BioOne DIGITAL LIBRARY

Mites (Acari) infesting stored animal feed products in northern Thailand

Authors: Ta-Phaisach, Naphacharakorn, Konvipasruang, Ploychompoo, Sringarm, Korawan, Chiu, Chun-I, Attasopa, Korrawat, et al.

Source: Systematic and Applied Acarology, 28(10) : 1579-1596

Published By: Systematic and Applied Acarology Society

URL: https://doi.org/10.11158/saa.28.10.2

The BioOne Digital Library (https://bioone.org/) provides worldwide distribution for more than 580 journals and eBooks from BioOne's community of over 150 nonprofit societies, research institutions, and university presses in the biological, ecological, and environmental sciences. The BioOne Digital Library encompasses the flagship aggregation BioOne Complete (https://bioone.org/subscribe), the BioOne Complete Archive (https://bioone.org/archive), and the BioOne eBooks program offerings ESA eBook Collection (https://bioone.org/esa-ebooks) and CSIRO Publishing BioSelect Collection (https://bioone.org/csiro-ebooks).

Your use of this PDF, the BioOne Digital Library, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Digital Library content is strictly limited to personal, educational, and non-commmercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne is an innovative nonprofit that sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Downloaded From: https://complete.bioone.org/journals/Systematic-and-Applied-Acarology on 01 May 2025
Terms of Use: https://complete.bioone.org/terms-of-use

Systematic & Applied Acarology 28(10): 1579–1596 (2023) ISSN 1362-1971 (print)
https://doi.org/10.11158/saa.28.10.2 ISSN 2056-6069 (online)

Article

Mites (Acari) infesting stored animal feed products in northern Thailand

NAPHACHARAKORN TA-PHAISACH[1,2], PLOYCHOMPOO KONVIPASRUANG[2], KORAWAN SRINGARM[3], CHUN-I CHIU[1], KORRAWAT ATTASOPA[1,*] & YAOWALUK CHANBANG[1,*]

[1] *Department of Entomology and Plant Pathology, Faculty of Agriculture, Chiang Mai University, Chiang Mai 50200, Thailand.*

[2] *Plant Protection Research and Development Office, Department of Agriculture, Bangkok 10900, Thailand.*

[3] *Department of Animal and Aquatic Science, Faculty of Agriculture, Chiang Mai University, Chiang Mai 50200, Thailand.*

**Corresponding authors. E-mail addresses: yaowaluk.c@cmu.ac.th, k.attasopa@gmail.com*

Abstract

Storage mites are serious pests of stored animal feeds and animals that consume mite-infested feed could reduce feed intake and eventually cause weight loss. To understand the mite species and infestation rates of them in animal feeds, we conducted a survey of mite infestations in samples of animal feeds from animal feed shops, feed mills, or chicken farms in eight provinces in northern Thailand. High mite infestation rates were observed in chicken feed (42.9%), followed by pig feed (26.7%). No mites were observed in fish and frog feeds. Mites were common in pelleted feeds (n = 96) or raw materials (n = 3), but was never observed in extruded feeds (n = 33). The mite species identified include three storage mites: *Suidasia pontifica*, *Dermatophagoides farinae*, and *Aleuroglyphus chinensis*, as well as the predatory mites *Cheyletus malaccensis*, *Blattisocius keegani*, and *B. everti*. Among them, *A. chinensis* and *B. everti*, are newly recorded in Thailand. *Suidasia pontifica* was dominant in chicken and pig feeds, and could be the major storage mite pest in northern Thailand. Figures and identification keys are provided.

Keywords: Animal feed, *Aleuroglyphus chinensis*, *Dermatophagoides farinae*, *Cheyletus malaccensis*, *Blattisocius*, *Suidasia pontifica*

Introduction

The animal feed market is economically important in Thailand. Research & Markets (2020) showed that the animal feed market in Thailand was worth 6.06 billion US dollars in 2019 and it will grow to 7.32 billion US dollars in 2025, with an annual growth rate of 3.18%. Infestation of mites may reduce the quality and quantity of animal feed by increasing feed moisture content, causing mold or fungus growth, and conveying mycotoxin-producing fungi or pathogenic bacteria (Hubert *et al*. 2004; Hubert 2012). Ingesting animal feed infested by mites may lead to allergic responses of animals, such as allergic asthma, atopic dermatitis, and allergic rhinitis (Ngu *et al*. 2019). In Thailand, animal feed infested by mites was commonly observed and the large number of mites may have originated from the packaging of animal feed. Moreover, farmers consider that mites in feeds release an unfavorable odor resulting in the animals rejecting the feed (Wilkin & Thind 1983). Although mites cause serious economic losses in the animal feed industry, the occurrence, and species composition of mites in animal feed are rarely examined.

© Systematic & Applied Acarology Society

Downloaded From: https://complete.bioone.org/journals/Systematic-and-Applied-Acarology on 01 May 2025
Terms of Use: https://complete.bioone.org/terms-of-use

A major diversity of mites in the families Acaridae, Glycyphagidae, Chortoglyphidae, Carpoglyphidae, Histiostomidae, and Pyroglyphidae can be found in agricultural products, such as grain, dried fruits, nuts, cheese, spices, cereals, flower bulbs, and animal feed in storage (Hoy 2011; Dizlek *et al*. 2019). More than 20 species of mites have been found in households around the world, and more than 100 species are associated with stored products (Hubert 2012). However, there was a lack of comprehensive studies of mites infested in animal feed and there is no taxonomic key to identify them in Thailand.

Material and manufacturing processes may affect the microenvironment in animal feed physically and chemically, and the occurrence of mites may be associated with specific materials and manufacturing processes of animal feed. However, these hypotheses are rarely examined. In this study, we aimed to (1) understand the diversity of storage mites in animal feeds (domestic and aquatic animals including insects and others) in northern Thailand; (2) understand the association between mite occurrence and the material or manufacturing process of animal feed; and (3) generate a taxonomic key for identifying storage mites, which would be beneficial for implementing an integrated pest management strategy to control mites in stored animal feed products.

Materials and methods

Study areas, sampling, and specimen preparation

Samples of feeds were obtained from 37 feed-providers in eight provinces in northern Thailand (e.g. animal feed mills, animal feed shops, and storage facilities), including Chiang Mai, Chiang Rai, Lamphun, Lampang, Phrae, Nan, Phayao, and Mae Hong Son Provinces (Figure 1A), during December 2020 to November 2021 (Table 1). A total of 132 samples of animal feeds were collected, including 56 samples of chicken feed, 2 samples of duck feed, 30 samples of swine feed, 23 samples of fish feed, 8 samples of frog feed, 1 sample of dog feed, 1 sample of cat feed, 3 samples of crayfish feed, 1 sample of cricket feed, 4 samples of rabbit feed, and 3 samples of maize. One to eight samples of animal feeds (1 kg/sample) were obtained from each source. Each sample was preserved in plastic zip bags, sealed, and the collection locality, the target animals of the feed, and the feed-processing method were also recorded. The feed-processing methods include pelleted feeds, extruded feeds, and raw material. In general, pelleted feeds are hard and dense, while extruded feeds are soft and porous or crunchy and dense. Pelleted feeds are generally round or cylindrical in shape, while extruded feed has a variety of shapes and sizes, including sticks, pellets, or chunks. Raw material ingredients are feeds without feed-processing. Samples were brought to laboratory within one week, and the mites in samples were extracted using Berlese funnel. For each sample, all mite species observed were mounted on glass slides in Hoyer's medium. The specimens were kept in a drying oven at 50–60°C for five days before examination (Siegert *et al*. 2018).

Identification of mite species

Mite specimens were examined and photographed using a phase contrast compound microscope (Olympus BX53) with a microscope camera (Lanoptik MC500W-G1). Mite specimens were identified based on morphological descriptions and taxonomic keys (Regev 1974, Hughes 1976, Tseng 1989, Jiang 1994, Fan & Zhang 2004, Fan & Zhang 2005, Fan & Zhang 2007, and Britto *et al*. 2012). Morphological characters of specimens were also compared with specimens of the Department of Agriculture's mite collection (Ministry of Agriculture and Cooperatives, Bangkok, Thailand), which were identified previously. A key to species level of storage mites was constructed based on morphological characters of mites reported in current study.

Downloaded From: https://complete.bioone.org/journals/Systematic-and-Applied-Acarology on 01 May 2025
Terms of Use: https://complete.bioone.org/terms-of-use

TABLE 1. Storage mite species observed in current study and their previous records in Thailand.

Mite species	Previous records		The current study
	References	Habitats	Habitats (Occurrence, proportion)
Suidasia pontifica Oudemans, 1905	Konvipasruang *et al*. (2010a)	Animal feed	Chicken feed (18, 64.2%), swine feed (2, 7.1%), and duck feed (8, 28.6%)
Dermatophagoides farina Hughes, 1961	Insung & Pumnuan (2008)	housedust	Crayfish feed (1, 100.0%)
Aleuroglyphus chinensis Jiang, 1994	NA	NA	Chicken feed (1, 50.0%), and cricket feed (1, 50%)
Cheyletus malaccensis Oudemans, 1903	Konvipasruang *et al*. (2010a)	White sesame seed	Chicken feed (3, 50.0%), crayfish feed (2, 33.3%), and maize (1, 16.7%)
Blattisocius keegani Fox, 1947	da Silva *et al*. (2014)	Palm plants	Chicken feed (3, 50.0%), duck feed (1, 16.7%), and swine feed (2, 33.3%)
Blattisocius everti Britto, Loes and Moraes, 2012	NA	NA	Chicken feed (4, 100.0%)

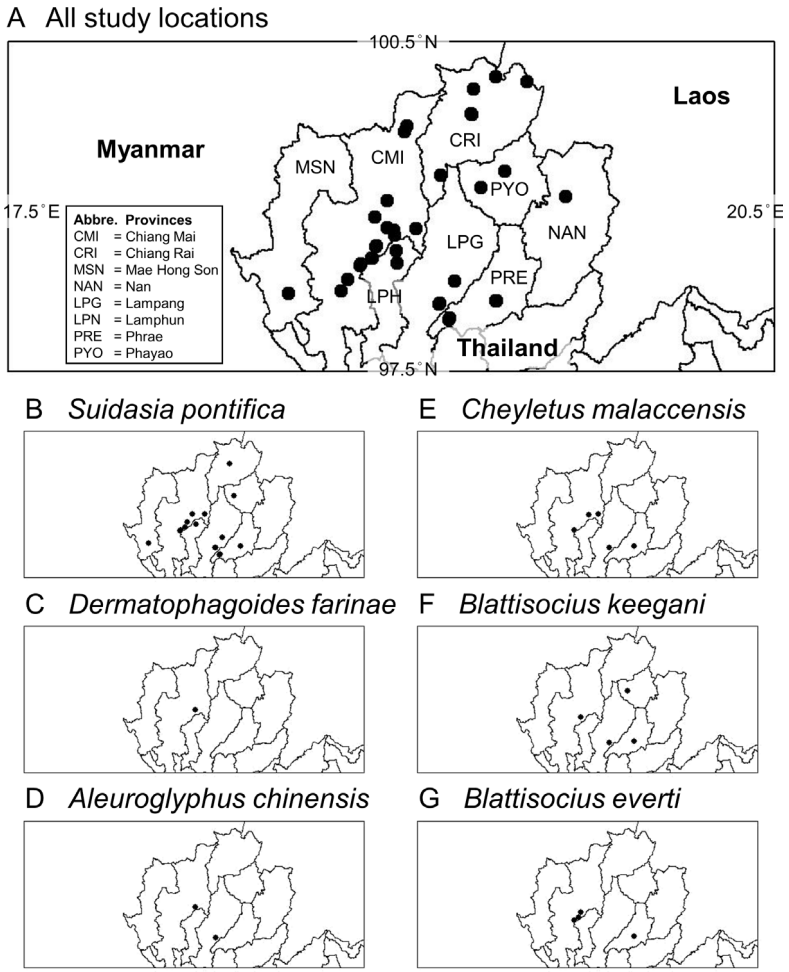

FIGURE 1. Distribution of study locations and mites infested animal feed in northern Thailand, (A) Study locations of animal feed (B) *Suidasia pontifica* (C) *Dermatophagoides farinae* (D) *Aleuroglyphus chinensis* (E) *Cheyletus malaccensis* (F) *Blattisocius keegani* (G) *Blattisocius everti*.

Downloaded From: https://complete.bioone.org/journals/Systematic-and-Applied-Acarology on 01 May 2025
Terms of Use: https://complete.bioone.org/terms-of-use

Results

Mite species identified

In this study, we identified a total of five genera and six species of mites from animal feeds from northern Thailand, including three species of storage mites, namely *Suidasia pontifica* Oudemans, *Dermatophagoides farinae* Hughes, and *Aleuroglyphus chinensis* Jiang, and three predatory mites, *Cheyletus malaccensis* Oudemans, *Blattisocius keegani* Fox, and *B. everti* Britto, Lopes & Moraes, were identified. A species belonging to family Glycyphagidae from chicken feed was also observed, however, we were unable to identify it to species level as only nymphs were available. Two mite species, *A. chinensis* and *B. everti,* are newly recorded species for Thailand (Table 1).

Taxonomy, data, and comments on mites found in this study

Storage mites

Family Suidasiidae

***Suidasia pontifica* Oudemans, 1905: page 209** (Figure 2)

Habitats in this study: Swine, egg-laying chicken, chicken, and duck feeds.

Material examined: Males, females collected by N. Ta-Phaisach on swine feed at animal feed mill, Wiangyong Sub-district, Mueang Lamphun District, Lamphun Province, Thailand, on February 5, 2021 (LPN-ML001). Egg-laying chicken and chicken feeds at animal feed shop, Rop Wiang Sub-district, Mueang Chiang Rai District, Chiang Rai Province, Thailand, on March 26, 2021 (CRI-MCR001-002). Chicken feed at animal feed shop, On Nuea Sub-district, Mae On District, Chiang Mai Province, Thailand, on April 29, 2021 (CMI-MO004). Swine feed at animal feed shop, Khuang Pao Sub-district, Chom Thong District, Chiang Mai Province, Thailand, on May 16, 2021 (CMI-CT005). Chicken feed at animal feed shop, Thung Satok Sub-district, San Pa Tong District, Chiang Mai Province, Thailand, on May 16, 2021 (CMI-SPT013). Egg-laying chicken feed at animal feed shop, Khuang Pao Sub-district, Chom Thong District, Chiang Mai Province, Thailand, on May 16, 2021 (CMI-CT007). Chicken feed at animal feed shop, Doi Lo Sub-district, Doi Lo District, Chiang Mai Province, Thailand, on May 16, 2021 (CMI-DL003). Egg-laying chicken feed at animal feed shop, Su Thep Sub-district, Mueang Chiang Mai District, Chiang Mai Province, Thailand, on May 19, 2021 (CMI-MCM002). Chicken and egg-laying chicken feeds at animal feed shop, Wang Chin Sub-district, Wang Chin District, Phrae Province, Thailand, on May 27, 2021 (PRE-WC003, 005). Chicken feed at animal feed shop, Mae Mo Sub-district, Mae Mo District, Lampang Province, Thailand, on May 27, 2021 (LPG- MM003). Chicken and duck feeds at animal feed shop, Rop Wiang Sub-district, Mueang Chiang Rai District, Chiang Rai Province, Thailand, on July 6, 2021 (CRI-MCR003-004). Chicken and swine feeds at animal feed shop, Huai O Sub-district, Long District, Phrae Province, Thailand, on July 12, 2021 (PRE-LON001-004, 007). Chicken and duck feeds at animal feed shop, Na Chak Sub-district, Mueang Phrae District, Phrae Province, Thailand, on July 7, 2021 (PRE-MPR007-008). Swine feed at animal feed shop, Na Chak Sub-district, Mueang Phrae District, Phrae Province, Thailand, on July 7, 2021(PRE-MPR010). Swine feed at animal feed shop, Mae Sariang Sub-district, Mae Sariang District, Mae Hong Son Province, Thailand, on July 6, 2021 (MHS-MSR001). Chicken and swine feeds at animal feed shop, Tha Wang Thong Sub-district, Mueang Phayao District, Phayao Province, Thailand, on September 8, 2021 (PYO-MPY001-003, 007). Collection localities are shown in Figure 1B. All deposited in Department of Agriculture's mite collection (Ministry of Agriculture and Cooperatives, Bangkok, Thailand).

Downloaded From: https://complete.bioone.org/journals/Systematic-and-Applied-Acarology on 01 May 2025
Terms of Use: https://complete.bioone.org/terms-of-use

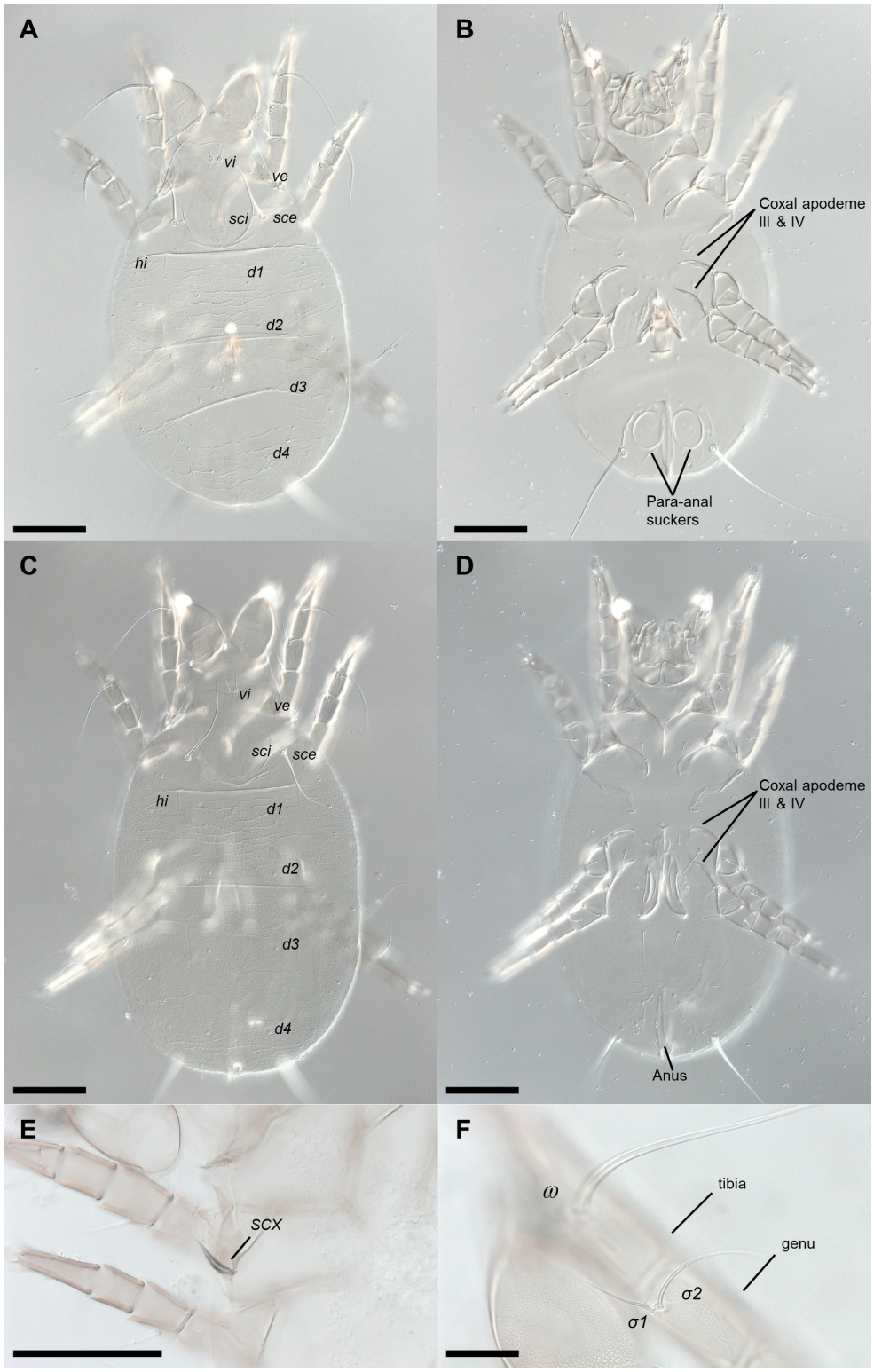

FIGURE 2. *Suidasia pontifica* male, (A) Dorsal view (B) Ventral view; *S. pontifica* female, (C) Dorsal view (D) Ventral view (E) Supracoxal seta (F) σ_1:σ_2 on genu I. Scale bars = 10 mm.

Downloaded From: https://complete.bioone.org/journals/Systematic-and-Applied-Acarology on 01 May 2025
Terms of Use: https://complete.bioone.org/terms-of-use

Remarks: The storage mite *S. pontifica* has a scale-like cuticle and a propodosomal shield (Ernieenor *et al*. 2018). According to our survey, *Suidasia pontifica* was mostly found on chicken, duck, and swine feed. Chicken feed showed higher contamination with a higher number of *S. pontifica* than the other feeds. The mites are barely visible to the naked eye but may be present in such large numbers that the surface of the animal feed packaging and surrounding shelves appear to have mite movement. Live and dead mites appeared as tan-colored dust covering animal feed packaging (Figure 3).

FIGURE 3. Live and dead mites appeared as tan-colored dust covering and leaking from the animal feed packaging in Thailand.

Family Pyroglyphidae

***Dermatophagoides farinae* Hughes, 1961: page 206** (Figures 4–6)

Habitat in this study: Crayfish feed.

Material examined: Males, females collected by N. Ta-Phaisach on crayfish feed at animal feed shop, Thasala Sub-district, Mueang Chiang Mai District, Chiang Mai Province, Thailand, on February 12, 2021 (CMI-MCM001). Collection localities are shown in Figure 1C. All deposited in Department of Agriculture's mite collection (Ministry of Agriculture and Cooperatives, Bangkok, Thailand).

Remarks: This is the first record of *D. farinae* in crayfish feed collected from Thasala Sub-district, Mueang Chiang Mai District, Chiang Mai Province. The House dust mite, *D. farinae*, is of significant medical importance, producing allergens harmful to humans.

Downloaded From: https://complete.bioone.org/journals/Systematic-and-Applied-Acarology on 01 May 2025
Terms of Use: https://complete.bioone.org/terms-of-use

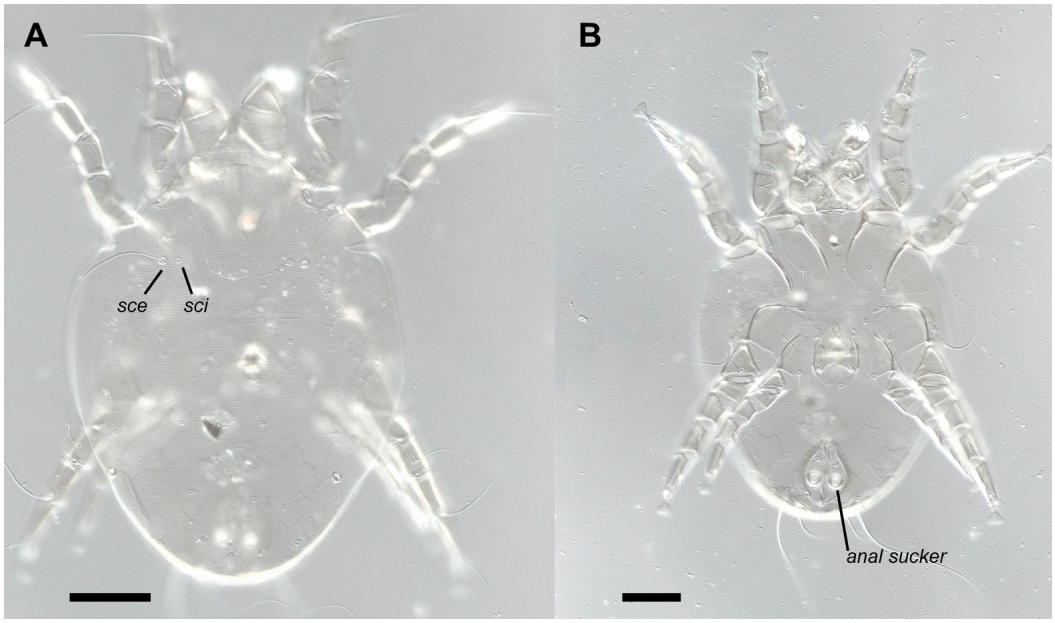

FIGURE 4. *Dermatophagoides farinae* male, (A) Dorsal view (B) Ventral view. Scale bars = 10 mm.

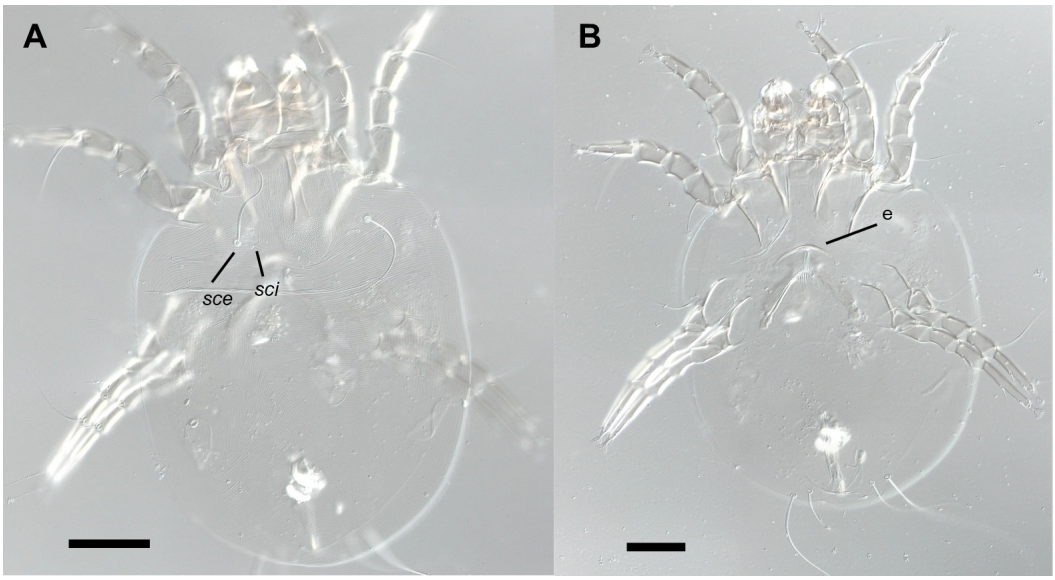

FIGURE 5. *Dermatophagoides farinae* female, (A) Dorsal view (B) Ventral view. Scale bars = 10 mm.

Family Acaridae

***Aleuroglyphus chinensis* Jiang, 1994: page 118** (Figures 7–9)

Habitats in this study: Chicken, and cricket feed.

Material examined: Males, females collected by N. Ta-Phaisach on chicken feed at animal feed shop, Huai O Sub-district, Long District, Phrae Province, Thailand, on July 7, 2021(PRE-LON010).

Downloaded From: https://complete.bioone.org/journals/Systematic-and-Applied-Acarology on 01 May 2025
Terms of Use: https://complete.bioone.org/terms-of-use

Cricket feed at animal feed shop, Yang Noeng Sub-district, Saraphi District, Chiang Mai Province, Thailand, on July 13, 2021 (CMI-SRP001). Collection localities are shown in Figure 1D. All deposited in Department of Agriculture's mite collection (Ministry of Agriculture and Cooperatives, Bangkok, Thailand).

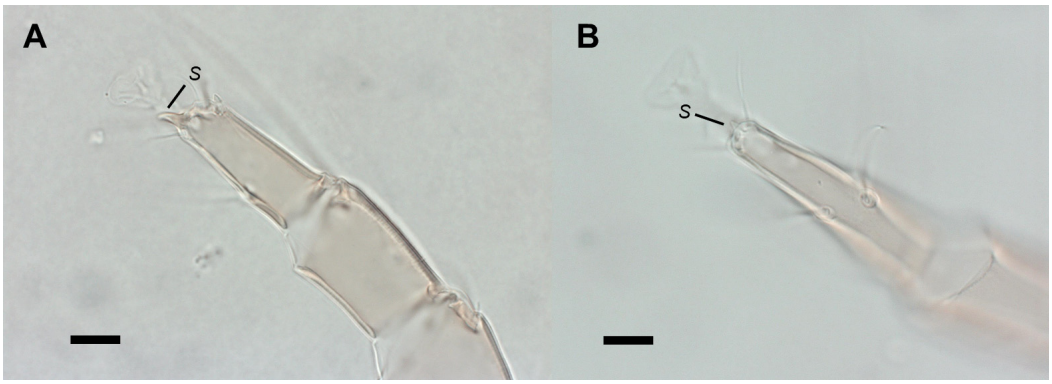

FIGURE 6. *Dermatophagoides farinae* process *S*, (A) On tarsus I of the female (B) On tarsus II of the male. Scale bars = 10 mm.

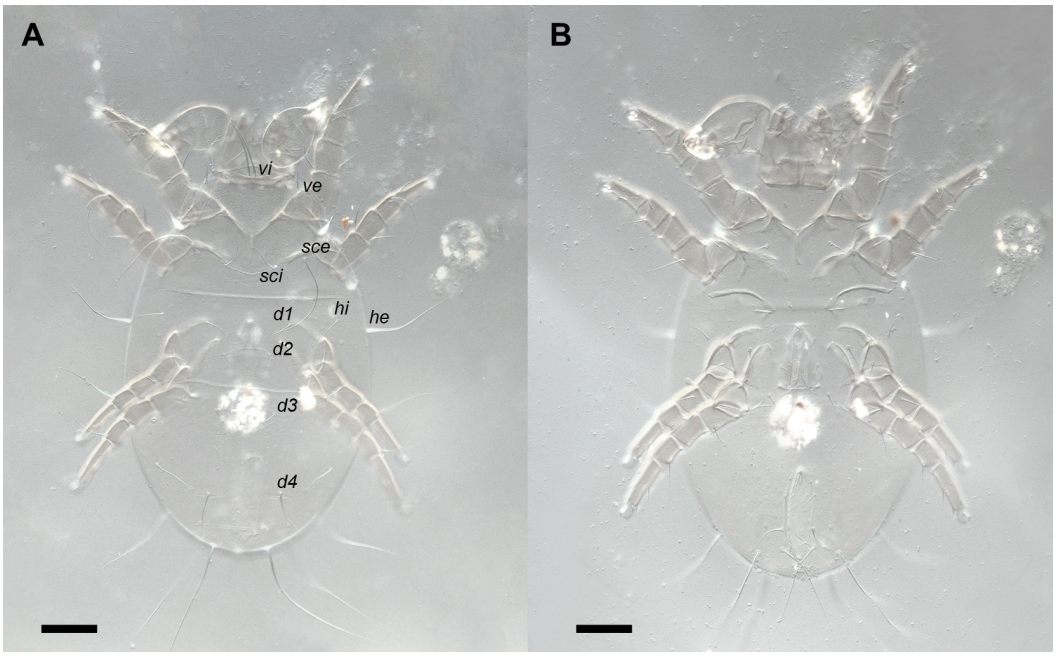

FIGURE 7. *Aleuroglyphus chinensis* female, (A) Dorsal view (B) Ventral view. Scale bars = 10 mm.

Remarks: *Aleuroglyphus chinensis* is a storage mite, and this is the first record of it in Thailand on chicken and cricket feeds in Huai O Sub-district, Long District, Phrae Province; and Yang Noeng Sub-district, Saraphi District, Chiang Mai Province. *Aleuroglyphus chinensis* is not economically important in any commodities. Moreover, the number of mites found was very small.

Downloaded From: https://complete.bioone.org/journals/Systematic-and-Applied-Acarology on 01 May 2025
Terms of Use: https://complete.bioone.org/terms-of-use

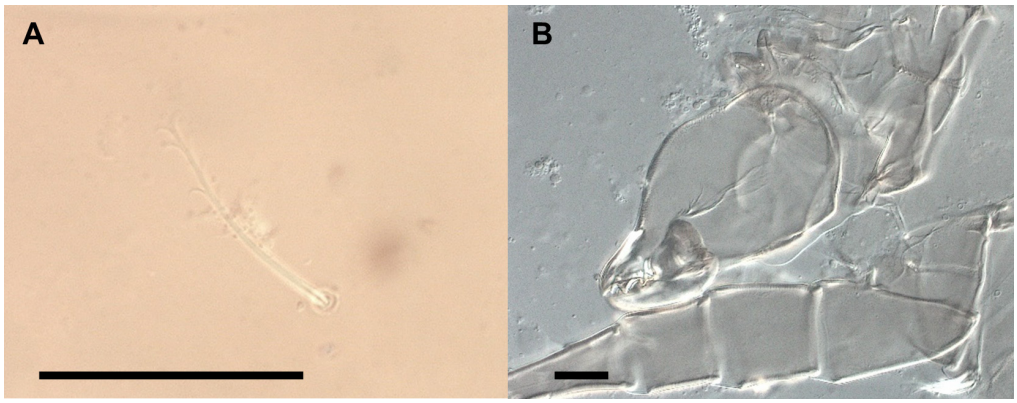

FIGURE 8. *Aleuroglyphus chinensis* female, (A) A *d1* setae of dorsal view (B) Chelicera. Scale bars = 10 mm.

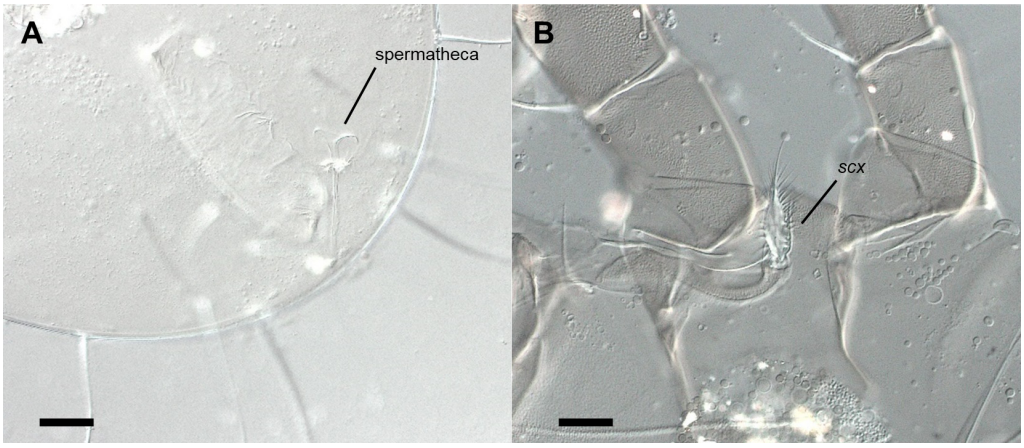

FIGURE 9. *Aleuroglyphus chinensis* female (A) Spermatheca (B) Supracoxal seta (*scx*). Scale bars = 10 mm.

Predatory mites
Family Cheyletidae

***Cheyletus malaccensis* Oudemans, 1903: page 84** (Figure 10)

Habitats in this study: Dust near exhaust fan, crayfish, chicken, and egg-laying chicken feeds, and maize.

Material examined: Males, females collected by N. Ta-Phaisach on dust nearby exhaust fan at chicken farm, Maefeak Sub-district, Sansai District, Chiang Mai Province, Thailand, on February 11, 2021 (CMI-SS001). Crayfish feed at animal feed shop, Thasala Sub-district, Mueang Chiang Mai District, Chiang Mai Province, Thailand, on February 12, 2021 (CMI-MCM001). Chicken feed at animal feed shop, On Nuea Sub-district, Mae On District, Chiang Mai Province, Thailand, on April 29, 2021 (CMI-MO001). Egg-laying chicken feed at Khuang Pao Sub-district, Chom Thong District, Chiang Mai Province, Thailand, on May 16, 2021 (CMI-CT007). Maize at animal feed shop, Huai O Sub-district, Long District, Phare Province, Thailand, on July 12, 2021 (PRE-LON012). Chicken feed and maize at animal feed shop, Na Chak Sub-district, Mueang Phrae District, Phare Province, Thailand, on July 13, 2021 (PRE-MPR003, 005). Collection localities are shown in Figure 1E. All deposited in Department of Agriculture's mite collection (Ministry of Agriculture and Cooperatives, Bangkok, Thailand).

Downloaded From: https://complete.bioone.org/journals/Systematic-and-Applied-Acarology on 01 May 2025
Terms of Use: https://complete.bioone.org/terms-of-use

Remarks: *Cheyletus malaccensis*, a predatory mite, is discovered on crayfish, chicken, egg-laying chicken feeds and maize in Thailand for the first time. Moreover, *C. malaccensis* was found in dust near an exhaust fan on a chicken farm. Males of *C. malaccensis* has two dissimilar homomorphic and heteromorphic forms.

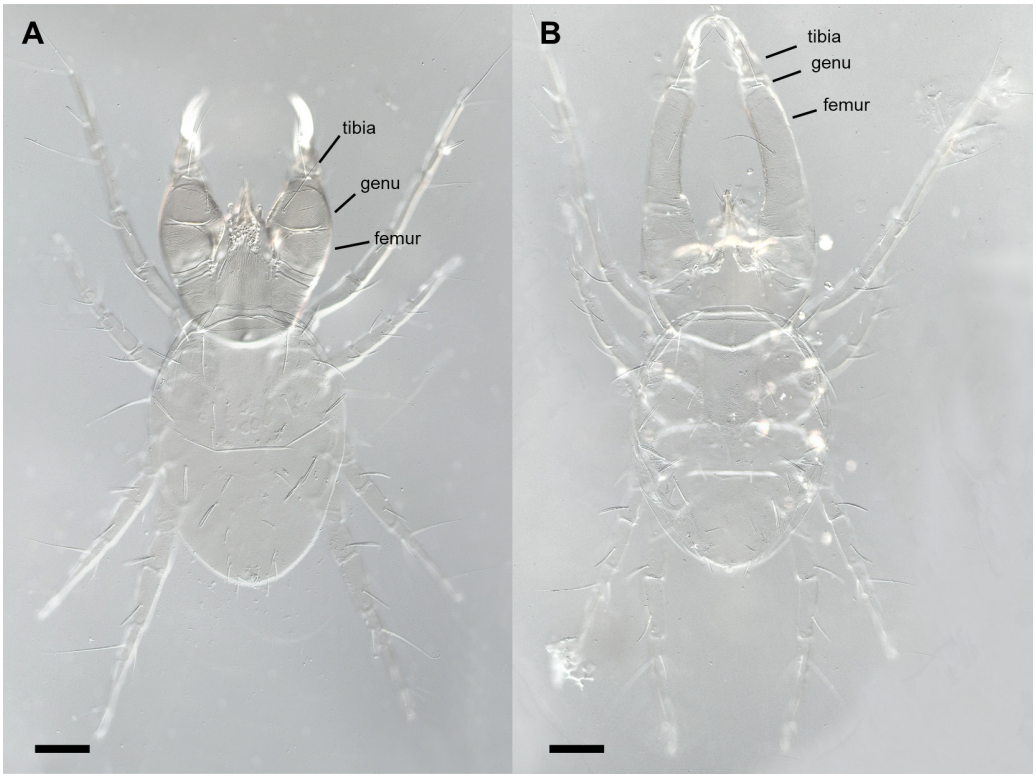

FIGURE 10. *Cheyletus malaccensis* male dorsal view (A) Homomorphic form (B) Heteromorphic form. Scale bars = 10 mm.

Family Blattisociidae

***Blattisocius keegani* Fox, 1947: page 599** (Figure 11)

Habitats in this study: Egg-laying chicken, chicken, swine, and duck feeds.

Material examined: Males, females collected by N. Ta-Phaisach on egg-laying chicken at animal feed shop, Thung Satok Sub-district, San Pa Tong District, Ching Mai Province, Thailand, on May 16, 2021 (CMI-SPT007). Chicken and swine feeds at animal feed shop, Huai O Sub-district, Long District, Phrae Province, Thailand, on July 12, 2021 (PRE-LON006-007). Chicken and duck feeds at animal feed shop, Na Chak Sub-district, Mueang Phrae District, Phrae Province, Thailand, on July 13, 2021 (PRE-MPR001, 008). Swine feed at animal feed shop, Tha Wang Thong Sub-district, Mueang Phayao District, Phayao Province, Thailand, on September 09, 2021(PYO-MPY007). Collection localities are shown in Figure 1F. All deposited in Department of Agriculture's mite collection (Ministry of Agriculture and Cooperatives, Bangkok, Thailand).

Remarks: This is the first report of *Blattisocius keegani* in animal feed in Thailand. It was collected from chicken, swine, and duck feed. In this study, *B. keegani* was associated with *B. everti* in chicken feed (CMI-SPT007, PRE-MPR001).

Downloaded From: https://complete.bioone.org/journals/Systematic-and-Applied-Acarology on 01 May 2025
Terms of Use: https://complete.bioone.org/terms-of-use

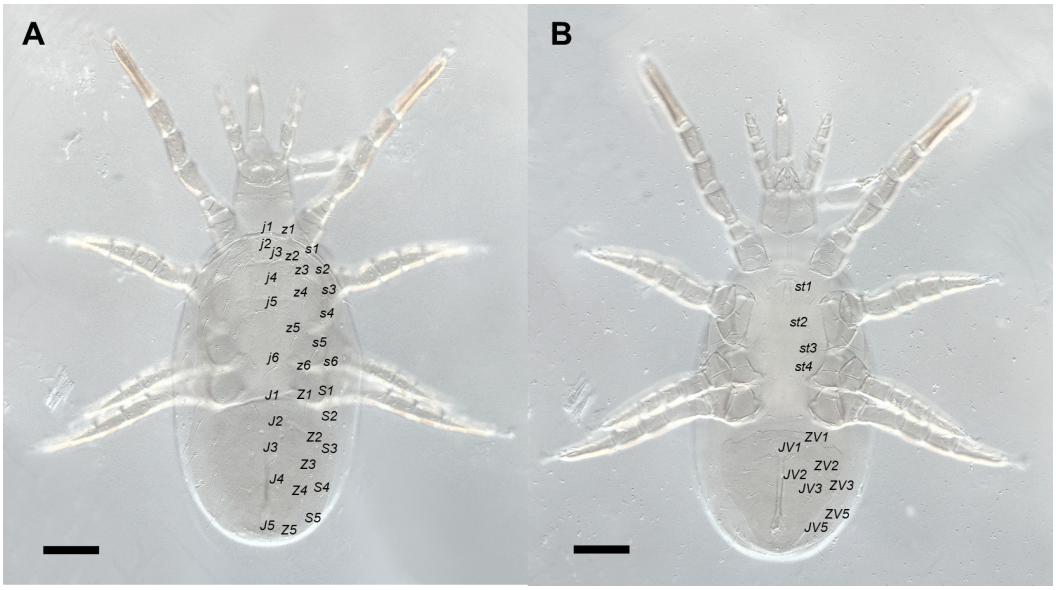

FIGURE 11. *Blattisocius keegani* male (A) Dorsal view (B) Ventral view. Scale bars = 10 mm.

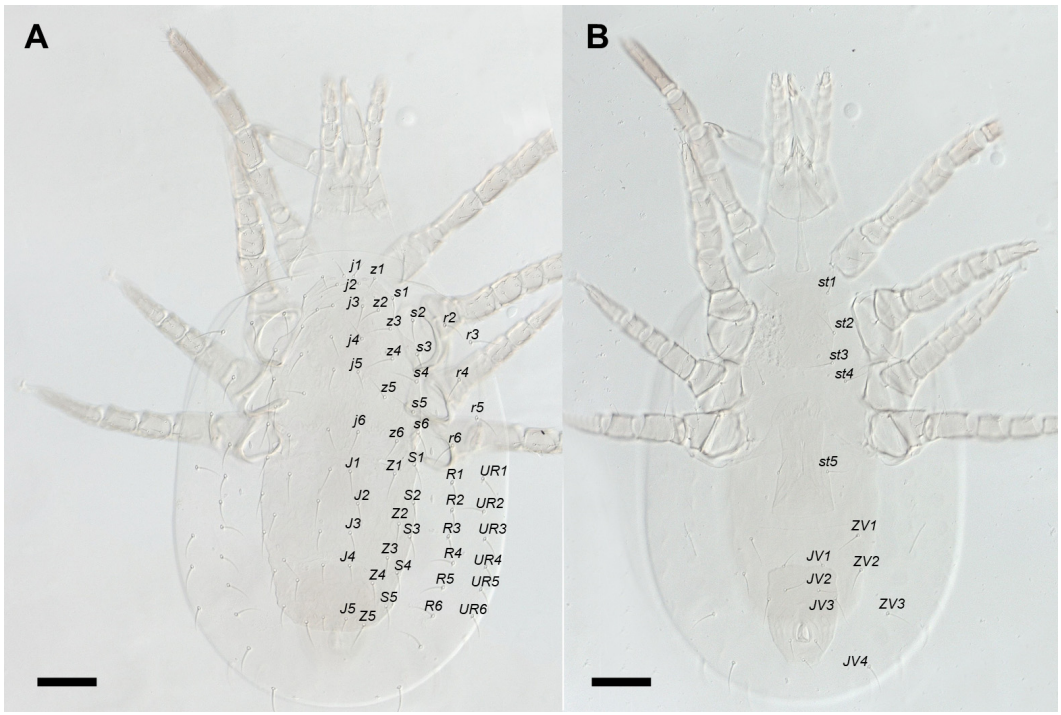

FIGURE 12. *Blattisocius everti* female (A) Dorsal view (B) Ventral view. Scale bars = 10 mm.

***Blattisocius everti* Britto, Lopes & De Moraes, 2012: page 35** (Figure 12)

Habitats in this study: Egg-laying chicken, and chicken feeds.

Downloaded From: https://complete.bioone.org/journals/Systematic-and-Applied-Acarology on 01 May 2025
Terms of Use: https://complete.bioone.org/terms-of-use

Material examined: Males, females collected by N. Ta-Phaisach on chicken feed at animal feed shop, Thung Satok Sub-district, San Pa Tong District, Chiang Mai Province, Thailand, on May 16, 2021 (CMI-SPT007). Chicken feed at animal feed shop, Khuang Pao Sub-district, Chom Tong District, Chiang Mai Province, Thailand, on May 16, 2021 (CMI-CT007). Chicken feed at animal feed shop, Doi Lo Sub-district, Doi Lo District, Chiang Mai Province, Thailand, on May 16, 2021 (CMI-DL003). Chicken feed at animal feed shop, Na Chak Sub-district, Mueang Phare District, Phare Province, Thailand, on July 13, 2021 (PRE-MPR001). Collection localities are shown in Figure 1G. All deposited in Department of Agriculture's mite collection (Ministry of Agriculture and Cooperatives, Bangkok, Thailand).

Remarks: The specimens of *Blattisocius everti* collected resembles the description of Britto *et al.* (2012) in all respects. This is a first recorded for Thailand and it was found in association with *C. malaccensis* and *B. keegani* in chicken feed (CMI-CT007 and CMI-SPT007, PRE-MPR001, respectively).

Infestation rates of mites in different animal feeds and processing methods

High mite infestation rates were observed in chicken feed (42.9%), followed by swine feed (26.7%) (Table 2). No mites were observed in fish and frog feeds. Sample sizes of duck feed, dog feed, cat feed, crayfish feed, cricket feed, rabbit feed, and maize were too small for comparison (n < 5). This result showed that mite infestation rates were different among feeds of different target animals. Among all samples (n =132), the most common mite species was *S. pontifica* (21.2%), followed *C. malaccensis* and *B. keegani* (4.5%), *B. everti* (3.0%), *A. chinensis* (1.5%), *D. farina* and nymphs of Glycyphagidae (1.8%). In chicken feeds (n = 56), the most common mite species was *S. pontifica* (32.1%), followed by *B. everti* (7.1%), *C. malaccensis* and *B. keegani* (5.4%), and *A. chinensis* and mites of Glycyphagidae (1.8%). In pig feeds (n = 30), the most common mite species was *S. pontifica* (26.7%), followed by *B. keegani* (6.7%). Moreover, *S. pontifica* was dominant in chicken feed and pig feed.

TABLE 2. Types of animal feeds and processing conditions with storage mite infestations.

Types of animal feed	Feed-processing Methods [a]	No. of samples examined	Occurrence of mite species[b] (Infestation rate, %)							
			SP	AC	DF	CM	BK	BE	FG	Total
Chicken feed	Pelleted feed	56	18 (32.1)	1 (1.8)	0 (0.0)	3 (5.4)	3 (5.4)	4 (7.1)	1 (1.8)	24 (42.9)
Duck feed	Pelleted feed	2	2 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (50.0)	0 (0.0)	0 (0.0)	2 (100.0)
Pig feed	Pelleted feed	30	8 (26.7)	0 (0.0)	0 (0.0)	0 (0.0)	2 (6.7)	0 (0.0)	0 (0.0)	8 (26.7)
Fish feed	Extruded feed	23	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Frog feed	Extruded feed	8	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Dog feed	Extruded feed	1	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Cat feed	Extruded feed	1	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Crayfish feed	Pelleted feed	3	0 (0.0)	0 (0.0)	1 (33.3)	1 (33.3)	0 (0.0)	0 (0.0)	0 (0.0)	1 (33.3)
Cricket feed	Pelleted feed	1	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)
Rabbit feed	Pelleted feed	4	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Maize	Raw material	3	0 (0.0)	0 (0.0)	0 (0.0)	2 (66.7)	0 (0.0)	0 (0.0)	0 (0.0)	2 (66.7)
Total		132	28 (21.2)	2 (1.5)	1 (0.8)	6 (4.5)	6 (4.5)	4 (3.0)	1 (0.8)	38 (28.8)

[a] feed-processing methods are defined based on the morphology of feed particles and information on packages of feeds.

[b] mite species: SP, *Suidasia pontifica*; AC, *Aleuroglyphus chinensis*; DF, *Dermatophagoides farinae*; CM, *Cheyletus malaccensis*; BK, *Blattisocius keegani*; BE, *Blattisocius everti*; FG, nymphs of mite in Family Glycyphagidae.

Downloaded From: https://complete.bioone.org/journals/Systematic-and-Applied-Acarology on 01 May 2025
Terms of Use: https://complete.bioone.org/terms-of-use

In this study, we found that mite infestations were common in pelleted feeds (n = 96) and raw materials (n = 3), and they were never observed in extruded feeds (n = 33), indicating that feed-processing methods affect the mite infestation rates.

Key to species of storage and predatory mites presented on animal feed in northern Thailand (modified from Hughes (1976), Jiang (1994), Krantz & Walter (2009), Britto *et al*. (2012), Fan & George (2012), and Salarzehi *et al*. (2018))

1a Stigma present, situated posterior to coxa II; coxa not fused to idiosoma; tarsus I subterminally bearing a cluster of solenidia and setae . . . . . **Parasitiformes: Mesostigmata: Blattisocidae** 2

1b Stigma, if present, situated anterior to the level of coxa II; coxa fused to idiosoma; tarsus I without a cluster of solenidia and setae . . . . . **Acariformes** 3

2a Chelicera with movable and fixed digits of similar lengths; seta *s2* inserted on unsclerotized cuticle (Figure 12). . . . . ***Blattisocius everti* Britto, Loes and Moraes**

2b Chelicera with movable digit much longer than fixed digit; setae *s2* on dorsal shield (Figure 11) . . . . . ***Blattisocius keegani* Fox**

3a Opisthosomal glands present; stigma absent; fixed and movable digit of chelicerae usually symmetric; subcapitulum with rutella or pseudorutellum; palp without thumb-claw structure . . . . . **Sarcoptiformes** 4

3b Opisthosomal glands absent; stigma usually present, on chelicerae or anterior prodorsum; fixed digits of chelicerae usually reduced; subcapitulum without rutella; palp usually with a thumb-claw structure . . . . . **Trombidiformes: Prostigmata**

Cheliceral stylophore fused to subcapitulum to form a gnathosomatic capsule; peritremes elaborated on dorsal surface of capsule; genu I with solenidion; palptibial claw present and well developed . . . . . **Cheyletidae**

Peritreme M-shaped on gnathosoma; well-developed palpi and thumb-claw complex; dorsal shields without median setae; femur IV with one seta; propodosomal shield 1.5 times or more, longer than hysterotomal shield. Distance between these shields and length of setae l1 almost subequal. Setae 12 situated almost on anterior margin of hysterosomal shield (Figure 10). . . . . ***Cheyletus malaccensis* Oudemans**

4a Without vertical setae in either sex. On tarsus I, omega1 reach to the distal end of this segment . . . . . **Pyroglyphidae**

Setae *Sce* long, much longer than *Sci* (Figure 5), the striae between *d2* and *d3* setae transverse; process *S* on tarsus I of the female large. In the male, *S* present as finger-like process on tarsus II (Figure 6) . . . . . ***Dermatophagoides farinae* Hughes**

4b With vertical setae in both sexes. On tarsus I, omega[1] arises from the base of the segment 5

5a Idiosomal cuticle with scaled-like wrinkles; all setae smooth . . . . . **Suidasiidae**

Setae *he* about the same length as *hi*; large flat anal suckers present in the male (Figure 2). . . . . ***Suidasia pontifica* Oudemans**

5b Idiosomal cuticle smooth; at least some setae barbed . . . . . **Acaridae**

The anal opening with five pairs of anal setae in females, the penis itself tapers turnea, on the tarsus the dorsal terminal seta *c* thickened as a spine (Figures 7–9) . . . . . ***Aleuroglyphus chinensis* Jiang**

Discussion

Storage mites are commonly found in animal feed worldwide. For example, in Queensland, Australia, *Tyrophagus putrescentiae* (Schrank) (Acaridae) has been observed (Nayak 2006), and *Acarus siro* Linnaeus (Acaridae) is commonly found in cow and swine feeds (Wilkin & Thind 1983). *Tyrophagus putrescentiae* has also been reported in Thailand infesting imported garlic at the Chiangsan Plant Quarantine Station, Chiang Rai Province (Konvipasruang *et al*. 2009), as well as in households in Kanchanaburi Province (Insung & Pumnuan 2008). However, these mites have not

Downloaded From: https://complete.bioone.org/journals/Systematic-and-Applied-Acarology on 01 May 2025
Terms of Use: https://complete.bioone.org/terms-of-use

been found in any animal feeds in current study. *Suidasia pontifica* has a scale-like cuticle and a propodosomal shield, which is distinct from the other mites. *Suidasia pontifica* commonly infests commodities stored in tropical countries, including animal feed in Thailand, resulting in significant economic losses for the country's feed industry (Konvipasruang *et al*. 2010a; de Assis *et al.* 2011; Mangoba & Alvinda 2019).

Dermatophagoides farinae is a common species of dust mite found in indoor environments and is a major source of allergens that can cause allergic diseases such as asthma and rhinitis (Li *et al*. 2006). According to Arlian (1992), *D. farinae* is one of the two most common dust mites found in house dust, along with *D. pteronyssinus*. *Dermatophagoides farinae* is known to feed on a variety of organic matter found in household dust, such as skin flakes and dander from humans and pets, as well as fungal spores and pollen (Arlian & Platts-Mills 2001). Studies have shown that *D. farinae* allergens can be found in high levels in the bedding, carpets, and upholstered furniture of homes, and can also be present in school and office environments (Arlian & Platts-Mills 2001). Exposure to *D. farinae* allergens has been linked to the development and exacerbation of asthma and other respiratory allergies, particularly in children (Salo *et al*. 2011). *Aleuroglyphus chinensis* is a species of storage mite that is commonly found in stored food products and animal feed. It is known to cause allergic reactions in humans and animals when ingested or inhaled (Fang & Cui 2009). *Aleuroglyphus ovatus* (Tropeau) (Acaridae) has been found in stored products, wheat, and chicken meal worldwide (Silton *et al*. 1991). *Aleuroglyphus chinensis* differs from *A. ovatus* by the following characters mentioned by Jiang (1994): the anal opening is bordered by five pairs of anal setae in females, the penis itself tapers turnea, the dorsal terminal seta c on tarsus is a thick spine.

In this study, we identified three species of predatory mites: *C. malaccensis*, *B. keegani*, and *B. everti*. The genus *Cheyletus* is known to be one of the most important in the Cheyletidae family as a predatory mite, and is mostly associated with stored grains, including animal feed and insect eggs. *C. malaccensis* is a dominant cheyletid in storage facilities in tropical regions and is also likely to be found in temperate regions (Athanassiou & Palyvos 2015). *Cheyletus malaccensis* has been found to be associated with other predatory mites, such as *Blattisocius* spp. (Mesostigmata: Blattisociidae) (Athanassiou & Palyvos 2015). In Thailand, *C. malaccensis* has been found in white sesame seed and rice, onion, garlic, sunflower seed, paddy, dried fish, and dust in rice storage (Konvipasruang *et al*. 2010a; Konvipasruang *et al*. 2010b).

The high infestation rates of *S. pontifica* in chicken feeds are consistent with the findings of Konvipasruang *et al*. (2010b), which showed that *S. pontifica* are commonly found in animal feed in Thailand. These mites are difficult to see with the naked eye but can exist in such large numbers that they cause movement on the surface of animal feed packaging and surrounding shelves. Based on our results, *S. pontifica* could be the major species that causes a tan-colored dust that covers the packaging and emits the offensive, lemongrass-like odor that reduces feed palatability and ultimately results in decreased animal growth rates in Thailand (Saensuwan & Chanbang 2017).

Various types of commercial animal feeds come in different physical forms due to the required processing methods and steam conditioning temperatures. Pelleted feeds, also known as sinking feeds, are manufactured for chickens (Massuquetto *et al*. 2019), ducks (Heuser & Scott 1951), pigs (Potter *et al*. 2009), crickets (Hanboonsong & Durst 2020), crayfish (Rout & Bandyopadhyay 1999), and rabbits (Prayoga *et al*. 2020). To form a pellet, moisture, heat, and pressure are required during the manufacturing process. This includes grinding, mixing, steam-pelleting, cooling, and crumbing. Steam is typically added to the ground feed mixture to raise the moisture level from 15 to 16% and the temperature from 70 to 85°C. The feed mixture is then conditioned in barrels for 30 to 60 seconds (Li *et al*. 2006). Extruded feeds, also known as floating feeds, are usually manufactured for fish (Hoyos-Concha *et al*. 2021), aquatic animals, cats (Dodd *et al*. 2021), and dogs (DeBoer & Schreiner

Downloaded From: https://complete.bioone.org/journals/Systematic-and-Applied-Acarology on 01 May 2025
Terms of Use: https://complete.bioone.org/terms-of-use

2001). In the extrusion process, the extruder barrel temperature generally ranges from 120 to 150°C (Li *et al*. 2006) and takes around 30 minutes.

A related report from the USA indicates that there is no evidence of mite contamination in commercial dry dog food during manufacturing or storage (DeBoer & Schreiner 2001). Another study conducted in Germany also reported no storage mite infestation in dry pet food after opening food bags (Henneveld *et al*. 2007), which implied that mites are generally absent in extruded feeds.

Evidence suggests that heat treatment of household dust mite, *Dermatophagoides farinae*, at 40 to 80°C for 30 minutes, can cause high mortalities of mites (Chang *et al*. 1998). Therefore, if mites can be exposed directly to high temperatures during the producing process of extruded feeds, it may be possible to eliminate mites. High temperatures used in the producing process of extruded feeds could potentially eliminate the risk of mite infestations in animal feeds. This may explain why no mites were found in dog, cat, frog, or fish feeds in this study. However, further research is required to determine how feed-processing methods affect mite infestations.

Acknowledgments

This research was funded by the Agricultural Research Development Agency (Public Organization) for funding the Ph.D. Scholarship to Naphacharakorn Ta-Phaisach, ARDA's Selective Scholarship of the Celebrations on the Auspicious Occasion of His Majesty the King's 70th Birthday Anniversary of Ph.D. Degree Scholarship Project Doctoral Studies in Thailand (HRD6401027).The authors thank the Postharvest Technology Innovation Center, Science, Research and Innovation Promotion and Utilization Division, Office of the Ministry of Higher Education, Science, Research and Innovation for supporting this work. We would like to express appreciation to Dr. Zhi-Qiang Zhang (The School of Biological Sciences, University of Auckland, New Zealand), for providing related publications and Dr. Gilberto José de Moraes (The Department of Entomology and Acarology, University of São Paulo, Brazil), for confirming the mite species. We thank anonymous referees and the Section Editor whose suggestions significantly improved the manuscript.

References

Arlian, L.G. (1992) Water balance and humidity requirements of house dust mite. *Experimental & applied acarology*, 16(1–2), 15–35. https://doi.org/10.1007/BF01201490

Arlian, L.G. & Platts–Mills, T.A. (2001) The biology of dust mites and the remediation of mite allergens in allergic disease. *Journal of Allergy and Clinical Immunology*, 107(3Suppl), S406–S413. https://doi.org/10.1067/mai.2001.113670

Athanassiou, C.G. & Palyvos, N.E. (2015) The Cheyletoidea (Prostigmata), with special reference to the potential of *Cheyletus malaccensis* Oudemans as biological control agent of post-harvest pests. *In*: Carrillo, D., de Moraes, G.J. & Peña, J.E. (Eds.), *Prospects for Biological Control of Plant Feeding Mites and Other Harmful Organisms*. Cham, Switzerland, Springer International Publishing, pp. 241–249.

Britto, E.P.J., Lopes, P.C. & de Moraes, G.J. (2012) *Blattisocius* (Acari, Blattisociidae) species from Brazil, with description of a new species, redescription of *Blattisocius keegani* and a key for the separation of the world species of the genus. *Zootaxa*, 3479(1), 33–51. https://doi.org/10.11646/zootaxa.3479.1.2

Chang, J.C.S., Arlian, L.G., Dippold, J.S., Rapp, C.M. & Vyszenski-Moher, D. (1998) Survival of the house dust mite, *Dermatophagoides farinae*, at high temperatures (40–80°C). *Indoor Air*, 8(1), 34–38. https://doi.org/10.1111/j.1600-0668.1998.t01-3-00005.x

da Silva, R.V.Z., Narita, J.P., Vichitbandha, P., Chandrapatya, A., Konvipasruang, P., Kongchuensin, M. & de

Downloaded From: https://complete.bioone.org/journals/Systematic-and-Applied-Acarology on 01 May 2025
Terms of Use: https://complete.bioone.org/terms-of-use

Moraes, G.J. (2014) Prospection for predatory mites to control coconut pest mites in Thailand, with taxonomic descriptions of collected Mesostigmata (Acari). *Journal of Natural History*, 48(11–12), 699–719. https://doi.org/10.1080/00222933.2013.839842

de Assis, C.P.O., Gondim, M.G.C., Siqueira, H.A.A. & Câmara, C.A.G. (2011) Toxicity of essential oils from plants towards *Tyrophagus putrescentiae* (Schrank) and *Suidasia pontifica* Oudemans (Acari: Astigmata). *Journal of Stored Products Research*, 47(4), 311–315. https://doi.org/10.1016/j.jspr.2011.04.005

DeBoer, D.J. & Schreiner, T.A. (2001) Commercial dry dog food in the north central United States is not contaminated by *Dermatophagoides* house dust mites. *Veterinary Dermatology*, 12(4), 183–187. https://doi.org/10.1046/j.0959-4493.2001.00248.x

Dizlek, H., Karagoz, M., Faraji, F. & Cakmak, I. (2019) Mites in dried figs of Turkey: diversity, species composition and density. *Systematic & Applied Acarology*, 24(6), 992–997. https://doi.org/10.11158/saa.24.6.4

Dodd, S.A.S., Shoveller, A.K., Fascetti, A.J., Yu, Z.Z., Ma, D.W.L. & Verbrugghe, A. (2021) A comparison of key essential nutrients in commercial plant-based pet foods sold in Canada to American and European canine and feline dietary recommendations. *Animals*, 11, 2348. https://doi.org/10.3390/ani11082348

Ernieenor, F.C.L., Ernna, G., Jafson, A.S. & Mariana, A. (2018) PCR identification and phylogenetic analysis of the medically important dust mite *Suidasia medanensis* (Acari: Suidasiidae) in Malaysia. *Experimental and Applied Acarology*, 76, 99–107. https://doi.org/10.1007/s10493-018-0285-4

Fan, Q.H. & George, S. (2012) *Keys to higher taxa and commonly intercepted families of mites (Acari)*. Plant health & Environment Laboratory, MPI, New Zealand.

Fan, Q.H. & Zhang, Z.Q. (2004) *Revision of* Rhizoglyphus *Claparède (Acari: Acaridae) of Australasia and Oceania*. Systematic and Applied Acarology Society, London, 374 pp.

Fan, Q.H. & Zhang, Z.Q. (2005) *Raphignathoidea (Acari: Prostigmata)*. Fauna of New Zealand 52. Lincoln, Mannaki Whenua Press, 400 pp.

Fan, Q.H. & Zhang, Z.Q. (2007) Tyrophagus *(Acari: Astigmata: Acaridae)*. Fauna of New Zealand 56. Lincoln, Mannaki Whenua Press, 291 pp.

Fang, W. & Cui, Y.B. (2009) A survey of stored product mites of traditional Chinese medicinal materials. *The Pan-Pacific Entomologist*, 85(4), 174–181. https://doi.org/10.3956/2007-42.1

Fox, I. (1947) Seven new mites from rats in Puerto Rico. *Annals Entomological Society of America*, 40, 598–603. https://doi.org/10.1093/aesa/40.4.598

Hanboonsong, A. & Durst, P. (2020) Guidance on sustainable cricket farming-A practical manual for farmers and inspectors. Available from https://ags.kku.ac.th/th/wp-content/uploads/2020/12/FAO-releases-a-comprehensive-guide-to-sustainable-cricket farming.pdf. (Accessed 11 October 2022).

Henneveld, K., Beck, W. & Müller, R. (2007) Evaluation of storage mites in commercial dry dog food and in the environment as well as their importance in veterinary medicine. *Tierärztliche Praxis*, 35, 325–332. https://doi.org/10.1055/s-0038-1622643

Heuser, G.F. & Scott, M.L. (1951) Studies in duck nutrition: 1. Methods of feeding. *Poultry Science*, 30(2), 161–163. https://doi.org/10.3382/ps.0300161

Hoy, M.A. (2011) *Agricultural Acarology: Introduction to Integrated Mite Management*. Boca Raton, Florida, CRC Press, 430 pp.

Hoyos-Concha, J.L., Villada-Castillo, H.S., Fernández-Quintero, A. & Ortega-Toro, R. (2021) Reological study of an extruded fish diet with the addition of hydrolyzed protein flour. *Applied Sciences*, 11, 8105. https://doi.org/10.3390/app11178105

Hubert, J. (2012) *The Pest Importance of Stored Product Mites (Acari: Acaridida)*. Nova Science Publishers Inc, 54 pp.

Hubert, J., Stejskal, V., Mumzber, gová, Z., Kubátová, A., Vánová, M. & Zd'árková, E. (2004) Mites and fungi in heavily infested stored in the Czech Republic. *Journal of Economic Entomology*, 97, 2144–2153. https://doi.org/10.1093/jee/97.6.2144

Hughes, A.M. (1961) *The Mites of Stored Food*. Ministry of Agriculture, Fisheries and Food. London, Her Majesty's Stationary Office, London, UK, 194 pp.

Downloaded From: https://complete.bioone.org/journals/Systematic-and-Applied-Acarology on 01 May 2025
Terms of Use: https://complete.bioone.org/terms-of-use

Hughes, A.M. (1976) *The Mites of Stored Food and Houses* (2nd edition). Her Majesty's Stationary Office, London, UK, 400 pp.
Insung, A. & Pumnuan, J. (2008) Species diversity of house dust mites in Amphur Thong Pha Phum, Kanchanaburi province. *Entomology and zoology gazette*, 26(1), 11–23. (in Thai)
Jiang, Z. (1994) A new species and a genus and species newly recorded of the family Acaridae from China (Acari: Acaroidea). *Jiangxi Science*, 12(2), 118–122. (in Chinese)
Konvipasruang, P., Kongchuensin, M. & Kulpiyawat, T. (2010a) Taxonomic study on storage mite pest in Thailand. *In*: *Plant Protection Research and Development Office Annual Report 2010*. Plant protection research and development office, Department of Agriculture, Bangkok, pp. 2047–2082. (in Thai)
Konvipasruang, P., Pumnuan, J. & Insung, A. (2010b) Species diversity of stored product mite in Central Thailand. *Entomology and Zoology Gazette*, 28(2), 10–18. (in Thai)
Konvipasruang, P., Kongchuensin, M. & Chaowattanawong, P. (2009) Study on mites pest on imported onion and garlic from China. *In*: *Plant protection research and development office annual report 2009*. Plant protection research and development office, Department of Agriculture, Bangkok, pp. 932–944. (in Thai)
Krantz, G.W. & Walter, D.E. (2009) *A Manual of Acarology Third Edition*. Texas, Lubbock, Texas tech university press, 807 pp.
Li, H.H., Lim, C.E. & Webster, C.D. (2006) Feed formulation and manufacture. *In*: Lim, C.E. & Webster, C.D. (Eds.), *Tilapia: biology, culture, and nutrition*, Food products press, pp. 517–545.
Mangoba, M.A.A. & Alvindia, D.G. (2019) Response of *Suidasia pontifica* (Acaridida: Suidasiidae) to phosphine fumigation. *Experimental and Applied Acarology*, 79, 377–386. https://doi.org/10.1007/s10493-019-00433-w
Massuquetto, A., Panisson, J.C., Marx, F.O., Surek, D., Krabbe, E.L. & Maiorka, A. (2019) Effect of pelleting and different feeding programs on growth performance, carcass yield, and nutrient digestibility in broiler chickens. *Poultry Science*, 98(11), 5497–5503. https://doi.org/10.3382/ps/pez176
Nayak, M.K. (2006) Management of mould mite *Tyrophagus putrescentiae* (Schrank) (Acarina: Acaridae): a case study in stored animal feed. *International Journal of Pest Management*, 48, 128–130.
Ngu, M.A.V., Bergantin, J.H. & Ramos, J.D.A. (2019) Development of a gold nanoparticle-labeled sandwich format lateral flow immunoassay kit for the detection of tropical house dust mite *Suidaisa pontifica*. *Protein & Peptide Letters*, 26(5), 357–363. https://doi.org/10.2174/0929866526666190212164751
Oudemans, A.C. (1903) Acarologische aanteekeningen, VI. *Entomologische Berichten*, 1, 83–88.
Oudemans, A.C. (1905) Acarologische aanteekeningen, XV. *Entomologische Berichten*, 1, 207–212. https://doi.org/10.5962/bhl.part.1124
Potter, M.L., Dritz, S.S., Tokach, M.D., DeRouchey, J.M., Goodband, R.D. & Nelssen, J.L. (2009) Effects of meal or pellet diet form on finishing pig performance and carcass characteristics. *Kansas Agricultural Experiment Station Research Reports*, 0(10), 245–251. https://doi.org/10.4148/2378-5977.6789
Prayoga, J., Astuti, A. & Kurniawati, A. (2020) Physical and chemical characteristics of rabbit complete pellet feed containing different level of Leucaena leaf meal. *IOP Conference Series: Earth and Environmental Science*, 425, 012088. https://doi.org/10.1088/1755-1315/425/1/012088
Regev, S. (1974) Morphological and genetic evaluation of male polymorphism in *Cheyletus malaccensis* (Cheyletidae: Acarina). *Acarologia*, 16(1), 85–93.
Research & Markets (2020) Thailand animal feed market – forecasts from 2020-2025. Available from https://www.researchandmarkets.com/reports/5125121/thailand-animal-feedmarket-foreasts-from-2020 (Accessed 4 March 2021).
Rout, R.K. & Bandyopadhyay, S.A. (1999) Comparative study of shrimp feed pellets processed through cooking extruder and meat mincer. *Aquacultural Engineering*, 19(2), 71–79. https://doi.org/10.1016/S0144-8609(98)00034-X
Saensuwan, S. & Chanbang, Y. (2017) Control of *Suidasia pontifica* using heat and formaldehyde incorporated with propionic acid in swine feed. *Journal of Agriculture*, 33(1), 39–47. (in Thai)
Salarzehi, S., Hajizadeh, J. & Ueckermann, E.A. (2018) A new species of *Cheyletus* Latreille (Prostigmata: Cheyletidae) from Iran and a key to the Iranian species. *Acarologia*, 58(3), 640–646. https://doi.org/10.24349/acarologia/20184260

Downloaded From: https://complete.bioone.org/journals/Systematic-and-Applied-Acarology on 01 May 2025
Terms of Use: https://complete.bioone.org/terms-of-use

Salo, P.M., Calatroni, A., Gergen, P.J., Hoppin, J.A., Sever, M.L., Jaramillo, R. & Zeldin, D.C. (2011) Allergy-related outcomes in relation to serum IgE: results from the National Health and Nutrition Examination Survey 2005-2006. *Journal of Allergy and Clinical Immunology*, 127(5), 1226–1235. https://doi.org/10.1016/j.jaci.2010.12.1106

Siegert, M.K., Silva, G.L., Toldi, M., Johann, L. & Ferla, N.J. (2018) Assessment on abiotic factors and the presence of storage mites in an animal feed factory. *Systematic & Applied Acarology*, 23(12), 2317–2330. https://doi.org/10.11158/saa.23.12.4

Silton, R.P., Fernández-Caldas, E., Trudeau, W.L., Swanson, M.C. & Lockey, R.F. (1991) Prevalence of specific IgE to the storage mite, *Aleuroglyphus ovatus*. *Journal of Allergy and Clinical Immunology*, 88(4), 595–603. https://doi.org/10.1016/0091-6749(91)90153-F

Tseng, Y.H. (1989) Redescription of *Tyrophagus kentinus* Tseng, *Tyrophagus bambusae* Tseng and *Aleuroglyphagus formosanus* Tseng and describes a new record species *Rhizoglyphus canadii* Manson. *Chinese Journal of Entomology, Special Publication*, 3, 37–50.

Wilkin, D.R. & Thind, B.B. (1983) Stored product mites detection and loss assessment in animal feed. *In*: *Proc. 3rd International Working Conference on stored products entomology*. Kansas State University, Manhattan, USA.

Submitted: 6 May 2023; accepted by Eddie Albert Ueckermann: 29 Sept. 2023; published: 6 Oct. 2023

Downloaded From: https://complete.bioone.org/journals/Systematic-and-Applied-Acarology on 01 May 2025
Terms of Use: https://complete.bioone.org/terms-of-use