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The first record of South American tomato leaf miner, *Tuta absoluta* (Meyrick 1917) (Lepidoptera: Gelechiidae) in Nepal

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Abstract
South American tomato leaf miner, *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae) is key and invasive pest of Tomato. This pest was recorded for the first time in Nepal from a commercial tomato farm of Kathmandu during May 2016. *Tuta absoluta* was identified studying external morphology and male genitalia in Entomology Division, NARC, Nepal and Division of Entomology, IARI, New Delhi India. Preliminary survey conducted showed this South American tomato leaf miner has spread within Kathmandu valley and surrounding areas.

Keywords: Gelechiidae, NARC, Nepal, tomato, *Tuta absoluta*, new entomological record

1. Introduction
South American tomato leaf miner, *Tuta absoluta* (Meyrick, 1997) (Lepidoptera: Gelechiidae) is devastating pest of tomato (*Lycopersicon esculentum* Miller). This oligophagous pest associated with solanaceous crops can reduce yield and quality of tomato in newly invaded areas 80-100% both in field and greenhouse conditions if control measures are not applied [1]. Larvae of this pest feed on leaves, buds, stem and fruits of tomato. Fruit rot occurs due to secondary pathogen invasion in fruits bored by the insect. The pest has been reported from various solanaceous crops including weeds *Solanum nigrum* L. and *Datura stramonium* L. Damage has been reported from eggplant (*Solanum melongena* L.) and pepper (*Capsicum annum* L.), and larvae feeding on above ground parts of potato (*Solanum tuberosum* L.) could grow and develop [2].
The invasive South American moth, *T. absoluta* has been key pest of tomato in the South American region since 1960s [3] and was reported in Spain in 2006 and subsequently spread throughout many European and Mediterranean countries [4]. The pest had been reported from Turkey in August 2009 [5] and from Iraq in 2010 autumn by Abdul-Razzak. It has been recorded from Maharashtra (India) during October, 2014 [6]. Since its introduction to India, the possibility of invasion of Nepalese's tomato farming by the pest was always existed due to open border, weak quarantine and import of tomato from India. This paper highlights the first report of *T. absoluta* in tomato farming of Nepal, details of identification procedures, its distribution, possible route of invasion and associated damage.

2. Materials and Methods
2.1 Diagnosis
Suspected insect pest damaged leaf samples along with larvae were received in Entomology Division, Nepal Agricultural Research Council from a commercial tomato grower of Balaju, Kathmandu (27°44.661'N latitude and 85°18.895'E longitude) on 16th May 2016 and immediate field visit was made to that farm. The samples of leaves, fruits along with larvae and adult insects were collected from the field. The collected larvae from the field were reared in Entomology Division and adults emerged form pupae were used for identification. External morphology and morphological structure of male genitalia was studied for identification of the pest following Cooperative Agricultural Pest Survey [7] identification aid and diagnosis method followed by Shashank *et al.* 2015 [6].

Abdomen of adult moths were treated with 10% KOH and heated in spirit lamp and then kept in just to boil condition for 5 minutes. The male and female genitalia cleaned and temporary slides were prepared in glycerol. These slides were observed under stereomicroscope (Euromax, Nexius Zoom, NZ1903-S and Best Scope, BS-3040B) and photographs were taken with digital cameras (Euromax, CMEX-3 and Best Scope BUC2B-500C). Adults emerged from field collected larvae were sent to National PUSA Collection, Division of Entomology, Indian Agriculture Research Institute, New Delhi, India for further identification and verification of the insect.

2.2 Field Survey

Once the pest was identified as South American tomato leaf minor, *T. absoluta* in Entomology Division (NARC) before verification from Division of Entomology (IARI) survey was carried out in Kathmandu valley (Kathmandu, Lalitpur and Bhaktapur districts) and tomato growing areas of Kavrepalanchowk and Dhading districts. A total of 17 locations were surveyed from these districts. In each location, five random plants were selected and thorough observation were made on leaves, buds and fruit to find percent infestation. The percent infestation was grouped into four categories: 1-25% infestation, 26-50% infestation, 51-75% infestation and 76-100% infestation. GPS coordinates of the each location was recorded with GARMIN (GPS map 62sc). Infested samples of leaves, buds and fruits along with larva were brought to the Entomology Division, NARC. Similarly, adult moths were collected with the help of insect collecting net and aspirator. These field collected larvae and adults were observed under stereomicroscope in Entomology Division (NARC) for further verification of South American tomato leaf miner.

3. Results and Discussions

3.1 Damage symptoms

Typical damage symptoms of *T. absoluta* on leaves are blotch mines that are visible from both adaxial and abaxial leaf surfaces (Fig. 1A). These mines consist of dark colored excrement inside and sometimes larva is found feeding on mesophyll tissue. Several such mines cause leaf to turn brown and die. In case of heavy damage, tomato plant become dead and whole tomato field seen dried (Fig. 1B). Larvae also bore apical buds and stems, identified by stunted growth, with dark frass visible externally and leaves are folded together (Fig. 1C). Usually insect enter into fruit near to the calyx and tunnel into the flesh leaving galleries clogged with frass. More than one holes are seen near to the calyx on fruit (Fig. 1D). When plants from heavily infested field are shaken, adult moths found flying near to ground surface.

Fig 1: Damage symptoms of *Tuta absoluta* in Tomato (A) Larval infestation on leaf (B) Heavily infested tomato field (C) Infestation symptom on apical stem (D) Larval punctures and exit holes on fruit

3.2 Identification

The insect was identified as South American tomato leaf minor, *Tuta absoluta* based on external morphology and male genitalia structure. *T. absoluta* is small moth measuring 5-6 mm body length and wing span of 8-10 mm. The color of adult moth is greyish or silvery gray with darker patches on forewings (Fig. 2 A). Labial palp prominent, projected forward, up-curved and with apical segment long and acute (Fig. 2 B). Head vertex covered with appressed scales (Scales flattened against the surface) and antenna filiform, long and banded with gray and dark brown (Fig. 2 C). Forewing narrow, apex fringed and speckled with brown silvery gray and black patches (Fig. 2 D). Hind wing narrow, margins fringed with long hairs, silvery gray in color and outer margin concave posterior of apex (Fig. 2 D).

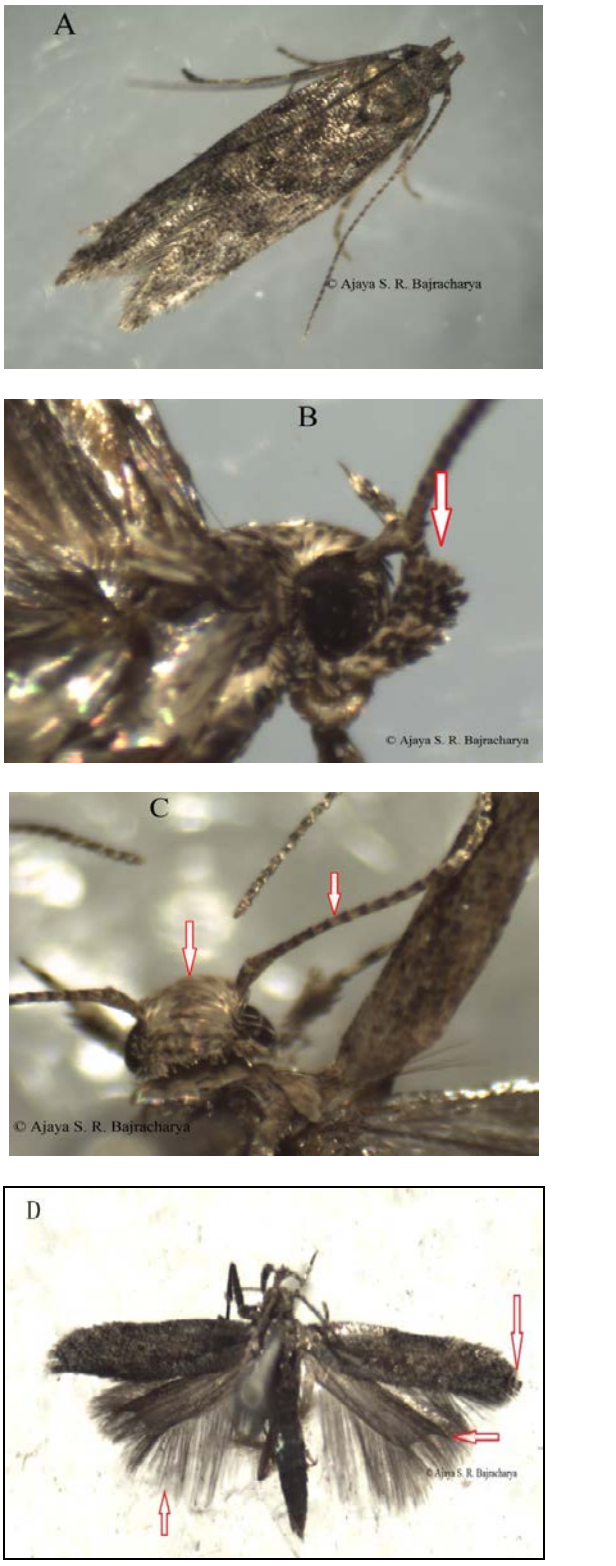

Fig 2: External morphology of *Tuta absoluta* (A) Adult moth (B) Labial palp (C) Head vertex and antenna (D) Structures on fore and hind wing

T. absoluta can be distinguished from other Gelechiidae moths by observing male genitalia. Valve of male genitalia are digitate and setose apically and inner margin is convex medially (Fig. 3 A) which is the best diagnostic character for male. It has broad and well-developed vinculum (Fig. 3B) and long and stout phallus (Fig. 3C). The adult moth samples were also sent to National Pusa Collection, Division of Entomology, Indian Agricultural Research Institute, New Delhi, 110012, India: the samples were confirmed as *T. absoluta* on the basis of external morphology and male genitalia.

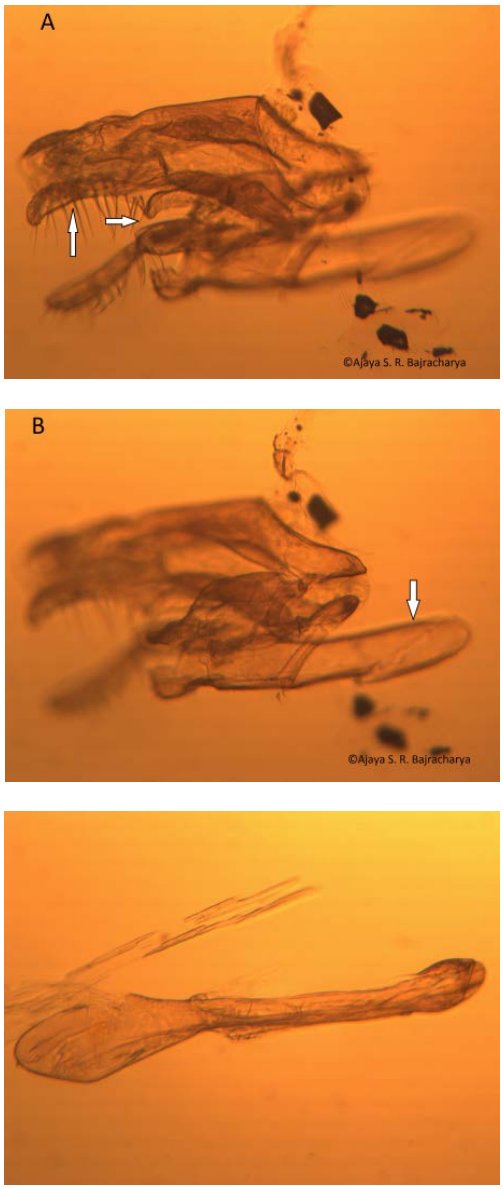

Fig 3: Male genitalia of *Tuta absoluta* (A) Valvae digitate, setose and convex medially (B) Vinculum broad and (C) Phallus long and stout

3.3 Distribution

Out of 17 locations surveyed during 16th May 2016 to 10th June 2016, *T. absoluta* was found from 14 locations. Occurrence and infestation level of this pest at various places of Kathmandu valley and its vicinity district is depicted in Table 1. All major tomato growing areas surveyed in Kathmandu, Lalitpur, Bhaktapur and Kavrepalanchowk district showed presence of the South American tomato leaf miner. The map showing distribution of *T. absoluta* within Kathmandu valley and its vicinity is given in Figure 4. However, in Dhading district, the pest was found only from one location (Sopyang Khola) surveyed which lies near to Kathmandu. It was not recorded from other three locations from the same district (Gajuri, Benighat and Dhusa-10), which are farther from Kathmandu valley. The pest was collected from altitude ranging 725 m asl (Sopyang Khola) to 1664 m asl (Tukucha Nala). Highest infestation was recorded from Ugrachandi Nala-2 and Panchakhal of Kavrepalanchowk district. Infestation above 50% was reported from Tarakeshwor -9 of Kathmandu district and Kamalbinayak-4 of Bhaktapur District. Srijana and Samjhana hybrids were most prevailing variety of tomato grown in most of the surveyed area.

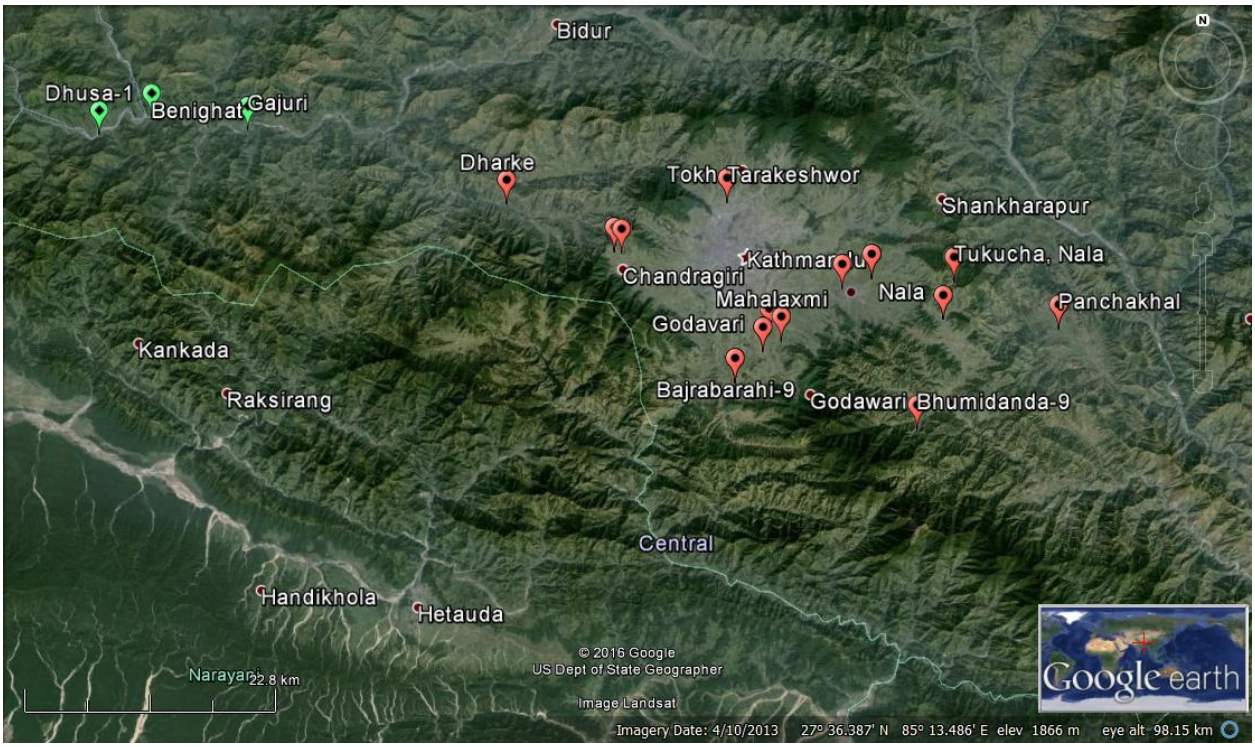

Fig 4: Map showing occurrence and distribution of *Tuta absoluta* in Nepal (Red colored balloons shows presence and green colored balloons shows absence of the insect)

The distribution map of *T. absoluta* showed that the insect is spreading from Kathmandu valley into its vicinity. Tomato imported in Nepal to fulfill the demand of Kathmandu valley could be probable source of entry of South American tomato leaf miner in Nepal which already had been reported in India during 2014 [6, 8]. A total of 15240 MT of tomato imported from India during fiscal year 2013/14 [9] and such importation is continuous in later years. Packaging material coming from infested countries is one of the causes behind long distance dispersal of this insect [10]. Short distance spread of this insect could occur by flight as this pest can actively fly several kilometers, while long distance dispersal could be occurred by human assisted means. The lack of internal quarantine and transportation of tomato from one part to another part of the country could spread this invasive tomato moth along whole country in future days within short period of time. Even new entry of *T. absoluta* into other parts of Nepal could happen along with imported tomato from different border points between Nepal and India.

Tomato is cultivated in 17273 ha of area in Nepal with 7285 ha in central region [9] where Kathmandu valley and adjoining areas lies. Life cycle and developmental duration of *T. absoluta* varies according to environmental conditions, with an average developmental period of 76.3 days at 14ºC, 39.8 days at 19.7ºC and 23.8 days at 27.1ºC [11]. Such weather condition prevails in most of hills and plain areas of Nepal except during winter season. *T. absoluta* is a multivoltine and r-selected insect species [2]. High dose and frequency, cocktail insecticides and even mixing more than one insecticide with different mode of actions are common practices among commercial tomato farmers of Kathmandu valley and surrounding areas. This could lead to development of resistant population of pest against most of the insecticides.

This pest had shown capacity to establish and spread very fast into newly introduced areas. This oligophagous moth is mostly associated with solanaceous crops and can feed on several species of the family. The host plant of the insect includes vegetable crops like *Solanum tuberosum* L., *Solanum melongena* L. and *Capsicum annuum* L. which are cultivated in Nepal in different seasons in different places and altitudes. This pest can feed, develop and grow on weeds, which help this pest to continue its existence in absence of cultivated host plants [12]. Wild plants like *Solanum nigrum* L. and *Datura stramonium* L. also serve as host plants that are easily found in plains and hills of Nepal. Besides, this pest has also been reported from plants of Fabaceae family like *Phaseolus vulgaris*, *Vicia faba*, *Vigna unguiculata* [13] and *Medicago sativa* [14], which are commonly cultivated plants in Nepal. Hence, this pest can spread even into new locations where tomato is not cultivated and even in absence of solanaceous vegetables.

4. Conclusion

The impending threat, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) found to be infesting tomato field in five districts of the country and is reported for the first time in Nepal. This devastating pest is likely to disseminate rapidly and potential to cause sizeable damage and even ruin the tomato farming, which is growing enterprise of horticulture based farming in the country. Considering these facts, the intensive research on development of Integrated Pest Management strategy is urgently needed to cope with the problem. In course of IPM management of *Tuta absoluta*, we think this paper will be useful to identify the insect and its damage symptoms in both laboratory and field.

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Table 1: Occurrence and infestation level of *Tuta absoluta* at various places of Kathmandu valley and its vicinity

S. no	District	Location	GPS Coordinates		Altitude (masl)	Variety	Level of infestation	Date of Observation	Field collection
			Latitude	Longitude					
1	Lalitpur	Godavari Nagar palika -12	27º37.473'N	85º20.847'E	1367	Sangita	+	7 June, 2016	Larva
2	Lalitpur	Mahalaxmi Nagarpalika-12	27º38.362 N	85º21.188'E	1328	Srijana	++	7 June, 2016	Larva
3	Lalitpur	Mahalaxmi Nagarpalika-6	27º37.978'N	85º21.849N'E	1345	Srijana	++	7 June, 2016	Larva
4	Lalitpur	Bajrabarahi-9	27º35.977'N	85º16.325'E	1425	Srijana	+	7 June, 2016	Larva
5	Kathmandu	Tarakeshwor Nagarpalika-9	27º44.661'N	85º18.895'E	1314	Samjhana	+++	17 May, 2016	Larva and adult
6	Kathmandu	Chandragiri Nagarpalika-3	27º42.277'N	85º12.751'E	1429	NA	++	8 June, 2016	Larva and adult
7	Kathmandu	Sasundol	27º42.193'N	85º13.147'E	1413	Samjhana	+	8 June, 2016	Larva
8	Bhaktapur	Bhaktapur-17	27º40.507'N	85º25.167'E	1308	Srijana	++	24 May, 2016	Larva and adult
9	Bhaktapur	Kamalbinayak-4	27º40.996'N	85º26.777'E	1344	Srijana	+++	24 May, 2016	Larva and adult
10	Kavrepalanchowk	Ugarchandi Nala-2	27º39.003'N	85º30.653'E	1458	Karita	++++	24 May, 2016	Larva and adult
11	Kavrepalanchowk	Tukucha, Nala	27º40.813'N	85º31.167'E	1664	Srijana	+	10 June, 2016	Larva
12	Kavrepalanchowk	Panchakhal	27º38.557'N	85º37.091'E	844	NA	++++	24 May, 2016	Larva and adult
13	Kavrepalanchowk	Bhumidand-9, Panchakhal	27º33.720'N	85º29.189'E	1497	NA	+	10 June, 2016	Larva
14	Dhading	SopyangKhola	27º44.618'N	85º06.839'E	725	NA	+	1June, 2016	Larva
15	Dhading	Gajuri	27º48.203'N	84º52.522'E	408	NA	ND	1June, 2016	ND
16	Dhading	Benighat	27º48.789'N	84º47.287'E	328	NA	ND	1June, 2016	ND
17	Dhading	Dhusa-1	27º47.956'N	84º44.380'E	340	NA	ND	1June, 2016	ND

NA: Not Available; ND: Not Detected; +: 1-25% infestation;++: 26-50% infestation; +++: 51-75%; ++++: 76-100%.

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