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Biological and Systematic Studies of Two Species of Cheyletid Mites, with a Description of a New Species (Acarina, Cheyletidae) *

BY

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ABSTRACT: Studies of the developmental stages of two species of cheyletid mites are reported in this paper. One of these species is new to science. In addition there is included a discussion of the taxonomy and morphology of these species as well as detailed remarks on rearing methods used.

Mites of the family Cheyletidae are segregated into nineteen genera, two of which are represented by species discussed in this work. *Cheyletus eruditus* (Schrank) a cosmopolitan species, has on numerous occasions been reported in the literature especially regarding its predatory habits, yet its complete developmental history has been unrecorded prior to the publication of this paper. The new species here described is a member of the genus *Cheletophyes* and is the second North American species to be described in this genus.

INTRODUCTION

The objective of this study was twofold. First, an effort was directed toward establishing the unequivocal identity, in all of its developmental stages, of a cheyletid mite species that apparently not only extends its range over a large area of the world, but quite possibly may be one of the most beneficial species in the family because of its predatism on many important pests. Second, it was hoped that some techniques developed in the rearing and observing of predaceous mite species might be recorded for use by others working with live cultures of predatory acariens.

The mite family Cheyletidae contains nineteen genera that are distinguished largely on the basis of characters of the dorsal shields, and on palpal and pretarsal structure and ornamentation. In the genus *Cheletophyes* five species have been described from various parts of the world, the species here concerned being the second

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from North America. *C. hawaiiensis* Baker is recorded from Kailua, Oahu, Hawaii; *C. marshalli* Baker was described from specimens taken at Imboden, Arkansas; *C. phillippinensis* Baker from Bataan, Philippine Islands; *C. semenovi* Kuzin from Uzbekistan, U. S. S. R.; *C. vitzthumi* Oudemans from Willomore, Cape Colony, Africa. To the knowledge of the present authors there are no published accounts of biological observations of any members of the genus.

The genus *Cheyletus* contains approximately thirty species, the uncertainty of the exact complement of the genus being due to the inclusion of some questionable species. *Cheyletus eruditus* (Schrank) is apparently a cosmopolitan species, being recorded from Europe, Asia, South America, Greenland and the United States.

The biology of *C. eruditus* has been investigated in America by Ewing (1912) and in England by Newstead *et al.* (1918). The species of mite studied by Beck (1866), whose work was repeated and confirmed by M'Intire (1869), had a life cycle very similar to that of *C. eruditus* and may have been this species. Some account was taken of this mite's life stages in connection with biological studies of predaceous mite species, Gause, *et al.* (1936), and on studies of interrelations between phytophagous and predaceous mites by Rodionov (1940).

C. eruditus has frequently aroused the interest of entomologists due to its usual role as a predator of arthropods associated with stored grains and foods. Some tests and observations have been made regarding its potential value in biological control of such pests. Ewing (1912), Newstead *et al.* (1918), Siggaard (1920), Redikortzev (1924), Rodionov (1937, 1940), Solomon (1946), and others contributed papers wherein biological observations of this type were recorded. Rennie and Harvey (1922-1923) state that the species probably is a valuable predator of *Tarsonemus aphidis* Rennie, *Gamasus* sp., and *Rhizoglyphus echinopus* Fumouze and Robin, when in situations where these species are destructive in bee nests. The mite has been found in stocks of bees infested with *Acarapis woodi* (Rennie), where, according to Homann (1933), it was thought to be feeding on the stocks of "wet-mold" mites rather than on the actual bee parasites.

Cheyletus eruditus (Schrank) has some medical and veterinary history. Pierce (1921) states that otoacariasis is caused in man by this species attacking the external auditory meatus and Riley and Johansson (1938) state that the mite has been taken in a pus discharge from the ear of man. An outbreak of dermatitis among American troops in North Wales reported by Hill and Gordon

(1945) was thought to involve *C. eruditus*. When searching for the cause, they discovered two species of rodent mites in the troops' bedding and two additional species in the palliasses used by the troops. *C. eruditus* was found only in the stockpile of straw used for stuffing the palliasses. The authors point out that rodent mites may have been the primary cause of this dermatitis in humans. Pillers (1920) lists *C. eruditus* as an accidental parasite in the ears of the domesticated rabbit and guinea pig in association with mites of the families Acaridae and Parasitidae and also mentions *C. eruditus* as the causal agent for a skin eruption in horses.

A detailed description of the adult female and developmental stages of *Cheyletus eruditus* and of both sexes and the developmental stages of *Cheletophyes knowltoni* are presented in a portion of this paper that follows. Rearing and observation techniques used in this study are also discussed in detail as an aid to persons engaged in similar studies.

REARING METHODS

The majority of specimens obtained for this study were collected in conventional berlese traps. Litter of straw and other detritus on the earth floor of an abandoned barn in Lawrence, Kansas was found to be heavily populated with the two species reported upon in this paper. The trapping jar beneath the funnel was prepared with a mixture of plaster of Paris and activated charcoal, utilizing the recipe of Farrell and Wharton (1949), poured to a depth of one inch. The plaster was kept moist during trapping operations after the early discovery that both species were extremely sensitive to desiccation. The cheyletids were removed from the trap jars at frequent intervals and placed in rearing pens.

The stender dish type rearing pens, prepared in the manner described by Lipovsky (1953a), were used only for mass culturing of the species being studied and for containing individual specimens in the deutonymphal or adult stages. For individual rearing of larvae and protonymphs, stender dishes having an outside diameter of 35 mm. and a depth of 18 mm. were used.

Preparation of a substrate within the rearing dish was accomplished as follows: The jar was filled with a mixture of plaster of Paris and charcoal, mixed in the proportion of 500 to 60 respectively by weight. The jar was filled to a depth of one fourth of an inch, the mixture then wetted and allowed to set. While soft, some of the mixture was plastered on the sides of the rearing pen to form a thin, even film about the inside of the pen, terminating

about one eighth of an inch from the top. Charcoal was added to the plaster of Paris to make the substrate more porous, so that when water was added during culture of the mites, it would sink immediately into the substrate and not leave a drop of moisture which might drown the mites. As *C. eruditus* is quite pale in color in all immature stages, the dark color given to the substrate by the addition of charcoal made it much easier to find the mites.

The plaster-charcoal substrate provided a roughened surface which is necessary in order that cheyletids may move freely and easily after their prey, [noted by Kozulina (1940)], and it also provided a method of keeping the relative humidity in the rearing pen within tolerable limits. However, it was found that humidity was not an important limiting factor in the adult stage, as *C. eruditus* will tolerate a relative humidity of thirty to thirty-five per cent for four to five days which confirmed observations of Rodionov (1940). The adults of *Cheletophyes knowltoni* seemed to be as resistant to desiccation as the adults of *Cheyletus eruditus*.

Before the substrate had hardened after being wetted in the rearing pen, a narrow depression was scratched in the bottom of the plaster to give the mites a hiding place. *C. eruditus* would not feed nor remain quiet unless such a place of concealment was provided. This practice was early discontinued, however, as it was possible for mite larvae and protonymphs to hide or molt under overhanging lips of such depressions and escape detection. As a substitute, a bit of paper or other foreign material was introduced into the chamber which seemed to be quite adequate for the purposes mentioned. To complete the rearing pen, a small amount of vaseline was spread around the top of the rearing pen and then the lid was pressed firmly into place and rotated until a firm and air-tight "seat" was effected. The vaseline also served as a repellent to *Cheletophyes knowltoni*. The rearing pen remained near laboratory temperature (approximately 80-85° F.) which was within the tolerance limits for *C. eruditus*. Rodionov (1937) reports the mite living at a temperature of 95° F. in laboratory culture.

In order to keep large cultures of predaceous mites in the laboratory, it was necessary also to rear large numbers of mites as a source of food. *Tyrophagus* sp. (Acaridae) was tried and found to be very useful for this purpose. These acarids have a high reproductive potential, are easily kept in the mass culture pens mentioned above and need to be fed only once a week with a bit of dried yeast. It was not necessary to add water to this type of culture.

As described by M'Intire (1869), acarids may occasionally attack cheyletids and overpower them, resulting in the death of the latter. This situation in culturing *C. eruditus* became a problem only at the time of molting. At that time, if the rearing pen held a number of semistarved acarids, regardless of the state of development, they would attack the molting cheyletid and feed upon it, usually resulting in the death of the cheyletid. Semistarved acarids in any appreciable quantity were dangerous to *Cheletophyes knowltoni*, regardless of whether the cheyletid was active or molting and regardless of the stage of development. Although the cheyletid was much more agile, the acarids would surround and overpower the mite, killing it in a short time. In one case a female *C. knowltoni* was placed in an individual rearing pen with ten acarids in varying stages of development and within two hours the cheyletid had been overpowered and a number of the acarids were feeding upon her. Within five hours the larger acarids had left the cheyletid and acarid larvae were devouring what remained of the cheyletid with the exception of legs and palps. In practice, when *Cheletophyes knowltoni* was observed in the premolt condition, all acarids were removed from the rearing pen.

Cheyletids of both species involved, cultured in individual rearing pens, were fed once a day. A microneedle mounted in a glass handle made a very serviceable instrument for the transferring of individual acarids from stock culture to rearing pen.

For the keeping of individual records of the cheyletids reared, ruled five-by-eight note cards were used. The plain side of the card was ruled into squares for the daily entry of such information as feeding and molting data. The ruled side of the record card was kept for such information as to where the mite was obtained, dates for stages in the life history, records of activities, etc. The cards were kept in a convenient file box and were identified with numbers corresponding to the numbers fastened to the lids of the rearing pens.

Mites to be mounted were cleared in a commercial solution of lactophenol, and if stained, a ten-percent solution of acid fuchsin was used. The specimens were then mounted in polyvinyl alcohol (PVA) containing lactophenol in the manner described by Lipovsky (1953b). Specimens were flattened to some degree in order to project the legs satisfactorily.

DESCRIPTIONS AND BIOLOGICAL NOTES

Cheyletus eruditus (Schrank)

- Acarus eruditus* Schrank, 1781, Enumeratio insectorum Austriae indigenorum, p. 513.
- Eutarsus cancriformis* Hessling, 1852, Illustr. Med. Zeit., vol. 1, p. 258. Oudemans, 1938, Tijdschr. voor Ent., vol. 81, p. lxxv.
- Cheyletus semivivorus* Packard, 1878, Guide to the study of insects, (Henry Holt and Co., New York), p. 665. (new synonymy). Ewing, 1909, Illinois Univ. Studies, vol. 3, pp. 76-77; 1912, Jour. Econ. Ent., vol. 5, pp. 416-420.
- Cheyletus ferox* Banks, 1906, Proc. Ent. Soc. Washington, vol. 7, p. 134.
- Cheyletus eburneus* Hardy, 1933, (in Andre), Ann. des Epiphyt., vol. 19, pp. 336, 344, 350.
- Cheyletus eruditus* (Schrank), Oudemans, 1903, Tijdschr. voor Ent., vol. 46, pp. 118-129; 1906, Mem. Soc. Zool. France, vol. 19, pp. 84-88. Newstead and Duvall, 1918, Reports of the Grain Pests (War) Committee, no. 2, pp. 14-16. Haarløv, N., 1942, Medd. Grønland, no. 1281, p. 171. Hughes, 1948, The mites associated with stored food products, Ministry of Agriculture and Fisheries, London, pp. 102-105. Baker, 1949, Proc. U. S. Natl. Mus., vol. 99, no. 3238, p. 278.

This is a robust, active mite, light yellow to orange in color as a young adult, darkening to brown with age. The immature forms are white to light yellow in color, the deutonymph becoming light brown toward the end of the stadium. The female has two dorsal plates while the immature stages have only the anterior dorsal plate present. The dorsum, with the exception of the gnathosoma, is finely striated where not covered by a plate. The mite is widest at the region of the shoulder setae, tapering rearward. Structural characteristics of the setae on the legs seem to vary from specimen to specimen, from finely pilose setae to simple setae. The degree of ornamentation for a given seta will be stated only when it is seen to be constant throughout the specimens examined.

Female: (Plate I, figures 1-4)—Length of body, 360-410 μ ; including rostrum, 527-637 μ . Width of body 286-332 μ . Palpus stout; femur two-thirds as broad as long with convex outer margin and nearly straight inner margin, the long dorsal seta situated near mid-segment minutely and sparsely pilose, its length about equal to length of segment, two small simple setae located ventrally on segment, one near inner basal angle, the other near outer apical angle of segment; genu short, nearly three times as broad as long, a long minutely pilose seta located dorsally near outer margin of segment, its length exceeding width of segment; tibia twice as broad at base as at apex, the inner margin with pronounced concavity extending from basal third of segment to apex, the tarsus adjoining tibia along posterior half of declivity of this inner tibial margin, tibia bears a simple dorsal seta one and one-half times

as long as segment situated on inner margin near mid-segment, and a strong slightly curved blunt claw with two stout protuberances near its inner basal margin, the claw more than one and one-half times as long as tibia and emanating, with its basal protuberances, from narrowed apex of tibia; tarsus small, as broad as long, outer tarsal comb borne at apex of segment, with thirteen to fourteen teeth, these decreasing in size toward base, inner tarsal comb attached to inner basal margin of segment, about one-half as long as outer comb, with fourteen to seventeen teeth with largest teeth in center of comb, segment with two long simple ventral setae; palpal coxa robust, as broad as long, with one simple ventral seta near apex; trochanter very short, without setae. Rostrum simple, narrow, broadening rearward, with two dorsolateral setae distally, two short ventrolateral setae subapically; peritreme segments bent to form letter M, four to five segments lying between spiracle and longitudinally directed limb. Dorsal propodosomal shield rounded anteriorly, widening posteriorly, covering most of propodosoma, with four pairs of narrow lanceolate pilose marginal setae, three pairs at anterior angles, one pair at posterior angles. One pair of lanceolate pilose setae on dorsum between propodosomal shield and hysterosomal shield. One pair of long lanceolate, finely pilose, dorsolateral shoulder setae between legs II and III. Hysterosomal shield trapezoidal, with rounded angles, shield slightly longer than wide, wider anteriorly, smaller than propodosomal shield, with three pairs of narrow lanceolate pilose marginal setae, one pair at anterior angles, one pair toward rear, one pair at posterior angles. One pair of lanceolate, pilose dorsal setae situated subterminally on opisthosoma. Venter of propodosoma with two pairs of submedian setae, first pair located mesad from coxae I, second pair posteromesad from coxae II. Venter of hysterosoma with two pairs of submedian setae, first pair mesad from coxae IV, second pair posteromesad from coxae IV. Venter of opisthosoma with two pairs of setae on either side of anterior extremity of vulvular opening, two pairs of lanceolate setae on folds of vulvular opening. One pair of lanceolate, finely pilose setae on terminal margin of opisthosoma; anal opening surrounded by four minute stout curved bristles. Coxae I, III and IV, each with two setae; coxa II with one seta; trochanters I, II and IV, each with one seta; trochanter III with two setae; femora I, II, III and IV, each with two setae; genua I, II, III and IV, each with two finely pilose setae; genu I with a small rod-shaped seta located dorsally at apex; tibia I with a small rod-shaped seta and one pilose lanceolate

seta; tibiae I, II, III and IV, each with four unclothed lanceolate setae; tarsus I with sensory seta about one-fourth as long as tarsus, one simple guard seta, one-half as long as sensory seta; tarsi I, II, III and IV, each with one finely pilose seta in center of segment, two long simple setae at distal end of segment, terminal on tarsus I, subterminal on tarsi II, III and IV, two small finely pilose setae at distal end of segment flanked by two short simple setae; tarsi I, II, III and IV, each terminate with an empodium flanked by two small, recurved claws. Tarsus I, 107μ long; tibia I, 71μ long. Leg I, 416μ long; leg IV, 387μ long.

Larva: (Plate II, figures 5-7)—The larva has been described and figured by Newstead and Duvall (1918, pp. 13-14, figure 3). A re-description follows: Length of body, $156-241\mu$; including rostrum, $202-307\mu$. Width of body, $94-158\mu$. Palpus slender; femur about one and one-half times as long as wide, with convex outer margin, dorsal seta finely and sparsely pilose, about as long as segment; genu with a dorsal pilose seta; tibia with two ventrolateral setae and a dorsal seta at distal end of segment, claw slightly bent, no protuberances at base; tarsus with two subterminal, sicklelike, ventral setae, outer tarsal comb with twelve teeth of equal size, inner tarsal comb with ten teeth, outer tarsal comb about two times as long as inner tarsal comb. Rostrum simple, narrow, broadening rearward, with two dorsolateral setae distally, two short, ventrolateral setae distally; peritreme segments bent to form letter M. Propodosomal shield rounded anteriorly, widening posteriorly, covering most of propodosoma, with four pairs of narrow, lanceolate, pilose, marginal setae; one pair of dorsal, pilose setae near posterior angles of shield; one pair of dorsolateral, lanceolate, shoulder setae. Dorsum of hysterosoma with three transverse rows of pilose setae, first row with two pairs, remaining rows with one pair each. Venter of propodosoma with one pair of setae mesad from coxae I. Venter of hysterosoma with two pairs of setae, one pair mesad from coxae III, one pair laterad from anus. Legs subequal in size; coxa I with one seta; coxae II and III bare; trochanters I, II and III bare; femora I, II and III, each with two setae; genua I and III, each with a simple seta; genu II with a pilose seta; tibia I with a short sensory seta; tibiae I, II and III, each with four simple setae; tarsus I with one guard seta one-half as long as tarsus, one sensory seta about as long as guard seta, one finely pilose seta, two lanceolate terminal setae unequal in length, two short terminal setae; tarsi II and III, each with two subterminal setae, two short simple terminal setae,

two short terminal finely pilose setae; tarsi I, II and III, each terminate with an empodium flanked by two small, recurved claws. Length of tarsus I, 50 μ ; length of tibia I, 23 μ . Length of leg I, 154 μ ; length of leg III, 145 μ .

Protonymph: (Plate II, figures 8-10)—The protonymph has been described and figured by Oudemans (1903, pp. 123-124, figure 34). A redescription follows: Length of body, 277-298 μ ; including rostrum, 359-385 μ . Width of body, 192-214 μ . Palpus stout; femur about as broad as long with convex lateral margin, segment with two ventrolateral setae the outer seta pilose, the inner simple, and one dorsal seta finely pilose and longer than segment; genual seta on posterior margin of segment, finely pilose; tibia with two ventrolateral setae and one seta at distal end of segment; a strong claw slightly bent, with two protuberances of equal size at base surmounts segment; tarsus with outer tarsal comb having twelve to fourteen teeth, teeth decreasing in size toward base, inner tarsal comb with eight to ten teeth decreasing in size toward base; outer tarsal comb about one and one-half times as long as inner tarsal comb; coxa with a simple ventral seta near apex; trochanter very small and unornamented. Rostrum simple, broadening posteriorly, with two dorsolateral setae distally, two short, ventrolateral setae distally, peritreme segments bent to form letter M, four to five segments lying between spiracle and longitudinally directed limb. Propodosomal shield rounded anteriorly, widening posteriorly, with five pairs of lanceolate pilose marginal setae, three pairs toward anterior angles, two pairs toward posterior angles; one pair of lanceolate, finely pilose, dorsolateral, shoulder setae between legs II and III; four transverse rows of lanceolate, finely pilose setae on dorsum of hysterosoma, each row with two pairs of setae. Venter of propodosoma with two pairs of lanceolate setae, one pair mesad from coxae I, second pair posteromesad from coxae II. Venter of hysterosoma with six pairs of lanceolate setae, one pair mesad from coxae IV, one pair posteromesad from coxae IV, anus flanked by four pairs of setae; one pair of terminal pilose setae. Coxae I and III, each with two setae; coxa II with one seta; coxa IV bare; trochanters I, II and IV bare, trochanter III with two setae; femora I, II, III and IV, each with two setae; genua I, II, III and IV, each with two setae; tibia I with one short rodlike seta, two lanceolate setae, three finely pilose setae; tibiae II, III and IV, each with four finely pilose setae; tarsus I with one sensory seta about one-half as long as segment, one simple, guard seta about one and one-half

times as long as sensory seta; tarsi I, II, III and IV, each with one finely pilose seta in center of segment, two long simple setae distally on segment, two small pilose setae at distal end of segment flanked by two short simple setae. Tarsus I, 58 μ . long; tibia I, 31 μ . long. Leg I, 222 μ . long; leg IV, 190 μ . long.

Deutonymph: (Plate II, figures 11-13)—The deutonymph has been described and figured by Oudemans (1903, pp. 124-125, figure 38). A redescription follows: Length of body 240-321 μ ; including rostrum, 356-449 μ . Width of body 148-235 μ . Palpus robust; coxa with a simple ventral seta near apex; femur longer than wide, with convex lateral margin, segment with two ventrolateral setae, the inner simple, the outer seta finely pilose and about as long as segment; genu with one ventrolateral, median seta and one finely pilose seta on posterior margin of segment; tibia with two ventrolateral setae, a dorsal tibial seta at distal end of segment and a stout terminal claw slightly bent with two equal protuberances at base; outer tarsal comb about two times as long as inner tarsal comb, with eleven to thirteen teeth, these decreasing in size toward base; inner tarsal comb with twelve to thirteen teeth, decreasing in size toward base; tarsus with two subterminal ventral sicklelike setae. Rostrum simple, narrow, broadening rearward, with two dorsolateral setae distally, two short ventrolateral setae distally; peritreme segments bent to form letter M, four to five segments lying between spiracle and longitudinally directed limb. Propodosomal shield rounded anteriorly, widening posteriorly, covering most of propodosoma dorsally, with four pairs of finely pilose marginal setae, three pairs at anterior angles, one pair at posterior angles, two pairs of submedian finely pilose setae toward caudal margin of shield. One pair of long lanceolate finely pilose dorsolateral shoulder setae between legs II and III laterad from shield. Dorsum of hysterosoma with four transverse rows of finely pilose setae, four setae in a row, lateral setae longer than median setae. Venter of propodosoma with two pairs of setae, first pair mesad from coxae I, second pair mesad from coxae II. Venter of hysterosoma with two pairs of submedian setae, first pair mesad from coxae IV, second pair posteromesad from coxae IV; anal opening flanked by four pairs of simple setae; one pair of pilose setae laterad from anus; one pair of subterminal, pilose, ventrolateral setae at distal end of hysterosoma. Coxae I, III and IV, each with two finely pilose setae; coxa II with one pilose seta; trochanters I, II and IV, each with two finely pilose setae; trochanter III with one finely pilose seta; femora I, II and III each with two

finely pilose setae; femur IV with one pilose seta; genua I, II, III and IV each with two finely pilose setae; genu I with a short rod-shaped seta distally; tibiae I and II each with four finely pilose setae; tibiae III and IV each with three finely pilose setae; tibiae I, III and IV each with a simple, lanceolate seta; tibia I with a short, rod-shaped seta distally; tarsi I, II, III and IV each with a pilose seta in center of segment, two long, simple setae distally, two small, pilose setae flanked distally by two short simple setae; tarsus I with a sensory seta about one-half as long as segment, guard seta simple, about one and one-half times as long as sensory seta; tarsi I, II, III and IV, each terminates with an empodium flanked by two small recurved claws. Tarsus I, 85 μ long; tibia I, 47 μ long. Leg I, 310 μ long; leg IV, 280 μ long.

Type locality: Austria.

Location of type: Unknown.

Type habitat: Unknown.

Distribution: The species has been recorded from Australia, Holland, India, Portugal, Mexico, Scotland, Yugoslavia, England, Germany, Japan, Colombia, Chile, Brasil, Greenland and the United States. In the United States it has been taken from house sparrows at Ithaca, New York, on *Sciurus carolinensis* at Thomasville, Georgia, and from California, Minnesota, and Oregon in warehouses, in grains. The description of the female and immature forms is based on material taken in stable litter from cattle barns at Lawrence, Kansas.

Cheyletus eruditus was found to be entirely predaceous, feeding on almost any arthropod small or weak enough to be overpowered. It has been observed feeding on tineid larvae one fourth of an inch long, adult psocids and various collembolans, to mention the larger prey. The mite has not been observed feeding on spiders or Acarina of the families Uropodidae, Oribatidae, or Bdellidae, even when the cheyletid was in a state of semistarvation and these arachnids abundant.

The mite was cannibalistic by nature. In mass cultures the larger forms were often seen feeding on smaller active stages of the same species, and nymphal forms were observed feeding on the eggs of their own species. Adults kept in the same pen without a sufficient food supply battled savagely with one another, the victor feeding on the vanquished. The species would by preference, however, attack the smallest and weakest prey conveniently available.

This species usually would not feed unless it had a small pit or

cut on the substrate in which to hide. It would remain at the opening of the depression with palps widespread, ready to seize any prey which ventured near. Rarely would it dash from the pit to catch a victim which did not pass close enough to be seized from ambush. As had been reported by Ewing (1912), the mite, if not starved, often fed a bit and then released its victim which would survive if too great a quantity of the victim's blood had not been removed. The present authors found that *C. eruditus* often would feed a bit on five or six different acarid adults during the course of an afternoon and all of these acarids usually survived the assault. However, if the predator was starved, it might completely drain an adult female acarid in as little as twenty minutes, leaving only an empty, shriveled skin.

If no pit was provided, the mite would lie in ambush under a piece of paper or any such concealment that was provided within the pen. If no method of concealing itself was available, the mite would usually wander about until it became stuck in the vaseline at the top of the rearing pen. While wandering about looking for a place of concealment the mite was quite timid, rushing wildly from arthropods smaller than itself, no matter how defenseless they might be.

Once entrenched in a hiding place, the cheyletid seemed able to cope only with arthropods approaching it from the front. If in some manner acarid larvae or other small and defenseless prey were introduced to the rear of the pit, the cheyletid would, upon being touched by the prey, jump forward or sideways. It was assumed that it was searching for the source of the stimulation. Being unable to find the cause of stimulation to the front or sides, the cheyletid would move from the hiding place and usually move to a new location. On the rare occasions that it returned to the original spot, the prey would be devoured if the cheyletid entered the pit head first. However, if the mite backed into the pit and was again stimulated by the prey which had remained in the pit, the same procedure of searching forward and sideways followed by leaving the pit, was repeated.

The mite would, if possible, grasp a leg of its prey with the strong palps and having inserted its needlelike chelicerae, suck the body fluids from the victim with powerful pumping movements of the pharynx. In the case of acarids, the body fluids could be seen through the translucent body wall as they flowed down the leg into the cheyletid. If a leg was not caught at the first thrust, the predator would usually seize its victim by any part of the body, inserting its

chelicerae in whatever portion of the anatomy that was readily available. Observations of great numbers of individual feedings seemed to indicate that a definite preference was shown by the cheyletid to grasp the victim by a leg and feed from this appendage.

It is doubted that the mite in any stage of the life history produced venom or toxic saliva. This assumption rests on the fact that arthropods attacked by *C. eruditus* often recovered from the attack of the predator as discussed above, and also victims usually continued escape attempts, flexing the legs and body parts while being fed upon, and if released shortly after the predator started to feed, seemed to recover fully from the attack.

C. eruditus seemed sensitive to light, making immediate attempts to escape from the more strongly illuminated parts of the pen. If the mite was within a hiding spot, it would withdraw as far as possible into the dark. Mites running loose on the substrate would invariably attempt to reach a dark portion of the rearing pen. It is possible that this was a reaction to the heat accompanying the illumination, but the same reaction was observed when the pen was illuminated by daylight in a cool, humid atmosphere.

The mite usually molted in the section of the pen where it normally lived. There was a premolt period which varied in duration for the different instars. During this premolt period the mite refused all food and its movements were inclined to be sluggish.

The mite was not observed actually assuming the molting position, but once settled, the position of the mite was prone on the substrate, dorsum up, with legs I and II directed forward at full length. This was a very typical position and was only assumed at the time of molting.

This species was not observed in copulation. During the course of this work, no males were taken from berlese funnels nor reared from eggs. All agamic eggs from laboratory cultures produced females.

Adult behavior. About forty-eight to sixty hours after emergence of the female, egg-laying commenced. A maximum of twenty-two eggs was laid over a period of seven days by one female. The most frequent procedure was for the female to lay eleven eggs at a time. The eggs were generally laid in a depression or under a bit of foreign material and were deposited in a cluster, but not fastened together nor fastened to the substrate. The eggs had no strands of silk or other material covering them. The female gradually moved forward as the eggs were deposited, making an oblong pile. Eleven eggs could be laid in about twelve hours. After laying a quota of

eggs, the female would stand guard over them for about twenty-four hours, palps spread in a defensive attitude, and would rush forward and repeatedly pinch any object presented. No attempt to feed was made during this period. Occasionally, while the eggs were being deposited, an acarid would move up behind the female and feed on the eggs as they were laid. So long as the acarid did not touch the cheyletid and moved slowly, it was not molested. One such acarid was prodded with a needle at such a time, the disturbance being enough to greatly excite the cheyletid which rushed from the pit, turned around and entered it head foremost and rapidly drove the acarid from the pit with repeated pinchings of legs and body of the intruder.

About seven days from the time of the first egg-laying, ten to eleven more eggs usually were deposited as described and guarded for the same length of time. The female would then live for some time, actively feeding but on no occasion were more eggs laid.

Egg-laying may be extended over a period of thirty days, two to three eggs being laid every other day or so until the full complement was reached, although some females reared have laid as few as four eggs during their life span. When laid in such a manner, the eggs may or may not be guarded by the female. Irregular egg deposition seemed to be caused by the availability of food. If the female was not fed after emergence, only two to five eggs might be laid, and if still not fed, the female would die without laying any additional eggs. However, if given ample food after the initial starving, a further complement of eggs was usually laid. One female laid four eggs and then fifty-seven days later deposited five additional eggs. During this entire period the female had ample food.

The length of the adult stadium varied widely in the laboratory, running from twenty-five to eighty-three days. However, the last few days before a normal death, the mite would be very feeble with poor co-ordination and rarely took food. About a week before death, drops of some clear exudate became visible, scattered over the body of the mite. This exudate was quite viscous, debris of all kinds adhering to it. The exudate seemed to be formed regardless of the relative humidity of the rearing pen.

The eggs were semitransparent, shiny and oblong-oval in shape being about two thirds as broad as long when laid. The eggs averaged 125μ in length and 90μ in width.

Egg:—The eggs laid in small batches, that were usually left unprotected after laying, were often preyed upon by mites of the families Acaridae and Tydeidae. In the mass rearing jars used for

Cheyletus eruditus various immature forms of other predatory mites were occasionally seen to feed on the eggs if there was a dearth of other food.

At temperatures of 80-85°F., the eggs hatched after two to four days, averaging three days. The process of hatching was fairly rapid, taking about thirty minutes. The rostrum was forced through the egg shell and moved from side to side a bit until an opening, large enough to allow the palps to protrude, was formed. Legs I were slowly projected from this opening, one at a time, in a continuous movement. Simultaneously, the palps and rostrum were prying on the substrate in such a manner as to urge the body forward. At about the same time, the forepart of the body was forced through the opening which continued to grow larger. The larvae seemed to push the forepart of the body from the shell by repeatedly contracting the body, which was followed by an active expansion and pushing forward of the body. Legs II eventually were released, one at a time, and fastened to the substrate. At this time legs III could be seen through the egg shell taking an active part in pushing the body forward. The mite always paused for a few moments after the anterior portion of the body was out of the shell and then would ease the remainder of the body from the shell and move some distance away.

Occasionally a mite would be found with one or more legs projecting through small holes that the legs had torn in the egg shell. Mites in this condition never emerged, although they have been seen struggling to do so for as long as seventy-two hours before death terminated the futile struggle to escape from the shell.

Larva:—The larva was able to move speedily about immediately after leaving the egg but seemed inclined to stay close to the location of hatching for five to eight hours; no food was taken during this period. Later it moved about on the substrate until a suitable hiding place was found. The larva would back into the hiding place and remain quiet with the palps projecting. The mite then would attack passing animals only if they made no threatening advances. The larva was extremely timid and would attack larvae much smaller than themselves only after many timid advances and retreats. The larva must have done much traveling about when not under observation, because if a number of larvae were confined in a rearing pen without ample food, within a short while there would be only one or two individuals remaining, . . . undeniable evidence of their cannibalistic habits.

The larvae were fed on the larvae and first nymphal instars of *Tyrophagus* sp., but usually in order to induce them to feed under observation, it was necessary to place the prey in the pit or depression with the larval form of *C. eruditus* and then replace the lid of the rearing pen for a short period, or else reduce the illumination of the pen very greatly. When observed a short time later, the larval predator usually would be feeding.

Six to twelve hours before molting the larva would take no food and would be very sluggish in its movements. No larvae were actually observed assuming the molting position although the typical attitude of forward extension of legs I and II was assumed before the ecdysis. The larval stadium at 80°-85° F. was from three to six days with an average of four days.

Protonymph: The protonymph emerged after a twenty-four hour molting period. The larval skin would split transversely on the dorsum, the line of suture being between legs II and III of the larval skin. During emergence legs IV were not used, but were held upward and rearward from the body with the genual and tibial segments appressed to these same segments of the opposite leg. The tarsi were free and could be seen flexing. The length of time the rear legs were held in this position is not known, but twelve hours after completing emergence they were in a normal position and were functional in locomotion.

The protonymph often refused food for about five to eight hours after emergence. Some tried to feed soon after emergence, but the palps did not seem to be hardened enough to hold the prey and, in one instance where the prey (*Tyrophagus* sp., larva) remained quiet, the predator's chelicerae did not seem to be able to pierce the body wall of the prey.

Protonymphs were fed on larvae and small nymphal instars of *Tyrophagus* sp. It was rare for a protonymph to attack prey its own size or larger. If several of the same age were confined in the same pen they were highly cannibalistic, however.

The protonymphal stadium at 80°-85° F. was from four to eight days, averaging five days, the nymph molting within the depression where it normally sought shelter. As in the larva, food was refused for some time (six to twelve hours) before molting actually began. The protonymph was not observed assuming the molting position, though the characteristic stance was invariably taken before ecdysis.

Deutonymph: Immediately after emergence, the deutonymph would usually refuse food. Occasionally, one would attempt to

feed soon after emergence but, as in other stages, the palps did not seem strong enough to hold the prey.

Deutonymphs were fed *Tyrophagus* sp. nymphs and males, but an attempt to feed them nymphs or females larger than themselves was usually unsuccessful. Toward the end of the deutonymphal stadium, the mite would often attack adult acarids or cheyletids, if these adults were in a weakened condition.

From the remains of prey found scattered about in the rearing pens, it is assumed that the deutonymphs moved about considerably, when not under observation, in the darkened rearing chambers. However, the deutonymph always seemed to return to the pit or debris selected for a hiding place, as they would normally be found in that location.

The deutonymph would molt in that portion of the rearing pen selected as its retreat after going through a premolt period of six to twelve hours. During this period it would take no food. The mite was not seen assuming the molting position. The deutonymphal stadium at 80°-85° F. was from eight to ten days, averaging nine days.

Cheletophyes knowltoni, sp. nov.

Superficially this species resembles *Cheletophyes hawaiiensis* Baker and *C. marshalli* Baker, but examination of the female will show distinct differences. *Cheletophyes knowltoni* is unique in having but one tooth on the palpal claw. The dorsal palpal femoral setae are rodlike and spinose. The tarsus of leg I has a rodlike sensory seta about one-half as long as the segment, with a finely spinose guard seta twice as long as the sensory seta. There are five spinose setae and one short peglike sensory seta on tibia I.

Observed under low magnification the dorsolateral body setae appear as flattened whitish subclavate frondlike erect structures.

The mite is orange to pink in color as an adult, the immature stages varying from yellow to orange. Legs I of all stages seem to be used as tactile organs and are not used to support the body. There is, in the adult stage, a single anterior and a single posterior dorsal plate. The nymphal stages have one anterior and two small posterior dorsal plates, while an anterior dorsal plate only is present in the larval stage. There is a dorsal rostral shield present on all active stages.

Female: (Plates III and IV, figures 14-16, 20)—Length of body, 384 μ ; including rostrum, 576 μ ; width of body, 287 μ . Palpus robust;

coxa robust, with one simple ventral seta near apex; trochanter small, unornamented; femur about as broad as long, strongly convex on outer margin, inner margin slightly concave, with two rodlike dorsal spinose setae, one ventrolateral lanceolate spinose seta and two ventrolateral simple setae; genu short and broad, unadorned; tibia as broad at base as long, inner margin with deep declivity at basal fourth of segment, width of segment decreasing from declivity to apex, segment with one dorsolateral simple seta situated near inner margin at base of segment, one long minutely pilose seta located near mid-segment at apical third; palpal claw long curved slender, acuminate at tip, with a single stout blunt tooth on inner margin at basal third of claw; tarsus small knoblike, as broad as long, with one apical short peglike seta on tubercle, two apical whiplike setae; two apical tarsal combs, the outer comb with twenty-three teeth, teeth decreasing in size toward base, comb stouter and longer than inner comb, inner comb with forty-two teeth, decreasing in size toward base. Rostrum with dorsal shield; forepart of shield split from spiracle forwards, notched distally on inner margins, longitudinally striated; rear part of shield extending to anterior margin of propodosoma, longitudinally striated, fine punctations in striations; peritreme simple, with elongate segments; rostrum with a pair of ventrolateral simple setae distally and a pair of short dorsolateral simple setae subapically. Single pair of eyes. Anterior dorsal shield large, covering most of propodosoma, rounded anteriorly, widening posteriorly, with four pairs of long marginal subclavate spinose setae, three pairs at anterior angles near eyes, one pair at posterior angles; shield coarsely striated. A pair of long subclavate spinose dorsolateral shoulder setae located slightly laterad from posterolateral angles of anterior dorsal shield. Posterior dorsal shield large, covering most of hysterosoma, broadest in front, rounded posteriorly, about equal in length to anterior shield; shield with five pairs of long marginal subclavate spinose seta, two pairs at anterior angles, two pairs at posterior angles, one pair located submesally at distal end of shield; shield coarsely striated; a pair of stout subclavate spinose setae located terminally at apex of opisthosoma behind shield. Dorsum of idiosoma with five pairs of submedian staghorn setae, two pairs on anterior dorsal plate, three pairs on posterior dorsal plate. Venter of propodosoma with two pairs of submedian simple setae, first pair located anteromesad from coxae I, second pair posteromesad from coxae II. Venter of hysterosoma with three pairs of submedian simple setae located in linear arrangement between coxae IV and anterior extremity of

vulva; vulva flanked posteriorly by a pair of small triangular genital plates each with rounded angles and bearing a pair of small simple setae. Anal plate small and subtriangular, its broad anterior margin slightly concave, posterior angle notched distally, with two short pilose setae and a transverse row of four simple setae distributed along anterior margin of plate, the medial setae shorter than lateral setae. Coxa I with two simple ventral setae; trochanter I with one lanceolate spinose seta; femur I with two spinose setae; genu I with two long spinose setae; tibia I with three long spinose setae subbasally, a very long (224μ) spinose seta distally, a long spinose seta subdistally, and a peglike sensory seta distally; tarsus I as illustrated. Coxa II with one simple seta; trochanter II with one spinose seta; femur II with two spinose setae; genu II with two spinose setae; tibia II with a simple sensory seta three times as long as segment and three spinose setae; tarsus II with a short peglike sensory seta at apical fourth of segment, a spinose seta at midsegment, a pair of simple setae terminally and a pair of finely spinose setae subterminally; tarsus II terminates in a fringed empodium flanked by two short recurved claws. Coxa III with two setae, one simple, one spinose; trochanter III with two spinose setae; femur III with two spinose setae; genu III like genu II; tibia III with three spinose setae and a simple seta; tarsus III lacking short peglike sensory seta, otherwise like tarsus II. Coxa IV with two simple setae; trochanter IV with one spinose seta; femur IV with one spinose seta; genu IV like genu II; tibia IV like tibia III; tarsus IV like tarsus III; pretarsal elements as on leg III. Length of tarsus I, 156μ ; length of tibia I, 144μ . Length of leg I, 700μ ; length of leg IV, 560μ .

Male: (Plate V, figures 21-23)—Length of body, 306μ ; including rostrum, 500μ ; width of body, 230μ . Palpus robust; femur broadly rounded on outer margin, about as broad as long, with two simple ventral setae, two stout spinose dorsal setae and one stout spinose ventrolateral seta; genu without ornamentation; tibia with two simple setae, one dorsal and one ventral, and one ventral spinose seta; palpal claw short, curved, slender, with a single large blunt tooth at basal third of claw; tarsus with one apical short peglike seta on tubercle, two apical simple whiplike setae; two apical tarsal combs, the outer comb stouter and larger than inner comb, outer comb with twenty-two teeth decreasing in size toward base, inner tarsal comb with forty teeth decreasing in size toward base; coxa with one ventral simple seta near trochanter; trochanter small, unornamented. Rostrum robust, its dorsal shield extending rear-

wards to propodosoma, longitudinally striated; anterior portion of shield lightly punctate; rostrum with a pair of ventrolateral simple setae distally and a pair of dorsolateral simple setae subapically; peritreme simple, segments elongate, two to three segments between spiracle and longitudinally directed member. Single pair of eyes located laterad from third setae of anterior shield. Dorsum of idiosoma almost completely covered by the two large dorsal plates; anterior plate about three-fifths as long as posterior plate, both plates projecting laterad nearly to margins of body. Anterior shield rounded anteriorly, posterior extremity slightly wider than anterior extremity. Posterior shield with hind margin rounded-truncate and anterior margin broadly and angularly truncate. Six pairs of large subclavate spinose setae distributed on lateral margins of plates, three on anterolateral angles of anterior plate, one on posterior angles of anterior plate, one at mid-length of posterior plate, one on posterolateral angle of rear plate. Five pairs of large subclavate spinose setae arranged in two longitudinal rows on dorsal plates submesally, two on posterior third of anterior plate the remaining three pairs on posterior plate. Two pairs of stout subclavate spinose setae located dorsally on idiosoma but not on dorsal plates, one of these slightly anterior to juncture of anterior and posterior shields, the other borne subterminally on opisthosoma in linear alignment with mesal setae of plates. Venter of idiosoma with two longitudinal rows of small simple setae, the first pair just mesad to coxae I, the second anteromesad from coxae III, the remaining three pairs posteromesad from coxae IV. Genital opening dorsoterminal on opisthosoma with two pairs of small hooked setae situated laterad from orifice and one pair of minute setae located dorsally just anterior to orifice; two pairs of small dorsal setae each borne on a minute plate, located between posterior margin of the large posterior dorsal plate and the cluster of setae around genital orifice. Aedeagus lancetlike. Coxa I with two simple setae; trochanter I with one stout subclavate spinose seta; femur I with two stout subclavate spinose setae; genu I with two rodlike spinose setae, unequal in length; tibia I with three subclavate spinose setae located on basal fourth of segment, one sensory seta subdistally, about one fifth as long as segment, two subclavate spinose setae subdistally, one very long (227μ); tarsus I as illustrated. Coxa II with one simple seta; trochanter II with one subclavate spinose seta; femur II with two setae, one subclavate spinose, the other lanceolate finely pilose; genu II with two subclavate spinose setae; tibia II with one long rodlike sensory

seta twice as long as segment, three long subclavate spinose setae, one lanceolate finely pilose seta; tarsus II with a short spinelike sensory seta and a subclavate spinose supporting seta distally on segment, two subterminal simple setae, four subterminal short finely pilose setae; tarsus II terminating in a fringed empodium flanked by two small recurved claws. Coxa III with one subclavate, spinose seta, one lanceolate simple seta; trochanter III with two pilose setae; femur III with two subclavate spinose setae; genu III like genu II; tibia III like tibia II; tarsus III without short spinelike sensory seta, otherwise like tarsus II; pretarsal elements as on leg II. Coxa IV with two simple setae; trochanter with one subclavate spinose seta; femur IV with one subclavate spinose seta; genu IV like genu III; tibia IV like tibia III; tarsus IV like tarsus III; pretarsal elements as on leg II. Length of tarsus I, 136μ ; length of tibia I, 146μ . Length of leg I, 672μ ; length of leg IV, 508μ .

Larva: (Plate IV, figures 17-19)—Length of body, 146μ ; including rostrum, 208μ ; width of body, 132μ . Palpus and rostrum robust; palpal femur rounded laterally, about as wide as long, with one dorsal clavate spinose seta; no dorsal genual seta; one dorsal tibial seta finely pilose; palpal claw long, slender, slightly curved, with a single tooth at basal fourth; tarsus with two apical whiplike setae, two ventrolateral setae, the outer finely spinose, the inner smooth, segment with two combs, outer tarsal comb longer and stronger than inner comb, with twelve teeth adorning basal two thirds of comb, teeth decreasing in size toward base, inner tarsal comb with twenty-seven teeth distributed along entire length of comb, teeth decreasing in size toward base. Rostrum with dorsal plate extending posteriorly to anterior margin of propodosoma, deeply emarginate anteriorly, finely punctate; peritreme simple with elongate segments, two to three segments between spiracle and longitudinally directed member; rostrum with one pair of simple ventrolateral setae distally. Single pair of eyes. Anterior dorsal plate large, covering most of propodosoma, rounded anteriorly, widened posteriorly, with three pairs of marginal subclavate spinose setae at anterior angles near eyes, one pair of submedian subclavate spinose setae on posterior margin of plate; entire plate finely punctate. One pair of dorsal subclavate spinose setae near but not on posterolateral angles of propodosomal plate and one pair of dorsolateral lanceolate spinose shoulder setae situated slightly laterad from these setae. Dorsum of hysterosoma

with four transverse rows of subclavate spinose setae; first row with four setae, second, third and fourth rows with two setae each; dorsal body surface of entire hysterosoma striated. Venter of propodosoma with one pair of submedian simple setae, situated mesad from coxae I. Venter of hysterosoma with two pairs of submedian simple setae, situated mesad from coxae IV and laterad from anus; anus flanked by three pairs of simple setae. Coxa I with one simple seta; trochanter I bare; femur I with two spinose setae, unequal in length; genu I with one spinose seta; tibia I with three spinose setae and one simple seta; tarsus I as illustrated. Coxa II bare; trochanter II like trochanter I; femur II with two setae, one spinose and one simple; genu II like genu I; tibia II like tibia I; tarsus II with one small peglike, sensory seta located distally on segment, two simple subapical setae, four short, finely pilose setae apically, segment terminated by a fringed empodium flanked by two small recurved claws. Coxa III like coxa II; trochanter III like trochanter I; femur III with one spinose seta; genu III like genu I; tibia III like tibia I; tarsus III without short peglike sensory seta, otherwise like tarsus II. Length of tarsus I, 75μ ; length of tibia I, 26μ . Length of leg I, 205μ ; length of leg III, 128μ .

Protonymph: (Plate VI, figures 24-26)—Length of body, 251μ ; including rostrum, 342μ ; width of body, 189μ . Palpus and rostrum robust; palpal femur rounded on outer margin, one simple seta and two dorsal rodlike spinose setae; genu bare; tibia with two long and one short setae, the long seta minutely pilose; palpal claw long, curved, slender, with a single prominent tooth at basal third; tarsus small knoblike, with two apical whiplike setae, two apical tarsal combs, the outer comb with fifteen teeth arranged on basal half of comb, teeth decreasing in size toward base, outer comb stouter and longer than inner comb, the inner comb with thirty-six teeth distributed along entire length of comb, teeth decreasing in size toward base; coxa with one simple, ventral seta. Rostrum with dorsal shield extending rearward to anterior margin of propodosoma, forepart broadly emarginate; shield finely punctate; peritreme simple, segments elongate, two to three segments between spiracle and longitudinally directed limb; rostrum with a pair of ventrolateral simple setae distally, one pair of shorter, dorso-lateral simple setae subapically. Single pair of eyes. Anterior dorsal plate large, covering most of propodosoma, rounded anteriorly, broadening posteriorly, finely punctate, with four pairs of marginal subclavate spinose setae, three pairs at anterior angles

near eyes, one pair at posterior angles; one pair of submedian subclavate spinose setae near posterior margin of plate. One pair of long subclavate spinose, dorsolateral, shoulder setae between legs II and III. Dorsum of hysterosoma with five horizontal rows of long subclavate spinose setae; anterior row with four setae, each borne on a minute plate, second row with two setae, each borne on a small distinct plate, third, fourth and fifth rows with two setae each; all six of the small dorsal hysterosomal plates finely punctate. Dorsum of hysterosoma finely striated in regions not covered by plates. Venter of propodosoma with two pairs of submedian simple setae, one situated mesad from coxae I, the other posteromesad from coxae II. Venter of hysterosoma with a pair of submedian simple setae, situated posteromesad from coxae IV; terminal anal opening flanked by four pairs of short simple setae. Coxa I with two simple setae; trochanter I bare; femur I with one clavate spinose seta and one subclavate spinose seta; genu I with two subclavate spinose setae; tibia I with four subclavate spinose setae and one short peglike seta; tarsus I as illustrated. Coxa II with one simple seta; trochanter II like trochanter I; femur II with one subclavate spinose seta and one simple seta; genu II like genu I; tibia II with three subclavate spinose setae and one simple seta; tarsus II with one finely spinose seta distally, one short peglike sensory seta distally, two simple setae and four finely pilose setae subterminally; tarsal segment terminates in a fringed empodium flanked by two small recurved claws. Coxa III with one lanceolate spinose seta and one simple seta; trochanter III with one lanceolate, spinose seta; femur III like femur II; genu III like genu I; tibia III like tibia II; tarsus III without short spinelike sensory seta, otherwise like tarsus II. Coxa IV bare; trochanter IV bare; femur IV with one subclavate spinose seta; genu IV bare; tibia IV like tibia II; tarsus IV without finely spinose seta distally, otherwise like tarsus III. Length of tarsus I, 102 μ ; length of tibia I, 71 μ . Length of leg I, 190 μ ; length of leg IV, 175 μ .

Deutonymph: (Plate VI, figures 27-29)—Length of body, 336 μ ; including rostrum, 462 μ ; width of body, 238 μ . Palpus and rostrum broad; palpal femur broadly rounded on outer margin, with two dorsal rodlike spinose setae, one ventrolateral finely pilose seta located near outer apical margin and two simple ventral setae; no genual setae; tibia with one long finely pilose seta and two simple setae, the segment terminated by a long curved simple

claw having a single tooth at basal fourth; tarsus small, knoblike, with one apical peglike seta on tubercle, two apical simple whip-like setae and two apical combs, the outer comb with eighteen teeth adorning basal two thirds of inner margin, teeth decreasing in size toward base, this comb stouter and longer than inner comb, the inner tarsal comb with forty-seven teeth distributed along its entire inner margin, teeth decreasing in size toward base; coxa with one ventral simple seta. Rostrum with dorsal shield broadly emarginate at anterior margin, forepart striate-punctate, rear part finely punctate; rostrum with two ventrolateral simple setae distally, two dorsolateral simple setae subapically; peritreme simple, segments elongate, two to three segments between spiracle and longitudinally directed member. Single pair of eyes. Anterior dorsal shield large, covering most of propodosoma, rounded anteriorly, widening posteriorly, with three pairs of long marginal subclavate spinose setae, located at anterior angles of shield near eyes, one pair of similar setae at posterior angles of shield, two pairs of spinose, subclavate setae located submesally on posterior half of shield; entire shield finely punctate. One pair of long dorsolateral spinose shoulder setae between legs II and III. Dorsum of hysterosoma with five horizontal rows of spinose setae; first row with four setae, each borne on a minute plate; second row with four setae, two borne on each of the two moderately large and widely separated dorsal plates; third row with four setae, each borne on a minute plate; fourth row with four setae; fifth row consisting of two setae situated terminally on opisthosoma; all dorsal hysterosomal plates are finely punctate with intervening integument finely striate. Venter of propodosoma with two pairs of submedian simple setae, one pair situated mesad from coxae I, the other pair posteromesad from coxae II. Venter of hysterosoma with three pairs of submedian simple setae one pair mesad from coxae IV, the other two pairs posteromesad from coxae IV; terminal anal opening flanked by four pairs of short stout setae. Coxa I with two simple setae; trochanter I with one spinose seta; femur I with two spinose setae; genu I with two spinose setae; tibia I with three spinose setae basally, one very long, one short spinose setae subapically, one very short, peglike, sensory seta situated subapically; tarsus I as illustrated. Coxa II with one simple seta; trochanter II like trochanter I; femur II with two spinose setae; genu II like genu I; tibia II with three spinose setae, one simple seta; tarsus II with one short peglike sensory

seta, one lanceolate spinose seta, and one short simple seta located distally on segment; two long simple setae located subterminally, one short sensory peg and one long, pilose seta located at about mid-segment; tarsal segment terminates in a fringed empodium flanked by two small recurved claws. Coxa III with one spinose seta and one lanceolate simple seta; trochanter II with two spinose setae; femur III with two spinose setae; genu III like genu I; tibia III like tibia II; tarsus III without short peglike sensory seta, otherwise like tarsus II; pretarsal elements as on leg II. Coxa IV with two simple setae; trochanter IV with one spinose seta; femur IV with one spinose seta; genu IV like genu I; tibia IV like tibia II; tarsus IV like tarsus III; pretarsus as on leg II. Length of tarsus I, 110μ ; length of tibia I, 80μ . Length of leg I, 453μ ; length of leg IV, 414μ .

Holotype: Female, Lawrence, Kansas, August 24, 1951, D. T. Dailey, from litter in cattle barn.

Allotype: Male, same data as holotype.

Paratypes: Larva (morphotype), Lawrence, Kansas, August 2, 1951, D. T. Dailey, reared in laboratory culture; protonymph (morphotype), Lawrence, Kansas, August 26, 1951, D. T. Dailey, reared in laboratory culture; deutonymph (morphotype), same data as protonymph; fifty female and forty-six male paratypes, all from Lawrence, Kansas.

Location of types: Holotype, allotype, morphotypes, forty-two female paratypes and thirty-eight male paratypes deposited in the Snow Entomological Museum, University of Kansas. Eight male and eight female paratypes deposited in the U. S. National Museum, Washington, D. C.

Type habitat: Most of the specimens of the type series were collected from straw litter taken on the ground in an abandoned cow barn in Lawrence, Kansas and removed from the litter by the berlese trap method or were reared in the laboratory from specimens collected in the field at the locality mentioned. Some specimens in the paratype series were collected from one year old, rotted hay taken from a field in Lawrence, Kansas and processed through a berlese trap. To date, this species is known only from specimens taken in Lawrence, Kansas.

This species is named to honor Dr. George F. Knowlton, who has contributed vast numbers of mite specimens to the Snow Entomological Museum collections and has in many other ways encouraged acarological studies at the University of Kansas.

Cheletophyes knowltoni was found to be entirely predaceous, feeding preponderantly on other species of mites. In only one instance, during the course of this study, was predation on an insect observed and this involved the feeding of a larva on an immature psocid. Within the order Acarina this mite has been seen to feed on members of the families Parasitidae, Laelaptidae, Cheyletidae, Bdellidae, Acaridae, and Tydeidae. No attempt was made to feed upon mites of the family Cunaxidae nor on the members of the groups Oribatei and Uropodina, even when the cheyletid was in a state of semistarvation and these mites abundant. They were not observed to feed on *Cheyletus eruditus*, although found in close association with that species in stable litter. However, *C. eruditus* was often observed feeding on *Cheletophyes knowltoni*. *Cunaxa* sp. taken in great numbers in berlese funnels along with *C. knowltoni* seemed to prey almost exclusively on this cheyletid. All life stages of the cunaxid could be found feeding on all stages of the cheyletid. The cunaxid usually attacked the mite from the rear, being able to outmaneuver the cheyletid by reason of their greater agility. Cunaxid larvae have been observed overpowering large cheyletid nymphs.

The mite was cannibalistic if the opportunity presented itself, feeding on smaller or weakened members of its own species. This behavior was usually seen in mass rearing pens when the acarids used for food became scarce. Adults of this species seemed to ignore extremely small prey such as acarid larvae and would die, apparently from starvation, in a rearing pen containing a quantity of the acarid larvae. If an adult acarid was introduced into this pen, the *Cheletophyes* would immediately feed upon it.

The immature stages were not seen feeding upon mite eggs of any species. However, one male kept in isolation with a female was observed to feed upon her eggs when there was a dearth of acarids for food.

This species did not require a pit or hiding place in which to lay in ambush as did *C. eruditus*. It would run actively about the rearing pen searching for food or, at times, lie flat on the substrate with legs and palps widespread until some victim brushed against legs I. The mite would then spring forward and seize its prey by a leg with the strong palps. The chelicerae would be inserted into the struggling victim's leg and, after about thirty seconds the victim would cease to offer any resistance, its legs would curl downward and all body movements would cease. During the period that the venom or toxic saliva was taking effect, the predator would be

tugging and lifting at its prey. When the prey offered no more resistance, it would, if not too large, be lifted from the substrate and carried about while its body contents were drained. The venom or toxic saliva seemed to have little or no effect on other mites of its own species for, in instances of a cannibalistic attack, the victim would attempt to escape for some time and if released before too great a quantity of its body fluids were removed, seemed to recover completely.

C. knowltoni actively avoided bright lights and would congregate in the darker corners of the rearing pen when under illuminated microscope observation. The mite has one pair of eyes and seems to be able to distinguish movement, turning actively away from a dissecting needle moved in front of it.

The long front legs are not used in walking but seem to be primarily tactile appendages, being waved constantly on and about every object the mite was investigating. In attacking prey, once the prey was close enough to touch with the palps, the front legs were held laterally and rearward, apparently an attitude adopted to protect these appendages. This pose was maintained after the prey was overcome and was being carried or dragged about.

The mite usually remained on the side rather than on the bottom of the rearing pen. The molting form was usually found in this section of the rearing pen, affixed to the substrate with no attempt at concealment even when such concealment was provided by pits or bits of foreign material.

There was a period of varying duration before molting in which the mite would take no food, although its movements were quite active. The mite was not observed actually assuming the molting position. In this position the mite was prone on the substrate, with legs I and II stretched forward at full length. The remaining legs were extended to the rear at full length. This was a very typical position and was only assumed at the time of molting.

Behavior of adults. Observations of adult activities were made repeatedly and on large numbers of individuals. Typical behavior patterns are noted in the following. The male was observed guarding a molting deutonymph twelve hours before its emergence. The male would move rapidly around and around the molting form, tapping and stroking it with the tactile front legs. At the approach of other mites, the male would stand over the quiescent form and stab at the intruders with his palps, eventually driving them away by making short runs at them pinching vigor-

ously with the palps. He would never move far from the deutonymph but immediately return and commence stroking and tapping it once more with legs I.

Upon emergence of the female, the male would run rapidly around her, tapping here and there over her body. The female would raise her front legs over her body and remain quiet. Eventually, the male would approach the female and repeatedly pinch first one and then the other of her palps. The female would remain quiet except for a slight movement of legs I held over her body. Receiving no rebuff, the male would seize one female palp in both of his and lead the female forward, sideways and backward for some time, moving very rapidly in this strange sort of dance. Then the male would half lift the female and slide beneath her, turning her in a half circle as he did so, so that she was above him, both mites facing in the same direction with the female legs placed indiscriminately on the dorsum of the male and on the substrate. Legs I of the female would still be held upward and to the side.

Swift and repeated copulation would ensue, the venter of the female bending downward to make contact with the phallus of the male. Contact was rapid and frequent. The female would then move away for some distance (about one centimeter) and remain quiet. The male would search for her and, upon locating her, the entire courtship and mating would be repeated. A total of ten courtships and subsequent matings were observed in a period of about ten minutes. There was no attempt on the part of the female to harm the male in any way after the mating activity was completed. In fact, the two mites shared the same rearing pen for ten days afterward without harming one another.

About forty-eight hours after copulation, egg deposition began. The eggs were laid singly, always in a depression or cavity of some type, if available, and were covered by strands of silk. The egg itself was not touched by the strands which were affixed at the mouth of the depression to form a loose network. The silk emerged from the apex of the rostrum in a continuous strand. The female walked sideways across the depression, but always turned and moved backward just before anchoring the strand of webbing. This was done by pressing the apex of the rostrum against the substrate. The angle formed by two connectively-anchored strands of silk was variable and did not seem to follow any set pattern. After a few strands had been deposited, the female would walk on them while crossing the pit. When a number of strands of silk

had been anchored close to and on the edge of the pit, the female would move away from the edge an increasingly greater distance, apparently to find fresh locations on which to anchor the silk. During the deposition of the webbing, legs I were held quiescent, upward and backward over the body. The palps were not observed to have any function in depositing the silk. The entire meshwork of silk was formed in about five minutes. Up to sixteen eggs from a single female were obtained in the laboratory, the eggs being laid over a period of nine days. The female usually died in one to two days after her total number of eggs were laid.

Females kept in isolation during the deutonymphal stage would, upon emerging as adults, start oviposition within two to twelve days. A maximum of twelve eggs was recovered from an unfertilized female. The eggs were viable, the larvae emerging from two to four days after the eggs were laid.

During the period of egg-laying the female ate voraciously, feeding on five to six acarid females every twenty-four hours and draining the bodies of each victim completely.

The male, after mating, was quite active for a period of about twelve days. It was an active feeder, consuming as many as five acarid females or nymphs within a twenty-four hour period. In one instance a male was observed feeding on an egg of its own species, feeding through the web which covered the eggs.

Egg: The eggs when first laid are ovoid, semitranslucent, smooth and shiny. The embryo head developed at the slightly broader end, the appendages being clearly visible before hatching. In size, the eggs averaged 137μ in length and 103μ in width.

The egg hatched in two to three days at 80° - 85° F., the average being two and one-fourth days. The egg shells were very conspicuous after hatching had taken place, as they reflected a brilliant blue light as has been reported by M'Intire (1869) for an unidentified species of cheyletid.

Larva: For some time after emergence from the egg, the larva remained under the strands of silk which had covered the egg. To get from under this silk, the larva would carefully work two strands apart and force the body through the opening thus made.

The larva usually refused food the first day of its life, but would make vigorous attempts to feed on any food presented the following day. Female acarids, much larger than the larva, were occasionally attacked, the larva seizing a leg with its palps and attempting to insert the chelicerae in the acarid's leg. These attempts

were usually unsuccessful, the larva being knocked off against the substrate during the acarid's efforts to escape. However, larvae have been observed to overpower acarid nymphs much larger than themselves. It appeared that if they were able to insert the chelicerae and remain attached for a period of time, the toxic saliva or venom which they seem to produce apparently had a quieting effect on the acarid, eventually producing a type of stupor during which the cheyletid could feed without interference. Continued success in rearing larval *C. knowltoni* was assured when they were fed a diet of acarid larvae exclusively.

In two instances, recently hatched larvae which were still under the protective web were killed by being exposed suddenly to a strong microscope light. Whether it was the light or the attendant heat is unknown. The larvae, when struck by the light, would stiffen and expand all legs and mouthparts. Aside from some flexing of the palps for a short interval following such exposure, there was no more movement. The larvae, in each case, were at once returned to the rearing pen and the relative humidity of the rearing pen was increased. Such larvae did not recover.

For a period of time before molting, the larva took no food. The larva was not actually observed assuming the molting position though this characteristic stance was taken before ecdysis. The duration of the larval stadium was from two to seven days at 80-85° F., averaging four days.

Protonymph: The protonymph emerged after a twenty-four to forty-eight hour molting period. In attempting to escape from the larval skin, the protonymph would pull backward and upward with the forepart of the body, stretching the larval skin in the vicinity of legs II. After some minutes of this stretching, a transverse split would appear in the dorsum of the larval skin between legs II and III. The mite backed from the forepart of the larval skin, freeing legs I and II along with the gnathosoma. After a pause of a few seconds duration, the mite stepped out of the rear portion of the larval skin which often remained attached to the dorsum of the protonymph for ten minutes or more before dropping off. The actual molting process lasted about twenty-five minutes.

Legs IV of the protonymph were used for walking as soon as the mite emerged and were not held from the substrate for a time as was the case in newly emerged protonymphs of *Cheyletus eruditus*.

The protonymphs occasionally attempted to feed soon after emergence, but the palps did not appear strong enough to hold the

prey. The protonymph was not observed feeding successfully until eight to twelve hours after emergence, when it would attack mites much larger than itself if they were slow-moving. In the laboratory the protonymph was fed acarid nymphs.

The protonymphal stadium endured from three to seven days at 80°-85° F., averaging four days, the nymph usually molting on the side of the rearing pen. As in the larval stage, the protonymph refused food for a short period before molting.

Deutonymph: The deutonymph emerged after approximately a twenty-four hour molting period and would usually refuse food for eight to twelve hours. The nymph was fed on acarid adults, having no trouble in subduing them with its toxic saliva or venom. This stage would refuse food for a period before molting and would molt on the side of the rearing pen. The deutonymphal stadium lasted from four to seven days at 80°-85° F., averaging five days.

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PLATE I

Cheyletus eruditus (Schränk)

- FIG. 1. Dorsal view of female.
FIG. 2. Ventral view of female.
FIG. 3. Portion of right palpus of female.
FIG. 4. Portion of leg I of female.

PLATE I

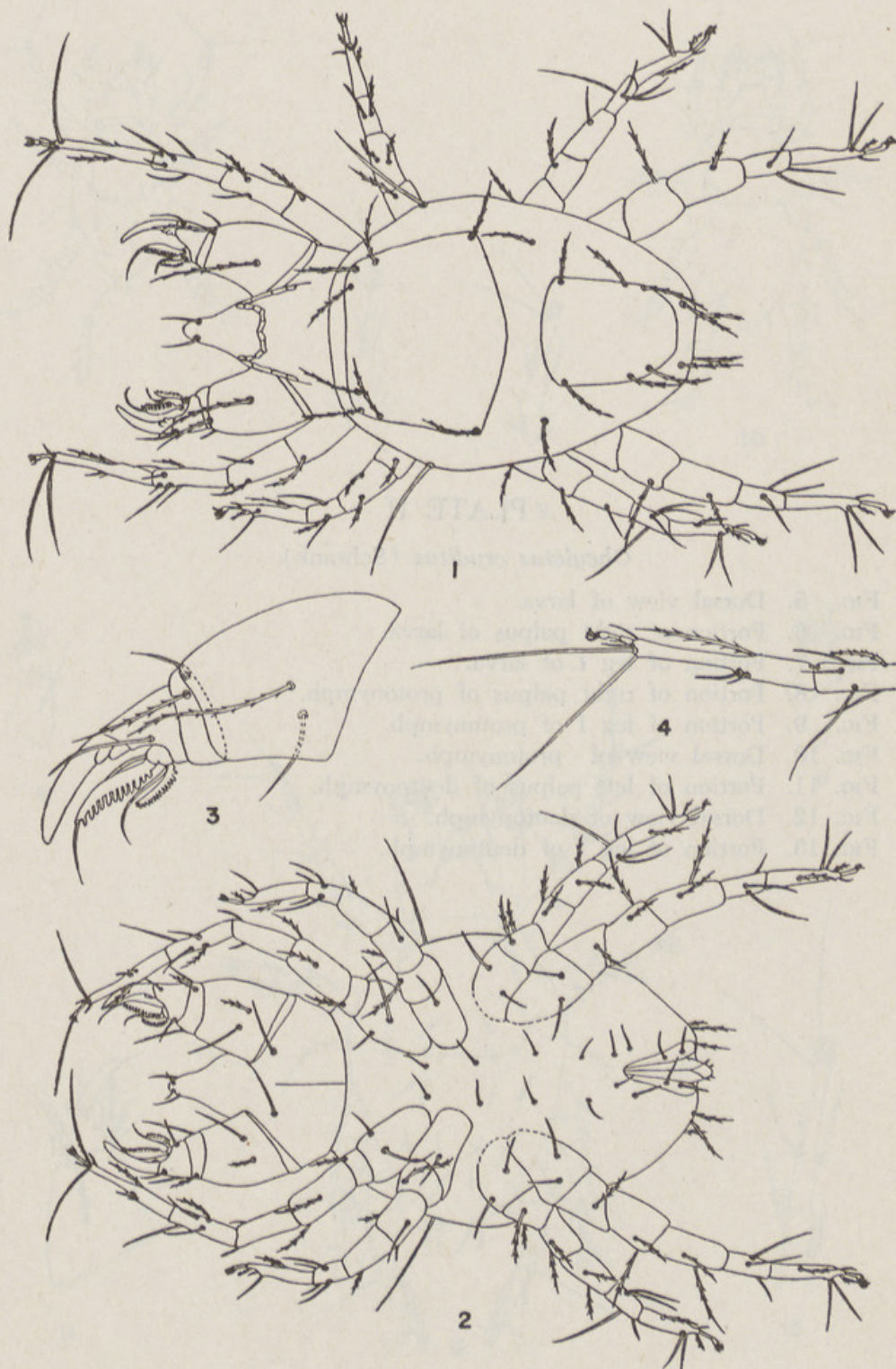


PLATE II

Cheyletus eruditus (Schrank)

- FIG. 5. Dorsal view of larva.
- FIG. 6. Portion of right palpus of larva.
- FIG. 7. Portion of leg I of larva.
- FIG. 8. Portion of right palpus of protonymph.
- FIG. 9. Portion of leg I of protonymph.
- FIG. 10. Dorsal view of protonymph.
- FIG. 11. Portion of left palpus of deutonymph.
- FIG. 12. Dorsal view of deutonymph.
- FIG. 13. Portion of leg I of deutonymph.

PLATE II

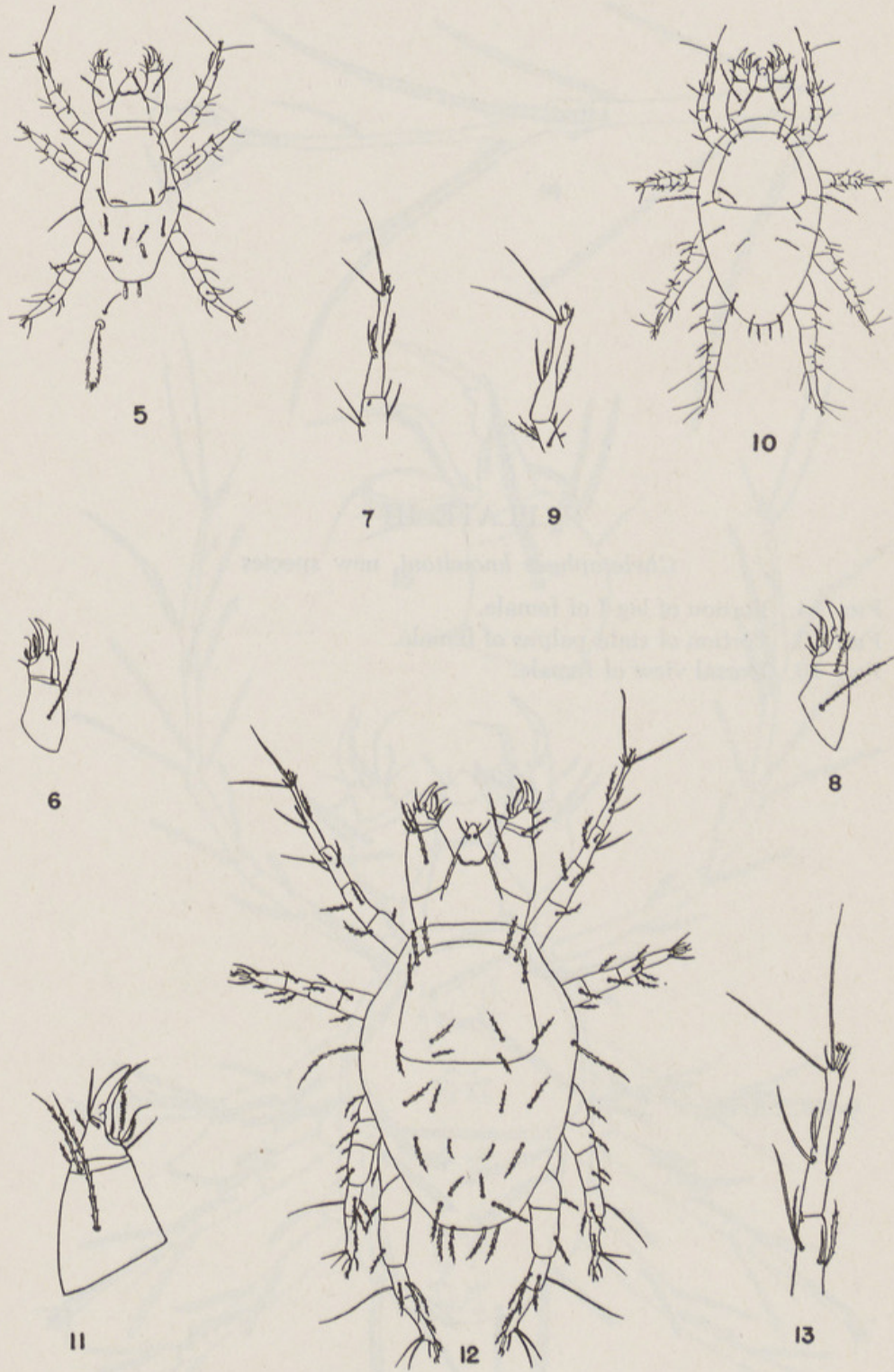


PLATE II



PLATE III

Cheletophyes knowltoni, new species

- FIG. 14. Portion of leg I of female.
FIG. 15. Portion of right palpus of female.
FIG. 16. Dorsal view of female.



PLATE III

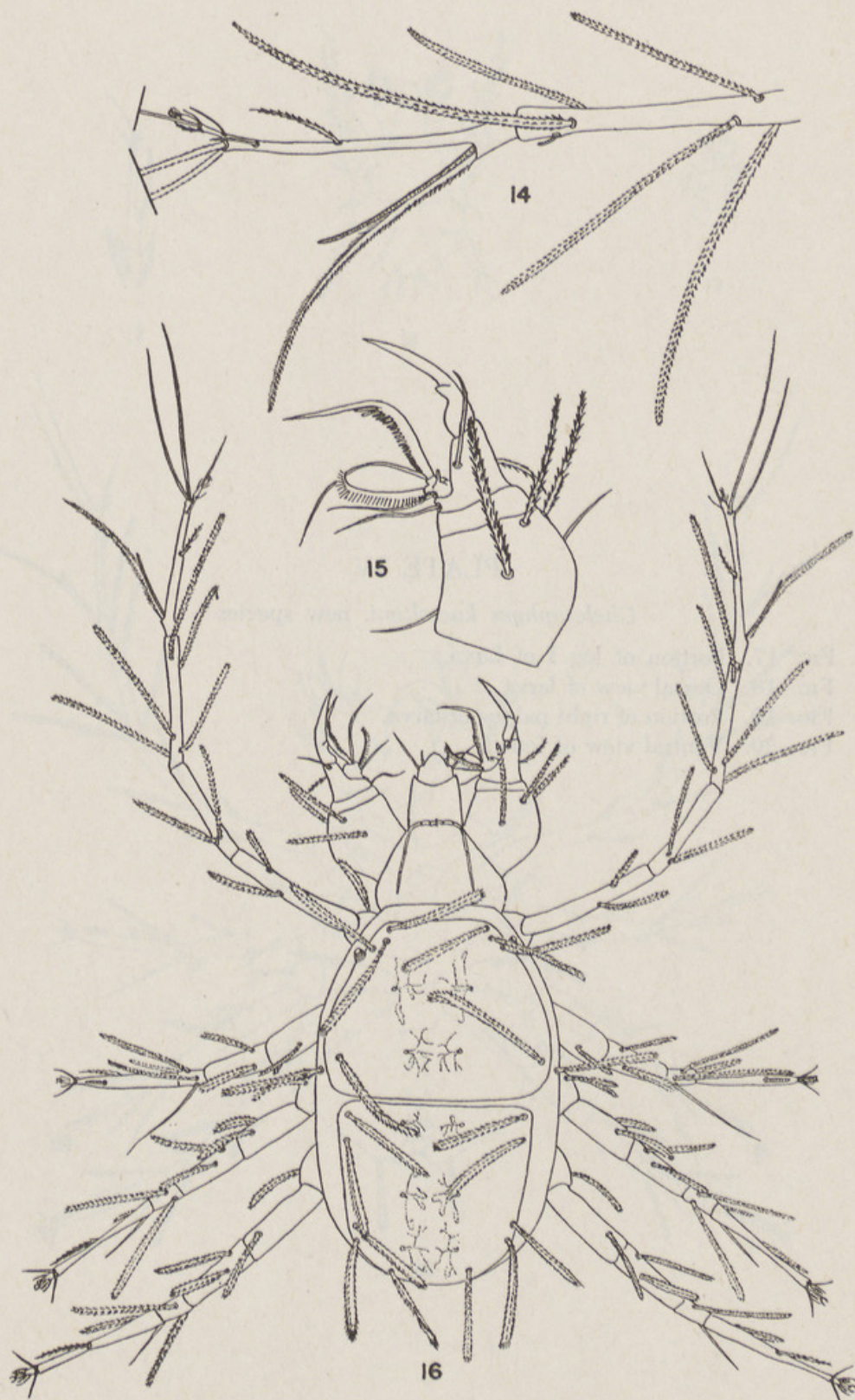


PLATE IV

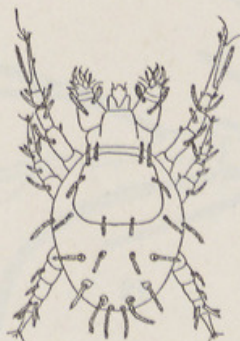
Cheletophyes knowltoni, new species

- FIG. 17. Portion of leg I of larva.
FIG. 18. Dorsal view of larva.
FIG. 19. Portion of right palpus of larva.
FIG. 20. Ventral view of female.

PLATE IV



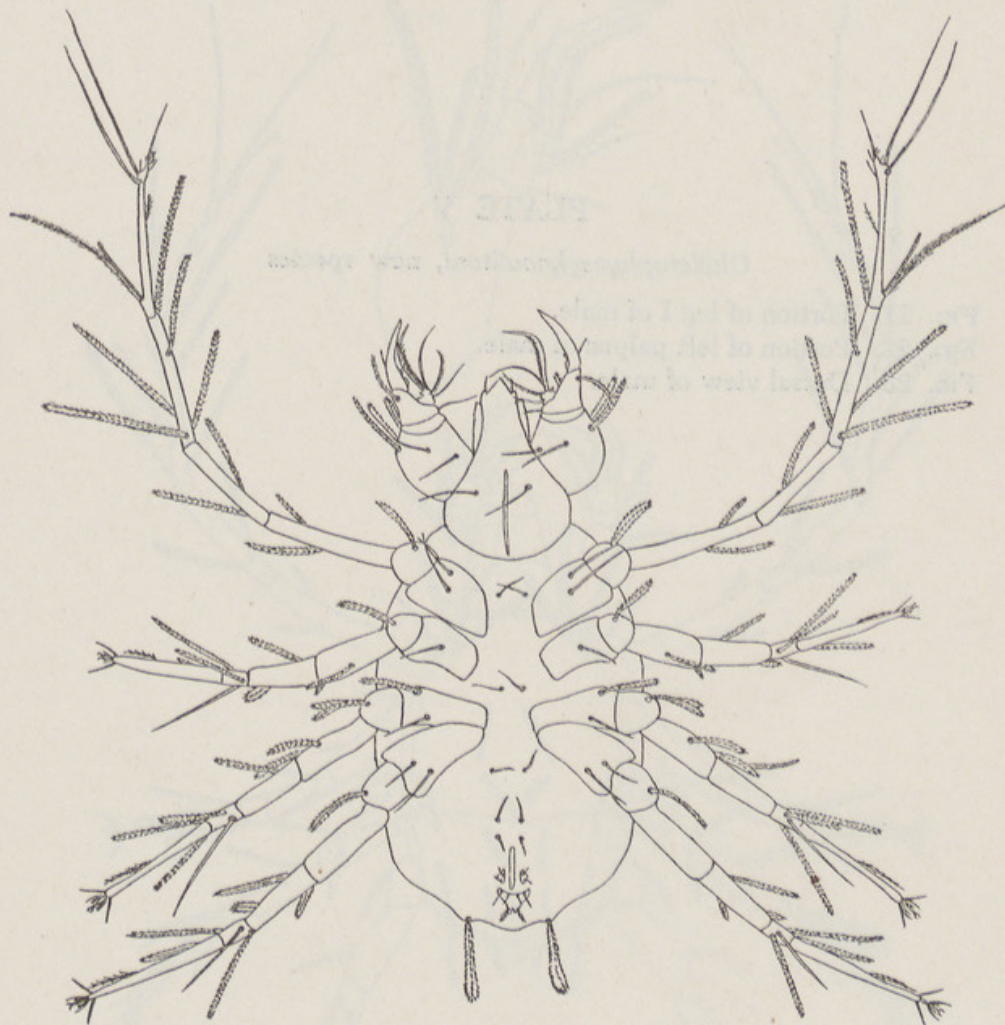
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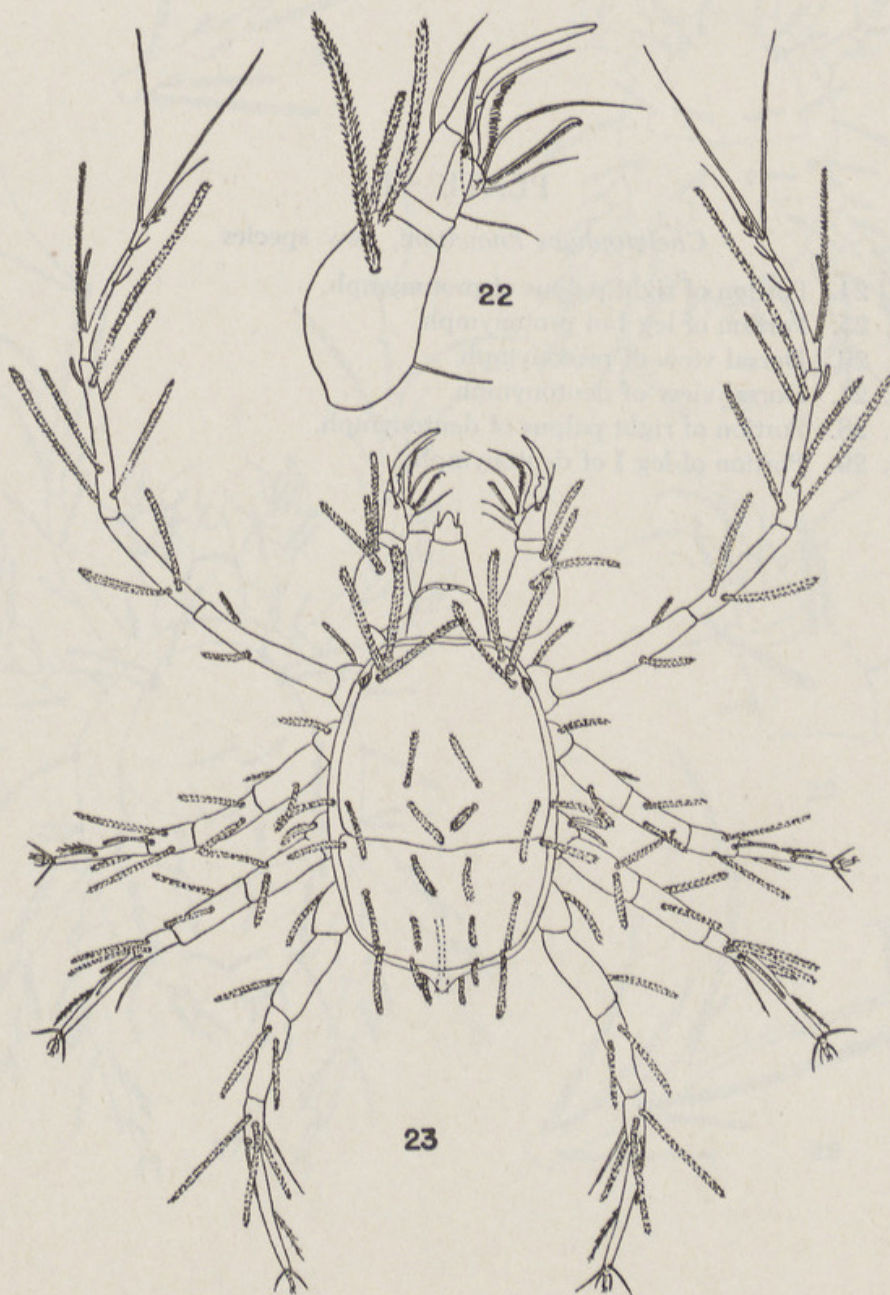
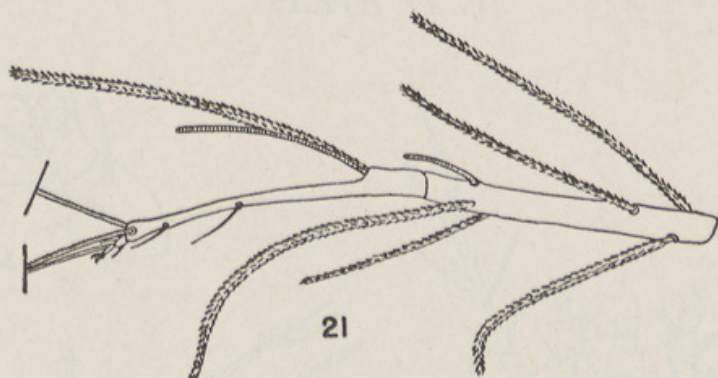
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PLATE V

Cheletophyes knowltoni, new species

- FIG. 21. Portion of leg I of male.
FIG. 22. Portion of left palpus of male.
FIG. 23. Dorsal view of male.

PLATE V



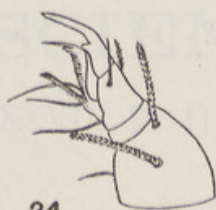
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PLATE VI

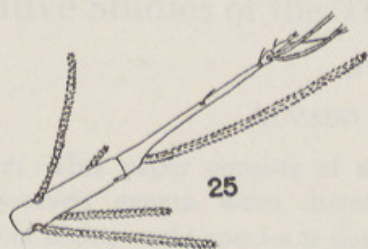
Cheletophyes knowltoni, new species

- FIG. 24. Portion of right palpus of protonymph.
FIG. 25. Portion of leg I of protonymph.
FIG. 26. Dorsal view of protonymph.
FIG. 27. Dorsal view of deutonymph.
FIG. 28. Portion of right palpus of deutonymph.
FIG. 29. Portion of leg I of deutonymph.

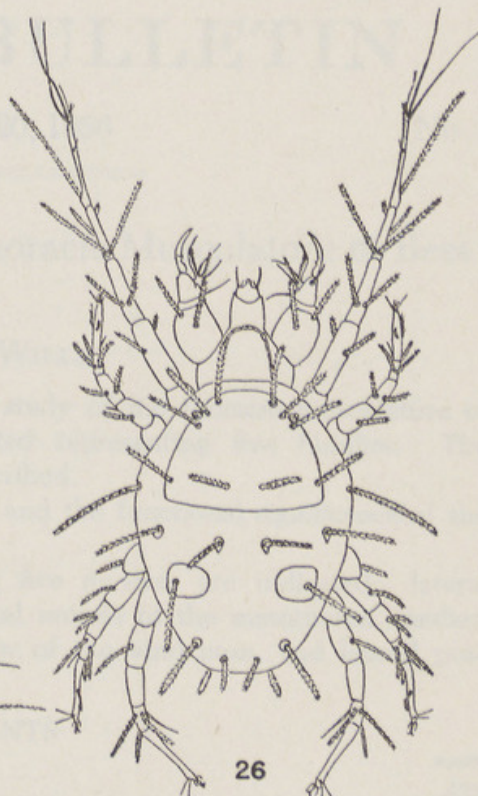
PLATE VI



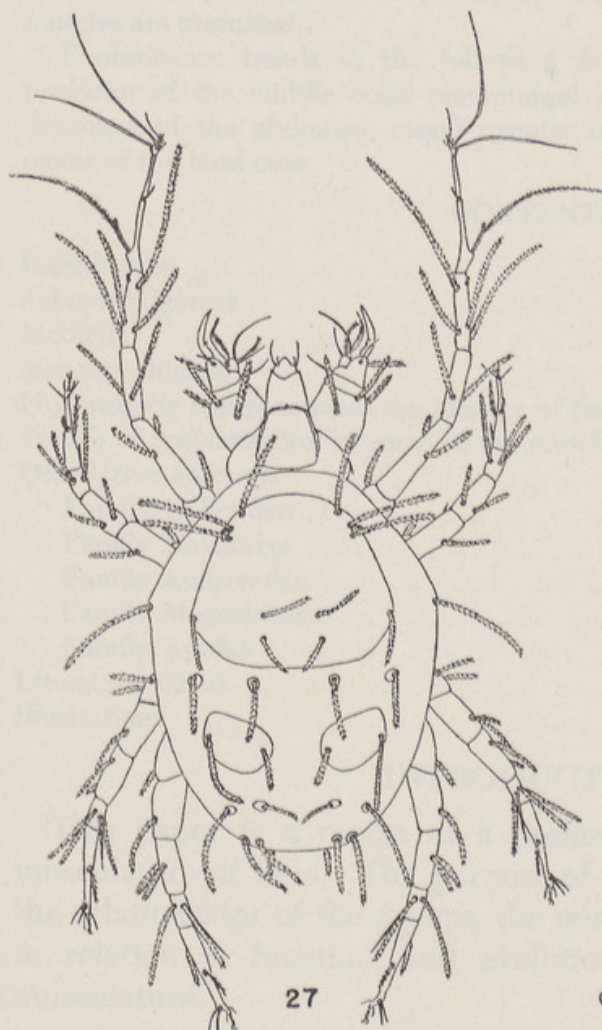
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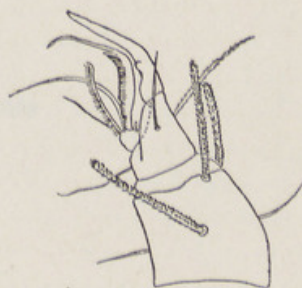
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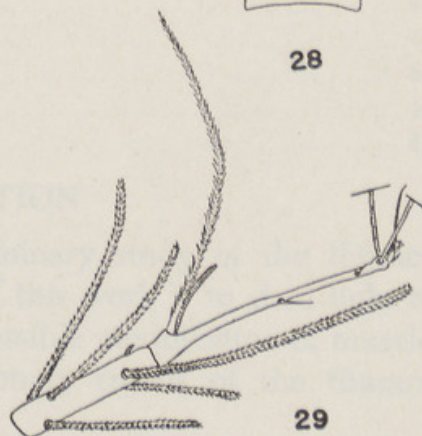
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