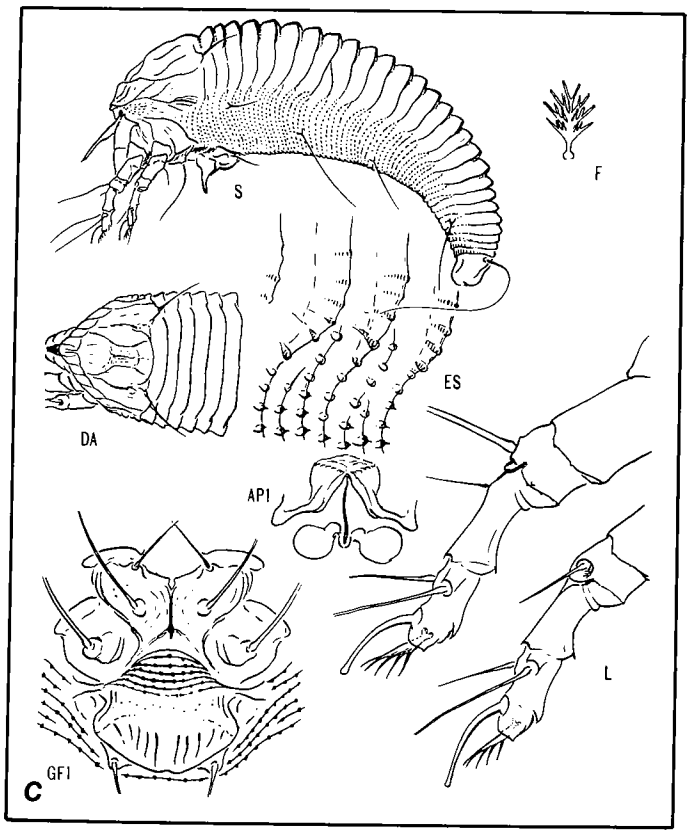
Aculops lycopersici is a robust, spindle-shaped, whitish-to-yellowish mite; the female measures 150–180 microns long and the male 140–150 microns. The featherclaws are 4-rayed; the peculiar structure of the dorsal shield and its design are characteristic features of this mite; the microtubercles on the hysterosoma are pointed and confined ventrally; and the coverflap of the female genitalia has 8–10 short, longitudinal ribs. The mites are vagrants and feed on the surface tissues of the leaves, stems, and fruit. The life cycle is completed in about 7 days; reproduction occurs during early May through November.

Aculops lycopersici was described as *Phyllocoptes destructor* by Keifer in 1940 from tomato plants in California. It was originally from Australia, and it is a serious pest of this plant during the summer and early fall in New South Wales. Its distribution is probably worldwide. Other hosts are common nightshade (*Solanum nigrum* L.), datura (*Datura inoxia* Mill.), popolo (*S. sodomeum* L.), petunia (*Petunia* sp.), and potato (*S. tuberosum* L.), all of the family Solanaceae. *Aculops lycopersici* should not, however, be confused with *Eriophyes lycopersici* (Wolffenstein), which causes patches of white hairy erineum on the stems and underside of the leaves of tomato plants.

References: Bailey and Keifer, *1943: 706;* Jeppson et al., *1975: 452;* Keifer, *1940c: 160;* Massee, *1937: 403.*

PLATE 58.—*A,* Infested tomato plants, showing browning and withering of leaves and stems; *B,* russeting of tomatoes; *C, Aculops lycopersici* (Massee).

B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Theaceae

***Camellia japonica* L. Common Camellia**

Discoloration of leaves, floral parts, and bud scales caused by *Acaphylla steinwedeni* Keifer, *Calacarus carinatus* (Green) (= *"Epitrimerus" adornatus* Keifer), and *Cosetacus camelliae* (Keifer) (pl. 59)

The following three eriophyid mites are serious pests of camellia:

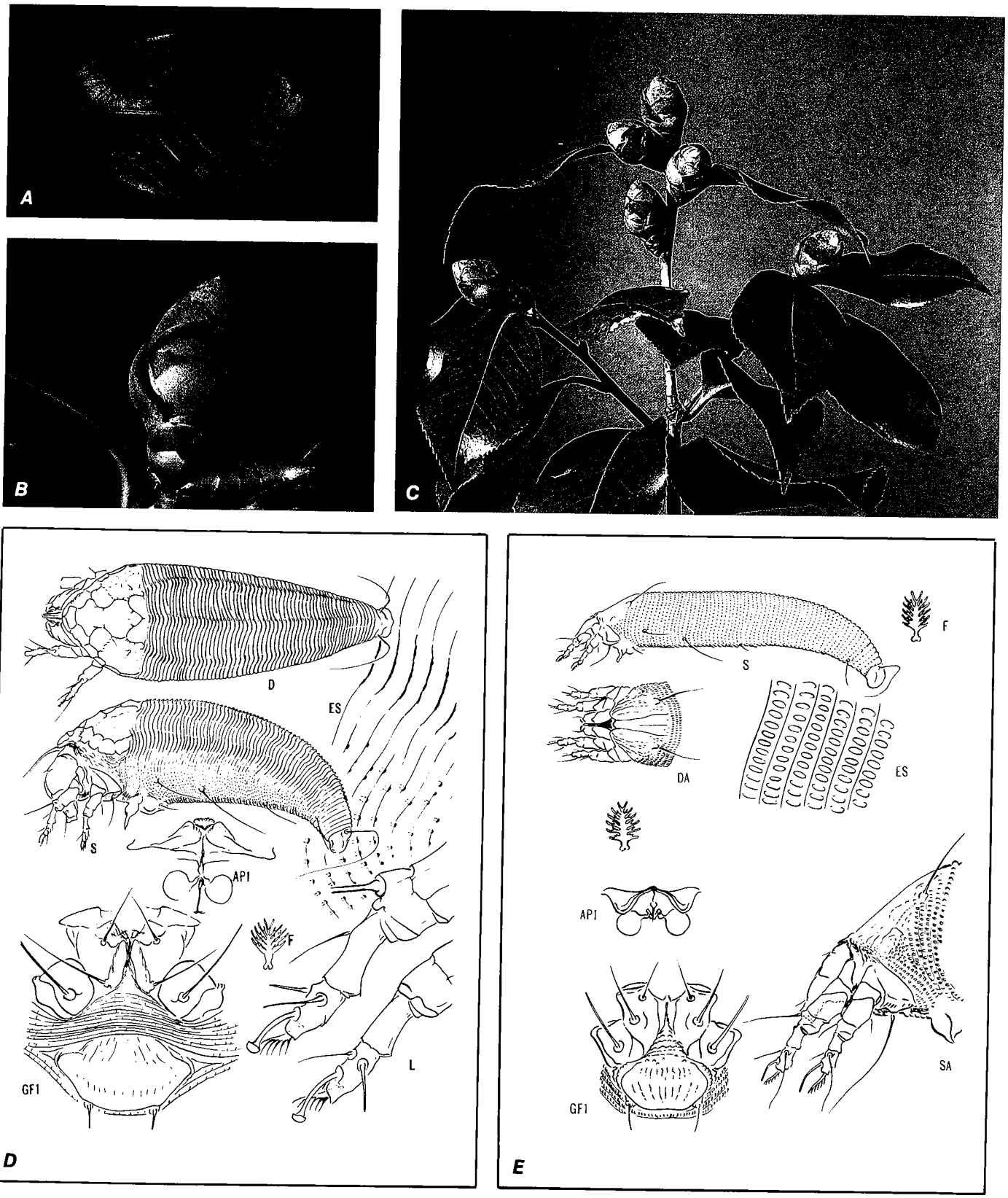
Acaphylla steinwedeni is a leaf vagrant that occurs on camellia leaves with *Calacarus carinatus*. Infestation may cause bronzing of the leaves. The mite is spindle shaped and yellow or orange; the dorsal setae are very short; the featherclaws are curiously bifurcate and three-rayed; and the hysterosoma has microtubercles ventrally. The bifurcate featherclaws readily separate *A. steinwedeni* from *C. carinatus*. Both species overwinter on the leaves. The former has been found only on camellia in California, Alabama, and Florida.

Calacarus carinatus is another leaf vagrant that causes bronzing of the upper surface and downward folding of the leaf edges. It also deposits debris on the leaves as white streaks of cast skins. The mite is spindle shaped and striking in appearance because of its purple color and the waxy exudates that form ridges on the dorsal shield and hysterosoma. The dorsal setae are absent, the featherclaws are five-rayed, and the hysterosoma has microtubercles ventrally. *Calacarus carinatus* infests camellia and also cranberry bush (*Viburnum opulus* L., Caprifoliaceae), but no injury has been observed on the latter. It has been reported in California, Florida, and Georgia.

Cosetacus camelliae is found under flower bud scales. Colonization of the buds results in browning at the edge of bud scales and floral parts. The flower buds turn brown and drop before blooming, and, according to Gibson (*1967*), dropping of buds, distortion of opening flowers, and premature drop of flowers occur. The mite also causes leaves to appear rusty. *Cosetacus camelliae* is white and wormlike; the dorsal setae are long and directed backward; the featherclaws are six-rayed; and the hysterosoma is completely covered with microtubercles. This mite occurs in California, Florida, and probably much of the Southeastern United States on camellia.

References: Denmark, *1965:* [*1*]; Gibson, *1967: 663;* Johnson and Lyon, *1976: 424;* Keifer, *1940a: 32; 1943: 215; 1945: 137.*

PLATE 59.—*A,* Bronzing of camellia leaf; *B, C,* damaged camellia buds, showing browning of bud scales; *D, Calacarus carinatus* (Green); *E, Cosetacus camelliae* (Keifer).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Leaf and Bud Blisters

Ericaceae

Gaylussacia baccata **(Wangenh.) C. Koch. Huckleberry**

Vaccinium **spp. Blueberry**

Bud blister, rosette, and fruit deformation caused by *Acalitus vaccinii* (Keifer) (pl. 60)

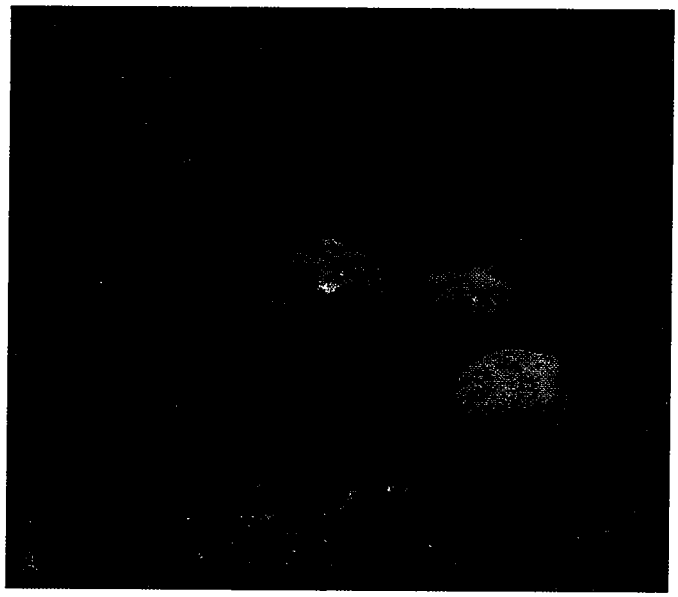
Acalitus vaccinii is one of the major pests of blueberry. This mite attacks the buds, which become succulent, fleshy, and closely packed in clusters or rosettes on the stem; they fail to expand and bloom. This results in the production of fewer berries and leaves, or bud loss. Affected berries appear roughened and malformed and may show small, reddish pimples or blisters. Infested plants in the field are easily recognized by the clustering or rosetting of the buds, which are sometimes abundant, and by marked discoloration of berries.

The mite is robust, yellowish white, and spindle shaped, measuring 185–210 microns long. The featherclaws are 6-rayed; the tibia of leg I lacks setae; the dorsal shield has 2 indistinct submedian curved ridges; the hysterosoma is covered with elliptical microtubercles; and the coverflap of the female genitalia has 8–10 ribs in a single row. The mites spend the entire life cycle of about 15 days in the bud. An increase in mite population occurs throughout the fall and winter, reaching its peak in December and January, when the injury becomes severe.

Acalitus vaccinii was first collected during March–April in North Carolina. It is present throughout the Eastern States and along the coastal areas from Canada to Florida and Texas. Keifer (*1941*) stated that this mite "occurs on wild and cultivated vacciniaceous plants, especially high bush types of *Vaccinium* spp." *Acalitus vaccinii* also infests huckleberry.

References: Cromroy and Kuitert, *1973: 1;* Jeppson et al., *1975: 469;* Keifer, *1939c: 329; 1941: 196;* Neunzig and Sorensen, *1976: 5.*

PLATE 60.—*A, B,* Clusters of injured buds of blueberry; *C,* affected berries, showing roughened surface; *D, Acalitus vaccinii* (Keifer).



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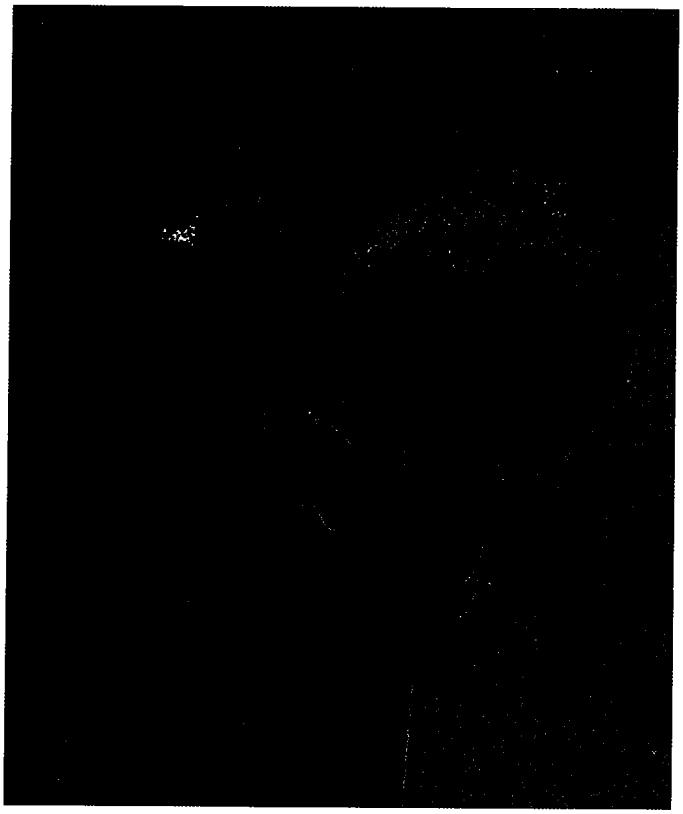

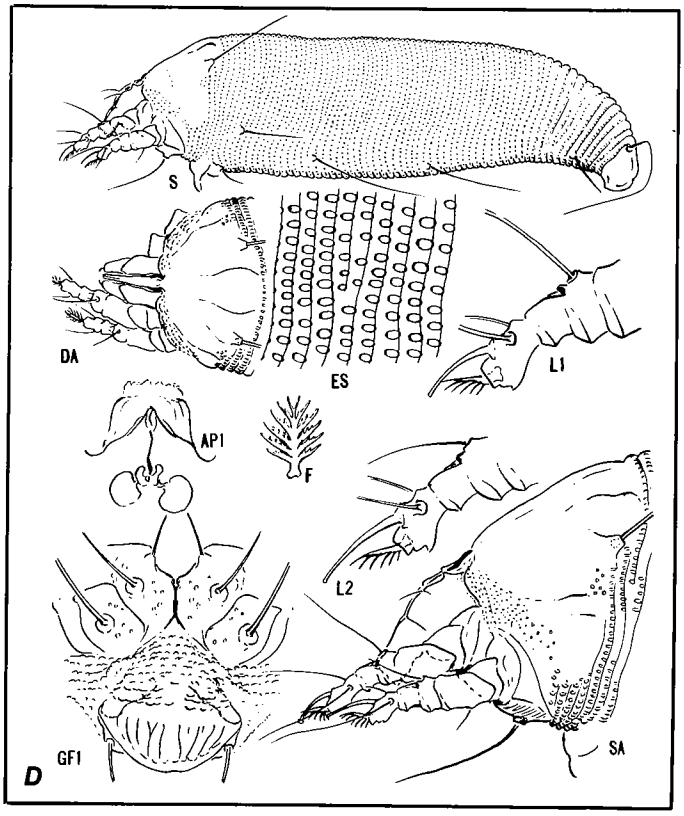
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Malvaceae

***Gossypium* spp. Cultivated and Wild Cotton**

Leaf blister, bud injury, and foliage deformation caused by *Acalitus gossypii* (Banks) (pl. 61)

Acalitus gossypii has been recognized for many years as a destructive pest of cultivated cotton. The mites attack the flower buds, and any parts arising from the buds may be infested. The leaves are contorted and crumpled or aborted and with short petioles. The flowers are covered with fine white hairs and the petals fail to open. Young plants show stunted, irregular growth and lack flowering branches. Mite feeding on the undersurface of the leaves causes chlorosis and whitish blisters. Damage appears severe on plants that were attacked when young.

This mite is wormlike and colorless, measuring over 200 microns long. The featherclaws are four-rayed; the tibia of leg I lacks setae; the dorsal shield has five longitudinal lines; the microtubercles are rounded; and the coverflap of the female genitalia lacks ribs. The mites are leaf vagrants. The life cycle is apparently short, and the mites reproduce throughout the year.

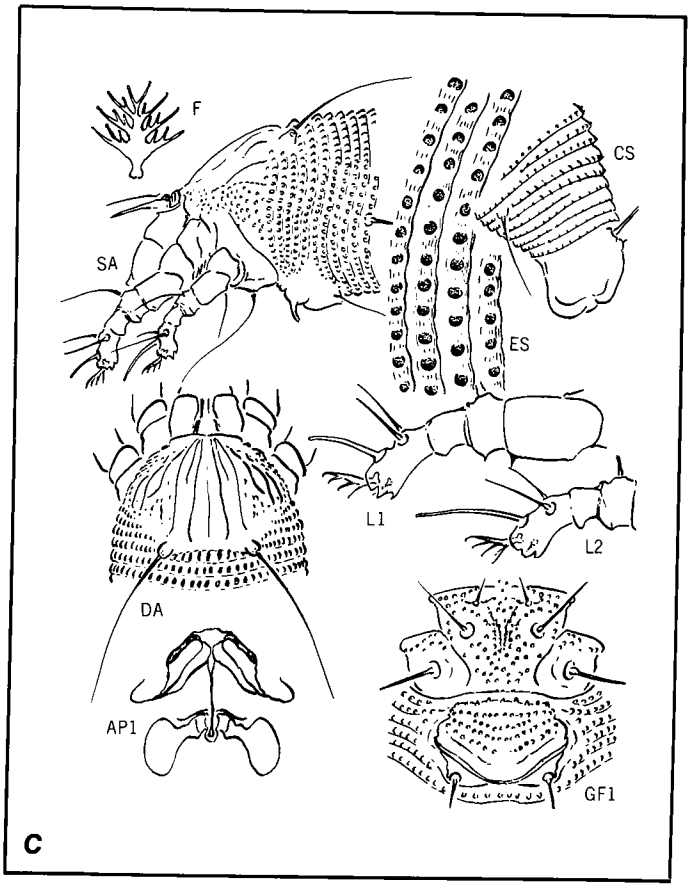
Acalitus gossypii infests various wild and cultivated cotton. It has been reported from southern Florida, Puerto Rico, the West Indies, Venezuela, and Brazil. This mite is similar to *Acalitus sphaeralceae* Keifer, which infests the leaves of globemallow (*Sphaeralcea* sp.) in Arizona. So far the latter mite has not been found on cotton.

References: Banks, *1904: 56;* Fife, *1937: 169;* Jeppson et al., *1975: 465;* Keifer, *1965c: 3.*

PLATE 61.—*A,* Injured cotton bud; *B,* erineum damage to branch; *C,* *Acalitus gossypii* (Banks).

A

B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Rosaceae

***Pyrus communis* L. Common Pear, Pear**

Leaf blister caused by *Phytoptus pyri* Pagenstecher (pl. 62)

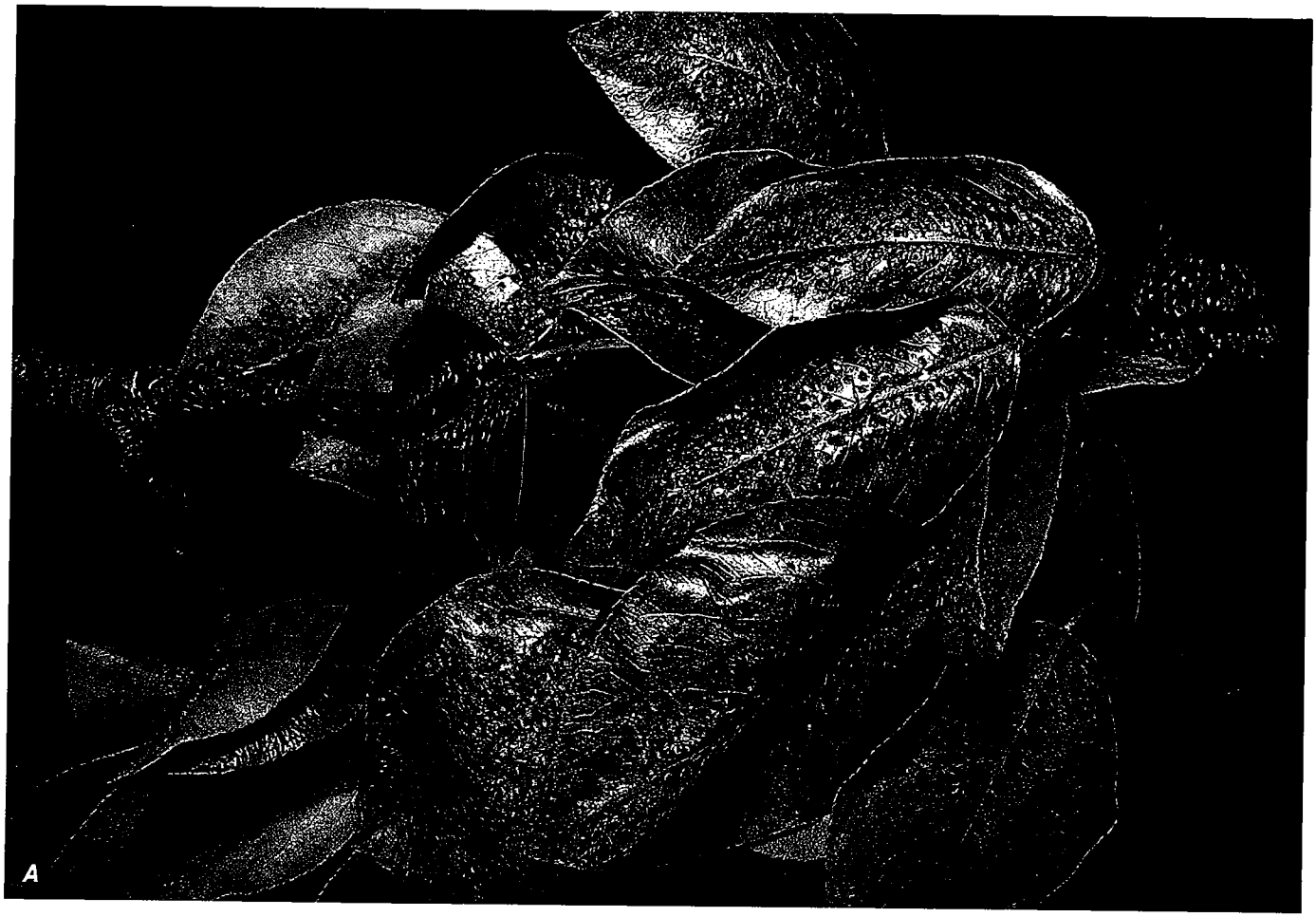
The pearleaf blister mite, *Phytoptus pyri,* has been an important pest of pear for many years. Feeding of the overwintering mites causes leaf blisters on the developing leaves as the buds commence growth in the spring. At first blisters appear as reddish or pinkish swellings, later as rough red swellings on the lower surface of the leaf blade. Often they coalesce, covering a large area of the leaf blade alongside the midrib. As blisters become infested with mites, they turn dark brown to black, and by the end of the growing season the affected tissue has become dead and shrunken. Blisters that are not colonized by mites are pale green. Later they may become inhabited by mites from old nearby blisters. However, blisters without exit holes never contain mites.

This mite is yellowish, slender, and wormlike, measuring 200–230 microns long. The featherclaws are 4-rayed; the dorsal shield has a distinct design of a broken median ridge flanked by a pair of longitudinal ridges, with the ends curving and joining posteriorly; the dorsal setae are directed forward; the microtubercles are elliptical; and the coverflap of the female genitalia has 10 ribs in a single row. The habits and life cycle of *P. pyri* have been observed by several workers, including Burts (*1959*) in the Pacific Northwest. The mites in the blisters develop several generations during late spring and summer. Development from egg to adult takes 20–30 days during the spring and 10–12 days in the warmer part of the summer. A useful summary is given in Jeppson et al. (*1975*).

Phytoptus pyri belongs to a group of eriophyids found on rosaceous plants, but it is confined to pear. Another eriophyid mite, *Phytoptus pseudoinsidiosus* (Wilson), also a pest of pear trees in certain areas of the Western United States, causes the same type of leaf blisters. It should not be confused with *P. pyri.*

References: Burts, *1959: 42;* Jeppson et al., *1975: 422;* Keifer, *1938a: 183;* Pagenstecher, *1857: 48;* Wilson, *1965: 327.*

PLATE 62.—Leaf blisters on pear: *A, B,* Upper surface; *C,* lower surface. *D, Phytoptus pyri* Pagenstecher.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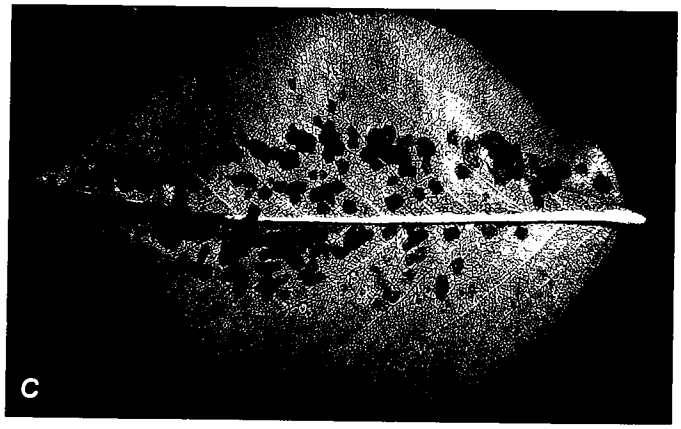
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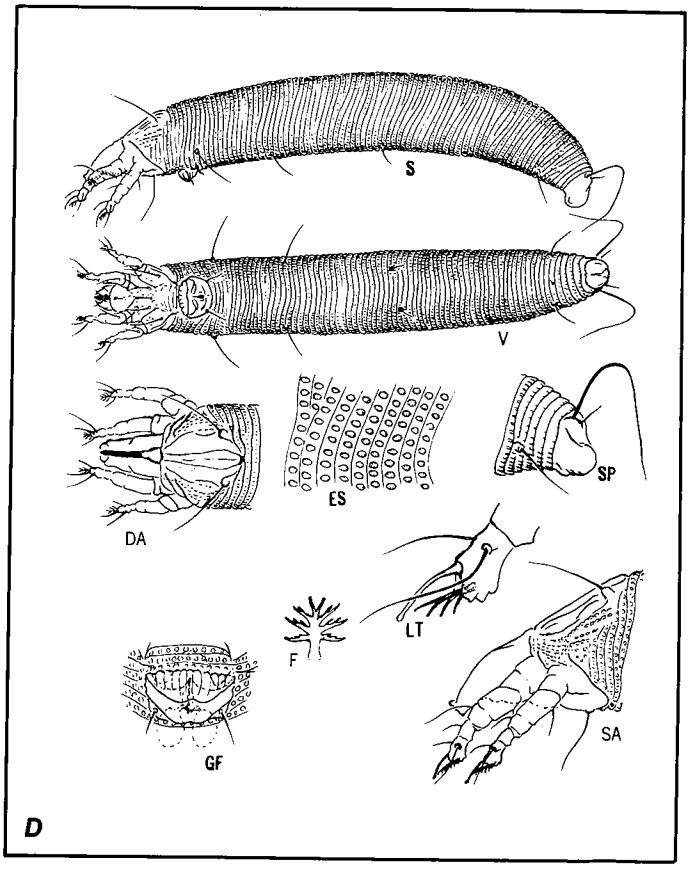
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Rosaceae

***Sorbus californica* Greene Mountain Ash**

***Sorbus scopulina* Greene Mountain Ash**

Leaf blister caused by *Phytoptus sorbi* Canestrini and erineum caused by *Phyllocoptes calisorbi* Keifer (pl. 63)

Two species of eriophyids producing different leaf symptoms are found on mountain ash. Because the taxonomy of the mites is complex, we are simplifying the descriptive entry of the two forms here.

(1) Blisters on leaves are similar to those on other rosaceous plants, particularly pear. They are small, puckered swellings on the upper surface of the leaves, varying from yellowish when the blisters first appear to brown on maturing. *Sorbus scopulina* in California is usually heavily infested by *Phytoptus sorbi.* This mite closely resembles *Phytoptus pyri* Pagenstecher, the pearleaf blister mite, and belongs to a complex of species with four-rayed featherclaws found on rosaceous plants.

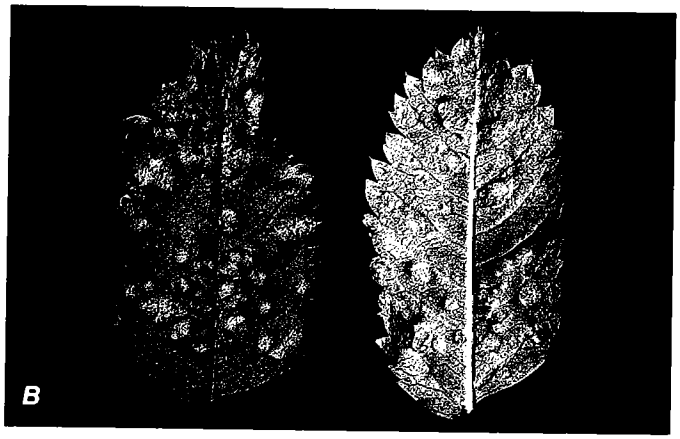
(2) Large patches of whitish erineum may be found on the lower surface of the leaves of *Sorbus californica.* The erineum hairs are elongate, of varying length and form, at first whitish, and later turning brown (see pl. 7, *B,* for detailed structure). They are abundant on plants in the shade.

Phyllocoptes calisorbi is distinct and easily separable from *Phytoptus sorbi,* but here again this erineum-forming mite belongs to a complex of species (*Phyllocoptes goniothorax* complex) that attacks pomaceous Rosaceae. For precise identification of the species, send the specimens to a specialist.

References: Canestrini, *1890: 282; 1891: 53;* Jeppson et al., *1975: 493;* Keifer, *1965a: 15.*

PLATE 63.—*A, B,* Blisters on mountain ash leaves caused by *Phytoptus sorbi* Canestrini; *C,* erineum on mountain ash leaves caused by *Phyllocoptes calisorbi* Keifer; *D, Phytoptus sorbi.*

A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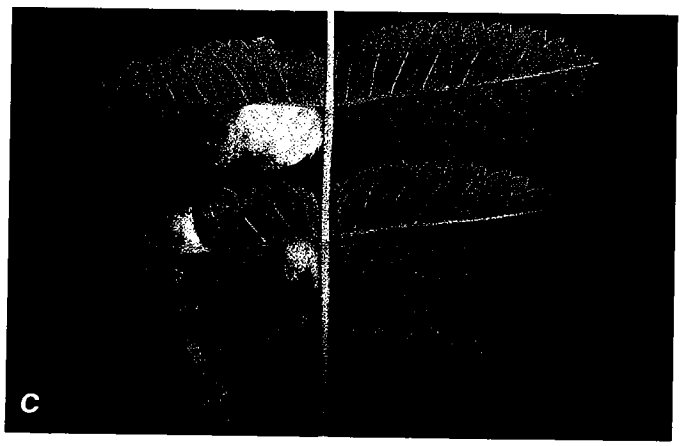
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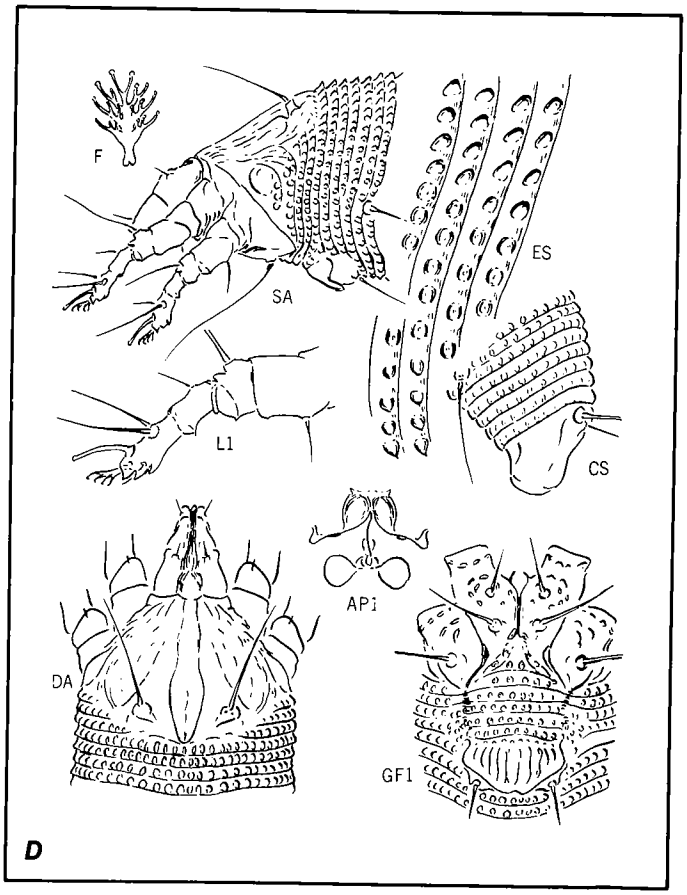
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Leaf Deformation, Distortion, Vein Atrophy, and Fruit, Bud, and Flower Abnormalities

Berberidaceae

Mahonia dictyota **(Jeps.) Fedde Holly Grape, Oregon Grape**

Leaf fold and twisting caused by *Eriophyes caliberberis* (Keifer) (pl. 64)

The inclusion of this injury is to illustrate an uncommon type of foliage distortion caused by an eriophyid. Colonization of a leaf by *Eriophyes caliberberis* results in considerable contortion; the leaf margin is curled upward, folded, and twisted across the upper surface toward the midrib. The leaf fold may involve the entire length of the leaf margin, with one or two windings forming a tube. The folded leaf eventually becomes crumpled and brown. The mite colonies are found in the tight leaf folds.

This mite is yellowish white and somewhat spindle shaped, measuring 175–195 microns long. The featherclaws are 5-rayed; the dorsal shield is unmarked except for 2 strong, short ridges posteriorly between the setal bases; the microtubercles are elliptical; the coxae have a few granules; and the coverflap of the female genitalia has 12 ribs in a single row.

Eriophyes caliberberis inhabits the leaf folds and buds. The mites were collected in November on *Mahonia dictyota,* an evergreen shrub found in the dry, rocky areas at 500–1,800 meters in California.

Reference: Keifer, *1952b: 66.*

PLATE 64.—*A, B,* Distorted leaves of holly grape; note curling of leaf margin; *C, Eriophyes caliberberis* (Keifer).

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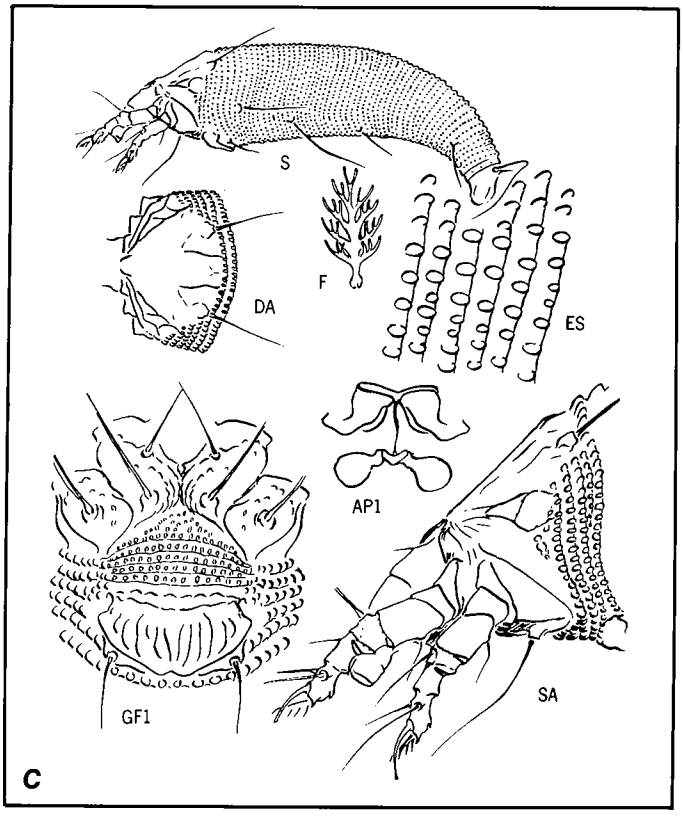
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Caprifoliaceae

***Symphoricarpos rivularis* Suksd. Snowberry**

Leaf roll caused by *Phyllocoptes triacis* Keifer (pl. 65)

The infested leaf is usually folded at the distal end of the blade, with the margin rolled tightly over the upper surface; at times only the lateral margin of the leaf is infolded, forming a podlike fold. The rolls are glabrous, somewhat thickened, and conspicuous against the green leaf blade. Although many leaves show severe deformation, the plant does not seem to be affected by the damage.

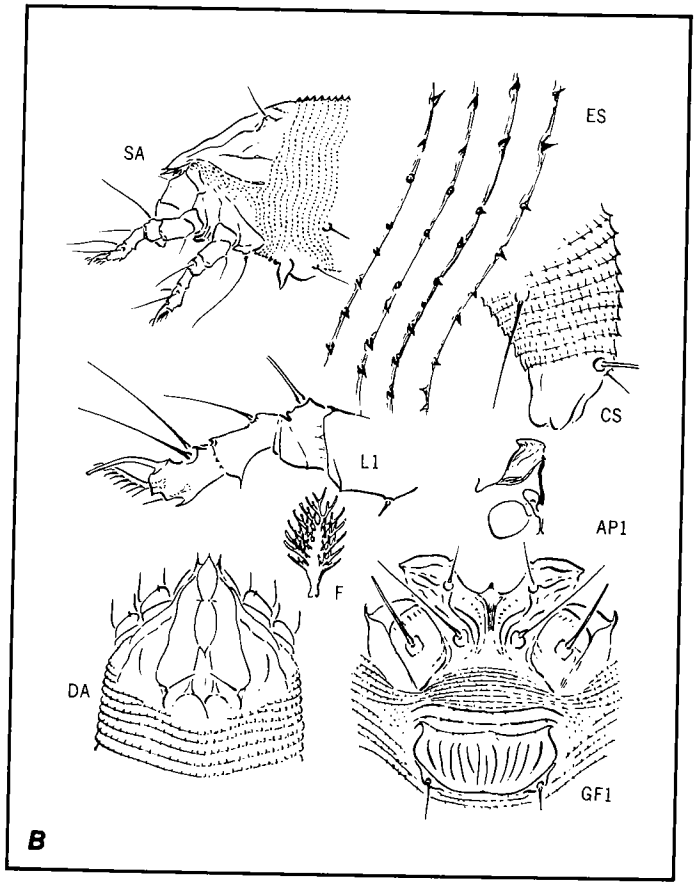
Phyllocoptes triacis is a robust, spindle-shaped, yellowish-white eriophyid, measuring 190–215 microns long. The featherclaws are eight-rayed. A distinguishing character is the presence of three spines on the anterior margin of the dorsal shield and a dorsal ribbon design formed by two median ridges. The dorsal setae are directed forward; the microtubercles are spinelike; and the coverflap of the female genitalia has 12 strong ribs.

In Oregon this mite occurs together with *Eriophyes brownei* Keifer in the hollow of the leaf fold; it was collected in May. In California, however, *P. triacis* is the only species present. The host is snowberry, which is found from Alaska to Montana and California.

Reference: Keifer, *1966a: 5.*

PLATE 65.—*A,* Leaves of snowberry with rolled margins; *B, Phyllocoptes triacis* Keifer.

A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Gramineae

***Cynodon dactylon* (L.) Pers. Bermuda Grass**

Terminal shoot and leaf blade distortion caused by *Eriophyes cynodonis* (Wilson) (pl. 66)

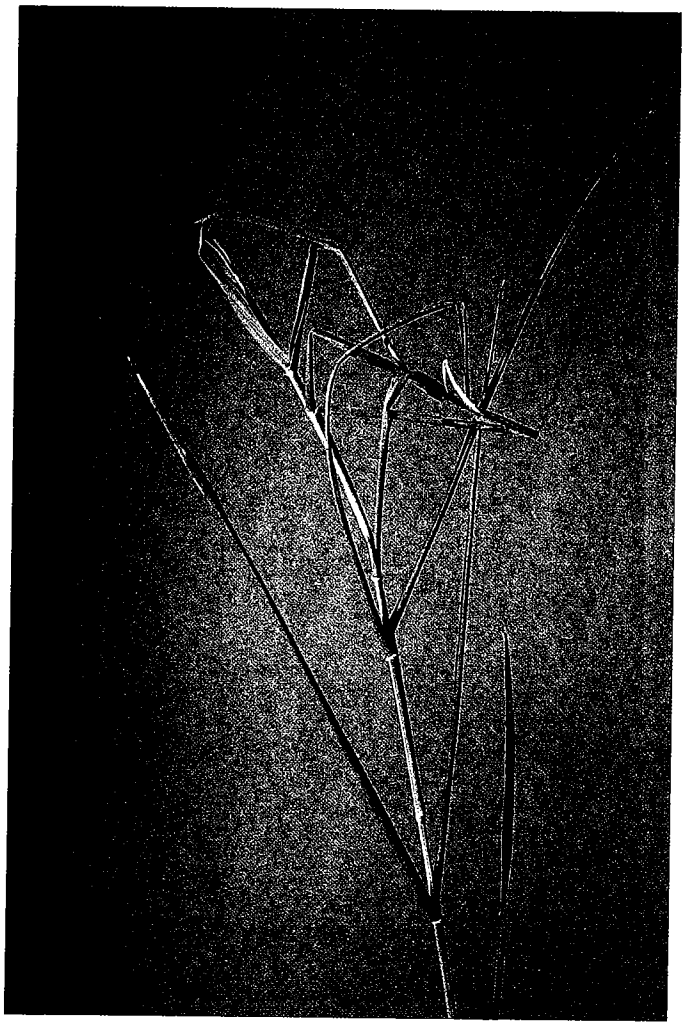
The mites are abundant in the folded terminal shoots, where their feeding apparently inhibits the expansion of the leaves. This results in the twisting of the folded terminal shoot and subsequent infolding, bending, and twisting of the leaf blade. Infested Bermuda grass may easily be recognized by the contorted terminal leaf blades.

Eriophyes cynodonis is a robust, spindle-shaped, whitish or yellowish mite, measuring 170–211 microns long. The featherclaws are 8-rayed; the dorsal shield is produced anteriorly and marked with 2 longitudinal ridges at the anterior angle of the shield running laterally; the microtubercles are minutely pointed; the accessory setae are present; and the coverflap of the female genitalia has 10 longitudinal ribs.

Specimens were collected on infested Bermuda grass in California and Arkansas. This mite is not to be confused with *Eriophyes cynodoniensis* (Sayed), which also infests Bermuda grass but causes a rosettetype injury.

Reference: Wilson, *1959: 142.*

PLATE 66.—*A, B,* Twisted terminal shoots and leaves of Bermuda grass; *C, Eriophyes cynodonis* (Wilson).



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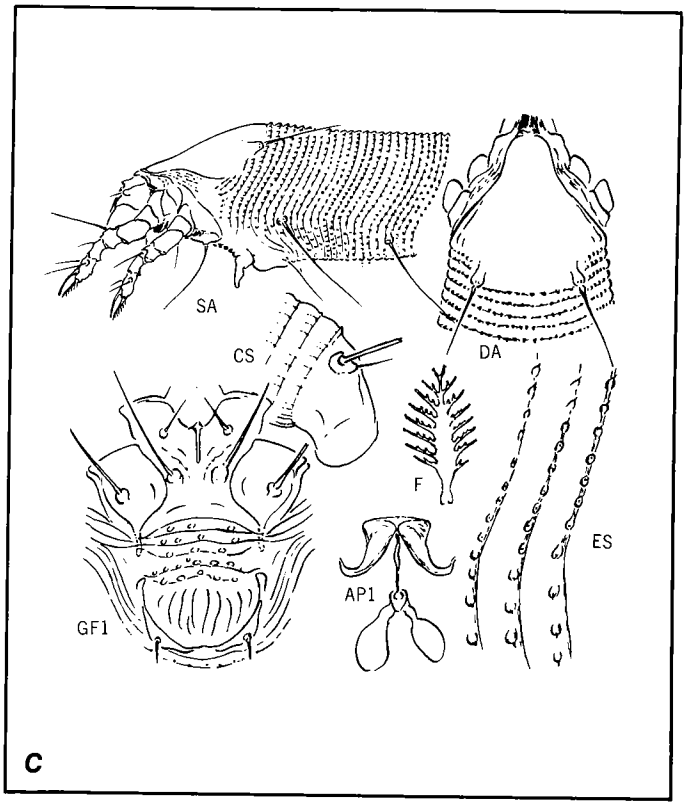
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Nyssaceae

***Nyssa sylvatica* Marsh. Pepperidge, Sour-Gum, Tupelo**

Leaf edge roll caused by *Eriophyes dinus* Styer & Keifer and leaf gall caused by *Cenalox conyssae* Styer & Keifer, *C. nyssae* Keifer, and *E. nyssae* Trotter (pl. 67)

Two species of *Eriophyes* infest tupelo. Their feeding causes leaf edge roll and leaf galls. *Eriophyes dinus* is responsible for the irregularities of the leaf margin, which consist of thickened rolled edges with one to two windings, and the transforming of the leaf tip into a twisted or spiral tube. At first the colonized areas are the same color as the rest of the leaf, later becoming reddish, and finally brown. The thickness of the leaf roll is variable, and the whole length of the leaf margin may become infested, producing an attractive crinkly, wavy leaf. Rolled edge leaf sometimes has beadlike galls colonized by *Eriophyes nyssae.* These galls, which also occur on the upper surface of the leaf, are small and may be solitary or coalesced.

Eriophyes dinus and *E. nyssae* are not separable by morphological characters. Both have three-rayed featherclaws; the dorsal shield is not marked with a design; the hysterosoma of primary females and males has microtubercles, whereas they are lacking or weakly developed in the overwintering females; and the coverflap of the female genitalia lacks ribs.

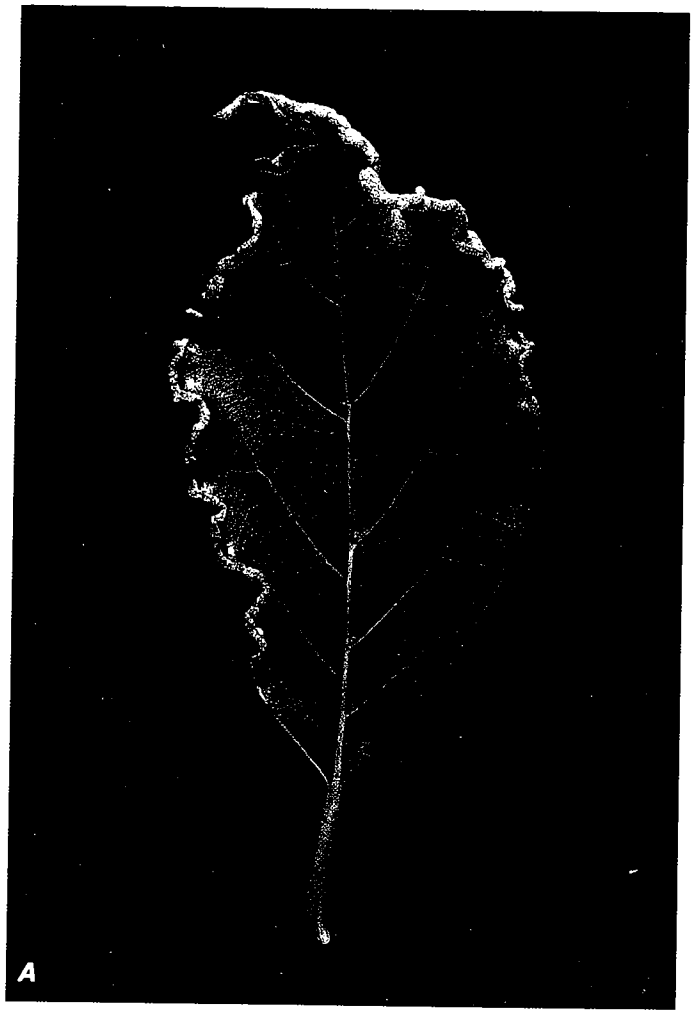
Besides the *Eriophyes* mites, two distinctive species, *Cenalox nyssae* and *C. conyssae,* also infest tupelo. Specimens were found recently on the underside of the leaves in galls along the midribs and veins. The simple distinctions of the two galls concern their form, position, and texture. Those caused by *C. nyssae* are small, rounded pockets filled with erineum; the galls appear alongside the midrib at angles of lateral veins. The *C. conyssae* galls are rough, open pockets filled with fleshy lobes, and they appear alongside the veins. Both galls form slight swellings on the upper surface of the leaves.

Cenalox mites are spindle shaped and whitish, with three- or four-rayed featherclaws and an obscure design on the dorsal shield. The basic morphological differences and similarities between these two gall-forming species are discussed by Styer and Keifer (*1978*).

The host is *Nyssa sylvatica,* commonly known locally as tupelo. The mites were collected in New York, Maryland, and from North Carolina to Georgia and Ohio.

References: Keifer, *1961: 7;* Styer and Keifer, *1978: 7;* Trotter, *1903: 67.*

PLATE 67.—*A,* Leaf edge roll of tupelo caused by *Eriophyes dinus* Styer & Keifer; *B,* leaf galls of tupelo caused by *E. nyssae* Trotter; *C,* close up of galls; *D, E. dinus; E, E. nyssae; F, Cenalox nyssae* Keifer.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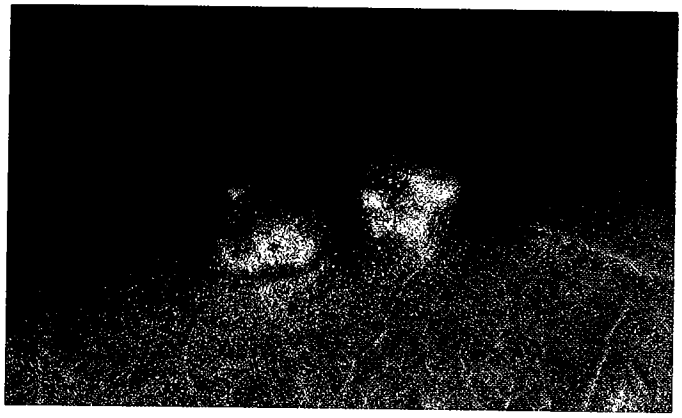

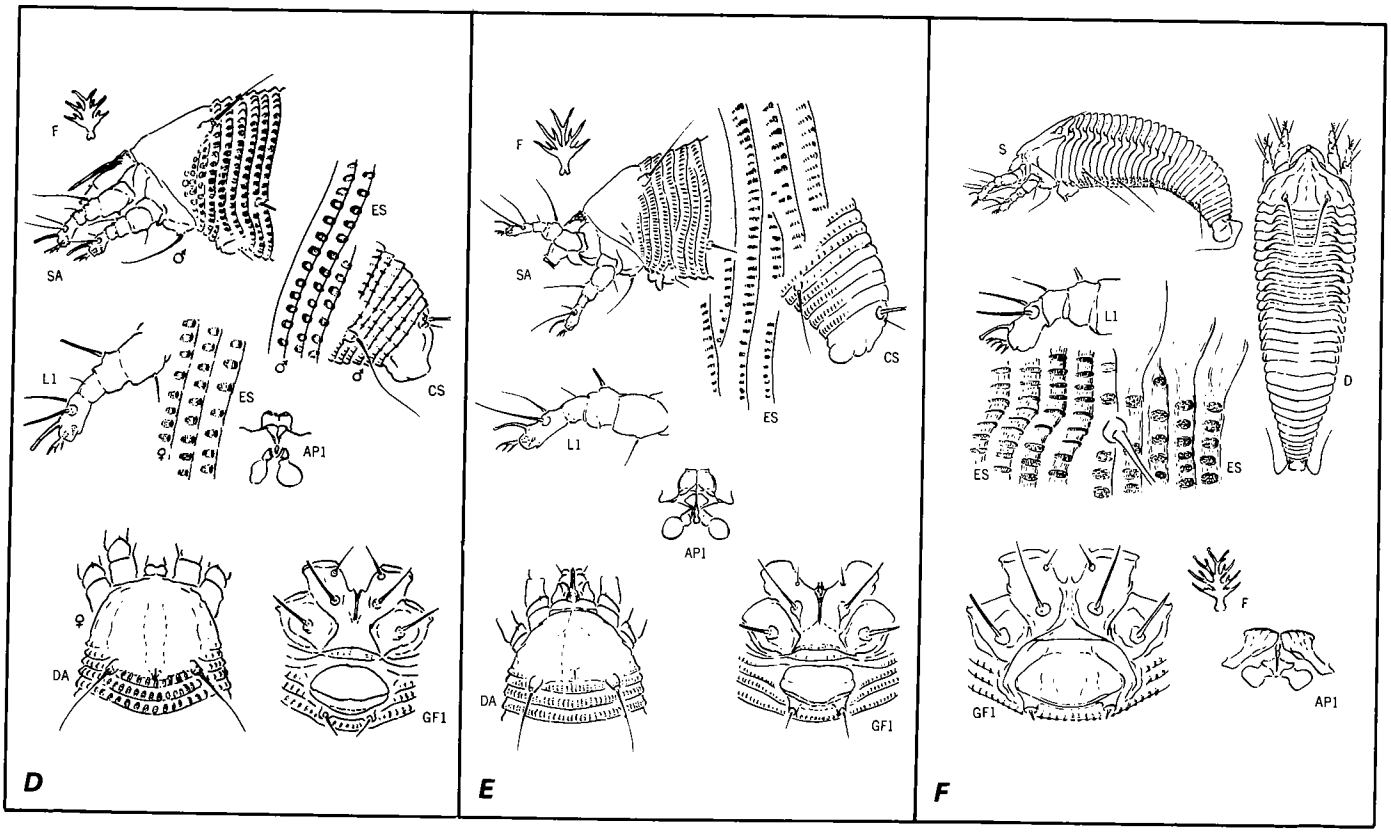
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Punicaceae

***Punica granatum* L. Pomegranate**

Leaf roll caused by *Eriophyes granati* (Canestrini & Massalongo) (pl. 68)

This is an interesting tubular leaf roll, which consists of a downward tight rolling and curling of the whole length of the leaf margin into a tube. Eventually the infested margin rolls toward the midrib but does not cover it. The mites are wrapped in the thickened turned-over leaf edge, where they live and reproduce inside the roll. In some plants, infestations are so heavy that nearly every young leaf is rolled, distorted, and twisted.

Eriophyes granati is a yellowish, somewhat robust eriophyid, measuring 165–180 microns long. The featherclaws are 4-rayed; the distinctive dorsal shield design has curved, straight ridges, with the median weakened anteriorly but ending dart shaped posteriorly; the microtubercles are rounded or elliptical; the coxae are covered with fine granules; and the coverflap of the female genitalia has 14–16 ribs in a single row.

This species was originally found in Italy on pomegranate, a widely cultivated plant in tropical and subtropical areas. Specimens were found in California on the same host.

References: Canestrini and Massalongo, *1894: 465;* Jeppson et al., *1975: 452;* Keifer, *1952d: 9, 13, 29.*

PLATE 68.—*A,* Infested pomegranate leaves; *B,* close up of contorted leaves; *C, Eriophyes granati* (Canestrini & Massalongo).

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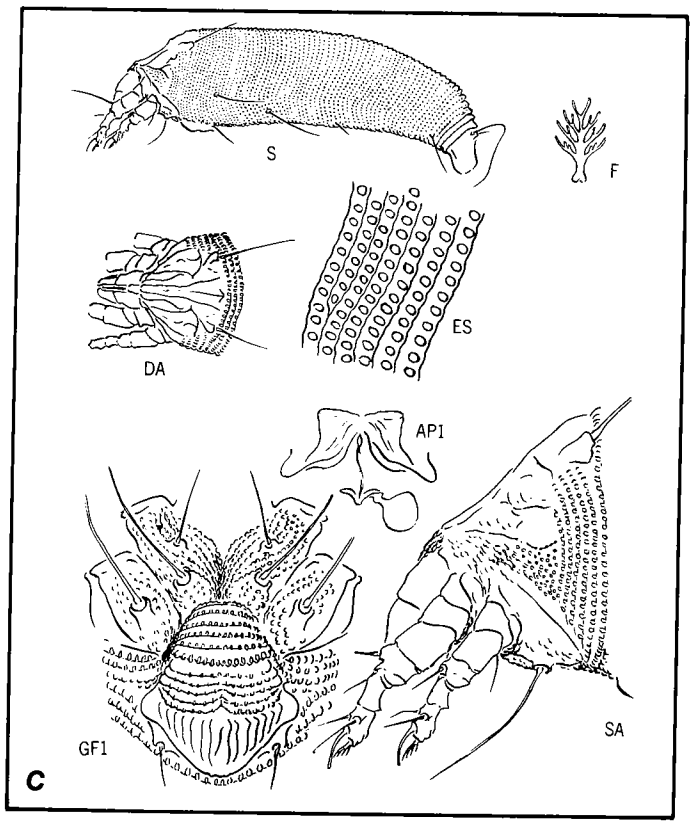
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Rhamnaceae

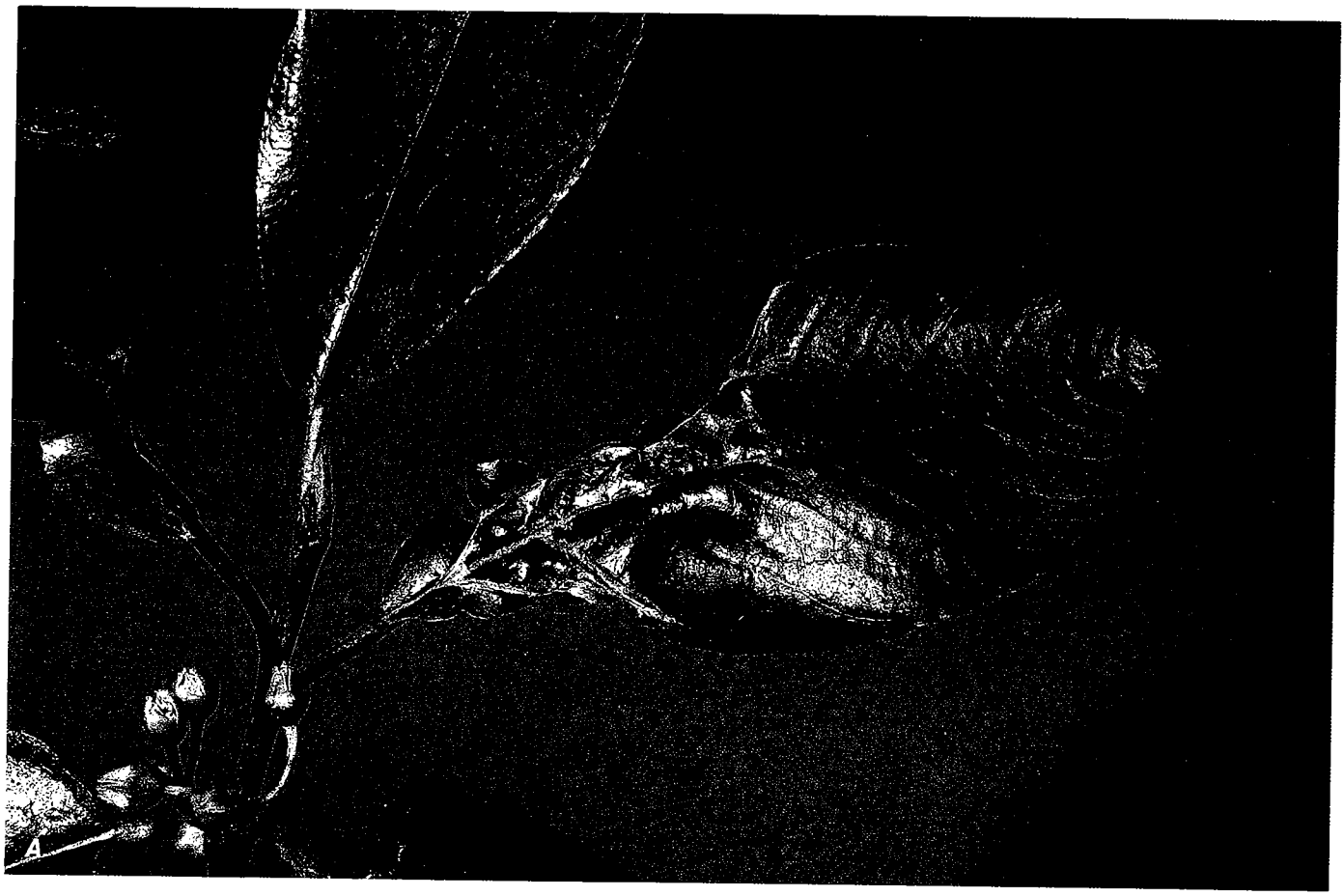
***Rhamnus californica* Eschsch. Coffeeberry**

Deformed leaves and atrophied, coalesced veins probably caused by *Thamnacus rhamnicola* (Keifer) (pl. 69)

This is a remarkable form of leaf injury associated with an eriophyid mite. The leaves of coffeeberry show considerable localized distortion of the affected parts, generally involving the lateral veins. Infested veins are yellowish and distinctly atrophied, tending to coalesce. The midrib may be swollen, and the leaf blade becomes pinched, wrinkled, and undeveloped. The mites presumably causing this injury are vagrants on the underside of the leaves of coffeeberry in California. They were collected in June.

Reference: Keifer, *1938b: 307.*

PLATE 69.—*A–C,* Malformed leaves of coffeeberry; note atrophied and coalesced lateral veins; *D, Thamnacus rhamnicola* (Keifer).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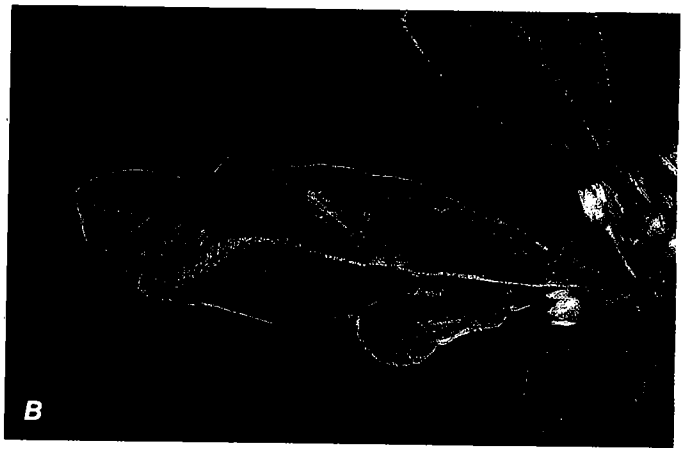
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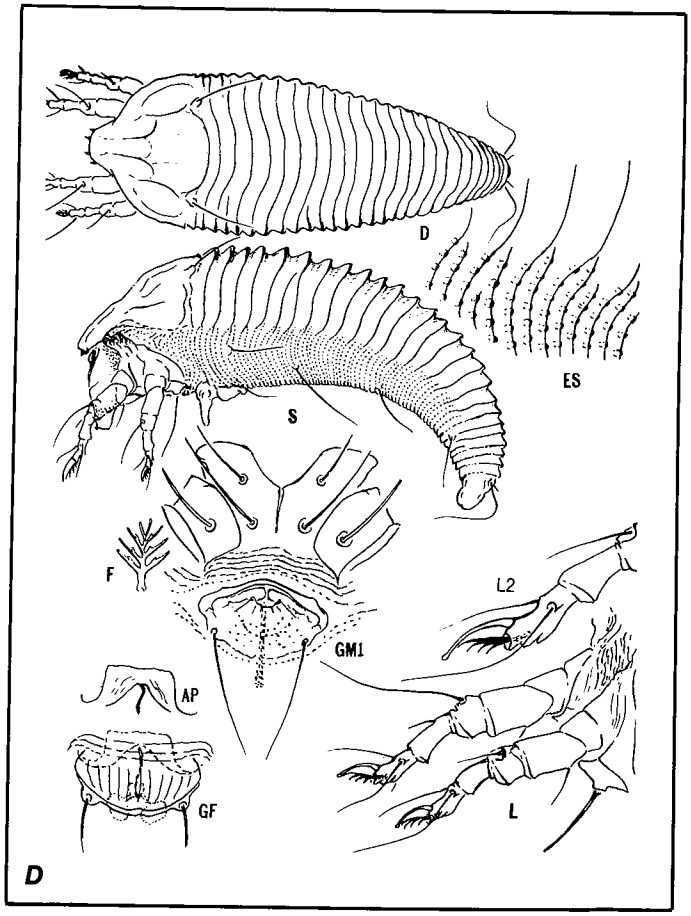
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Rutaceae

***Citrus* spp. Grapefruit, Lemon, Lime, Orange, Other Citrus**

Deformed buds, flowers, leaves, and fruit caused by *Eriophyes sheldoni* Ewing (pl. 70)

The citrus bud mite, *Eriophyes sheldoni,* has been known as a serious pest of lemon and orange trees for many years. Its feeding within the buds invariably results in distortion of shoot growth, excessive and grotesque deformation of fruit, foliage, and blossoms, discoloration of fruit, and more commonly the production of numerous buds. The last may develop abortive twigs in tight clusters resembling witches'-broom and bunched terminal growth of distorted stems and leaves. Most malformed fruit drops prematurely. Mature lemon fruit shows blackened areas on the rind beneath the sepals (buttons), where large colonies of mites are concealed. Deformed leaves and blossoms assume various shapes; the leaf blades are constricted at their middle, curled and twisted, and divided and divergent at the tips; and the blossoms are stunted and abnormal. The symptoms of injury on oranges are similar to those on lemons except fruit deformation is not so grotesque. Affected oranges usually develop to maturity, but they are commonly flattened, resembling the shape of tomatoes; or there are skin folds, seams and ridges, or small apertures in the stylar end.

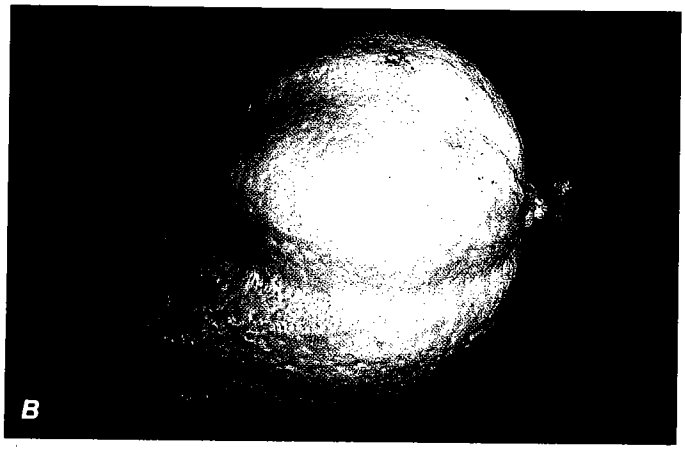
Eriophyes sheldoni is a robust, wormlike mite, measuring 170–180 microns long; it varies from yellowish to pinkish, to orange. The featherclaws are 5-rayed; the dorsal shield has a variable design of indistinct short and broken or 2 parallel ridges running the entire length of the shield, and a median broken ridge that ends posteriorly as dart shaped; the microtubercles are elliptical; the coxae have fine granules; and the coverflap of the female genitalia has 10–12 ribs. The mites inhabit protected areas in the buds, in developing blossoms, and beneath the sepals (buttons) of the fruit. The life cycle has been summarized by Jeppson et al. (*1975*). It takes about 15 days during the summer and 20–30 days during the winter to develop from egg to adult.

Eriophyes sheldoni attacks lemons, oranges, limes, grapefruit, and other citrus. It probably occurs throughout the citrus-growing areas of the world. In California and New South Wales, *E. sheldoni* is important in coastal districts. Heavy infestations of lemons and oranges can cause great economic loss to citrus growers.

References: Boyce and Korsmeier, *1941: 745;* Boyce et al., *1942: 1;* Ewing, *1937: 193;* Gellatley, *1977: 1;* Jeppson et al., *1975: 440;* Keifer, *1938a: 186.*

PLATE 70.—*A,* Feeding injury on lemon leaves; note distorted young leaves; *B, C,* malformed oranges; *D, Eriophyes sheldoni* Ewing.

A


B

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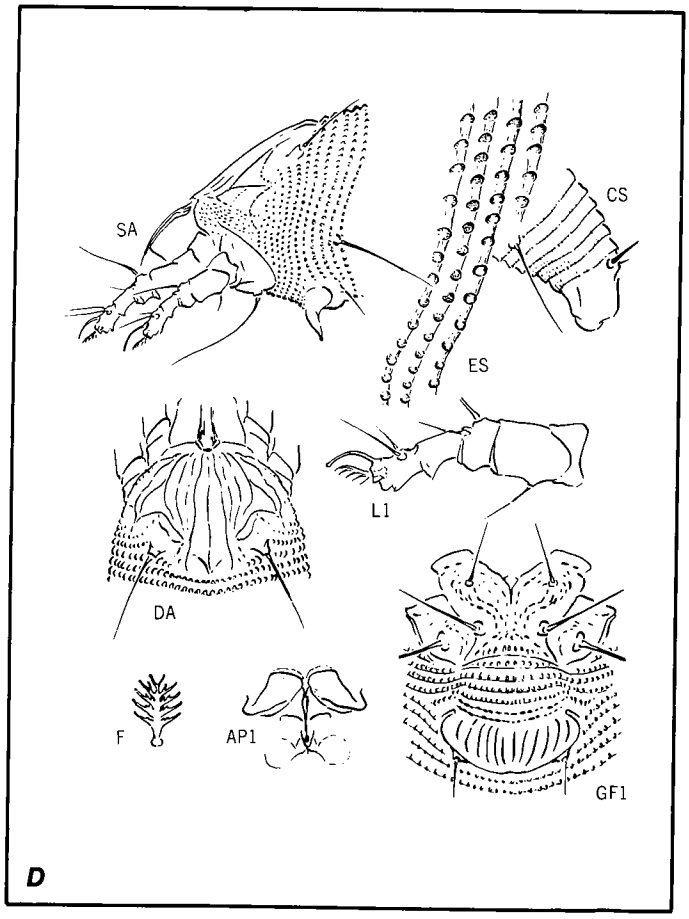
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Anacardiaceae

***Mangifera indica* L. Mango**

Leaf coating caused by *Cisaberoptus kenyae* Keifer (pl. 71)

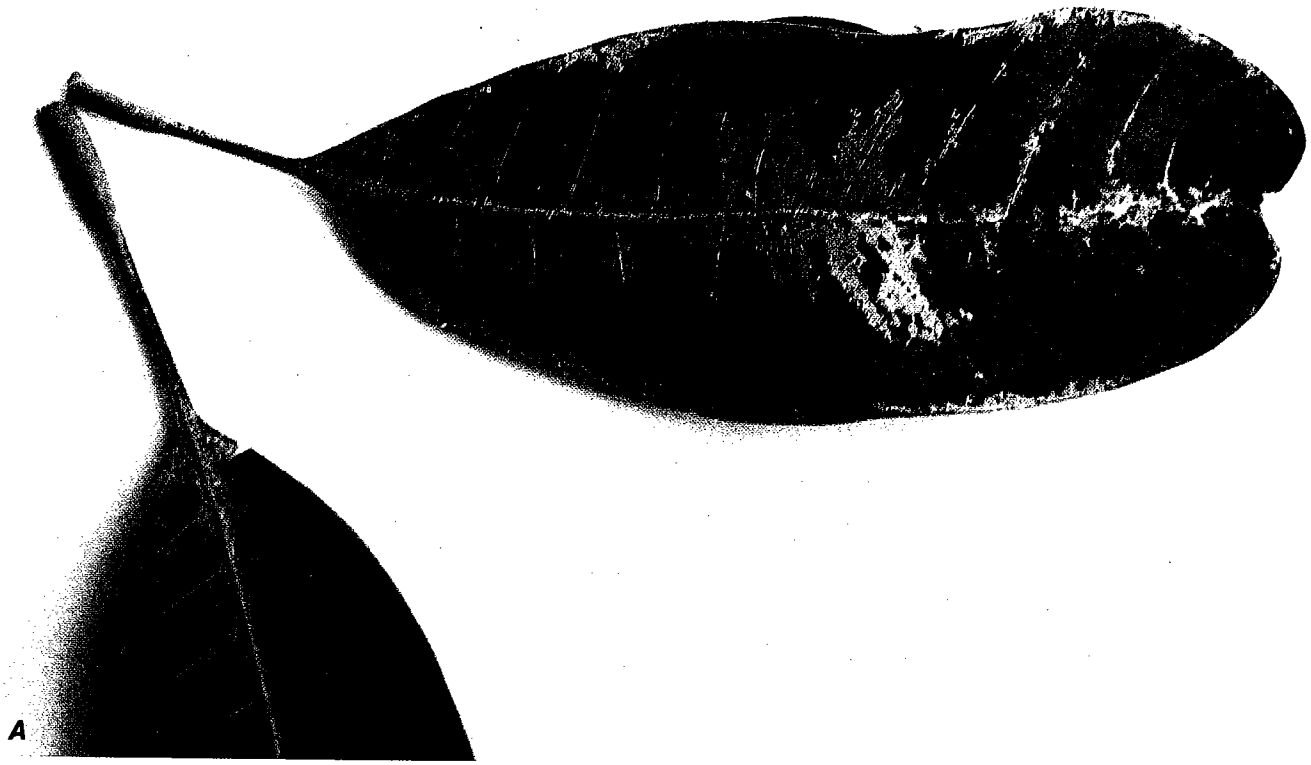
The whitish coating on mango leaves caused by *Cisaberoptus kenyae* generally resembles that produced by *Aculops knorri* Keifer on leaves of a sapindaceous tree. The coating develops at the petiole, just below the leaf blade on young leaves, and extends to the upper surface of the blade. It covers mainly the areas along the midrib and lateral veins and in between the veins. Narrow patches may be seen bordering the leaf margins. The material and structure are not known, although they are weblike and somewhat thickened.

Cisaberoptus kenyae is an interesting heteromorphic eriophyid mite. The body is flattened dorsoventrally and yellowish white, measuring 190–210 microns long. The featherclaws are elongate, bulbous, and with 17 or more fine rays; the gnathosoma is curiously spatulate, but normal males and females have the short, typical eriophyid gnathosoma; the dorsal shield is broad and unmarked, with a pair of posterior lobes near the base of the dorsal setae; the hysterosoma is covered with granular microtubercles; and the coverflap of the female genitalia has an irregular series of 14–16 ribs. Heteromorphic females are usually found at the border area of the webbing. Larger colonies of mites are under the weblike patches.

This species is known in East Africa, Southeast Asia, and Brazil on mango.

References: Keifer, *1966b: 1;* Knorr et al., *1976: 229.*

PLATE 71.—*A*, Whitish coating on upper surface of mango leaf; *B*, *Cisaberoptus kenyae* Keifer.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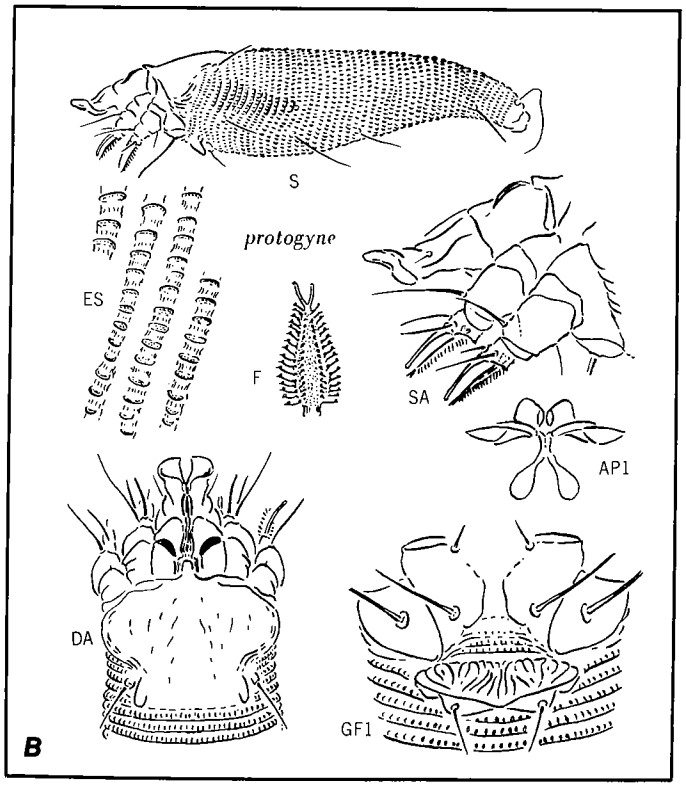
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Sapindaceae

***Erioglossum rubiginosum* (Roxb.) Blume**

Leaf webbing caused by *Aculops knorri* Keifer (pl. 72)

This interesting phenomenon of web spinning and coating of the leaf surface by *Aculops knorri* is the first record among eriophyid mites. A second is mentioned under *Cisaberoptus kenyae* Keifer (p.156). The weblike patches on sapindaceous leaflets are initially dull grayish white, resembling powdery mildew, and later becoming shiny. Webbing may cover the entire upper surface of the leaflet; pinhead-sized webs are scattered at random over the surface, and small patches commonly border or lie along the grooves of the lateral veins. Affected areas of the leaflet under old patches show slight russeting or necrosis. Under the scanning electron microscope, the weblike coating consists of fine crisscrossing filaments and woven strands that form the fabric of the webbing.

Aculops knorri is a robust, brownish-orange, spindle-shaped mite, measuring 128–148 microns long. The featherclaws are 6-rayed; the dorsal shield is smooth, unmarked; the microtubercles are slender, elongate; and the coverflap of the female genitalia has 12 ribs. Numerous mites in all stages of development are found on the upper surface of the leaflet under the webbing. Infestation and web formation occur from April to June; approximately 5 percent of the leaves are affected. New leaves that emerge after the start of the rainy season are free from webbing.

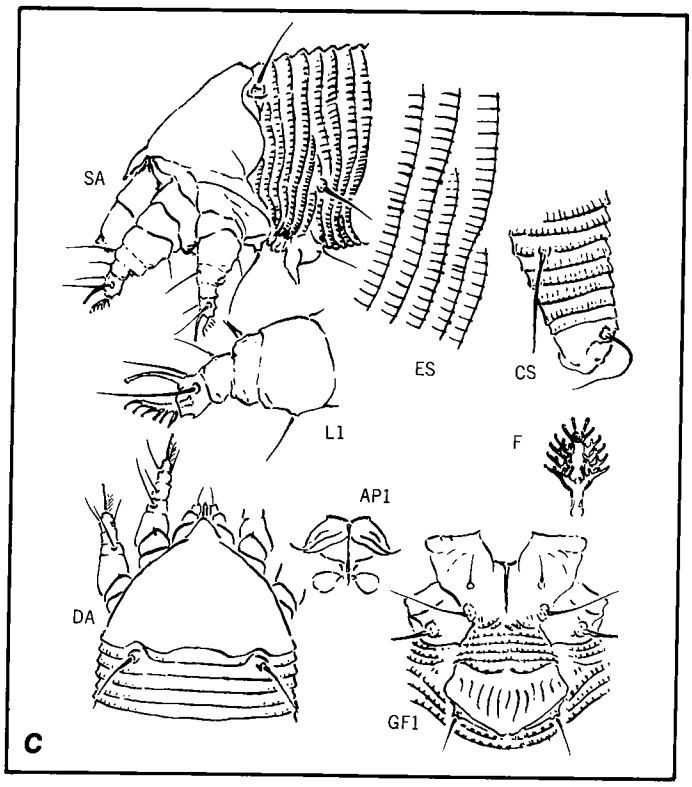
This mite is known only from Thailand on *Erioglossum rubiginosum,* a common sapindaceous fruit tree native to tropical Asia and northern Australia.

References: Keifer, *1976: 2;* Knorr et al., *1976: 228.*

PLATE 72.—*A, B,* Whitish webbing on upper surface of leaves of *Erioglossum rubiginosum* (Roxb.) Blume; *C, Aculops knorri* Keifer.

A

B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Gramineae

***Triticum aestivum* L. Wheat**

***Zea mays* L. Corn**

Mosaic virus disease of corn and wheat and red streak of corn caused by *Eriophyes tulipae* Keifer (pl. 73)

Eriophyes tulipae is the vector of wheat streak mosaic virus (WSMV) and wheat spot mosaic virus (WSpMV). These viruses are destructive to wheat, causing chlorotic spots, necrosis, and stunting; sometimes they kill the plant. According to Jeppson et al. (*1975*), WSMV may be transmitted by *E. tulipae* to barley (*Hordeum vulgare* L.), oats (*Avena sativa* L.), rye (*Secale cereale* L.), and certain wild annual grasses. Barley and rye have been known to be an occasional source from which *E. tulipae* may transfer WSMV to spring wheat-fields. The mites may colonize other grasses, such as wheatgrass (*Agropyron* sp.), Canada wild rye (*Elymus canadensis* L.), Virginia wild rye (*Elymus virginicus* L.), Indian ricegrass (*Oryzopsis hymenoides* (Roem. & Schult.) Ricker.), and Canada bluegrass (*Poa compressa* L.), all of which may become infected with the virus. *Eriophyes tulipae* can also infest some common perennial grasses, including Wheeler bluegrass (*Poa* sp.), western wheatgrass (*Agropyron* sp.), and foxtail barley (*Hordeum* sp.), which are immune to WSMV. It also transmits both WSMV and WSpMV to corn. All stages of the mites, except the egg, carry the virus.

In addition, the feeding of the mites on corn kernels causes a disease known as kernel red streak, whereby discolored corn ears show red-striped pericarps. The color ranges from deep red in yellow kernels to pink or purple in white kernels. Streaked kernels may appear randomly but more concentrated at the ear tips. Mite feeding injury on young corn is indicated by spotting, curling, or rolling of the leaves. On wheat, high mite populations result in tightly curled, rolled, or trapped leaves. Numerous reports have been published on this mite and its relation to viruses and feeding injury to both corn and wheat. See Slykhuis (*1955, 1962, 1967*), Slykhuis et al. (*1968*), and Oldfield (*1970*). A useful summary is given by Jeppson et al. (*1975*).

This mite is whitish, slender, and somewhat spindle shaped, measuring 210–250 microns long. The female has 7-rayed featherclaws; those of the male are 6-rayed and usually shorter than those of the female; the dorsal shield has 1 short median ridge posteriorly, flanked by 2 divergent ridges running the entire length of the shield; the microtubercles are elliptical; the coxae are covered with minute granules; and the coverflap of the female genitalia has 10 long ribs.

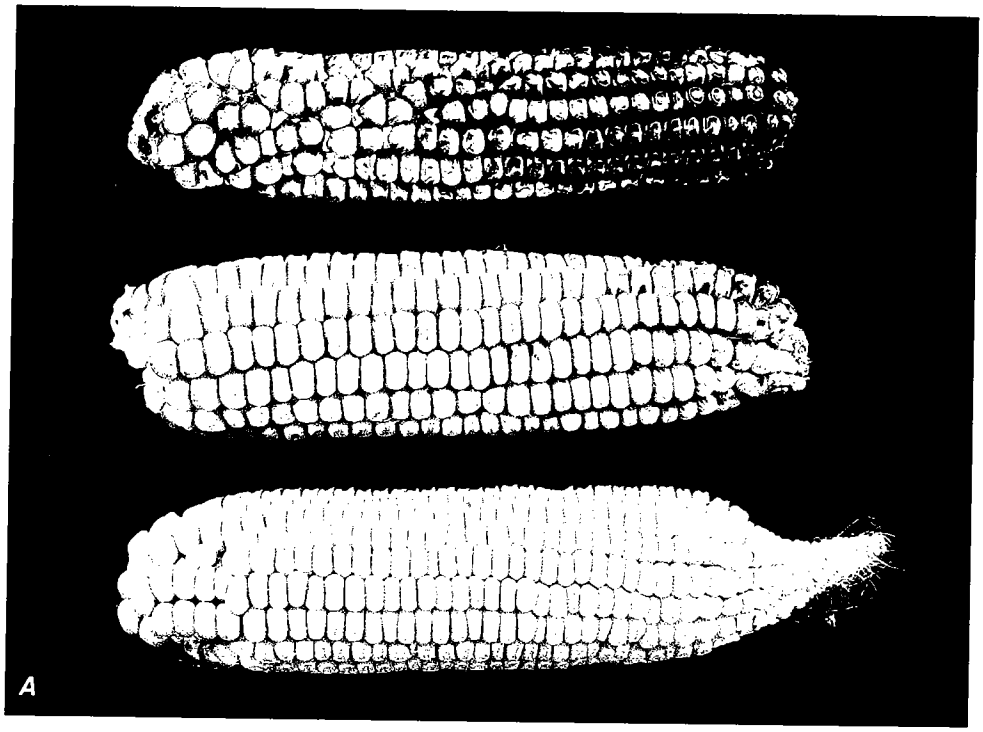
Nault and Styer (*1969*) observed the biology in Ohio as follows: The mites are found in all stages of development on wheat, in curled leaf margins, in unopened leaves, in leaf sheaths and ligules, and in glumes on the heads. On corn, they are found in rolled leaves, on kernels and silks, and under husks of the ear. They overwinter on wheat; high populations were found in the spring and early summer and on corn in late summer and early fall. As the wheat heads dry up in July, the mites disperse to corn; in the fall when the corn has matured, they move to the fall-planted winter wheat, completing the cycle. Corn apparently has a significant role in the biology and transmission of mosaic virus.

For further discussion on mite biology and habits, see Jeppson et al. (*1975*).

Eriophyes tulipae is common and widespread throughout much of the area where corn and wheat are grown in the United States and Canada. Besides the cultivated crops and wild grasses (Gramineae) mentioned here, other hosts include garlic and onions (*Allium* spp., Amaryllidaceae) and tulip (*Tulipa* sp., Liliaceae), where this mite is found between layers in the bulbs.

References: Jeppson et al., *1975: 443;* Keifer, *1938a: 185; 1954: 123;* Nault, *1970: 27;* Nault and Briones, *1968: 31;* Nault et al., *1967: 986;* Nault and Styer, *1969: 1446;* Slykhuis, *1955: 116; 1962: 41; 1967: 349;* Slykhuis et al., *1968: 411.*

PLATE 73.—*A,* Red streak of corn, showing discolored ears; *B,* left, mite-infested garlic plant, right, healthy plant; *C,* red streaked kernels; *D,* feeding injury on garlic cloves; *E,* distorted and trapped leaves of young wheat plant; *F, Eriophyes tulipae* Keifer.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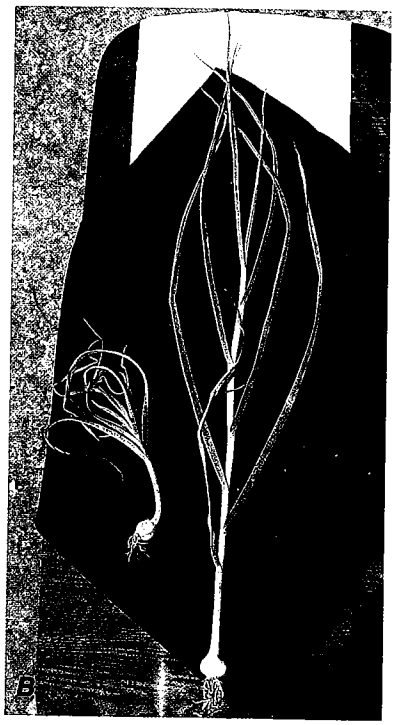
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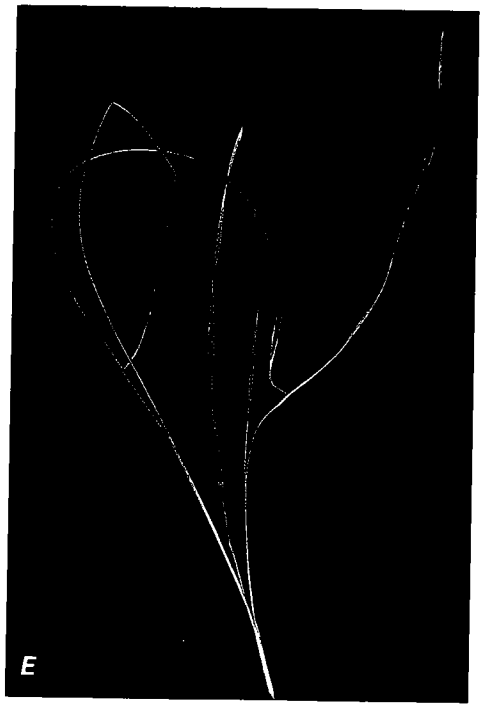
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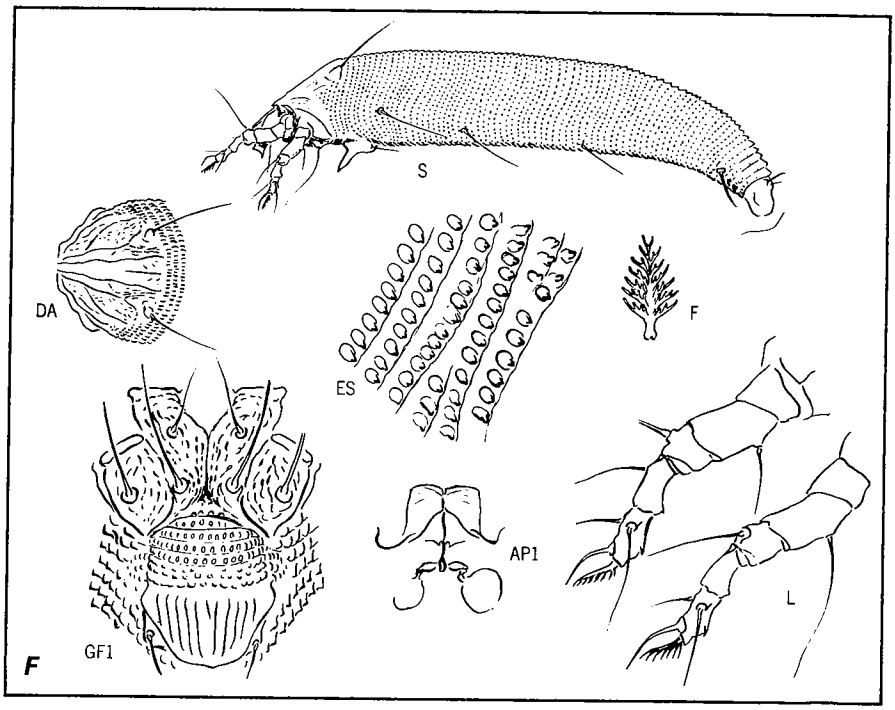
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Moraceae

***Ficus carica* L. Fig**

Mosaic virus disease caused by *Eriophyes ficus* Cotte (pl. 74)

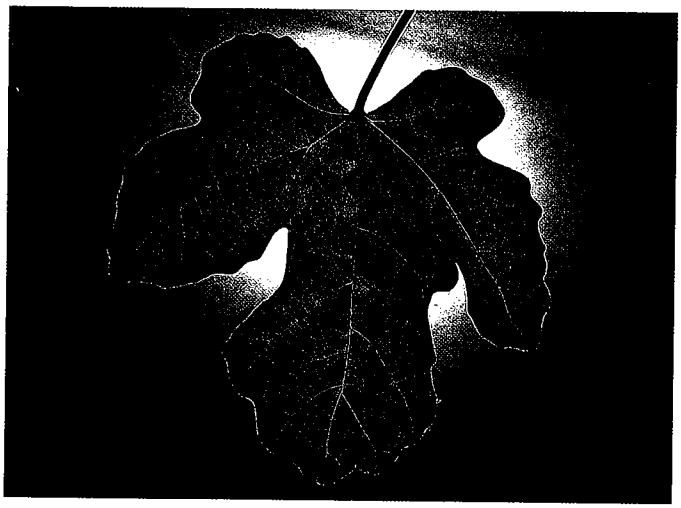
No proof was provided until 1955 that *Eriophyes ficus* was the vector of a virus causing fig mosaic. This mite proved to be an efficient vector. In addition to transmitting this virus, it causes leaf distortion, chlorosis, russeting, and scarring of the eye scales and seeds of the fruit. It occasionally causes stunting of twigs and premature leaf drop.

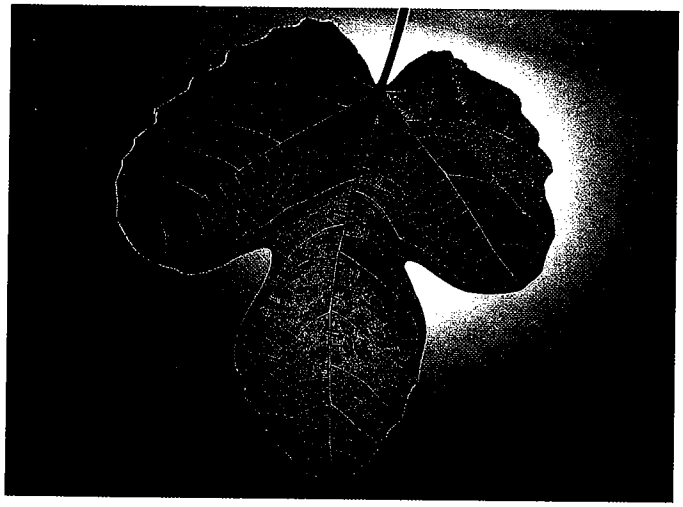
Eriophyes ficus is a yellowish, slender, spindle-shaped mite; the female measures 160–202 microns long and the male about 140 microns. The featherclaws are five-rayed; the dorsal shield is marked with longitudinal ridges, the lateral ones forming closed cells anterior to the setal bases; the hysterosoma is covered with elliptical microtubercles; and the coverflap of the female genitalia has eight ribs. All stages and both sexes of the mites are found on the leaves, in the buds and fruit, and occasionally on the stems throughout the year. Eggs are laid in the buds, on branches, and on both surfaces of the leaves following bud burst in the spring. During July many mites move off the leaves to enter the fruit, where they lay eggs among the eye scales, and all stages are found inside the fruit. The mites overwinter in the buds.

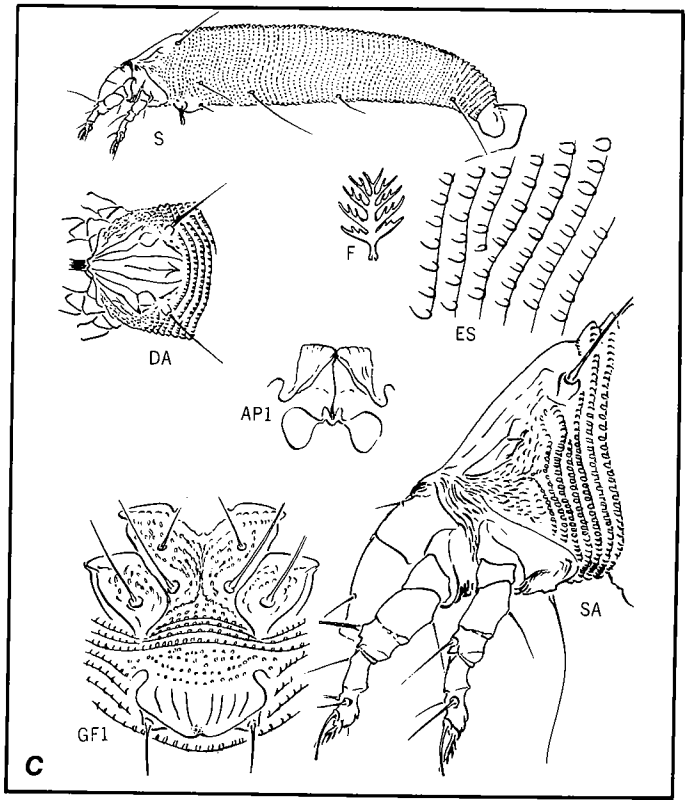
Fig mosaic virus has been reported from fig. The vector, *E. ficus,* is widespread on this plant in California; it also occurs in Oregon, Italy, and India. It is likely that both virus and mite will be found in most areas where figs are grown.

References: Baker, *1939: 266;* Cotte, *1920: 26;* Keifer, *1938b: 303;* Oldfield, *1970: 361.*

PLATE 74.—*A, B,* Fig leaves, showing distortion and chlorosis; *C, Eriophyes ficus* Cotte.



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Rosaceae

***Rosa* spp. Cultivated and Wild Roses**

Rose rosette virus disease caused by *Phyllocoptes fructiphilus* Keifer (pl. 75)

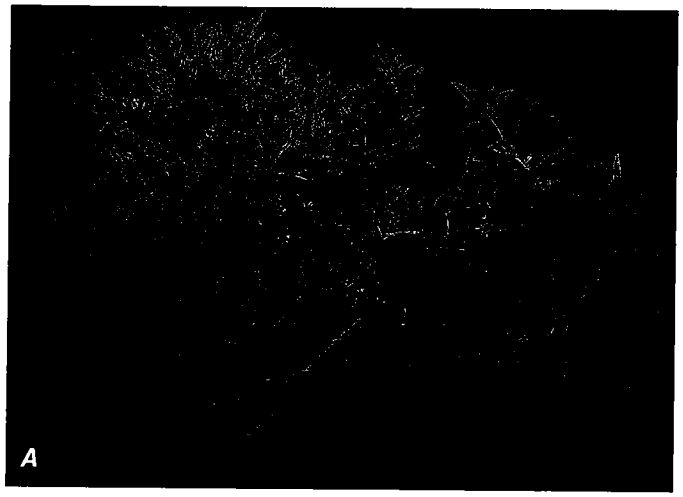
Allington et al. (*1968*) demonstrated in Nebraska that rose rosette virus could be transmitted to cultivated roses by *Phyllocoptes fructiphilus.* Infected wild rose plants generally exhibit malformation of the stems and leaves and multiplication of stunted shoots, with the individual structures forming a bunch. The appearance is that of a rosette. A common rosette virus symptom on cultivated roses is the premature breaking of the axillary buds, which become malformed, and stunted shoots; the leaves may appear normal, but those toward the tips are small and deformed. On other varieties, the affected leaves are puckered; they may turn red or become chlorotic. The floral parts are aborted and distorted. A few rose plants may show an increase in thorns.

The mite is a robust, yellowish-to-yellowish brown, spindle-shaped eriophyid, measuring 140–170 microns long. The featherclaws are five-rayed; the dorsal shield is marked with a design; the dorsal setae are directed forward and dorsocentrally; the microtubercles are elliptical; and the coverflap of the female genitalia has six to seven ribs. Specimens were originally found in wild rose hips (*Rosa californica* Cham. & Schlechtend.) in California. In cultivated roses, the mites may be seen in the angles between the leaf petioles and axillary buds; they are in the bud scales during the winter and early spring. The mite population becomes numerous in mid-June and early July, reaching its peak in September. A closely related mite, *Phyllocoptes slinkardensis* Keifer, also occurs on infected rose plants.

Rose rosette disease is found in several species of wild and cultivated roses in California, Nebraska, Wyoming, and Manitoba, Canada. Wild roses apparently serve as a reservoir for the virus.

References: Allington et al., *1968: 1137;* Keifer, *1940a: 30.*

PLATE 75.—*A*, Infected wild rose plants, showing reddish leaves; *B*, common rose rosette virus symptom; note malformed stems and leaves; *C*, *Phyllocoptes fructiphilus* Keifer.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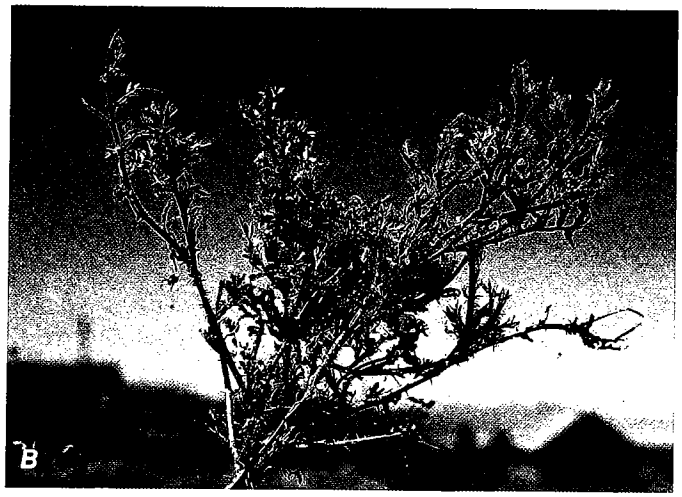
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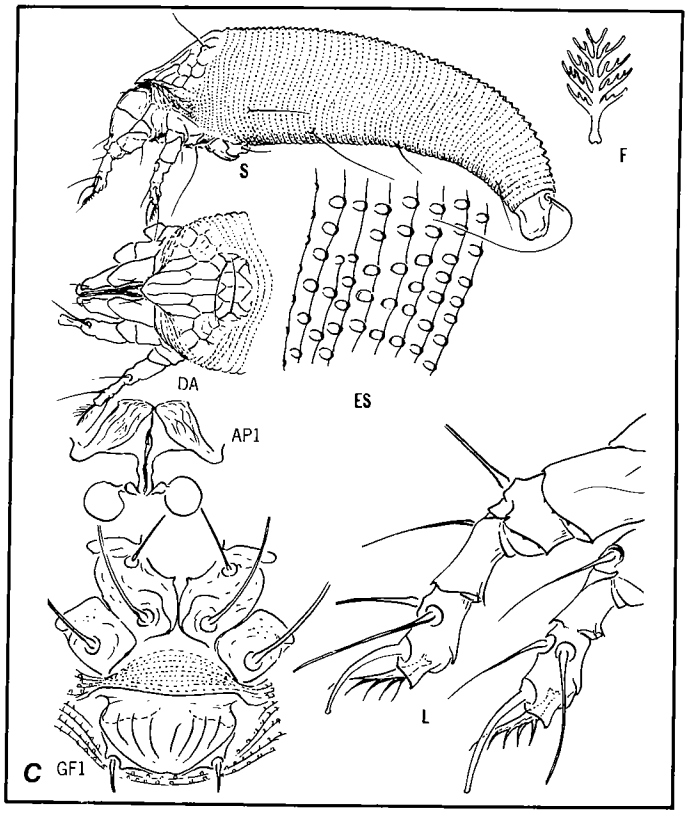
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Glossary

ACARI, ACARINA—Small to minute arachnids, including mites and ticks, with body divided into gnathosoma (mouthparts) and idiosoma and with two to four pairs of legs in adult stage.

ALTERNATION OF GENERATIONS—Type of reproduction as seen in some eriophyid mites, when two forms are involved during the life cycle, one consisting of only females (deutogynes) and the other of individuals of both sexes (protogynes and males).

APICAL—At the tip, the distal end.

BASAL—At the base.

BLISTER—Injury to leaves or fruit by mite invasion of plant epidermal tissue, resulting in leaf withering and fruit swelling.

BRACT—Reduced or scalelike leaf in a flower cluster.

BROOMING—Cluster of stunted, slender twigs in crowded bunches arising basally or apically from an axis with greatly shortened internode.

CAPITATE—Type of hair with knobbed tip in erineum or gall.

CATKIN—Spikelike inflorescence bearing scaly bracts and apetalous unisexual flowers, characteristic of oak, walnut, and willow.

COVERFLAP—Shaped like a scoop; covers genital structure of an eriophyid mite.

COXA (pl. COXAE)—Basal segment of the leg, by which it is articulated to the body.

DEUTOGYNE—Strictly in Eriophyoidea, an overwintering female adult morphologically different from the protogyne.

ERINEUM—Form of gall; abnormal growth of hairs from leaf epidermis caused by mite attacks, especially Eriophyidae.

ERIOPHYIDAE, ERIOPHYOIDEA—Specifically wormlike mites with two pairs of legs.

FAMILY—Taxonomic category, including one or more genera or tribes, ending in idae (ex. Eriophyidae).

FEATHERCLAW—Single branched or rayed structure at end of an eriophyid leg.

GALL—Strictly defined, whatever its form, an abnormal growth on a plant as a result of a parasite attack; as used here, it is caused by eriophyid mites.

GENITALIA—All genital or reproductive structures, especially external sex organs.

GNATHOSOMA—Mouth and mouthparts; in Eriophyoidea, commonly referred to as rostrum by H. H. Keifer; anterior part of acarine body.

HETEROMORPHIC—Having different forms at different life stages.

HYSTEROSOMA—In eriophyids, elongate posterior part of body from anterior two pairs of legs; thanosome according to H. H. Keifer.

IDIOSOMA—Includes body of mites posterior to the gnathosoma.

INDUSIUM—Small flap of epidermal tissue that covers a sorus; in bracken, a thin flap of pale tissue continuous with the underside edge of the pinnule.

INFLORESCENCE—Flowering part of a plant or flower cluster.

INQUILINE—Mite or insect guest of other mites or insects, or organism that lives as a guest in the gall or erineum of other mites.

LIFE CYCLE—Series of changes or period of time from egg to adult stage.

LIGULE—Thin membrane attached to a leaf of grass at the point where the blade meets the leafstalk; projection from top of the sheath in grasses, palms, and some other plants.

MICROTUBERCLE—In Eriophyoidea, a minute and rounded or pointed hysterosomal structure.

MITE—Any numerous minute arachnids (Acarina, Acari) often found in almost every habitat, infesting plants, animals, and stored food.

MORPHOGENESIS—Structural changes during development; evolution of morphological characters.

OPISTHOSOMA—Section of body posterior to the legs; abdomen according to H. H. Keifer.

PAPILLA (pl. PAPILLAE)—Minute soft projection.

PEDICEL—Stem or stalk of a flower.

PERICARP—Wall of a ripened ovary or fruit.

PETIOLE—Stalk of a leaf.

PINNA—Primary leaflet or a featherlike leaf.

PINNULE—Any leaflet of a pinnate leaf; segment of a pinna leaflet.

PROTOGYNE—One of two adult female forms of the same species and similar to the male.

ROSE HIP—Fruit of a rose, consisting of fleshy floral cup and true fruits (achenes) enclosed within it.

ROSETTE—Cluster of flowers, leaves, or stunted twigs in crowded circles arising basally or apically from an axis with shortened internode.

RUSSETING—Brownish roughened area on leaves or skin of fruit.

SAPINDACEOUS—Applied to a tropical plant of the soapberry family Sapindaceae.

SETA (pl. SETAE)—Hair.

SHEATH—Basal part of a grass leaf or of a palm leaf when surrounding the stem.

SHIELD—Anterior dorsal part of the eriophyid body, which is broad, smooth, or marked with a design.

SORUS—Cluster of sporangia or spore case in ferns.

SUPERFAMILY—Category in classification above family and below order, ending in oidea (ex. Eriophyoidea).

SYNONYM—One of two or more names given to the same species or genus previously named and described; a name rejected as being incorrectly applied.

TUBERCLE—Small, lobelike body structure bearing a seta.

UMBEL—Flat-topped or convex inflorescence in which the flower pedicels arise from the same point.

VACCINIACEOUS—Applied to plants of the genus *Vaccinium* L. (blueberry, huckleberry, cranberry).

Index of Host Plants

Page

Aceraceae 11, 30, 32, 34, 102, 104
Acer campestre 11
A. glabrum 11, 102, 104
A. negundo 11, 30
A. rubrum 11, 32
A. saccharinum 11, 32
A. saccharum 11, 34, 102, 104
Adenostoma fasciculatum 19, 56
African oil palm 18, 122
Agropyron sp. 15, 160
alder 13, 28, 38, 39
alfalfa 17
Allium spp. 11, 160
almond 20, 92, 124
Alnus oregona 12, 38
A. rhombifolia 12, 38
A. rubra 12, 38
A. rugosa 12, 38
Alnus sp. 13
A. tenuifolia 12, 38
aloe 47
Aloenobilis 17, 46
A. spinosissima 17, 46
Amaryllidaceae 11, 160
American beech 14, 108, 109
American black currant 22
American elm 23, 72, 73
American linden 23
Anacardiaceae 12, 36, 74, 156
Annonaceae 12, 106
Annona muricata 12, 106
apple 19
Araliaceae 12
Arizona walnut 16, 42
ash 18, 88
aspen 26
Avena sativa 15, 160
Baccharis glutinosa 13, 40
B. pilularis var. *consanguinea* 13, 40
B. viminea 13, 40
barley 15, 160
basswood 23, 70
Berberidaceae 12, 142
Bermuda grass 15, 84, 85, 146, 147
Betula 100
Betulaceae 12, 38, 76
birch 100
bitter cherry 20, 58
blackberry 20, 21, 126
blackcherry 20, 60
black walnut 16, 28, 44, 45
blueberry 14, 134, 135
box elder 11, 30, 31
boysenberry 21, 126
bracken 19, 52, 53
bridal-wreath 21, 92, 93

Page

butternut 16, 112, 113
buttonbush 21, 62, 63
California juniper 14, 82
California live oak 14, 110, 111
California walnut 16, 42, 44, 86
camellia 23, 132, 133
Camellia japonica 23, 132
Canada bluegrass 15, 160
Canada wild rye 15, 160
Caprifoliaceae 13, 144
carnation 13
carrot 24
Carya illinoinensis 16
C. pecan 16
Caryophyllaceae 13
Ceanothus velutinus 19, 54
cedar 82
cedar pine 18, 90
Celtis occidentalis 23, 100
Cephalanthus occidentalis 21, 62
Chamaedorea sp. 18
chaparral broom 13, 40, 41
cherry 20, 61
chokecherry 20, 58
Chondrilla juncea 13, 78
chrysanthemum 13
Chrysanthemum sp. 13
Citrus spp. 21, 128, 154
coastal black gooseberry 22, 68
coconut 18, 120, 121
Cocos nucifera 18, 120
coffeeberry 19, 152, 153
Compositae 13, 40, 78, 80
Convolvulaceae 14
corn 16, 160, 161
Corylus avellana 13, 76
cotton 17, 136, 137
cottonwood, Fremont 21, 94
cranberry 132
Cupressaceae 14, 82
Cynodon dactylon 15, 84, 146
datura 22, 130
Datura inoxia 22, 130
Daucus carota var. *sativus* 24
dewberry 21, 126
Dianthus caryophyllus 13
Diospyros virginiana 14
Douglas fir 19, 90
Eastern white pine 18
Ebenaceae 14
Elaeis guineensis 18, 122
elm 72
Elymus canadensis 15, 160
E. virginicus 15, 160
English ivy 12
English walnut 16, 28, 112, 114, 115

Page

Ericaceae 14, 134
Erioglossum rubiginosum 22, 158, 159
European ash 18, 50
European plum 19, 58
Fagaceae 14, 108, 110
Fagus grandifolia 14, 108
fern 26
Ficus carica 17, 162
fig 17, 162, 163
filbert 13, 76, 77
foxtail barley 160
Fraxinus americana 17, 50
F. excelsior 18, 50
F. latifolia 18, 50, 88
F. pennsylvanica var. *lanceolata* 18, 50
Fraxinus sp. 18, 88
Fremont cottonwood 21, 94
garlic 11, 160, 161
Gaylussacia baccata 14, 134
globemallow 136
golden-tooth aloe 17, 46
gooseberry, coastal black 22, 68
gooseberry, Sierra 22, 68, 69
Gossypium spp. 17, 136
Gramineae 15, 84, 146, 160
grape 24, 118, 119
grapefruit 21, 128, 154
greasewood 19, 56, 57
green ash 18, 50
hackberry 23, 100, 101
Haworthia sp. 17, 46
hazel alder 12, 38
hazelnut 13, 76
Hedera helix 12
hedge maple 11
Himalaya berry 20, 126
Hind's walnut 16, 42, 86, 87
holly grape 12, 142, 143
Hordeum sp. 160
H. vulgare 15, 160
huckleberry 14, 134
Indian ricegrass 15, 160
Ipomoea batatas 14
Juglandaceae 16, 42, 44, 86, 112, 114
Juglans californica 16, 42, 86
J. cinerea 16, 112
J. hindsii 16, 42, 86
J. major 16, 42
J. microcarpa 16, 42
J. nigra 16, 44
J. regia 16, 112, 114
juniper 82, 83
Juniperus californica 14, 82
J. communis 82
J. occidentalis 14, 82
J. scopulorum 14, 82

Page

J. virginiana 14, 82
Lantana camara 24
Leguminosae 17
lemon 21, 128, 129, 154, 155
Lepidospartum squamatum 13, 80, 81
Liliaceae 17, 46, 160
lime 21, 128, 154
lime tree 23, 70
linden 23, 27, 70, 71
Litchi chinensis 22, 116
litchi, lychee 22, 28, 116, 117
little walnut 16, 42
Lolium sp. 15
Lycopersicon lycopersicum 22, 130
Mahonia dictyota 12, 142
Malus pumila 19
Malvaceae 17, 136
Mangifera indica 12, 74, 156
mango 12, 74, 75, 156, 157
maple 34, 102, 105
Medicago sativa 17
Meliaceae 17, 48
Moraceae 17, 162
mountain alder 12, 38
mountain ash 21, 28, 140, 141
mule-fat 13, 40
nectarine 20, 124
nightshade 23, 130
Nyssaceae 17, 148
Nyssa sylvatica 17, 148
oak 110
oats 15, 160
Oleaceae 17, 50, 88
onion 11, 160
orange 21, 128, 129, 154, 155
Oregon alder 12, 38
Oregon ash 18, 50, 88
Oregon grape 12, 142
ornamental palm 18
Oryza sativa 15
Oryzopsis hymenoides 15, 160
palm 123
Palmae 18, 120, 122
peach 20, 124, 125
pear 20, 138, 139, 140
pecan 16
pepperidge 17, 148
persimmon 14
petunia 22, 130
Petunia sp. 22, 130
Phleum sp. 15
Pinaceae 18, 90
pine 90
Pinus clausa 18, 90
P. elliottii 18, 90
P. glabra 18, 90

Page

P. lambertiana 18, 90
P. monticola 18, 90
P. strobus 18, 90
P. sylvestris 18, 90
pistachio 27
plum 19, 20, 26, 58, 92
Poa compressa 15, 160
Poa sp. 160
poison ivy 12, 36, 37
poison oak 12, 36, 37
poison sumac 12, 36
Polypodiaceae 19, 52
pomegranate 19, 150, 151
poplar 22, 94, 95, 96, 97
popolo 23, 130
Populus fremonti 21, 94
Populus sp. 22, 94, 96
P. tremuloides 21, 64, 94
potato 23, 130
Prunus americana 19, 58
P. domestica 19, 58, 92
P. dulcis var. *dulcis* 20, 92, 124
P. emarginata 20, 58
P. munsoniana 20, 58
P. persica 20, 124
P. persica var. *nucipersica* 20, 124
P. serotina 20, 60
Prunus spp. 20, 27, 58
P. subcordata 20, 58
P. virginiana var. *demissa* 20, 58
Pseudotsuga menziesii 19, 90
Pteridium aquilinum var. *lanuginosum* 19, 52
P. aquilinum var. *latiusculum* 19, 52
Punicaceae 19, 150
Punica granatum 19, 150
Pyrus communis 20, 138
quaking aspen 21, 64, 65, 94
Quercus agrifolia 14, 110
Q. alba 14, 110
red alder 12, 38
red ash 18, 50
red cedar 14, 82
red maple 11, 32, 33
redroot 19, 54
redwood 23, 98, 99
Rhamnaceae 19, 54, 152
Rhamnus californica 19, 152
Rhus diversiloba 12, 36
R. radicans 12, 36
R. vernix 12, 36
Ribes americanum 22
R. divaricatum 22, 68
R. roezlii 22, 68
rice 15
Rocky Mountain juniper 14, 82
Rocky Mountain maple 11, 102, 103, 104

Page

Rosa californica 164
Rosaceae 19, 56, 58, 60, 92, 124, 126, 138, 140, 164
Rosa spp. 20, 164
roses 20, 164, 165
Rubiaceae 21, 62
Rubus macropetalus 126
R. procerus 20, 126
Rubus spp. 21, 126
R. ursinus var. *loganobaccus* 126
R. vitifolius 20, 126
Rutaceae 21, 128, 154
rye 15, 160
ryegrass 15
Salicaceae 21, 64, 66, 94, 96
Salix spp. 22, 66, 94
Sandoricum koetjape 17, 48, 49
sand pine 18, 90
santol 17, 48
Sapindaceae 22, 116, 158
Saxifragaceae 22, 68
Scotch pine 18, 90
Secale cereale 15, 160
seep willow 13, 40
Sequoia sempervirens 23, 98
Sierra gooseberry 22, 68, 69
Sierra juniper 14, 82
Sierra plum 20, 58
silver maple 11, 26, 32, 33
skeletonweed 13, 78, 79
slash pine 18, 90
snowberry 13, 144, 145
Solanaceae 22, 130
Solanum nigrum 23, 130
S. sodomeum 23, 130
S. tuberosum 23, 130
Sorbus californica 21, 140
S. scopulina 21, 140
sour-gum 17, 148
soursop 12, 106
Sphaeralcea sp. 136
spider aloe 17, 46
Spiraea densiflora 21, 92
Spiraea sp. 21
star cactus 17, 46
sugar maple 11, 26, 27, 34, 35, 102, 104, 105
sugar pine 18, 90
sweet potato 14
Symphoricarpos rivularis 13, 144
Taxodiaceae 23, 98
Theaceae 23, 132
Tilia americana 23
Tilia spp. 23, 70
Tiliaceae 23, 70
timothy 15
tomato 22, 130, 131
Triticum aestivum 15, 160

Page

tulip 17, 160
Tulipa sp. 17, 160
tupelo 17, 148, 149
Ulmaceae 23, 72, 100
Ulmus americana 23, 72
Umbelliferae 24
Vaccinium spp. 14, 134
Verbenaceae 24
Viburnum opulus 132
Virginia wild rye 15, 160
Vitaceae 24, 118
Vitis spp. 24, 118
walnut 27, 43, 86, 114
wart plant 17, 46
western wheatgrass 160
western white pine 18, 90

Page

wheat 15, 160, 161
wheatgrass 15, 160
Wheeler bluegrass 160
white alder 12, 38
white ash 17, 50
white oak 14, 110
white pine 18
wild cotton 136
wild-goose plum 20, 58
wild plum 19, 58
wild rose 20, 164, 165
willow 22, 66, 67, 94
yam 14
yellow sage 24
Zea mays 16, 160

Index of Eriophyid Mites

Page

abnormis, Phytocoptella 23
acericola, Phytoptus 11, 34
aceris, Eriophyes 11, 32
aceriscrumena, Vasates 7, 11, 34, 35
adenostomae, Phytoptus 19, 56, 57
adornatus, "Epitrimerus" 23, 132
aenigma, Aculops 22, 66
alborum, Trisetacus 18, 90, 91
aleyrodiformis, Trimerocoptes 8
aloinis, Eriophyes 17, 46, 47
amiculus, Eriophyes 16, 42
annonae, Eriophyes 12, 106, 107
avellanae, Phytocoptella 13, 76, 77
baccharices, Eriophyes 13, 40
baccharipha, Eriophyes 13, 40, 41
baileyi, Calepitrimerus 19
batonrougei, Trisetacus 14, 82
brachytarsus, Eriophyes 6, 9, 16, 27, 42, 43, 44
breakeyi, Eriophyes 22, 68, 69
brevitarsus, Acalitus 13, 28
brevitarsus, Eriophyes 16, 42
brownei, Eriophyes 144
calaceris, Eriophyes 11, 102, 103, 104
calibaccharis, Eriophyes 40
caliberberis, Eriophyes 12, 142, 143
calisorbi, Phyllocoptes 21, 28, 140, 141
camelliae, Cosetacus 23, 132, 133
campnodus, Trisetacus 18, 90
carinatus, Calacarus 23, 132, 133
caryae, Eriophyes 16
caulis, Eriophyes 16, 28, 44, 45
ceanothi, Eriophyes 19, 54, 55
celtis, Eriophyes 23, 100, 101
cephalanthi, Eriophyes 21, 62, 63
cerasicrumena, Phytoptus 20, 60, 61
chondrillae, Eriophyes 13, 78, 79
chondriphora, Eriophyes 17, 18, 50, 51
chrysanthemi, Paraphytoptus 13
cinereae, Eriophyes 16, 112, 113
comatus, Aculus 13, 76
confusus, Eriophyes 11, 32
conyssae, Cenalox 17, 148
cornutus, Aculus 20, 124, 125
cynodoniensis, Eriophyes 15, 84, 85, 146
cynodonis, Eriophyes 15, 146, 147
destructor, Phyllocoptes 22, 23, 130
didelphis, Phyllocoptes 21, 26, 64, 65
dinus, Eriophyes 17, 148, 149
diospyri, Eriophyes 14
dormitor, Aculus 21, 64
elaeis, Retracrus 18, 122, 123
elongatus, Eriophyes 11, 26, 102, 104, 105
emarginatae, Phytoptus 19, 20, 58, 59
erineus, Eriophyes 16, 28, 112, 114, 115
essigi, Acalitus 20, 126, 127
fagerinea, Acalitus 7, 14, 108, 109

Page

ficus, Eriophyes 17, 162, 163
floridanus, Trisetacus 18, 90, 91
fockeui, Aculus 20
fraxinicola, Eriophyes 18, 50
fraxinivorus, Eriophyes 18, 88, 89
fructiphilus, Phyllocoptes 20, 164, 165
gastrotrichus, Eriophyes 14
gemmavitians, Trisetacus 18, 90, 91
glabri, Aculops 11, 102
goniothorax, Phyllocoptes 140
gossypii, Acalitus 17, 136, 137
granati, Eriophyes 19, 150, 151
guerreronis, Eriophyes 18, 120, 121
hedericola, Phytocoptella 12
helicantyx, Phytoptus 19, 52, 53
hystrix, Abacarus 8, 15
insidiosus, Phytoptus 20
johnstoni, Retracrus 18
kenyae, Cisaberoptus 12, 156, 157, 158
knorri, Aculops 22, 156, 158, 159
laevis, Phytoptus 12, 38, 39
lantanae, Eriophyes 24
lepidosparti, Eriophyes 13, 80, 81
litchii, Eriophyes 22, 28, 116, 117
lycopersici, Aculops 22, 23, 130, 131
lycopersici, Eriophyes 130
mackiei, Eriophyes 14, 110, 111
macrochelus, Eriophyes 11
maculatus, Aculops 11, 104
major, Eriophyes 11, 32
mangiferae, Eriophyes 12, 74, 75
medicaginis, Eriophyes 17
microcarpae, Eriophyes 16, 42
minutissimus, Eriophyes 11, 32
modestus, Eriophyes 11, 27, 104, 105
negundi, Eriophyes 11, 30, 31
neobeevori, Eriophyes 16, 86
neocynodonis, Aceria 15, 84
neoessigi, Eriophyes 21, 22, 94, 95
neoquadrisetus, Trisetacus 14, 82
newkirki, Eriophyes 21, 62
nyssae, Cenalox 17, 148, 149
nyssae, Eriophyes 17, 148, 149
oleivora, Phyllocoptruta 21, 128,129
ornatus, Eriophyes 11, 32
orthomera, Acalitus 21, 126
padi, Phytoptus 26
paradianthi, Eriophyes 13
paraglabri, Aculops 11, 102
paramackiei, Eriophyes 14, 110
parapopuli, Eriophyes 22, 96, 97
paraspiraeae, Phytoptus 21, 92, 93
parulmi, Eriophyes 23, 72, 73
peucedani, Eriophyes 24
phloeocoptes, Acalitus 19, 20, 92
populinquis, Aceria 21, 94

Page

prunidemissae, Phytoptus 58
pseudoinsidiosus, Phytoptus 20, 138
pseudotsugae, Trisetacus 19, 90, 91
pteridis, Eriophyes 52
pteridis, Phytoptus 52
pyri, Phytoptus 20, 138, 139, 140
quadripedes, Vasates 11, 26, 32, 33, 34
quadrisetus, Trisetacus 14, 82, 83
quinquilobus, Eriophyes 11, 32
regulus, Eriophyes 11, 104
rhamnicola, Thamnacus 19, 152, 153
rhodaspris, Acaricalus 8
ribis, Cecidophyopsis 22
rudis, Eriophyes 100
sandorici, Eriophyes 17, 48, 49
schlechtendali, Aculus 19
sequoiae, Trisetacus 23, 98, 99
sheldoni, Eriophyes 21, 154, 155
similis, Eriophyes 27
slinkardensis, Phyllocoptes 164
snetsingeri, Aceria 23, 100
sorbi, Phytoptus 21, 140, 141

Page

spermaphaga, Eriophyes 16, 86, 87
sphaeralceae, Acalitus 136
spiraeae, Phytoptus 21, 92
spongiosus, Tegolophus 8
stefanii, Eriophyes 27
steinwedeni, Acaphylla 23, 132
strobacus, Setoptus 18
tetanothrix, Aculops 22, 66, 67
tiliae, Phytoptus 23, 27, 70, 71
toxicophagus, Aculops 12, 36, 37
triacis, Phyllocoptes 13, 144, 145
triplacis, Eriophyes 14, 110
tristriatus, Eriophyes 16, 114
tulipae, Eriophyes 6, 11, 15, 16, 17, 160, 161
ulmi, Eriophyes 23, 72
uranomus, Tegonotus 8
vaccinii, Acalitus 14, 134, 135
vermiformis, Cecidophyopsis 13, 76
vitis, Calepitrimerus 24, 118
vitis, Colomerus 24, 118, 119
zeasinis, Eriophyes 16