Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Population fluctuation of Acalitus essigi and Acalitus orthomerus (Acari: Eriophyidae) associated with inhibited ripening of blackberry (Rubus spp.)

Santos Díaz-Martínez
Colegio de Postgraduados
Gabriel Otero-Colina
gotero@colpos.mx
Colegio de Postgraduados
Geremías Rodríguez-Bautista
Centro Universitario de la Costa Sur-U
Daniel L. Ochoa-Martínez
Colegio de Postgraduados
Marcelino Martínez-Núñez
Colegio de Postgraduados

Research Article

Keywords: bud mites, Eriophyoidea, inhibited ripening, redberry

Posted Date: February 26th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-8817421/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License

Additional Declarations: No competing interests reported.

Version of Record: A version of this preprint was published at Experimental and Applied Acarology on July 15th, 2026. See the published version at https://doi.org/10.1007/s10493-026-01160-9.

Abstract

The objective of this research was to confirm the identity of the mites associated with the disease known as inhibited ripening of blackberries, also known as redberry, in all phenological stages of three commercial varieties of blackberry (*Rubus* spp.). The association of the mites with red berry is reported through an exhaustive analysis that includes the study of their fluctuation in the different morphological structures of the plant throughout its phenology, as well as taxonomic determination by optical and scanning electron microscopy. *Acalitus essigi* and *Acalitus orthomerus* were found in nine morphological structures of the plants, showing preferences for vegetative buds, reproductive buds, and polydrupes, where both species were frequently found in coexistence. Redberry occurred in the late stages of polydrupe harvest in Tupy and X001 varieties, while the SP-Erandy variety did not show symptoms of this disease. In addition, two additional species of the Eriophyoidea superfamily associated with *Rubus* sp. were identified, *Diptacus rubuscolum* and *Aculus schlechtendali*; they infested the surface of leaves, being determined as vagrants.

Introduction

The problem known as “redberry”, which will hereafter be called inhibited ripening of blackberries and abbreviated as RB, was first observed in California, USA, on Himalayan blackberry (*Rubus armeniacus*) (Essig and Smith 1922). This problem is characterized by heterogeneous ripening of the drupelets in the same polydrupe, resulting in some drupelets ripening, while others remain red, with a hard consistency and sour taste, thus rendering the polydrupes completely worthless (Essig 1925). On the affected polydrupes, abundant mites were found, which were initially identified as *Eriophyes gracilis* (Essig 1925). This species was described as *Eriophyes essigi* by Hassan (1928), later relocated into the genera *Aceria* by Keifer (1952) and *Acalitus* by Keifer (1965). With this background, several authors currently cite *Acalitus essigi* as the cause of RB (Jeppson et al 1975; Keifer et al 1982; De Lillo and Dusso 1996).

Research suggesting that *A. essigi* is the cause of RB may be significantly misleading, due to the appearance of another pest mite species in wild boysenberry (*Rubus ursinus* var. loganobaccus (Keifer 1952; Manson 1971) and cultivated *Rubus* spp. (Amrine and Stasny 1994), identified as *Acalitus orthomerus*. This species is known as the bud mite (Shi 2000; Ayala-Ortega et al 2019) and is supposedly responsible for the formation of blisters on vegetative shoots and at the base of polydrupes, where it feeds, causing galls on the apical shoots and delaying their development (Keifer 1952; Manson 1971).

The aforementioned data show that the association of *A. essigi* with RB is not determinant (Keifer 1952), since *A. orthomerus* could also be associated with this disease (Manson 1984). In addition, this species has high morphological similarity with *A. essigi*, with which it could be confused (Keifer et al. 1982) and has been found in association with polydrupes affected by RB (Trinidad et al 2018; Arreguín-Zavala et al 2021).

Some studies have documented the existence of mixed populations of *A. essigi* and *A. orthomerus* in polydrupes with RB (Manson 1971; Keifer et al 1982). This information raises doubts about the statement that points to *A. essigi* as the only causal agent of RB (Shi 2000), since other authors have only detected *A. orthomerus* in vegetative shoots of *Rubus* sp. (Ayala-Ortega et al 2019), and both in the vegetative buds and in polydrupes, with habits similar to those of *A. essigi*, without associating it with damage (Acuña-Soto et al. 2019); or associating it with RB (Arreguín-Zavala et al 2021).

Given the importance of the crop, it is essential to understand where and when the populations of *A. essigi* and *A. orthomerus* fluctuate, allowing technicians and farmers to more efficiently use management tactics in their crops, thus ensuring their productivity and long-term sustainability. To clarify the relationship between *A. essigi* and RB, as well as the possible involvement of *A. orthomerus*, this study aimed to sample all phenological stages of three commercial varieties of *Rubus* spp. and to analyze the colonization habits of both species. In addition, this study identified other mite species of the Eriophyoidea superfamily present in blackberries in the study area.

Materials and methods

Biological material

The study was carried out in three 0.5 ha blackberry plots of the varieties SP-Erandy, X001 (true name omitted for confidentiality reasons), and Tupy, all subjected to forced production (Rivas 2016). The plots of the first two varieties were located in the town of San Sebastián (19°34’47.1” N, 102°29’50.52 W, and 19°34’42.7” N, 102°29’49.9” W, respectively), while the third variety was located in the town of Los Limones (19°36’19.4” N, 102°32’36.0” W), locations belonging to the municipality of Los Reyes de Salgado, Michoacán, Mexico.

The observations covered all phenological stages of the crop, starting with a sampling during the last stage of the polydrupe harvest in May 2022 for the SP-Erandy and X001 varieties, and in June 2022 for the Tupy variety. After this stage, the plants were pruned at ground level and sampling continued during the following months, concluding in July 2023.

Five plants of each variety were collected monthly, following a simple quincunx design (SENASICA 2024). Each plant was placed individually in a plastic bag previously labeled, the inner walls of which were lined with Senior® paper. All samples were kept in a cool environment to preserve their turgidity and were stored at 4 ºC until their observation under a Carl Zeiss 475022® dissecting microscope, for the search and quantification of *A. essigi* and *A. orthomerus* specimens in the morphological structures that were present on each sampling date, using the following method.

The vegetative buds (VB) and the reproductive buds (FRB) were analyzed by removing the scales that cover them one by one. For sampling in the canes, all internodes and areas around the thorns were checked, from the base of each plant to the apical and lateral development. Leaves, stipules, petioles, leaflet junctions, rachis, adaxial and abaxial surfaces of all the leaflets were analyzed. In the inflorescences, the floral buds (FLB) were analyzed, starting with the peduncles, pedicels, stipules, and external and internal sepals. In the flowers, the same structures were examined, adding the receptacles. In the polydrupe

clusters, the peduncles, stipules, and external and internal sepals were examined. For all stages of polydrupe development, a longitudinal cut was made to thoroughly check the presence of eriophyoids between the drupelets.

The mites present in each morphological structure were removed with the tip of wooden toothpicks (Great Value®) and were separated by morphospecies (Fig 1), placing them in 0.5 mL Eppendorf tubes with absolute ethanol for conservation, processing, and identification.

Phase contrast microscopy

During all monthly samplings, mites were extracted from the above listed plant parts (when present, according to the phenological stage), three plants per variety. The adult specimens were processed, separated by morphospecies, placed in lactic acid for one to three days (Manson 1984) and then mounted in a dorsoventral position between a slide and a coverslip using F medium (Jeppson et al. 1975). They were dried at 60 °C for 15 days (Walter and Krantz 2009), and were visualized with a Carl Zeiss phase contrast microscope, model Axiostar®.

Scanning electron microscopy

Eriophyoid morphospecies were processed and separated by color and grossly by their shape: white (60 specimens), translucent (20 specimens), and cream-colored (60 specimens), collected from RB symptomatic polydrupes and VB, for analysis by scanning electron microscopy (SEM) following the method by Alberti and Nuzzaci (1996). The images were documented in a JEOL electron microscope model JSMIT800®. Taxonomic identification was performed using the keys and descriptions of Keifer (1952), Manson (1984) and Lindquist and Amrine (1996).

Analysis of population data

Adult females present in each morphological structure, for each variety and sampling date, were counted and their population densities were compared among varieties using ANOVA and multiple comparison test of means (Tukey, P=0.05), excluding those living on leaf surfaces (vagrant species).

Results

Identification of the mites

Four eriophyoid morphospecies were identified (Fig. 1): two were vagrants (Jeppson et al. 1975); one of them was brown (Fig. 1d), and the other was yellowish (Fig. 1f). The first vagrant species preferably inhabited the abaxial surface of senescent and mature leaves, with low populations on juvenile leaves, located from the base to the middle part of the plants. The second vagrant species was located on juvenile leaves that were at the limit between the middle part and the apex of the plant (Fig. 1f), where they were rarely observed in association with the yellowish morphospecies, due to the low population of the latter (Fig. 1e). The first mite was identified as *Diptacus rubuscolum*, and the second as *Aculus schlechtendali*.

Out of the other two morphospecies, one was translucent white (Fig. 1a) and one was cream-colored (Fig. 1c); they were found within the scales of VB, FRB, at the base of the drupelets of green polydrupes (GP), and in polydrupes with symptoms of RB. Due to their preferential location in narrow sites, they were classified as bud mites (Jeppson et al. 1975). In addition, they were sporadically observed on the abaxial surface of juvenile leaves, on FLB and on stipules, both morphospecies occasionally coexisting (Fig. 1b). When observing these mites by optical and electron microscopy, with special attention to the ornamentation of the dorsal and genital plates, the species *A. essigi* and *A. orthomerus* were identified, without association with the color of the specimens that had originally been determined as morphospecies. Given the relevance of these two mites in relation to the disease attributed to them, in this paper we discuss their comparative population data.

Morphology of Acalitus essigi and Acalitus orthomerus

Acalitus essigi was found in all three sampled varieties of *Rubus* sp. Its body is elongated and worm-shaped (Fig. 2c), and its color is white and sometimes creamy. The simultaneous presence of *A. orthomerus*, which has cream and white colors, was frequently observed in the same morphological structures, accompanied by immature individuals of translucent white color. Therefore, the coloration of the specimens was not a conclusive criterion to differentiate the species or to determine to which of them each immature state belongs.

One of the distinctive characteristics of *A. essigi* lies in the design of the lines of the dorsal shield (Fig. 2a), compared to *A. orthomerus*, which laterally presents “ocellar” spots (Fig. 2b). Moreover, the genital region of *A. essigi* has granules on the anterior part of the genital coverflap and crescent-shaped transverse lines on its posterior edge (Fig. 2b), which is key at distinguishing it from *A. orthomerus*. This second species exhibits between 9 and 11 longitudinal ridges on the genital coverflap (Fig. 2e). Also, the striations of the dorsal shield are different and the microtubercles present in the opisthosoma are elongated on the dorsal part, compared to the semicircular ones of *A. essigi* (Fig. 2c and 2f).

Population fluctuation

Mixed populations of *A. essigi* and *A. orthomerus* were identified. Given the coexistence of both species, no numerical data are presented on the immature stages and eggs, since their corresponding parents were unknown; males were also excluded because of they were scarce and we were unable to determine to which species they belonged.

The population fluctuation data (Tables 1 and 2) are based on the population average of *A. essigi* and *A. orthomerus*, In the sampling carried out in May 2022, on the stage prior to the ground pruning practiced out by the producers, *A. essigi* was found on the abaxial surface of tender leaflets and sepals, in flower

buds, and between the drupelets of GP.

On no sampling date, corresponding to the successive phenological stages and cultural practices, was there a significant difference between varieties (Tukey, P = 0.05). However, a certain gap in the presence of this mite was observed, especially in the Tupy variety, in which an average of 0.33 specimens per leaf was found on their abaxial surface during the vegetative stimulation period (June 2022). In polydrupes, specimens of *A. essigi* were collected around the base of the drupelets. In polydrupes with RB, their presence was only recorded in the Tupy variety (average 2.33 specimens per polydrupe).

Acalitus essigi presented three population peaks, all of them in VB; the first was recorded in May, coinciding with the final stage of production and prior to pruning at ground level. At the end of the fruiting stage, the plants were cut about 5 cm from the ground. Although the aerial layers were removed from the plots, the residual small canes contained VBs with populations of *Acalitus* spp. It is postulated that these populations were the first to begin colonizing the new shoots.

During July 2022, two months into the vegetative development of the canes, the first populations of *A. essigi* were detected in variety X001 (Table 1), some of them on the open leaf surfaces, and others in the base of the apical vegetative bud.

In the August sampling, no populations of *A. essigi* were detected in any of the three varieties. It is speculated that this absence or undetectable population may be due to the incipient development of the canes and the abundant rains that are recorded at this time in the study site.

Both in the sampling prior to ground pruning (May) and from the second population peak (September), egg laying and translucent immature stages were observed and with them, the simultaneous presence of *A. essigi* and *A. orthomerus*.

From September to November, a second population peak of *A. essigi* was recorded, with a certain gap between varieties. At the beginning of October, leaf fall is induced by spraying hormonal solutions that inhibit vegetative growth and imitate winter dormancy. This process begins with the spraying of copper and ethylene-based products (etephon) to induce physiological maturity of the leaves, followed by defoliation and apical pruning, which stimulates lateral buds and homogenizes the sprouting of lateral canes for fruiting. In the middle of this month, *A. essigi* was located between the VB of the canes of the SP-Erandy and Tupy varieties. In the X001 variety, no infestation of the VB was observed, and in Tupy, infestation was observed on the abaxial surface of the juvenile leaves.

At the beginning of polydrupe development, no specimens of *A. essigi* were detected; later, in the middle of the fruiting and harvesting season, a third population peak of this species was observed, but only in VB. No infestation of buds, flowers, or polydrupes in their different states of physiological ripening was observed.

On the other hand, the populations of *A. orthomerus* were characterized by a clear preference for VB as the main habitat in the three varieties; however, it was the only species present in polydrupes of the Tupy variety with RB in the stage prior to ground level pruning, and at that time, in the variety X001, it coexisted with *A. essigi* (Table 2). Throughout the successive samplings, which represented the progression of the phenological stages and cultural practices from ground pruning, this mite was present only in VB and was not found in FLB or polydrupes during the reproductive period from December 2022 to April 2023.

Table 1
Population fluctuation of *Acalitus essigi* throughout the phenological cycle of three varieties of *Rubus* spp. Means ± sta

Sampling date	Vegetative bud			Abaxial surface			Polydrupe stipule			Sepal			Floral bud			Gr
	SP-Erandy	Tupy	X001	SP-Erandy	Tupy	X001	SP-Erandy	Tupy	X001	SP-Erandy	Tupy	X001	SP-Erandy	Tupy	X001	SP Era
2022 Pre-sampling, May	**1.33 ± 0.33**	**0.33 ± 0.41**	**5.33 ± 3.05**	0.00	0.00	**0.33 ± 0.58**	0.00	0.00	0.00	0.00	0.00	**0.33 ± 0.58**	**0.70 ± 0.67**	**0.0 ± 0.1**	**0.33 ± 0.58**	**0.3 0.3**
Veg. Dev., June	0.00	**3.67 ± 1.78**	0.00	0.00	0.00	0.00	0.00	**1.33 ± 1.08**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Veg. Dev., July	0.00	0.00	**4.33 ± 2.94**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Veg. Dev., August	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Veg. Dev., September	0.00	**0.33 ± 0.41**	**2.30 ± 1.60**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Defoliation, October	**2.00 ± 1.20**	**3.33 ± 1.08**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Stimulation, November	**0.33 ± 0.41**	**0.33 ± 0.41**	**1.00 ± 0.71**	0.00	**0.33 ± 0.41**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Floral Bud, December	**0.33 ± 0.41**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2023 Flower and green polydrupes, January	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Green polydrupe harvest 1, February	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Ripe polydrupe and harvest 2, March	0.00	0.00	**0.67 ± 0.41**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Final harvest, April	0.00	**0.33 ± 0.41**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Veg. Dev., May	**0.67 ± 0.82**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Veg. Dev., June	00.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0

At no phenological stage and morphological structure was significant difference observed between varieties (Tukey, P = 0.05).

Table 2
Population fluctuation of *Acalitus orthomerus* throughout the phenological cycle of three varieties of *Rubus*

Sampling date	Vegetative bud			Polydrupe bud			Leaflet base			Polydrupe stipules			Sepal			Fl
	SP-Erandy	Tupy	X001	SP-Erandy	Tupy	X001	SP-Erandy	Tupy	X001	SP-Erandy	Tupy	X001	SP-Erandy	Tupy	X001	S E
2022 Pre sampling, May	**4.67 ± 0.33**	**2.33 ± 0.33**	**0.33 ± 0.33**	**2.00 ± 1.15**	0.00	0.00	**1.33 ± 0.33**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0. 0.**
Veg. Dev., June	**0.00**	**10.0 ± 0.57**	**3.33 ± 1.20**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**2.0 ± 0.58**	0.00	0.00	**7.0 ± 2.08**	0.00	0.
Veg. Dev., July	0.00	0.00	**7.33 ± 0.88**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
Veg. Dev., August	**0.33 ± 0.33**	0.00	**9.33 ± 0.33**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
Veg. Dev., septiembre	**3.0 ± 1.15**	**2.0 ± 0.57**	**12.0 ± 1.76**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
Defoliation, October	**10.67 ± 0.88**	**1.33 ± 0.88**	**10.0 ± 0.58**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
Stimulation, November	0.00	**1.00 ± 0.58**	**4.67 ± 1.45**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
Floral bud, December	**9.33 ± 0.33**	**3.00 ± 1.73**	**0.67 ± 0.33**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
2023 Flower and green polydrupe, January	**4.33 ± 0.88**	**3.67 ± 2.19**	**5.33 ± 1.86**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
Green polydrupe harvest 1, February	**8.0 ± 0.58**	**10.67 ± 2.73**	**2.0 ± 1.53**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
Ripe polydrupe and harvest 2, March	**8.33 ± 3.18**	**6.67 ± 3.18**	**4.67 ± .88**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
Final harvest, April	**8.33 ± 0.88**	**11.0 ± 2.89**	**2.89 ± 0.88**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
Veg. Dev., May	**5.00 ± 1.73**	0	**3.67 ± 1.20**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.
Veg. Dev., June	**3.00 ± 0.58**	0	**0.33 ± 0.33**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.

At no phenological stage and morphological structure was significant difference observed between varieties (Tukey, P = 0.05).

Discussion

Acalitus essigi has been reported as white and translucent, and occasionally cream-colored, according to some authors. However, in Oregon and Washington, USA, reddish hues have been observed during winter (Borgman 1950; Edwards et al. 1935). Several authors have pointed out that the white and translucent color is characteristic of *A. essigi*, especially in specimens collected from polydrupes with RB (Essig 1925; Massee 1931; Hanson 1933; Edwards et al. 1935; Keifer 1941). This conclusion has led several researchers to assume that the mite causing RB is *A. essigi*, without corroborating the identification (Davies et al 2001; Lemus-Soriano 2017). Similarly, other authors have made descriptions based on these arguments about the coloration and life habits of *A. essigi* (Flores-Martínez 2010).

The results of this research suggest that coloration and habits are not sufficient to differentiate between *A. essigi* and *A. orthomerus*, since both species have similar shades and analogous behaviors. According to our observations, the variations in color are more associated with the phenological stage of the crop, in particular, when these mites come out to colonize the apical and lateral VB. However, once the plants have more morphological structures, the adults enter within the scales of the VB and FRB, and their color changes to white, although sometimes they present combined populations (see Fig. 1b), and next to them, groups of eggs and immature stages.

In California, USA, buds offer protection to *A. essigi* during the winter, where hibernating mites can be present in both mature and immature forms, which are inactive in winter and reactivated in spring (Essig 1925). In wild and cultivated varieties from Oregon, USA, drupelets of dried polydrupes with RB on the plant serve as a refuge for the survival of *A. essigi* during the winter (Massee 1931). In addition, superimposed broods accompanied by eggs are observed in summer polydrupes (Essig 1925). In the sites where the current study was conducted, the reproduction of these species occurs mainly in autumn, winter, and spring in the three varieties studied, especially in VB; however, during winter, *A. essigi* reduces its population, while *A. orthomerus* persists in VB.

The absence of *A. essigi* and *A. orthomerus* in polydrupes at the fruiting stage from November 2022 to 2023 is attributed to the fact that during that period there was a high infestation of *Tetranychus urticae* and unidentified thrips, which motivated the application of repeated chemical treatments. In addition, during the systematic collection of the plants, no plants with polydrupes presenting RB were present.

In GP and RB-affected polydrupes, both *A. essigi* and *A. orthomerus* were collected, in mixed populations, at the base of the affected drupelets (Tables 1 and 2). This coexistence had already been observed by other authors (Manson 1972; Keifer et al. 1982). The highest frequency of mixed populations was found in VB, FRB, and polydrupes with RB. Therefore, we consider that *A. orthomerus* contributes to the development of this disease, as suggested by Manson (1984) and Arreguín-Zavala et al. (2021). In fact, *A. orthomerus* was the only species present in polydrupes with RB of the Tupy variety. The simultaneous presence of both species suggests that they could exhibit female dimorphism, or an alternation of generations known as deuterogyny, a common phenomenon in Eriophyoidea. In other words, *A. essigi* and *A. orthomerus* could be a single species. However, the data from this work do not provide information to confirm or reject the existence of such a phenomenon.

Compared to other countries, the state of Michoacán, in southwestern Mexico, presents favorable conditions for blackberry production during the winter season, continuing until spring without presenting major damage from the RB disease, at least in the Tupy and X001 varieties, in contrast to the SP-Erandy variety, which did not present this disease. In the USA, late maturing varieties such as Himalayan var. suffer heavy losses compared to early varieties such as Mammoth, Oregon Evergreen, Lawton, and raspberries, even when intercropped (Essig 1925; Edwards et al. 1935; Breakey and Brannon 1946).

In Mexico, forced crops of blackberry are programmed to be harvested according to international demand. Ground-level pruning practices at the end of each season interrupt the continuous development of *Acalitus* spp. populations. This practice differs from late varieties, which suffer greater losses because they maintain morphological structures for long periods, providing food and refuge for both *Acalitus* species (Edwards et al. 1935; Breakey and Brannon 1946). In X001 and Tupy, the number of polydrupes with RB was very low (Tables 1 and 2). Based on the background, if these varieties remained in the field for a longer time, we would observe an increase in the populations of *Acalitus* spp. and in the number of polydrupes with RB.

The number of *A. essigi* and/or *A. orthomerus* necessary for the polydrupe to manifest RB is unknown. There are population data from analyses of polydrupes with RB, which vary from less than 100 to more than 700 specimens on each damaged polydrupe (Breakey and Brannon 1946). In other cases, between 100 and 1400 mites have been recorded in a single symptomatic polydrupe (De Lillo and Dusso 1996). In the present study, much lower populations of both *A. essigi* and *A. orthomerus* were detected, and RB was still observed, so it suggests that the varieties observed are very susceptible to damage caused by these mites, expressed as RB, or alternatively, that the mites themselves do not cause this disease, but are vectors of a phytopathogenic microorganism.

The results of this study reinforce the observations of other authors that suggest that both *A. essigi* and *A. orthomerus* mites are the cause or at least are associated with RB. However, further research is still needed to determine whether the disease is caused by the direct effects of feeding on epidermal cells, by the salivary toxins of these mites, which could cause alterations in the underlying tissue, or through the transmission of a phytopathogenic microorganism. Furthermore, it is essential to investigate whether both species, although reported taxonomically as different, could present a complex deuterogynous way of life through DNA analysis.

Conclusions

The study confirms the coexistence of *A. essigi* and *A. orthomerus* as mites associated with inhibited ripening of RB disease, suggesting a complex relationship in their contribution to this disease. Their presence was recorded in various morphological structures of the varieties studied, mainly in vegetative and fruiting buds.

Acalitus essigi significantly reduces its population during the formation of flower buds, presents two population peaks during the stimulation stage, and recolonizes at the final stage of harvest. On the other hand, *A. orthomerus* persists in vegetative buds throughout all phenological stages.

The coexistence of both mite species on blackberry plants suggests the need for further analysis to determine whether they could be a single species. This includes considering possible deuterogyny.

The varieties studied show different susceptibility to RB: while the Tupy and X001 varieties showed symptoms of the disease, the SP-Erandy variety did not show any damage.

The study has important implications for the effective management of mites, highlighting the need to intervene at key moments depending on the phenological stage of the crop. It is suggested that systemic and contact products be applied before populations reach their maximum peaks, in order to

prevent migration towards key structures, such as VB towards the polydrupes.

It is essential that future research clarifies whether RB is caused by direct feeding by mites, by the action of salivary toxins, or by inoculation of a phytopathogenic microorganism.

Declarations

Funding

The authors thank the CONAHCYT for the financial support provided, the Colegio de Postgraduados for the facilities, and to the Mexican company Splendor Produce, S. de R.I. de C.V., for financing part of the research.

Competing interests

The authors have no relevant financial or non-financial interests to disclose.

Author Contributions

Santos Díaz-Martínez carried out all field and laboratory activities to get a PhD degree. Gabriel Otero-Colina was responsible of research design. He was designed as the corresponding author. Geremías Rodríguez-Bautista was on charge during the field activities. Daniel L. Ochoa-Martínez and Marcelino Martínez-Núñez followed Informed consent was obtained from all individual participants included in the study.

Data availability

Vouchers of slides with *A. essigi* and *A. orthomerus* were deposited in the Colección de Insectos del Colegio de Postgraduados (CEAM), Texcoco, Mexico. Original numerical data on mite populations are available upon request.

Ethics approval

No approval of research ethics committees was required to accomplish the goals of this study because experimental work was conducted with an unregulated invertebrate species.

Consent to participate

This study was not carried out on humans.

Consent to publish

The authors provided informed consent for publication of the images in all figures and tables included in the document.

References

1. Acuña-Soto JA, Vargas-Madriz H, Talavera-Villarreal A, Lázaro-Dzul MO, Grifaldo-Alcántara PF, Azuara-Domínguez A (2019) New Distribution records of phytophagous mites associated with cultivated blackberries at Zapotitlan de Vadillo, Jalisco, Mexico. Southwestern Entomologist 44:779–83. https://doi.org/10.3958/059.044.0324
2. Alberti G, Nuzzaci G (1996) 1.6.5 SEM and TEM Techniques. In: Lindquist EE, Sabelis MW, Bruin J (eds) Eriophyoid Mites - Their biology, natural enemies and control. Elsevier Science BV, Amsterdam, pp 399–410. https://doi.org/10.1016/S1572-4379(96)80025-X
3. Amrine JW Jr. Stasny TA (1994) Catalog of the Eriophyoidea (Acarina: Prostigmata) of the World. Indira Publishing House, West Bloomfield, Michigan
4. Arreguín-Zavala JJ, Otero-Colina G, Pineda S, López-Bautista E, Flores-Martínez BA, Rebollar-Alviter A (2021) Evaluation of different control strategies for the management of redberry disease associated with *Acalitus orthomera* (Eriophyoidea: Eriophyidae) in commercial blackberry crops. J Plant Dis Prot 128(1):191–202. https://doi.org/10.1007/s41348-020-00361-7
5. Ayala-Ortega J de J, Acuña-Soto JA, Martínez-Castillo AM, Lara-Chávez MBN, Vargas-Sandoval M (2019). Primer registro de *Acalitus orthomera* (Keifer) (Acari: Eriophyidae) asociado al cultivo de la zarzamora (*Rubus fruticosus* var. Tupy) en Ziracuaretiro, Michoacán, México. Acta Zool Mex (ns) 35:1–4. https://doi.org/10.21829/azm.2019.3501223
6. Borgman HH (1950) De “Rode vrucht ziekte” bij bramen, veroorzaakt door de galmijt*Eriophyes essigi* Hassan . Tijdschr Plantenziekten 56:149–160. https://doi.org/10.1007/BF01998541
7. Breakey EP, Brannon DH (1946) The control of the blackberry mite. Extension Service Institute of Agricultural Sciences, The State College of Washington Pullman Extension Bulletin No. 346:1–4.
8. Davies JT, Allen GR, Williams MA (2001) Intraplant distribution of *Acalitus essigi* (Acari: Eriophyoidea) on blackberries (*Rubus fruticosus* agg.). Exp Appl Acarol 25:625–39. DOI: 10.1023/A:1016179817089
9. De Lillo E, Duso C (1996) 3.2.6 Currants and berries In: Lindquist E.E., Sabelis M.W., Bruin J. (Eds.) Eriophyid mites-Their biology, natural enemies and control, Amsterdam, 583–591. https://doi.org/10.1016/S1572-4379(96)80037-6

10. Edwards WD, Gray KW, Wilcox J, Mote DC (1935) The blackberry mite in Oregon (*Eriophyes essigi* Hassan). Agricultural Experiment Station Oregon State Agricultural College, Corvallis Bulletin 337:1–36.
11. Essig EO, Smith EH (1922). Two interesting new blister mites. Monthly Bull Calif Dept Agr:11:63.
12. Essig EO (1925) The blackberry mite, the cause of redberry disease of the Himalaya blackberry, and its control. University of California, College of Agriculture, Agricultural Experiment Station. Berkeley, California. Bulletin 399:1-10. https://hdl.handle.net/2027/uiug.30112019432274
13. Flores-Martínez BA (2010) Organismos asociados a la necrosis de yemas florales de zarzamora (*Rubus* sp.) y su distribución en las zonas productoras de Michoacán. Dissertation, Universidad Autónoma Chapingo, Mexico
14. Hanson AJ (1933) The blackberry mite and its control (*Eriophyes essigi* Hassan). State college of Washington, Agricultural Experiment Station Pullman, Bulletin No 279:1–21.
15. Hassan AS (1928) The biology of the Eriophyidae with special reference to *Eriophyes tristriatus* (Nalepa). Univ Calif Publ Entomol.4: 341–394.
16. Jeppson LR, Keifer HH, Baker EW (1975) Mites injurious to economic plants. Univ California Press, Berkeley, Los Angeles, London.
17. Keifer HH (1941) Eriophyid Studies XI. Bull Dept Agr XXX (2):195–216.
18. Keifer HH (1952) The eriophyid mites of California (Acarina: Eriophyidae). Bull Calif Insect Surv 2 (l):1.123.
19. Keifer HH (1965) Eriophyid studies B-16. Bureau of Entomology, Bull Cal Dept Agr:1.20.
20. Keifer HH, Baker EW, Kono T, Delfinado M, Styer WE (1982) An illustrated guide to plant abnormalities caused by Eriophyid mites in North America. Agriculture Handbook Number 573, USDA.
21. Lemus-Soriano BA (2017). El ácaro del berry rojo, una amenaza en la producción de zarzamora. Serie Frutillas Núm. 16. Artículos Técnicos de INTAGRI. México 2 p.
22. Lindquist EE, Amrine JW Jr (1996) 1.1.2. Systematics, diagnoses for major taxa, and keys to families and genera with species on plants of economic importance. In: Lindquist EE, Sabelis MW, Bruin J (eds) Eriophyoid Mites - Their biology, natural enemies and control. Elsevier Science BV, Amsterdam, pp 33-87. https://doi.org/10.1016/S1572-4379(96)80004-2
23. Manson DCM (1971) New species and new records of Eriophyid mites (Acarina: Eriophyidae) from New Zealand and the Pacific area. Acarologia 13:351-360.
24. Manson DCM (1984) Eriophyinae (Arachnida: Acari: Eriophyoidea). Fauna of New Zealand 5, Auckland, New Zealand
25. Massee AM (1931) The Blackberry Mites. J Pomol Hortic Sci 9:298–302. https://doi.org/10.1080/03683621.1931.11513384
26. Rivas CG (2016) Manejo y producción forzada del cultivo de zarzamora. Serie Frutillas. Núm. 07. Artículos Técnicos de INTAGRI. México. https://www.intagri.com/articulos/frutillas/manejo-y-produccion-forzada-del-cultivo-de-zarzamora. Accessed 06 February 2026
27. SENASICA (2024) Manual de muestreo programa de vigilancia epidemiológica fitosanitaria. Servicio Nacional de Sanidad, Inocuidad y Calidad Agroalimentaria. Versión 2:1–47.
28. Shi A (2000) Eriophyoid mites of blackberries and raspberries (*Rubus* spp.). Bulletin OILB/SROP 23:63-66
29. Trinidad CTO, Duarte ME, Cunha US Da, Navia D (2018) Eriophyoid mites associated with the blackberry in Brazil - A new species in the genus *Diptacus* Keifer 1951 (Diptilomiopidae) and first report and supplementary description of *Acalitus orthomerus* (Keifer, 1951) (Eriophyidae). Syst Appl Acarol 23:1199–216. http://doi.org/10.11158/saa.23.6.15
30. Walter DE, Krantz GW (2009) Collecting, rearing and preparing specimens. In: Krantz GW, Walter DE (eds) A Manual of Acarology. Third Edition. Texas Tech Univ Press, Lubbock, TexasWA, pp 83-96

Figures

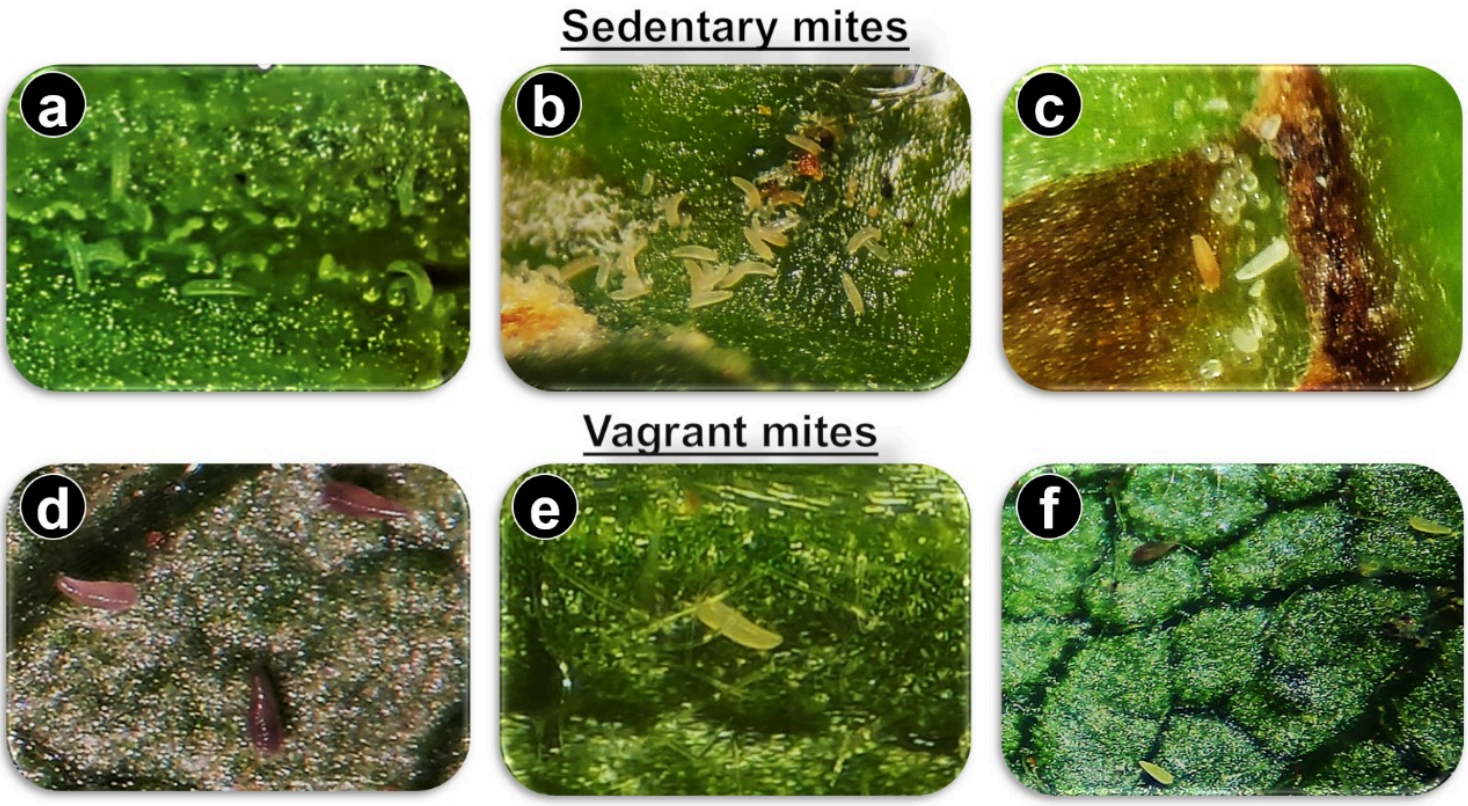


Figure 1

Morphospecies of mites of the Eriophyoidea superfamily associated with varieties of *Rubus* spp. (Tupy, SP-Erandy, and X001): bud or sedentary mites; translucent white mite (a), cream mite (b), and bud mites coexisting between the scales of the vegetative buds (c). Vagrant mites; brown mite (d) and yellowish mite (e) and both vagrant mites coexisting (f) on the abaxial surface of leaflets

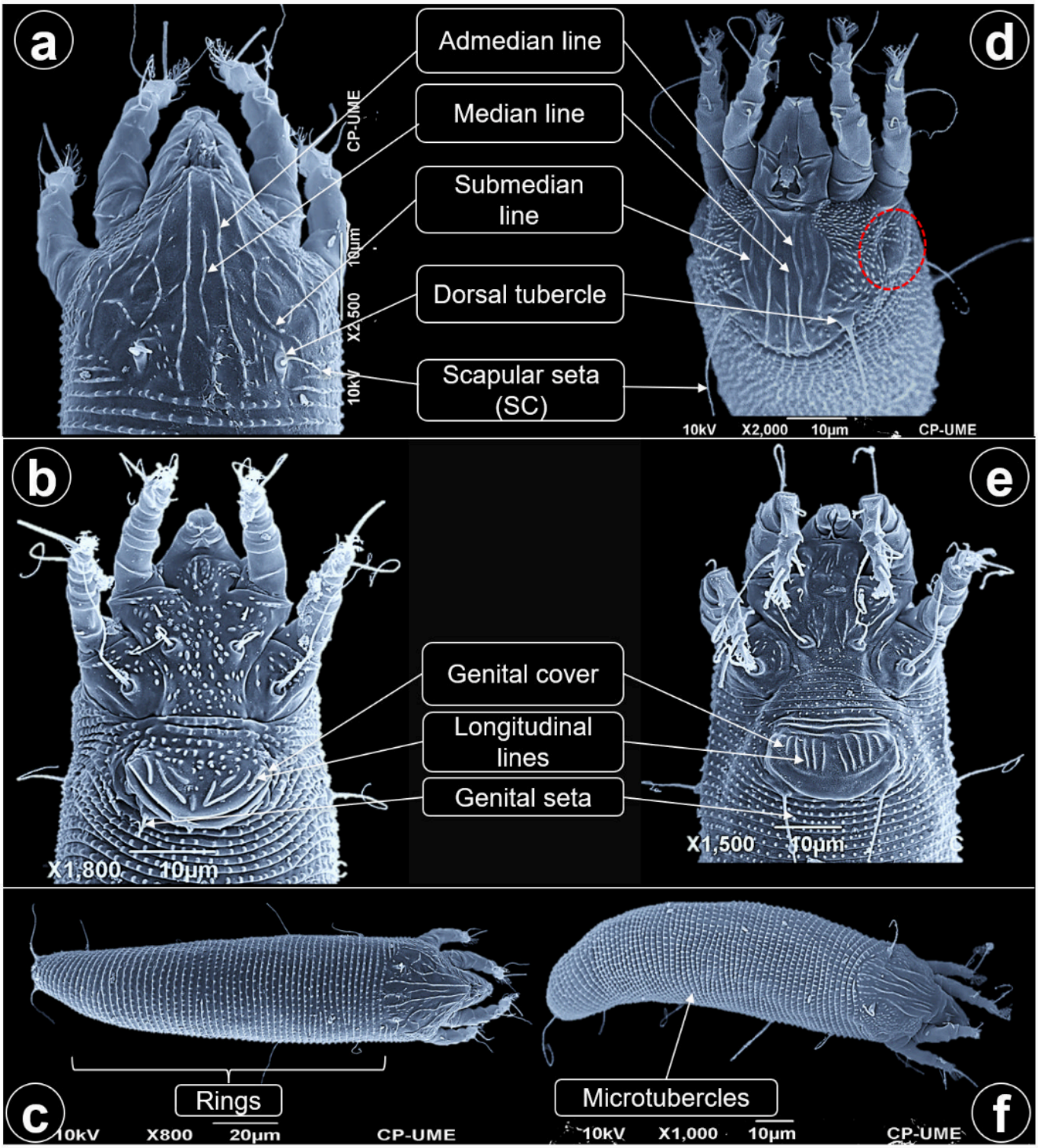


Figure 2

Morphological characteristics of bud mites associated with three varieties of *Rubus* spp. (Tupy, X001, and SP-Erandy): *Acalitus essigi*, view of the dorsal shield and the distribution of the lines (a); ventral view of the coxal and genital region characteristic of the female of the species, with crescent-shaped ridges on the coverflap (b); dorsal view of the adult with semicircular annuli and microtubercles covering the body (c). *Acalitus orthomerus*; distribution of the lines on the dorsal shield and "ocellar" spot (marked with a red oval) (d); ventral view of the coxal and genital region with longitudinal ridges of the coverflap (e); dorsal view and arrangement of the annuli and elongated microtubercles covering the body of the adult (f)