



First Report of *Tetranychus truncatus* Ehara (Acari: Tetranychidae) Infesting Groundnut (*Arachis hypogaea* L.) in India through Morphological and Molecular Insight

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ABSTRACT

Background: Red spider mite, *Tetranychus truncatus* Ehara (Acari: Tetranychidae) infests many agriculture and horticulture crops in India, but to date it had not been found damaging cultivated groundnut. During 2022-23, the incidence of this species was high in many groundnut growing regions of Tamil Nadu. Identification of the species is highly essential for effective management of the particular pest. Hence, the aim of this research was to identify the mite species infesting groundnut crop and describe the damage caused.

Methods: Survey was carried out all over Tamil Nadu and samples of mite infested groundnut leaves were collected from field based on damage symptoms, observed and examined under Stereo zoom microscope, microslides were prepared using Hoyer's medium and taxonomic characters were studied under phase contrast microscope. Molecular analysis was done by genomic DNA isolation, PCR amplification, sequencing and BLAST performed to check the identity with GenBank Sequences. ITS2 primer was used.

Result: Red spider mite species, *T. truncatus* was identified first time in groundnut through both morphological characters and molecular tools. Female: Idiosomal setae longer than the interval between their longitudinal bases and gradually tapers distally. Diamond-shaped pattern of striae between e1 and f1 setal bases. Tarsus I with 4 tactile setae proximal to proximal duplex setae. Male: Aedeagus with tiny terminal knob, apparently truncate with a slight indentation on the dorsal margin.

Key words: Groundnut, Identification, Spider mite, Taxonomy, *Tetranychus truncatus*.

Abbreviations: sp.- Species; cx- Coxa; tr- Trochanter; fe- Femur; ge- Genu; ti- Tibia.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) belongs to the family Fabaceae is a leguminous plant that is widely cultivated and valued for its high-oil content and edible seeds. Groundnut is the fourth most important source of edible oil and a third most important source of vegetable protein in the world. Groundnut is not only an important oilseed crop of India, but also an important agricultural export commodity. Globally, Groundnut covers 315 lakh hectares with the production of 536 lakh tonnes with the productivity of 1701 kg per hectare (FAOSTAT, 2021), with annual all-season coverage of 55.71 lakh hectares, globally. India ranks first in Groundnut area under cultivation and is the second largest producer in the world with 102 lakh tonnes with productivity of 1831 kg per hectare during 2020-21.

Several arthropod pests may cause severe loss in the agro-ecosystem reducing the productivity of groundnut (Lourençao *et al.*, 2001; Mound, 2005; Mound and Ng, 2009; Riley *et al.*, 2011; Seeman and Beard, 2011; Biswas and Das, 2011; Biswas, 2014). High infestations of mites, may impair the development and reduce yield of the crop, increase the production costs (Flechtman and Knihinicki, 2002; Mendonça *et al.*, 2011), contribute to the contamination of the environment and affect humans, due to the intensive use of pesticides to control these organisms (Chhillar *et al.*, 2007; Roy *et al.*, 2011; Silva and Gondim Junior, 2016). Among the mites, 31 species of Tetranychidae

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family are associated with groundnut crop, of which 22 belong to the genus *Tetranychus* (Migeon and Dorkeld 2023). The red spider mite, *Tetranychus (cinnabarinus) urticae* was reported as a minor pest in groundnut by Gupta and Sandhu (1969). The two-spotted spider mite, *T. urticae* is a destructive pest of groundnut and considered as the most harmful species in this crop in several countries (Campbell *et al.*, 1974; Johnson *et al.*, 1982; Heagle *et al.*, 1994; Nandagopal and Gedia, 1995; Ashley *et al.*, 2006). Initially, *T. truncatus* was reported on groundnut by Ho *et al.* (1997). In India it has been reported on Morus in Karnataka

(Srinivasa *et al.*, 2012) and on ornamental plants in Kerala (Prakash *et al.*, 2022) but to date as far as reported it has not been found damaging cultivated groundnut. The groundnut plants, on infestation by *T. truncatus* initially exhibit white spots on upper surface of leaves due to feeding by the mites on the lower surface, which turn into chlorotic spots followed by drying of leaves. On severe infestation profuse webbing is formed over the foliage, giving it a carpet like appearance (Plate 1).

MATERIALS AND METHODS

Infested plant parts were collected directly from the groundnut crop based on the symptoms and were examined under LEICA Stereo zoom microscope. Some mites were maintained separately as isoline cultures for the purpose of DNA analysis. Live mite specimens, both adult males and females, were slide mounted separately in Hoyer's medium for microscopic study. The mites were mounted dorsally, ventrally and laterally for clear examination of taxonomic characters. Females (dorsal and ventral) and males (lateral) were also mounted to identify the species. After mounting, the slides were processed by gently warming the slides at 45-50°C for 2-3 days in a hot air oven and then sealed all around and preserved. Measurements and photographs were taken with a Leica DM750 phase contrast microscope equipped with a drawing tube, at 400× or 1000× under differential interference contrast optics (DIC). Morphological terminologies were followed as per Lindquist (1985). The material used for the description is from Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu. Measurements are given in micrometers. Leg setal numbers are written as the total number of setae followed by the number of sensory setae (solenidia + eupathidia) in parentheses.

Molecular characterization of mites

DNA extraction and PCR analysis

The DNA isolation of *T. truncatus* isolines was obtained by using the HotShot method (Montero Pau *et al.*, 2008). Five fresh adult females from the same colony were chosen and placed in a 1.5 ml Eppendorf tube with 20 microliters of alkaline lysis buffer (To prepare 50 ml of alkaline lysis buffer (pH 12), 125 µl of 10N NaOH and 20 µl of 0.5 M Na₂ EDTA (pH 8) were added in 50 ml of ddH₂O). The samples were then crushed for two minutes with a toothpick or micro pestle and kept in hot water at 90°C for 30 minutes. After cooling for 10 minutes at 4°C, an equal volume of neutralizing buffer (To prepare 100 ml of neutralizing lysis buffer (pH 5), 630 mg of Tris- HCL was added in 100 ml of ddH₂O) was added and vortexed. Before being used, these samples were kept in a deep freezer (-80°C).

The PCR amplification

Amplification of ITS2 region was carried out using specific primers. Primer set for the ITS2 region is as follows: forward (5'- ATATGCTTAAATTCAGCGGG-3') and reverse (5'- GGGTCGATGAAGAACGCAGC-3') primers which amplified

the complete ITS2 region. The PCR was performed in a volume of 50 µl (Eppendorf) in the Mastercycler® containing 27 µl 2× Master mix (Takara), 10 µl of Nuclease free water, 7 µl of template DNA and 3 µl of each primer. The mixtures were amplified by the following conditions: an initial denaturation at 94°C for 4 min followed by 35 cycles at 94°C for 1 min and 72°C for 1 min and a final elongation step at 72°C for 1.30 min.

Analysis of DNA samples

The quality of DNA sample was evaluated using a 1 per cent agarose gel. In a microwave, agarose and 1× TAE buffer were combined and melted. Ethidium bromide (5 µl) was added after the liquid had been cooled to 60°C and was gently stirred to prevent the formation of bubbles. The fluid was then poured into the gel mould that contained the comb and left until it set. The gel buffer reservoir in the electrophoresis apparatus was filled with 1× TAE buffer and emptied into the gel electrophoresis tank about 2 mm above the gel surface. The appropriate gel slots were loaded with the contents and electrophoresis was performed at 70 V. The gel was examined and documented using a gel documentation unit after the run (GELSTAN 4× Advanced). PCR products were analyzed by 1% agarose gel electrophoresis and visualized by UV light after staining with ethidium bromide solution in "Gelstan 4X Advanced" system and software gel i.

Sequencing and data analysis

The purified PCR product of the amplified fragment of *T. truncatus* was sequenced at Syngene Private Limited, Tamil Nadu and sequenced through double pass sequencing in both forward and reverse directions. The nucleotide sequence was compared to identify the similarity between them by the Basic Local Alignment Search Tool (BLAST). The MUSCLE algorithm was used to multiple align the ITS2 sequences of tetranychid mites (Edgar, 2004). The multiple alignments were further trimmed to derive a uniform length of alignment at both ends for further phylogenetic tree construction. Pairwise distance among the trimmed ITS2 sequences of tetranychid mites was computed using MEGAX (Tamura *et al.*, 2007). The sequenced ITS2 was confirmed by a sequence similarity search against the nucleotide database (nt) using the BLAST program and it was further submitted into the NCBI GenBank database.

RESULTS AND DISCUSSION

Description

Tetranychus truncatus Ehara, 1956. J. Faculty Sci. Hokkaido Univ. Ser. VI, Zool., 12: 507.

Materials examined (not types) India

5♂♂, TNAU-Coimbatore, Tn-GN-007-011, 09.ix.2023 and 6 ♀♀, TNAU- Coimbatore, Tn-GN-001-006, 09.ix.2023 on *Arachis hypogaea*. The specimens are retained in the Acarology laboratory, Department of Agricultural Entomology, Tamil Nadu Agricultural University Coimbatore, TN, India.

Diagnosis

Female

Body, idiosoma length excluding gnathosoma (v2-f2) 332-370 μm , width (sc2-sc2) 204-289 μm (Plate 2a and 2b). The mites were red in colour (Plate 1).

Dorsum

Idiosomal setae longer than the interval between their longitudinal bases and gradually tapers distally (Plate 3a). Dorsal striae between setae *e1-e1* mixed longitudinal and oblique; dorsal striae between setae *f1-f1* longitudinal; dorsal striae between setae *e1* and *f1* transverse, forming a diamond-shape medially (Plate 3b); ventral striae without lobes; pregenital striae entire, unbroken (Plate 3c). Peritreme hook 27-28 μm long with slightly expanded bulbous tip forming a distinct 'U' shaped (Plate 2e). Dorsal setae of

prodorsum barbed. Opisthosomal setae long, pubescent (except setae *h2*, *h3* thin, smooth. Empodia with 6 proximoventral hairs, empodia I-IV each with a spur ($>2 \mu\text{m}$ long) (Plate 6a); tarsus I with sockets of 4 tactile setae proximal to proximal pair of duplex setae; D^{duplex} 24-26 (Plate 2d); tarsus III with 1 proximal tactile seta.

Gnathosoma (Palp)

Terminal sensillum or spinneret (eupathidion *su* ζ), equal in length and breadth with a pit at tip (Plate 4b) and slightly shorter (5 μm) than both eupathidia *ul'* ζ and *ul''* ζ (6 to 9 μm) (Plate 4c); dorsal sensillum (solenidion ω), slightly taller (6.1 μm) than, terminal sensillum and tapering distally (Plate 4a). Trochanter is glabrous, palpal chaetotaxy is from trochanter to tibia, 0-1 (*dPFe*)-1 (*l'PGe*)-3 (*dPTi*, *l'PTi*, *l''PTi*). The dorsal seta (*dPFe*), on the femur is long and thin.

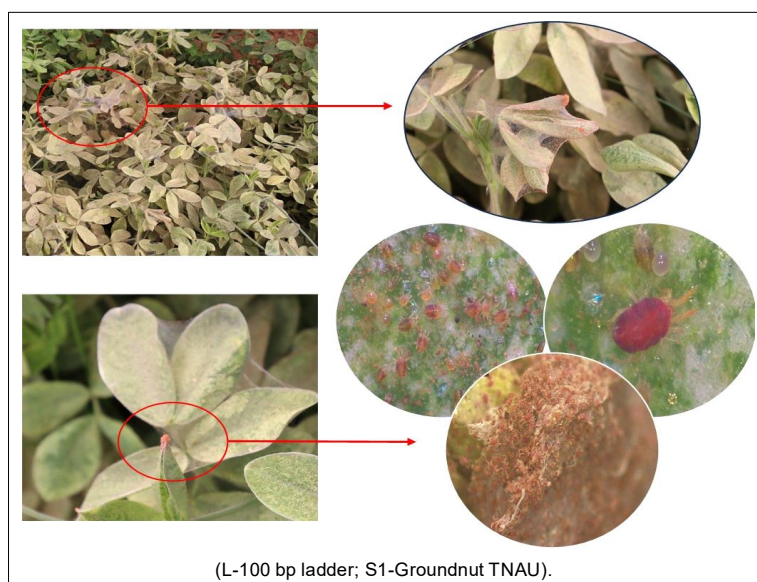


Plate 1: Life stages of *Tetranychus truncatus* on groundnut leaves showing damage symptoms.

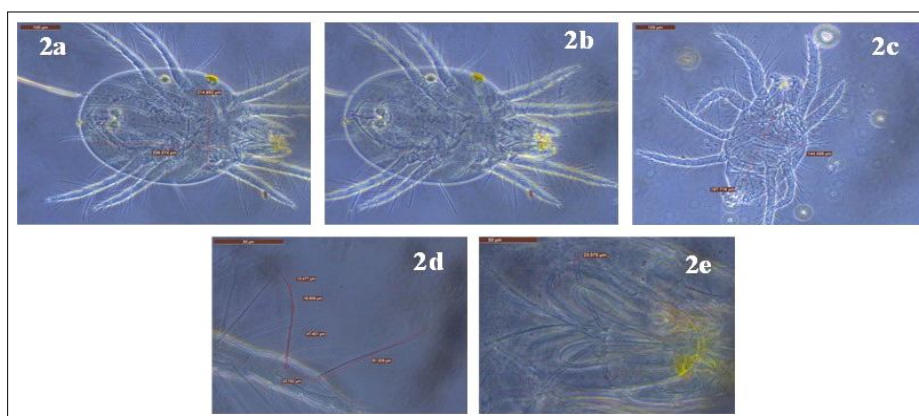


Plate 2: *Tetranychus truncatus* female, dorsal view (2a); ventral view (2b); *Tetranychus truncatus* male, dorsal view (2c); Female, tarsus I, Duplex setae (2d); Female, Peritreme -hooked (2e).

Legs

Setal counts: *cx* 2,2,1,1; *tr* 1,1,1,1; *fe* 10,6,4,4; *ge* 5,5,4,4; *ti* 10,7,6,7; *ta* 18,16,10,10. Tarsus I with two sets of duplex setae (solenidion on proximal 55-63, solenidion on distal 85-93), 1 solenidion, 3 eupathidia and 10 tactile setae; with 4 tactile setae proximal and 1 solenidion adjacent, to proximal duplex setae (Plate 2d).

Male (n=5)

Body, idiosoma length excluding gnathosoma (v2-f2) 197-210 μ m, width (sc2-sc2) 145-156 μ m (Plate 2c). Colour in life red.

Dorsum

Peritreme with hook (length of hook 26-28) and slightly enlarged bulbous tip. Striae on prodorsum finely spaced. Dorsal setae of prodorsum barbed and slender. Opisthosomal setae long and pubescent (except setae *h*2, *h*3 thin, smooth).

Venter

Setae thin, mostly smooth (generally anterior setae smooth, posterior setae barbed).

Gnathosoma (Palp)

Eupathidia (*ul'* ζ , *ul''* ζ) approximately equal in size (Plate 5c and 5d), solenidion ω slightly shorter (Plate 5b). Terminal sensillum or spinneret (eupathidion *su* ζ), twice as long as wide (4.1 in length and 2.7 in width) (Plate 5a). The trochanter is glabrous, palpal chaetotaxy is from trochanter to tibia, 0-1 (*dPFe*)-1 (*l'PGe*)-3 (*dPTi*, *l'PTi*, *l'PTi*). The femoral seta *d* is formed as a short, stout, partly sunken spine-like process exhibiting sexual dimorphism.

Legs

Setal counts: *cx* 2,2,1,1; *tr* 1,1,1,1; *fe* 10,6,4,4; *ge* 5,5,4,4; *ti* 13,7,6,7; *ta* 20,16,11,11. Tarsus I with two sets of duplex setae (proximal solenidion 47-51, distal solenidion 59-61), 3 solenidia, 3 eupathidia and 10 tactile setae; with 4

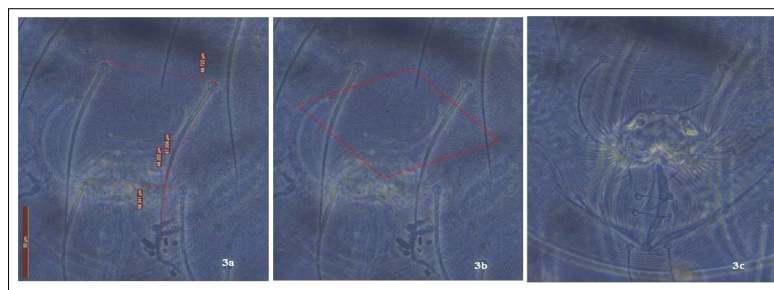


Plate 3: Adult female of *Tetranychus truncatus*, Hyterosomal pattern of adult female with setal measurements of dorsocentral setae *e*1 and *f*1 and distance between their bases (3a); diamond-shaped pattern (3b); Pattern of striae around genital opening of adult female (3c).

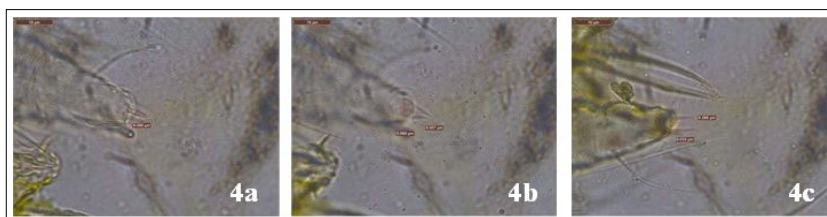


Plate 4: Adult female, *Tetranychus truncatus*, palpal (Solenidion ω , Spinneret *su* ζ and Eupathidia *ul'* ζ and *ul''* ζ) measurements (a-c).

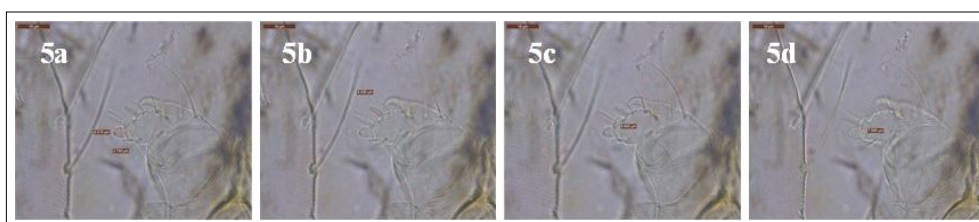


Plate 5: Adult Male, *Tetranychus truncatus*, palpal (Spinneret *su* ζ , Solenidion ω , Eupathidia *ul'* ζ and *ul''* ζ) measurements (a-d).

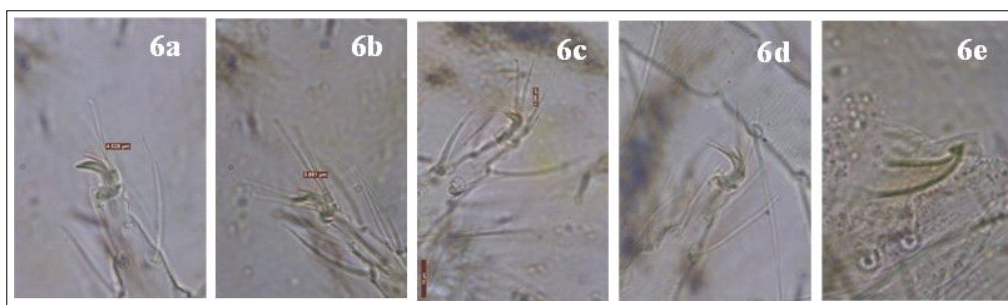


Plate 6: Adult *Tetranychus truncatus*, lateral view of empodium IV Female (a); Male (b); Adult male *Tetranychus truncatus*, lateral view of empodium I (c) and II (d); Male aedeagus (e).

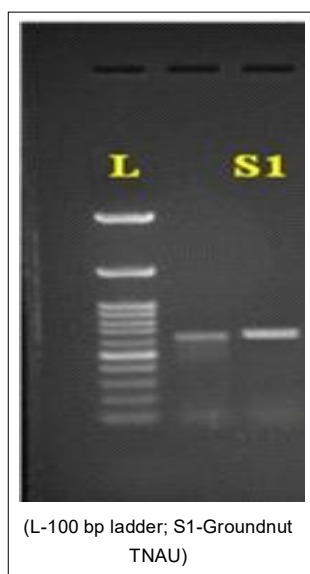


Fig 1: ITS2 amplicon profile of *Tetranychus truncatus* Ehara.

tactile setae and 3 solenidia proximal to proximal set of duplex setae; Empodia I-IV each with obvious dorsal spur 4 µm long; empodia I and II claw-like (uncinate) (Plate 6c and 6d), empodia III and IV each with proximoventral hairs long and free (Plate 6b).

Aedeagus

Aedeagus with terminal knob, anterior and posterior projection short and pointed; flat to slightly convex dorsal surface and a medial indentation (Plate 6e).

Remarks

The infestation was high during the summer months. Symptom of damage caused by *T. truncatus*, is more similar to that of other *Tetranychus* spp. and is hard to differentiate unless proper mounting of the specimens and careful examination of the morphological characters done particularly that of male aedeagus. Reports of *T. truncatus* from North-western Himalayan regions of Jammu and Kashmir and Himachal Pradesh by Rather (1983) claims to

be the first report of this species in India. Despite Gupta and Gupta (1994) stating it could be *T. urticae*, which was known to infest Dahlia. Nearly two decades later, Srinivasa *et al.* (2012) reported *T. truncatus* to infest *Morus* sp. from Karnataka. In Kerala, *T. truncatus* was reported by Bennur *et al.* (2015) on vegetable crops; on cucumber and amaranthus grown in polyhouses by Lenin and Bhaskar, 2016; on cowpea, pumpkin, tapioca, banana and Dahlia by Arunima (2017); on banana (Nendran) by Bhaskar and Lenin, 2018. Recently *T. truncatus* was recorded on marigold, cock's comb and rose from different localities of Thrissur district, Kerala by Prakash *et al.* (2022).

Hosts

Occurrence of *T. truncatus* has been recorded from 104 host plant species, of which major reports have been on *Morus* sp (Migeon and Dorkeld, 2023). In India, reports of incidence and damage has been given by Srinivasa *et al.* (2012) and Prakash *et al.* (2022).

Distribution

Tetranychus truncatus has so far been reported from 14 countries including India viz., Japan, China, Korea, Bangladesh, Indonesia, Philippines, Taiwan, Thailand, Vietnam, Iran, Guam, Burkina Faso and Northern Mariana Is. In India, reports of its occurrence have been claimed from Karnataka and Kerala (Migeon and Dorkeld, 2023).

Molecular characterization of Tetranychid mites

Molecular sequence analysis was performed to supplement the morphological description and taxonomic identity of tetranychid mites based on the sequence information obtained for the Internal Transcribed Spacer region 2 (ITS2). ITS2 gene, the most commonly used species-specific primer, was amplified, yielding an amplicon size of ~620 bp (Fig 1). The PCR products were purified and sequenced. The resulting sequences were searched against GenBank nucleotide database for deriving their annotation using nBLAST program. The results of BLAST analysis showed that *Tetranychus truncatus*, had 99 per cent similarity with GENBANK sequences (Fig 2).

Fig 2: BLASTN analysis of ITS2 sequences of *Tetranychus truncatus*.

CONCLUSION

Red spider mite *Tetranychus truncatus* has been reported on 14 host plants from 104 countries worldwide. In India, reports have been claimed from Karnataka on *Morus* sp. and Kerala on few vegetables and ornamental plants. At present, the incidence of red spider mites on groundnut was found to be severe and identified the species, *T. truncatus* based on morphological characters and molecular tools. The severity of the damage caused and the adaptability of the mite to warm and dry conditions indicate that this species as a potential pest in Tamil Nadu.

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Conflict of interest

There is no conflict of interest pertaining to this study.

REFERENCES

- Arunima, V. (2017). DNA barcoding of spider mites (Prostigmata: Tetranychidae) on major crop plants of Kerala. M.Sc. (Agri.) Thesis. KAU, Thrissur. pp. 59.
- Ashley, J.L., Herbert, D.A., Lewis, E.E., Brewster, C.C. and Huckaba, R. (2006). Toxicity of three acaricides to *Tetranychus urticae* (Tetranychidae: Acari) and *Orius insidiosus* (Anthocoridae: Hemiptera). Journal of Economic Entomology. 99: 54-59.
- Bennur, S., Abida, P.S., Valsala, P.A., Mathew, D. and Bhaskar, H. (2015). DNA barcoding of spider mites (Prostigmata: Tetranychidae) in vegetables using *COI* and *ITS2* markers. Genome. 58(5): 195.

- Bhaskar, H. and Lenin, N. (2018). Management of Banana Leaf Mite, *Tetranychus truncatus* (Prostigmata: Tetranychidae), A New Pest of Banana. Book of Abstracts, National Seminar on Frontiers in Biological Research March 12-14, 2018. Department of Zoology, University of Calicut, Kerala, p.9.
- Biswas, G.C. (2014). Insect pests of groundnut (*Arachis hypogaea* L.), nature of damage and succession with the crop stages. Bangladesh Journal of Agricultural Research. 39(2): 273-282. doi: 10.3329/bjar.v39i2.20429.
- Biswas, G.C. and Das, G.P. (2011). Insect and mite pest's diversity in the oilseed crops ecosystems in Bangladesh. Bangladesh Journal of Zoology. 39: 232-235.
- Campbell, W.V., Batts, R.W., Robertson, R.L. and Emery, D.A. (1974). Suppression of the two spotted spider mite on peanuts. Peanut Science. 1(1): 30-34.
- Chhillar, B.S., Gulati, R. and Bhatnagar, P. (2007). Agricultural Acarology. New Delhi: Daya Publishing House.
- da Silva, C.A.D. and Gondim Junior, M.G.C. (2016). First record and characteristics of damage caused by the spider mite *Tetranychus neocaledonicus* André on peanuts in the State of Paraíba, Brazil. Bragantia, Campinas. 75(3): 331-334.
- Edgar, R.C. (2004). MUSCLE: Multiple sequence alignment with high accuracy and high throughput. Nucleic Acids Research. 32(5): 1792-1797.
- Ehara, S. (1956). Tetranychoid mites of mulberry in Japan. Journal of the Faculty of Sciences, Hokkaido University, Series VI, Zoology. 12: 499-510.
- FAOSTAT. (2021). Rome, Italy. <http://faostat.fao.org/>.
- Flechtmann, C.H.W. and Knihinicki, D.K. (2002). New species and new record of *Tetranychus* Dufour from Australia, with a key to the major groups in this genus based on females (Acari: Prostigmata: Tetranychidae). Australian Journal of Entomology. 41: 118-127.
- Gupta, J.C. and Sandhu, R.S. (1969). Outbreak and new records. F.A.O. Plant Protection Bulletin. 17: p. 17.
- Gupta, S.K. and Gupta, Y.N. (1994). A taxonomic review of Indian Tetranychidae (Acari: Prostigmata) with description of new species, redescription of known species and keys to genera and species. Memoirs Zoological Survey of India. 18: 1-196.
- Heagle, A.S., Brandenburg, R.L., Burns, J.C. and Miller, J.E. (1994). Ozone and carbon dioxide effects on spider mites in white clover and peanut. Journal of Environmental Quality. 23: 1168-1176.
- Ho, C.C., Lo, K.C. and Chen, W.H., (1997). Spider mite (Acari: Tetranychidae) on various crops in Taiwan. Journal of Agricultural Research of China. 46: 333-346.
- Johnson, D.R., Wynne, J.C. and Campbell, W.V. (1982). Resistance of wild species of *Arachis* to the two spotted spider mite (Acari: Tetranychidae). Journal of Economic Entomology. 75: 1045-1047.
- Lenin, N. and Bhaskar, H. (2016). Mite pests of vegetable crops under protected cultivation in Kerala. Entomon. 41(3): 305-308.
- Lindquist, E.E. (1985). Anatomy, Phylogeny and Systematics. In: Spider Mites: Their Biology, Natural Enemies and Control. [Helle, W. and Sabelis, M.W. (Eds.)], Elsevier Sci. Publ. B.V., Amsterdam. Vol. 1A. pp. 3-28.
- Lourencao, A.L., Kasai, F.S., Navia, D., Godoy, I.J. and Flechtmann, C.H.W. (2001). Ocorrência de *Tetranychus ogmophallus* Ferreira e Flechtmann (Acari: Tetranychidae) em amendoim no Estado de São Paulo. Neotropical Entomology. 30: 495-496.
- Mendonça, R.S., Navia, D., Diniz, I.R. and Flechtmann, C.H.W. (2011). South American spider mites: New hosts and localities. Journal of Insect Science. 11: 1-18.
- Migeon, A. and Dorkeld, F. (2023). Spider Mites Web: A comprehensive database for the Tetranychidae. Available from <https://www1.montpellier.inrae.fr/CBGP/spmweb>.
- Montero Pau, J.G., Africa Munoz, Joaquín. (2008). Application of an inexpensive and high throughput genomic DNA extraction method for the molecular ecology of zooplanktonic diapausing eggs. Limnology Oceanography: Methods. 6(6): 218-222.
- Mound, L.A. (2005). Thysanoptera: Diversity and interactions. Annual Review of Entomology. 50: 247-269.
- Mound, L.A. and Ng, Y.F. (2009). An illustrated key to the genera of thripinae (Thysanoptera) from South East Asia. Zootaxa. 2265: 27-47.
- Nandagopal, V. and Gedia, M.V. (1995). Biology of the red spider mite *Tetranychus cinnabarinus* (Boisd)-a pest of groundnut. Entomon. 20(1): 41-43.
- Prakash, J., Bhaskar, H., Mathew, D.C.V., Gowda, C. and Shylaja, M. (2022). Diversity of spider mites (Tetranychidae) on ornamental plants in central Kerala. Indian Journal of Entomology. 84: 82-87.
- Rather, A.Q. (1983). New records of five genera and eighteen species of phytophagous mites (Acarina) from India with notes on their host range, distribution and economic importance. In: Abstracts of 2nd All India Symposium on Acarology, Pune, pp 25-26.
- Riley, D.G., Joseph, S.V., Srinivasan, R. and Diffie, S. (2011). Thrips vectors of tospoviruses. Journal of Integrated Pest Management. 1: 1-10.
- Roy, I., Aditya, G. and Saha, G.K. (2011). Preliminary assessment of selected botanicals in the control of *Tetranychus neocaledonicus* André (Acari: Tetranychidae). Proceedings of the Zoological Society. 64: 124-127.
- Seeman, O.D and Beard J.J. (2011). Identification of exotic pests and Australian native and naturalised species of *Tetranychus* (Acari: Tetranychidae). Zootaxa. 2961: 1-72.
- Srinivasa, N., Chinnamade Gowda, C., Mallik, B. and Raghavendra, P. (2012). New record of *Tetranychus truncatus* Ehara (Acari: Tetranychidae) as a potential pest from Karnataka. Indian Journal of Entomology. 74: 379-383.
- Tamura, K.D., Nei, J., Kumar, M. and Sudhir, (2007). MEGA4: Molecular evolutionary genetics analysis (MEGA) software version 4.0. Molecular Biology Evolution. 24(8): 1596-1599.