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# Tomato borer *Tuta absoluta* Meyrick, 1917 (Lepidoptera: Gelechiidae); Invasion and first record of its natural enemies in Cameroon

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**Abstract**
*Tuta absoluta* is an invasive pest of tomato *Lycopersicon esculentum*. Originated from South America, *T. absoluta* has been reported in some West African countries such as Nigeria since 2014. Aimed at limiting the impact and expansion of this species; we followed up its distribution in the main agro-ecological zones of Cameroon 6 years after it was observed in the countrythrough field investigations. In Bambili, one of the infested sites, the incidence of the pest was evaluated, search for their potential natural enemies were done using incubation of infested organs. *T. absoluta* destroyed tomato in 10 different localities situated in 4 of the 5 agro-ecological zones of Cameroon. In Bambili, *T. absoluta* causes a mean damage of 79% and 94% respectively on fruits and leaves. There was a significant difference (t-test at $p<0.05$) in the infestation rate between seasons. Dry season appeared to be the most prolific period. The natural enemies of *T. absoluta* included the social wasps of the families Polistinae; *Poliste* sp., *Synoeca* sp., *Belenogaster juncea* and one Hemiptera Miridae *Macrolophus pygmaeus* which are predators of larvae meanwhile *Necremnus* sp., Hymenoptera Eulophidae was identified as it parasitoid.

**Keywords:** tomato, incidence, *Tuta absoluta*, expansion, predator, parasitoid

## Introduction
Tomato (*Lycopersicon esculentum* or *Solanum Lycopersicon*) accounts for about 5.2 million hectares of globally cultivated land area, with an estimated yield of 172 million tons (FAO, 2016) [10]. Cameroon is classified as the fifth producer of tomato in Africa after Egypt, Nigeria, Morocco and Tunisia. It's estimated production is about 877.937 tons with an accompanying yield level of 12.286Kg/ha (FAO, 2016) [10], which is much lower than the mean world yield (33.988kg/ha) (FAO, 2016) [10]. It is a low-calorie vegetable, low in fat, has no cholesterol, and is an excellent source of antioxidants, dietary fiber, minerals, potassium, and vitamins. Eating tomatoes has been promoted as helping to prevent some human diseases such as cancer and heart diseases, improving the immune system response (anti-tumor immune response) (Ntonifor *et al.*, 2013) [21].
However the low production of tomato is associated to a number of factors amongst which insect pests, which attacks the plants reducing agricultural yields (Heumou *et al.*, 2015 and 2019) [13,14]. Amongst the present insect pests, some species have been transported and introduced into many parts of the world, but very few became invasive in their introduced area (Duyck *et al.*, 2008) [7]. Usually, the new invaded species and the indigenous ones may sometimes outcompete, and generally the invaded species may not have any natural enemies to control its population. Numerous cases of species displacements attested for the occurrence of inter-specific competition, particularly after invasions (Duyck *et al.*, 2008) [8].
Of the most important pest worldwide is the invasive species *Tuta absoluta*, a non-native species that significantly modify or disrupt tomato agro-systems. Evidence from molecular studies on the invasion pathway of *T. absoluta* suggest that Central Chile likely the origin of the introduction of the pest in Europe (Guillermaud *et al.*, 2015) [11].The first record of *T. absoluta* outside neotropical America is Spain in 2006 (Desneux *et al.*, 2011) [7], later in Bulgaria (Karadjava *et al*., 2013) [15] from where it spread to other Mediterranean countries and has established itself in Asia and Countries (Kortam *et al.*, 2014) [16] and in sub-saharan Africa (Brevault *et al.*, 2014) [5]. *Tuta absoluta* has been introduced to several exotic ranges, where it has become invasive, threatening the production of tomato (Campos *et al*., 2017) [6]. *Tuta absoluta* has spread and expanded its ranges in Africa; it was reported in 41 of the 54 African countries (Mansour *et al*., 2018) [19]. In central Africa no report was available except in Cameroon and Democratic Republic of Congo which were classified as suspected countries

that are awaiting confirmation (EPPO, 2018) [9]. Cross-border trade of tomato fruit has been cited as the main pathway in which *T. absoluta* has spread and expanded it ranges (Desneux *et al.*, 2011) [11]. *Tuta absoluta,* has gained notoriety as the most important and devastating pest of tomato wherever it has invaded. Infestation by the pest causes yield losses of up to 100% on tomato, although the pest also attacks other Solanaceae. *T. absoluta* is known as responsible of the damage on tomato in the border country of Nigeria. From the work of Aigbedion-Atalor (2019) [1], this pest has demonstrated a rapid speed of spread following its arrival in Nigeria in 2015. We therefore hypothesized that *T. absoluta* may be present in Cameroon and may have possible local natural enemies.

Little has been done to confirm the status of this invasive pest of tomato in Cameroon. The aim of this work was to: produce a location map of Tuta *absoluta* in Cameroon, evaluate its economic importance and identify it potential natural enemies in the Western Highlands agro-Ecologic Zone of Cameroon.

## Materials and Methods

### Study site

Cameroon is located at the North East end of the Gulf of Guinea. It extends from the 9$^{e}$ to the 16$^{e}$ degree East longitude and stretches from 2$^{e}$ to 13$^{e}$ degree North latitude (Neba Suh, 1987) [22]. According to Menkou *et al.* (2013) [18] it is divided in to 5 Major agro-ecological zones namely: the western Highlands, the Mono-modal Equatorial, Bi-modal Equatorial, Guinea Savana, Sudano-Sahel. From November 2020 to May 2021, Field observations were conducted in farmers' gardens located in 4 agro-ecological zones of Cameroon. The impact of *T. absoluta* and the natural enemies where evaluated in an experimental garden in the site of Bambili a locality situated in the North West region within the Western Highlands agro-ecologic zone. The geographical coordinates are: 10$^{o}$15'529'' N; 06$^{o}$00'784''E.

### Localization of the pests

Random inspections were carried out in farms in the different regions. The GPS locations of all the positive points were recorded to realize the distribution map.

### Experimental design

The surface area of the cultivated garden was around 200 m$^2$ and no pesticides were used. Tomato variety used was Rio-grande and each ridge supported approximately 15 plants, planted 40cm apart on both side of the ridge. Three weeks old tomato seedlings were transplanted, late in the month of November. One week before transplanting, fowl droppings (manure) was applied on the experimental garden

### Assessment of population dynamics of *Tuta absoluta* larvae

The study on the population fluctuation of *T. absoluta* larvae was conducted from December 2020 to May 2021. Regular larvae counts within leaves and fruits on 20 randomly selected plants were made at one-week interval until the termination of the development cycle of tomato.

### Impact of *Tuta absoluta* on fruits and leaves

To assess the impact of *Tuta absoluta*, 20 plants were chosen at random and subjected to random active check for larvae. Sampling was done weekly. The leaves were gently held at the petiole by thumb and fore finger and turned until the entire underside was clearly visible. Sampling for fruit infestation started at the beginning of fruit appearance (Leite *et al*., 2001) [17]. The total number of leaves and fruits per plant were counted and infested leaves and fruits with visible larvae and mines were counted. Weekly infestation was then calculated and express in percentages (Heumou *et al*., 2015) [13].

$$\text{Level of leaf/fruit infestation} = \frac{NIL/F}{tNL/F} \times 100$$

Where NIL/F= number of infested leaves/fruit.
tNL/ F= total number of leaves/fruit.

### Identification of possible enemies of *Tuta absoluta*

The activities of insects hovering around the infested plants were observed. These insects were caught using a mouth aspirator. They were then taken to the laboratory for identification.

To investigate possible parasitoids of *Tuta absoluta*, infested leaves and fruits were incubated in the laboratory under the temperature (19.5 ± 2°C), and at mean relative humidity 57±8% following the method used by (Heumou, 2019) [14]. After two weeks of incubation, the emerged insects were caught and identified.

### Statistical analysis

Data analysis was performed using statistical software package IBM SPSS 21.0. A descriptive statistical analysis was done. Data was presented as percentages and compared using an independent t-test at p-value <0.05 considered to be statistically significant.

## Results

### Mapping location of *Tuta absoluta* in Cameroon

This specie has a broad distribution range since it was first observe in Bambili in 2014, after 1 year it was observed in Bangangté some 200 km from where it was first seen. In Cameroon today, *T. absoluta* is confirmed present in 10 different localities of 5 regions situated in 4 of the 5 Major agro-ecological zones of Cameroon (Fig 1). These regions are the North-west and West situated in Western highlands agro-ecological zone, South-west situated in the Mono-modal Equatorial agro-ecological zone, Center situated in the Bi-modal Equatorial agro-ecological zone and the Far-north situated in Sudano-Sahel agro-ecological zone. The pest is suspected in the Guinea Savana agro-ecological zone.

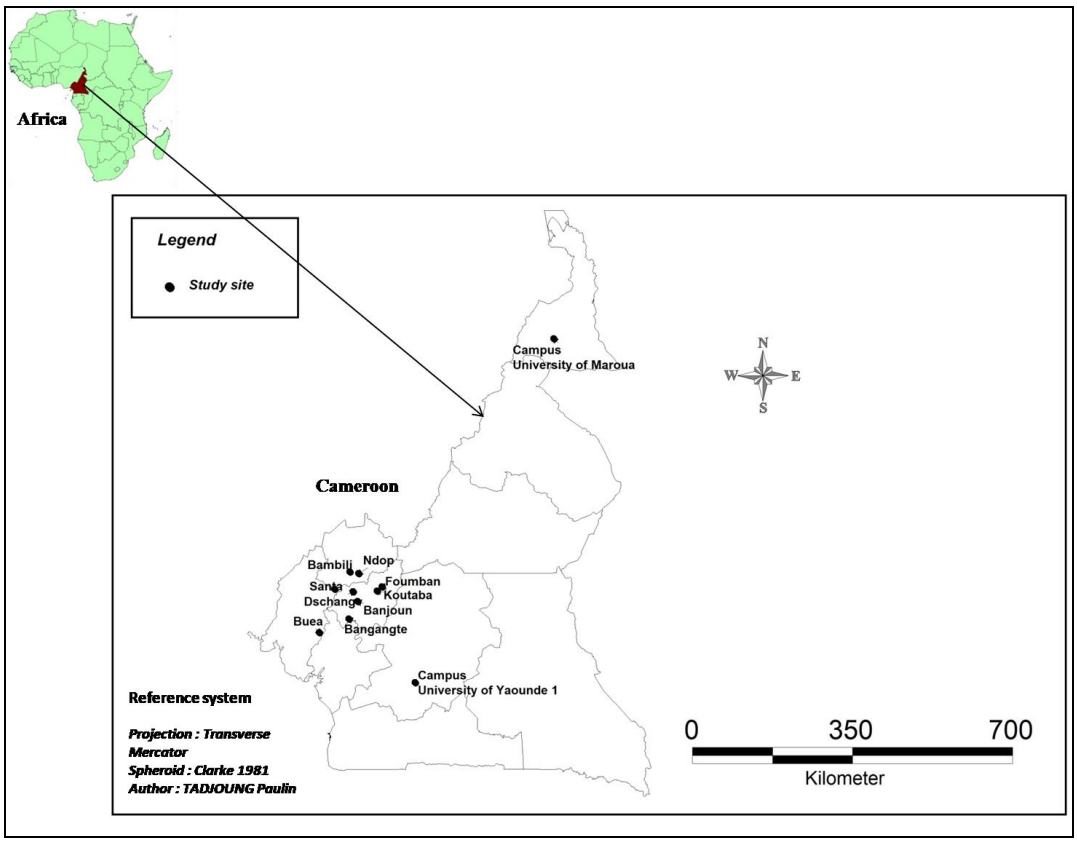


**Fig 1:** Geographic location of *Tuta absoluta* in Cameroon, observations between 2015-2021.

### Impact of Tuta absoluta on tomato

The symptoms of infestation were noted at the different parts of the plants both on the leaves and on the fruits. *T. absoluta* larvae mined the leaves, destroy the chlorophyll content and the leaves shows sign of burnt (Figure 2A), at maturity the small caterpillar emerge (Figure 2B). Larvae penetrate in all the stages of tomato from the juveniles to matures fruits and consume it interior, thus making it unfit for consumption (Figure 2C).


**Fig 2:** Impact of *Tuta absoluta* larvae on leaves (A, B) and on tomato fruits (C).

One month after transplantation (3D), the farm was gradually devastated by *T. absoluta*. In the periods of heavy infestations, farms were totally destroyed after two month (3E, 3F). Almost 100% of the farms attacked by this pest were simply abandoned. These abandoned farms later serve as multiplication spots from where the pest spread to contaminate new farms around (Fig 3).


**Fig 3:** Evolution of *Tuta absoluta* attacks from the first symptom to complete destruction of the farm.

**Seasonal variation of *Tuta absoluta* infestation in the experimental farm**

The percentage of plants infested in the entire farm was progressively increasing in both seasons. In the drying season, the rate of infestation was 10.3% in December and increased progressively and by February 100% of plants were infested and the curve flattens. In the rainy season, the level of infestation was only 3% and increased to 43% by May at the end of the cycle. There was a significant difference in the rate of pest infestation in the rainy and drying seasons (t-test at $p<0.05$) (Fig 4).

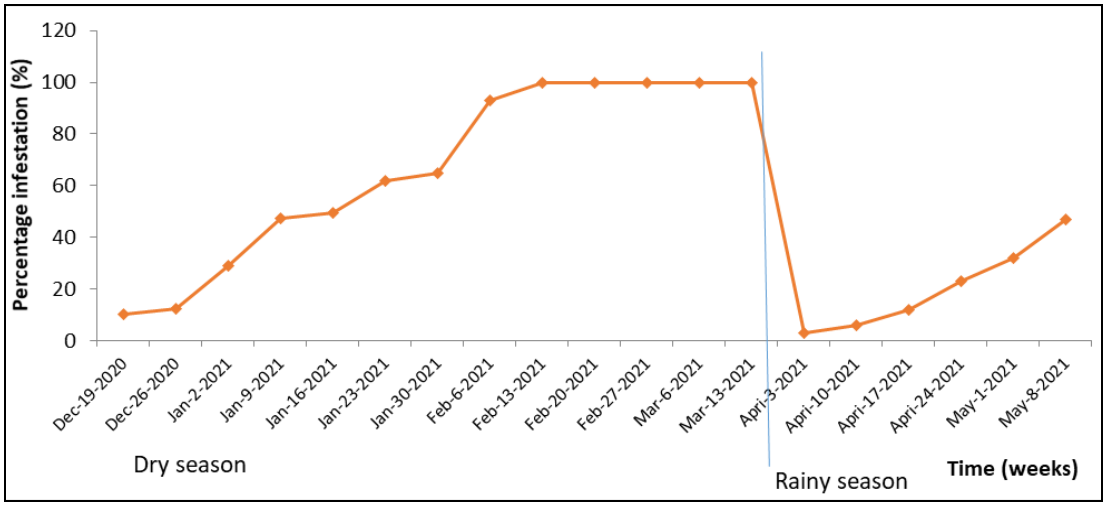


**Fig 4:** Seasonal variation of infected plants by *Tuta absoluta* during 2020-2021.

**Variation of *Tuta absoluta*'s larvae population in the experimental farm**

The graph showed that the population of the larvae was gradually increasing from December 2020 to March 2021 that is during the dry season. In March the severity reached a maximum of more than 120 larvae on 20 plants that is 6 larvae per plants. In the rainy season that is from April 2021 to May 2021, the severity was low and was maximum 20 larvae counted on 20 plants that is a mean of one larva per plants. The Student t test showed a significant difference in the variation of larvae population between seasons ($P<0.05$) (Fig 5).

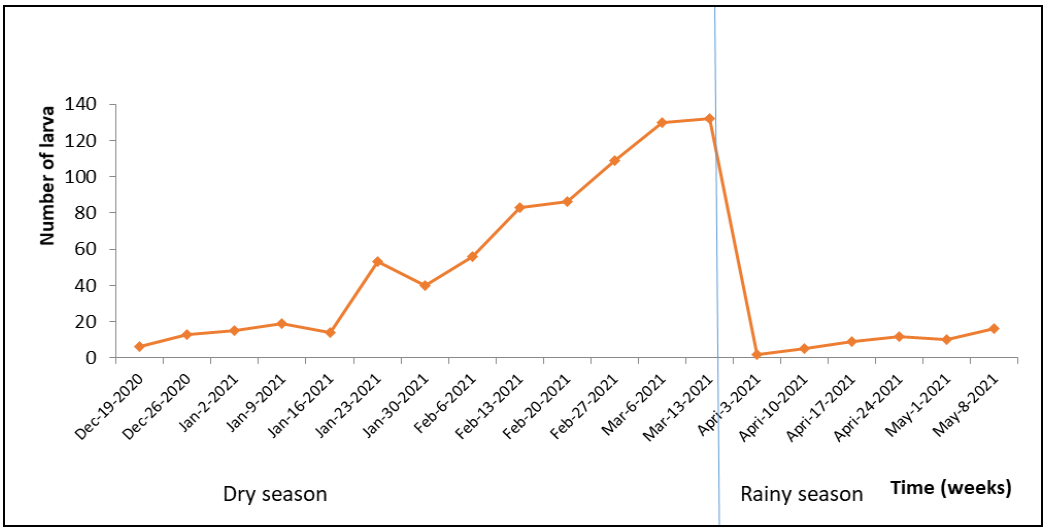


**Fig 5**: Seasonal variation in the larvae population of *Tuta absoluta*

**Impact of *Tuta absoluta* on leaves and fruits**

Leaves and fruits damages caused by larva occurred throughout the experimental period from December 2020 to May 2021. Our results showed that maximum damage on the fruits and leaves occurred at the end of each cropping period (that is March in the dry season and May in the raining season) There was a progressive increase in the number of leaves and fruits infested by the pest in both season but the number of leaves infested in the rainy season was low as compare to that in the dry season ($p>0.05$). By the end of the cultivation period in the dry season, 94% of the leaves were infested and 79% of the fruits were tunneled (Fig 6).

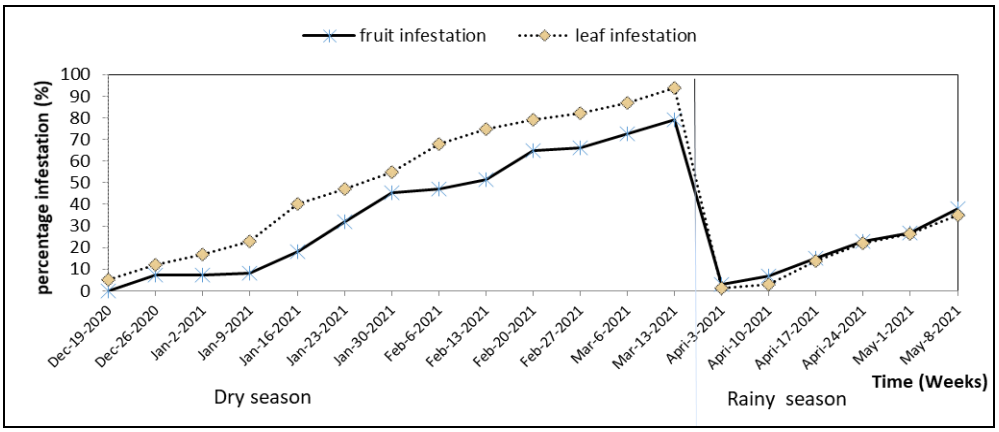


**Fig 6:** Seasonal variation of leaf and fruit attacks by *Tuta absoluta*

**Natural enemies of *Tuta absoluta***

**Predators of *Tuta absoluta***

The predators of *T. absoluta* larvae were found in two different orders: Hymenoptera and that of Hemiptera. 03 species of social wasps (Paper wasp) of subfamily Polistinae and family Vespidae were identified preyed on *T. absoluta's* caterpillars. They were *Poliste* sp. (fig7 G), *Synoeca* sp. (fig7 H) and *Belenogaster juncea* (fig7 I). The wasps showed behavioral pattern by locating the mines with caterpillar in the leaves, opening the mines, catching the caterpillars, transporting them to their nests. Also, 01 Hemiptera of the family Miridae, *Macrolophus pygmaeus* (fig7 J) were very effective as predator of *T. absoluta.* One individual *Macrolophus* is able to suck more than 50 larvae/eggs per day. These insects are promising bio-control agent of *T. absoluta.*


**Fig 7:** Predators of *Tuta absoluta:* **(**G) *Poliste* sp., (H) *Synoeca* sp., and (I) *Belenogaster juncea* (J) *Macrolophus pygmaeus*.

**Parasitoids of *Tuta absoluta***

One specie *Necremnus* spp was identified as *Tuta absoluta* parasitoid. Female of the parasitoid laid they eggs in the larvae of *T. absoluta*. The impact of *Necremnus* spp can reach considerable rates of parasitism (up to 38%) in the dry season. They appear as promising biological agent that can be used to control the pinworm pest of tomato (Fig.8).

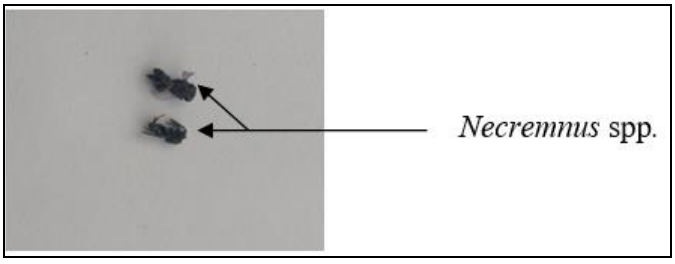


**Fig 8:** *Necremnus* spp. Parasitoid of *Tuta absoluta.*

**Discussion**

The present work documented on the rapid expansion of *T. absoluta* in Cameroon ever since it was first recorded in 2014 by Djieto-Lordon (none published). It has expanded its range to include the 5 Major agro-ecological zones of Cameroon within the period of 6 years. The neighboring Nigeria, second Africa producer of tomato, *T. absoluta* was observed around 2014 and just 2 years after it became the major tomato pests of tomato (Brevault *et al.,* 2014) [5], may be the pathway of this pest to Cameroon. *T. absoluta* was reported in 41 of the 54 African countries (Mansour *et al*., 2018) [19]. Because of cross-border trade between Cameroon and its neighboring countries and its great capacity of dispersion, *Tuta absoluta* could be present in other regions of Cameroon and may have started its new invasion journey to Central African countries. This pest currently causes extensive damage to tomato production in West African countries. In northern Nigeria for example, a state of emergency has been declared in tomato sector after 80% of tomato farms were ravaged (Borisade *et al.,* 2017) [4].

The rate of attack was progressive for both seasons. Mid-way into the dry season, all the plants were infested showing either leaf or fruit infestation. This was different in the rainy season which had a lower rate of infestation. This increase in pest attack was also accompanied by an increase in the population of the larva. The number of larvae increased sharply by January in the dry season and dropped drastically in the rainy season. This indicates that rainfall greatly influence the population of the pest and subsequently the rate of infestation. This is in line with the work of Guenaoui (2008) [12] who showed that *T. absoluta* populations were regulated by abiotic factors, particularly temperature and humidity. A high rate of pest infestation is often associated to increased severity of infestation.

The severity of the pest attack was examined both on the leaves and fruits. On the leaves, larvae penetrate and feed on the mesophyll parts.

This results in irregular mines on the leaf surface, subsequently, decreasing the photosynthetic capacity of the plant. The galleries and mines in the leaves alter the general development of the plant and can cause necrosis (Biondi *et al.,* 2018) [3]. Under severe attacks, the leaves have a burnt appearance. More of the leaves (94%) were attacked in the dry season as compared to the rainy season. The low attack in rainy season may be due to reduced numbers of hatched eggs (Allache *et al*., 2012) [2]. Martins *et al*. (2016) [20] considered temperature as a key factor which affected the insect development.

On fruits, common signs and symptoms of *Tuta absoluta* damage include: puncture marks, abnormal shape, exit holes and rot due to secondary infection agents, and larvae feces. The level of pest damage on the fruit was 79%. These results are concurrent with that of Desneux *et al*. (2010) [7] who reported yield losses of up to 50–100% as a result of the direct and indirect damage in Spain. In Ethiopia, the yield loss due to *Tuta absoluta* was reported to be in the range of 60.08 to 82.31% (Shiberu and Getu, 2017) [24]. The mines and galleries in the leaves and fruits are entry routes for secondary infection by pathogens, further increasing the damage and cost of control, and lowering the market value of the fruits (Campos *et al*., 2017) [6].

Biological control approaches could potentially be used against *T. absoluta* in Africa (Urbaneja *et al*., 2012) [25]. Amongst the natural enemies of *Tuta absoluta* were: One Hymenoptera, Eulophidae *Necremnus* sp. a parasitoid highly effective in controlling *T. absoluta*. As per the predators of *Tuta absoluta*, one Hemiptera Miridae *Macrolophus pygmaeus* was identified. It feed on the *T. absoluta* larva by transpiercing and sucking them with theirs rostrums. Also many social wasp species were effective. They performed a series of predation behaviors on *T. absoluta* caterpillars. In the general pattern of predation on *T. absoluta* caterpillars by Vespidae, initially the wasp flew up the tomato plants and landed on a plant leaf. After landing, the wasp examined the leaf to see if it had a mine of *T. absoluta*. After finding a mine in the leaf, the wasp touched the mine with their antennae and mouthparts. If the mine had a caterpillar, the wasp would open the mine using its mandibles and captured the caterpillar. Then, the wasp would carry the caterpillar away to feed its larvae. This similar behavior was noted by Pereira *et al*. (2007) [23]. Previous studies provide evidence that the combined use of bio-control agents (i.e. parasitoids, predators and microbials) could enhance their action against *T. absoluta* in tomato (Kortam *et al*., 2014) [16].

**Conclusion**

*Tuta absoluta* is present in Cameroon in different agro-systems. This pest is of great economic importance causing severe damage to the plant especially on the fruit and leaves of tomato. The pest is more abundant in the dry season especially between January and February and the natural enemies of this pest are still very few, mostly available are the predatory wasps of family Polistinae which feeds on the larva and a single parasitoid of the genus *Necremnus spp.*

**Acknowledgement**

We thank all the farmers who despite their multiple activities voluntarily participated actively in identifying some signs and symptoms associated to plants in their farms and granting us permission to work in their farms without constraints.

**References**

1. Aigbedion-Atalor Osa P, Abiola O, Oke Samira, Mohamed A. *Tuta absoluta* (Lepidoptera: Gelechiidae): invasion in Nigeria: first report of its distribution. Journal of Plant Diseases and Protection,2019:126: 603-606.

2. Allache F, Houhou MA, Osmane I, Naili L, Demnati F. Survi de l'évolution de la population de Tuta absoluta Meyrick (Gelichiidae), un nouveau ravageur de la tomate sous serre a Biskra. Entomologie faunistique- Faunistic entomology,2012:65:149-155.
3. Biondi A, Guedes R, Wan F. Ecology, Worldwide Spread, and Management of the Invasive South American Tomato Pinworm, Tuta absoluta: Past, Present, and Future. Annual Review of Entomology,2018:(3):239-258. https://doi.org/10.1146/annurev-ento-031616
4. Borisade OA, Kolawole AO, Adebo, GM, Uwaidem YI. 'the tomato leafminer' Tuta absoluta (Lepidoptera: Gelechiidae): attack in Nigeria: effect of climate change on over –sighted pest or agro-bioterrorism? Journal of agricultural Extension and rural Development,2017:9(8):163-171.
5. Brevault T, Sylla S, Diate M, Bernadas G, Diarra K. Tuta absoluta Meyrick (Lepidoptera: Gelechiidae): A new Threat to tomato production in Sub-Saharan Africa. Africa Entomology,2014:22(2):441-444. DIO:10.4001/003.022.0202
6. Campos MR, Biondi A, Adiga A, Guedes RNC, Desneux N. From the Western Palaearctic region to beyond: *Tuta absoluta* 10 years after invading Europe. Journal of Pest Science,2017:90(3):787-796. https://doi.org/10.1007/s10340-017-0867-7
7. Desneux N, Wajnberg E, Wyckhuys KAG, Burgio G, Arpaia S, Narváez-Vasquez CA *et al*. Biological Invasion of European Tomato Crops by Tuta absoluta: Ecology, Geographic Expansion and Prospects For Biological Control. Journal of Pest Science,2010:83(3):197-215.
8. Duyck P-F, David P, Quilici S. A review of relationships between interspecific competition and invasion in fruit flies (Diptera: Tephritidae). Ecological Entomology,2004:29:511-520.
9. EPPO. 2018. EPPO Global database (available online). Paris, France: EPPO. https://gd.eppo.int/https://gd.eppo.int/taxon/GNORAB.
10. FAO. Food and Agriculture Organization of the United Nations [Online]. Rome-Italy: Food and Agriculture organiation of the United States, 2016. Available: faostat3.fao.org/search/tomato%20/E [Accessed].
11. Guenaoui Y. Nouveau ravageur de la tomate en Algérie: Première observation de Tuta absoluta, mineuse de la tomate invasive, dans la région de Mostaganem, au printemps 2008. Phytoma La Défense des Végétaux,2008:617:18-19.
12. Guillermaud T, Blin A, Le Goff I, Desneux N, Reyes M, Tabone E *et al*. invading the Mediterranean basin, originates from a single introduction from Central Chile. Scientific report,2015:5:8371.
13. Heumou CR, Djiéto-Lordon C, Aléné CD, Elono APS. Diversity and agronomic status of tomato and pepper fruits pests in two agro-ecological zone of Southern Cameroun: Western Highland and Southern Plateau of Cameroon. African Journal of Agricultura Research,2015:10(11):1224-1232.
14. Heumou CR, Elono Azang PS, Aléné CD, Ngassam P, Djiéto-Lordon C. Host range and distribution pattern of *Dacus punctatifrons* and *Helicoverpa armigera*: two fruigivorous pests; elucidation of interspecific competition in tomato's agro-system. International Journal of Biosciences,2019:14(3):6-29.
15. Karadjova O, Ilieva Z, Krumov V, Petrova E. and Ventsislavov V. *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae): Potential for Entry, Establishment and Spread in Bulgaria. Bulg. J. Agric. Sci,2013:19(3):563-571.
16. Kortam MN, El-Arnaouty SA, Afifi AI, Heikal IH. Efficacy of Different Biological Methods for Controlling the Tomato Leaf Miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) on Tomato in Greenhouse in Egypt. – Egyptian Journal of Biological Pest Control,2014:24:523-528.
17. Leite GLD, Picanço M, Guedes RNC, Zanuncio JC. Role of plant age in the resistance of *Lycopersicum hirsutum* f. glabratum to the tomato leafminer *Tuta absoluta* (Lepidoptera: Gelichiidae). Sci Hort,2001:89:103-113.
18. Menkou Bele Youssoufa, Tiani AM, Sonwa D, Somorin Olufunso. Exploring vulnerability and adaptation to climate change of communities in the forest zone of Cameroon. Climatic change, 2013, 119(3-4).
19. Mansour R, Brévault T, Chailleux A, Cherif A, Grissa-Lebdi K, Haddi K *et al*. Occurrence, biology, natural enemies and management of *Tuta absoluta* in Africa. Entomologia Generalis,2018:38:83-112.
20. Martins JC, Picanço MC, Bacci L, Guedes RNC, Santana JPA, Ferreira DO *et al*. Life table determination of thermal requirements of the tomato borer *Tuta absoluta*. J. Pest Sci,2016:89:897-908.
21. Ntonifor NN, Nsobinenyui DN, Fokam EB, Fontem LA. Developing an Integrated Management Approach for the Fruit Fly *Dacus punctatifrons* on Tomatoes. American Journal of Experimental Agriculture,2013:3:470-481. http://dx.doi.org/10.9734/AJEA/2013/3846
22. Neba AS. Géographie Moderne de la République du Cameroun 2nd ed.Ed Neba, Camden, New Jersy, 1991, 211.
23. Pereira EJG, Picanço L, Bacci TMC, Della Lucia EM, Fernandes FL. Natural mortality factors of *Leucoptera coffeella* (Lepidoptera: Lyonetiidae) on *Coffea arabica*. Biocontrol Science and Technology,2007:17:545-553.
24. Shiberu T, Getu E. Estimate of yield losses due to *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) on tomato crops under glasshouse and field conditions in Western Shewa of Central Ethiopia. International Journal of Fauna and Biological Studies,2017:4(5):104-108.
25. Urbaneja A, González-Cabrera J, Arnó J, Gabarra R. Prospects for the Biological Control of *Tuta absoluta* in Tomatoes of the Mediterranean Basin. Pest Manage. Sci,2012:68(9):1215-1222.