Mononychellus tanajoa

(Cassava Green Mite)

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Background Information

Common Names:
Cassava green mite, CGM

Scientific Name:
Mononychellus tanajoa (Bondar)

Synonyms:
Tetranychus tanajoa Bondar; *Mononychus tanajoa* (Bondar) Flechtmann & Baker; *Mononychellus progresivus* Doreste

Taxonomy:
Kingdom: Animalia; Phylum Arthropoda;
Class: Arachnida; Order Acari; Family Tetranychidae

Primary Crop Hosts:
Cassava (*Manihot esculenta* Crantz; *Manihot* spp.)

Figure 1. Adult female of the cassava green mite, *Mononychellus tanajoa*. Photo copyright: Georg Goergen/ IITA Insect Museum, Cotonou, Benin.

Introduction

The cassava green mite, *Mononychellus tanajoa* (Figure 1), is an important pest throughout Sub-Saharan Africa. In Africa, it only feeds on cassava and related *Manihot* species (Nyiira 1973, Nyiira 1972 in Yaninek and Herren 1988), and is particularly problematic during the dry season (e.g., Akinlosotu 1982, Yaninek and Herren 1988). Cassava green mites originated in South America, and were mostly likely transported to Africa on cassava cuttings in about 1970 (e.g., Yaninek and Herren 1988). *Mononychellus tanajoa* first appeared in Uganda in 1971 (Lyon 1973, Nyiira 1982), and by 1985 it had dispersed to 27 countries within the cassava belt (Yaninek and Herren 1988, Bellotti et al. 1999). It is now widespread and is considered to be one of the most destructive pests of cassava in Africa (Nyiira 1982, Bellotti et al. 1999). It contributes to reduced root size, poor root quality and late root formation (Byrne et al. 1982, Nyiira 1982).

Although there has been some confusion in the taxonomy of this species, it is now agreed that *M. tanajoa* and *M. progresivus* are one and the same species (Gutierrez 1987, Rogo et al. 1988, Yaninek and Herren 1988, Murega 1989, Yaninek et al. 1989c, Bellotti et al. 1999).

Known Distribution

Mononychellus tanajoa was recorded as serious pest of cassava in Brazil in 1921 (Bondar 1938, in Nyiira 1977), but was not seriously investigated until the 1970's, after it was discovered in Uganda in 1971 (Nyiira 1977). In South America, it is present in the Bahamas, Brazil, Colombia, Costa Rica, Guyana, Panama, Paraguay, Surinam, Trinidad, and Venezuela, (e.g., see Flechtmann and Baker 1969, Aranda and Flechtmann 1971, Yaseen and Bennet 1977, Guerrero and Bellotti 1981, Byrne et al. 1983). The species apparently does not occur in north-western and north central Mexico (Tuttle et al. 1974).

In Africa, *M. tanajoa* has been recorded from most counties in the cassava belt (e.g., see Nyiira 1973, Flechtmann 1982, Byrne et al. 1983, Yaninek and Herren 1988, Bellotti et al. 1999). In 1990, only four countries within the cassava belt were not infested: Gambia, Guinea-Bissau, Madagascar, and Senegal (Herren and Neuenschwander 1991).

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In Asia, the reported distribution is somewhat confused. Although Lu et al. (2012) report it as a major pest of cassava in China, this appears to have been a misidentification of *Mononychellus mcgregori*, as subsequent publications by Lu et al. (Lu et al. 2014a, Lu et al. 2014b) refer to *M. mcgregori*, even when they cite their own work on *M. tanajoa*. Machi et al. (2014) indicate that *M. tanajoa* was first reported in Asia (Thailand) in 2008, and now also occurs in Cambodia, Indonesia, Laos, Malaysia, Myanmar, New Guinea, and Vietnam. Although Fletchmann (2013) indicates that specimens of *M. tanajoa* were correctly identified from Thailand, this species has not been reported to occur in Vietnam (Dr. Duong Minh Tu, pers. comm.), and its presence has not been confirmed in the other countries (Cambodia, Indonesia, Laos, Malaysia, Myanmar and New Guinea) mentioned by Machi et al. (2014).

Description and Biology

Reproduction of *M. tanajoa* is arrhenotokous (a form of parthenogenesis whereby unfertilized eggs develop into males), with four active stages: a six-legged larval stage, two nymphal stages and an adult stage, with quiescent periods before each moult (Gutierrez 1987, Yaninek and Herren 1988, Yaninek et al. 1989c).

Development time, fecundity and reproduction are all affected by environmental conditions (temperature, humidity, host plant) (e.g., Byrne et al. 1983, Yaninek et al. 1989a, Yaninek et al. 1989b). Tetranychid mites are known for rapid reproductive rates in hot dry weather (Byrne et al. 1983). Numerous authors have indicated that infestations are heaviest and/or population density increases in the dry season (e.g., Nyiira 1973, Skovgård et al. 1993, Costa et al. 2012, Rêgo et al. 2013). It has been postulated that densities decrease in rainy seasons due to the physical effects of heavy rainfall and wind conditions (e.g., Yaseen and Bennet 1977, Akinlosotu 1982, Byrne et al. 1983, Yaninek et al. 1987, 1989b, Rêgo et al. 2013); however, Skovgård et al. (1993) could find no evidence of rain having a negative effect on populations of *M. tanajoa* in Kenya.

Green mites disperse by walking or by wind (Yaseen and Bennet 1977, Byrne et al. 1983), or by human movement of infected material (Yaninek et al. 1989c). Walking and wind dispersal are responsible for movement within fields. These forms of dispersal are associated with movement rates of 10 km per year (Yaninek and Herren 1988, p 215). Because *M. tanajoa* can endure on cassava cuttings (without leaves or buds) for up to 60 days (Yaninek et al. 1989c), it is easy to see how transportation of infected material could have resulted in the rapid spread of this species in Africa.

Cassava damaged by *M. tanajoa* suffers from reduced photosynthesis, stunted root bulking and lack of fresh root growth. High densities of *M. tanajoa* can result in defoliation following chlorosis, resulting in increased susceptibility to stress (Yaninek et al. 1987, Yaninek et al. 1989a).

Host Crops and Other Plants

Mononychellus tanajoa is commonly considered to be oligophagous, only attacking cassava (*Manihot esculenta* Crantz); however, it can reproduce on *Manihot* species other than cassava (*Manihot psudoglazviovii*, Euphorbiaceae), and on *Passiflora cincinnata* Mart (Passifloraceae) (Mendonca et al. 2011). In Africa, *M. tanajoa* only feeds on cassava and related *Manihot* species (Nyiira 1973).

Mononychellus tanajoa has been collected from *Passiflora edulis* Sims & *Fabeola vulgaris* L (Mendonca et al. 2011). Whilst it can develop on the common bean, *Phaseolus vulgaris* L. (Fabaceae), it does not oviposit on *P. vulgaris* (de Moraes et al. 1995). It has been collected/reported from other families (see Tuttle et al. 1977, de Moraes et al. 1995, Mendonca et al. 2011), but there is no indication as to whether or not *M. tanajoa* can reproduce on these hosts.

Potential Distribution

A CLIMEX model (Sutherst et al. 2007) for *M. tanajoa* was developed using the CliMond 1975H historical climate dataset (Kriticos et al. 2012). The model parameters (Table 1) were fitted using a natural rainfall scenario, and were initially fitted to the South American distribution, using location points provided by B.V.H. Campo and G.G. Hyman of CIAT. The predicted distribution in Africa was then used to adjust parameter values for Heat Stress, and the final model was validated against the know distribution in Asia. Finally, an irrigation scenario (2.5 mm day^{-1} applied as top-up) was run and a composite climate suitability map was created by combining the natural rainfall and irrigation scenario results using the data from Siebert et al. (2005).

Soil moisture parameters were set to accord with evidence that there are higher numbers of *M. tanajoa* in dry seasons in wet seasons in both Africa and Brazil (Akinlosotu 1982, Bellotti et al. 1999, Costa et al. 2012, Rêgo et al. 2013). The upper soil moisture threshold was set at 1.5 to allow the Moisture Index to be suitable in eastern Brazil (Campo et al. 2011).

The lower temperature threshold was set to 14 °C, in accordance with Yaninek et al. (1989a), who calculated the lower temperature threshold for development to be 14.4 °C limiting the distribution to tropical and subtropical conditions. The optimum range was based on the data presented by Yaninek et al. (1989a), but is also in agreement with other authors (Muaka-Toko and Leuschner 1981, Byrne et al. 1983, Walangululu et al. 1998, Rêgo et al. 2013). The maximum threshold was set to 36 °C, since 34 °C is still marginally suitable (Yaninek et al. 1989a, Walangululu et al. 1998) and since Muaka-Toko and Leuschner (1981) obtained some development and reproduction at 35 °C.

Both a temperature threshold and a degree-day mechanism for Cold Stress were used. The temperature threshold model (effectively modelling frost intolerance) allows for Cold Stress to accumulate in the very high altitudes of Peru, Bolivia, and Argentina. The degree-day model extends the region of Cold Stress, but still allows some persistence in Chile, where *M. tanajoa* supposedly occurs (CABI, http://www.cabi.org/isc/datasheet/34767; Campo et al. 2011).

Table 1. CLIMEX Parameter Values for *Mononychellus tanajoa*

Parameter	Description	Value
Moisture		
SM0	lower soil moisture threshold	0.1
SM1	lower optimum soil moisture	0.2
SM2	upper optimum soil moisture	0.8
SM3	upper soil moisture threshold	1.5
Temperature		
DV0	lower threshold	14 °C
DV1	lower optimum temperature	24 °C
DV2	upper optimum temperature	28 °C
DV3	upper threshold	36 °C
Cold Stress		
TTCS	cold stress temperature threshold	0°C
THCS	temperature threshold stress accumulation rate	-0.01 week^{-1}
DTCS	degree-day threshold (stress accumulates if the number of degree-days above DV0 is below this value)	15 °C days
DHCS	degree-day stress accumulation rate	-0.0002 week^{-1}
Heat Stress		
TTHS	heat stress temperature threshold	38 °C
THHS	temperature threshold stress accumulation rate	0.01 week^{-1}
Dry Stress		
SMDS	soil moisture dry stress threshold	0.1
HDS	stress accumulation rate	-0.01 week^{-1}
Wet Stress		
SMWS	soil moisture wet stress threshold	1.8
HWS	stress accumulation rate	0.01 week^{-1}
Threshold Heat Sum		
PDD	number of degree-days above DV0 needed to complete one generation	204 °C days
Irrigation Scenario		
	2.5 mm day^{-1} as top-up throughout the year	

The temperature threshold (38 °C) for Heat Stress was set marginally higher than the developmental threshold (36 °C) to allow persistence within the known range in Africa. The chosen parameter values make northern Africa (the Saharan region) and most of Saudi Arabia unsuitable, but do not result in any Heat Stress in South America.

Dry Stress was used since decreasing host quality suppresses population growth (Yaninek et al. 1989a, Yaninek et al. 1989b, Skovgård et al. 1993). The threshold was set to 0.1 (also the soil moisture threshold for growth, SM0), on the basis that if plants are stressed, populations of *M. tanajoa* will also be stressed. This value approximates the wilting point of plants (Kriticos et al. 2003). The rate of stress accumulation precludes persistence mostly in the Saharan region of Africa, although a few other areas experience lethal Dry Stress (parts of Namibia, South Africa, northwest Kenya, northeast Somalia, and Ethiopia). Dry Stress has minimal impact in South America.

Wet Stress parameters were set to allow persistence in all central Colombian sites. A known location record is excluded from the modeled distribution, but this is likely to be a geo-coding error. Rainfall exceeds 4200 mm year^{-1} in this grid cell, making it unlikely that *M. tanajoa* can persist here.

A PDD value (the number of degree-days above 14 °C needed to complete a generation) of 204 was calculated using the data in Yaninek et al. (1989a), using a base temperature of 14 °C rather than their calculated value of 14.4 °C.

With the parameter values given in Table 1, all but one of the location records of *M. tanajoa* in South America fall within the area projected to be suitable (Figure 2). As discussed above, it is likely that his aberrant location has been incorrectly geo-coded.

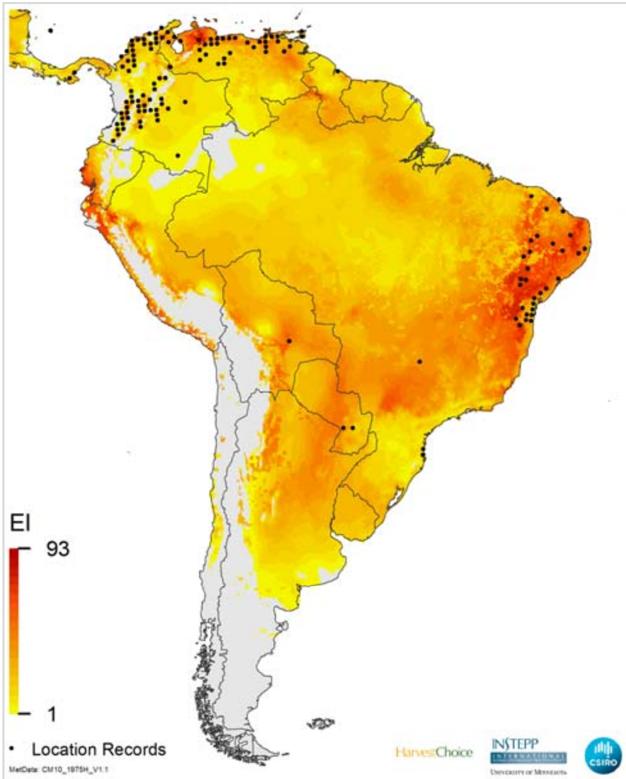

Figure 2. Modelled climate suitability of South America for *Mononychellus tanajoa* as a composite of natural rainfall and irrigation based on the irrigation areas identified in Siebert et al. (2005). Location records were provided by B.V.H. Campo and G.G. Hyman of CIAT.

In Africa, the northernmost projections do not fully extend to the limits of the cassava belt in a handful of countries (Senegal, Mali, Burkina Faso, Niger, and Chad); however, the distribution of *M. tanajoa* is projected to be able

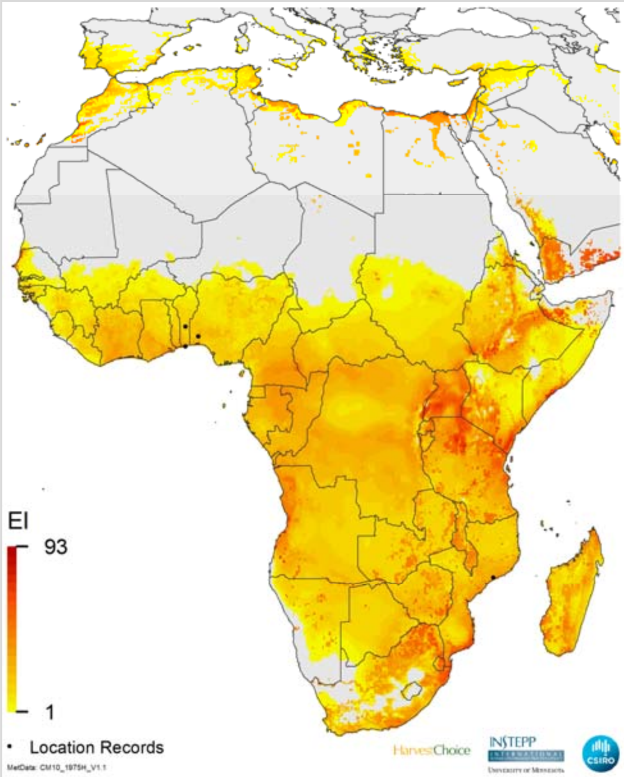

Figure 3. Modelled climate suitability of Africa for *Mononychellus tanajoa* as a composite of natural rainfall and irrigation based on the irrigation areas identified in Siebert et al. (2005). Location records were provided by B.V.H. Campo and G.G. Hyman of CIAT.

to extend much further south than the southern limit of the cassava belt (Figure 3).

The projected suitability of Asia (Figure 4) for *M. tanajoa* is consistent with the information provided on its distribution (Lu et al. 2012, Machi et al. 2014). Elsewhere, *M. tanajoa* could spread further west in Asia through India and across to Iran; southwards from Indonesia into Australia; and northwards from South America through Central America and into the southern parts of North America (Figure 4).

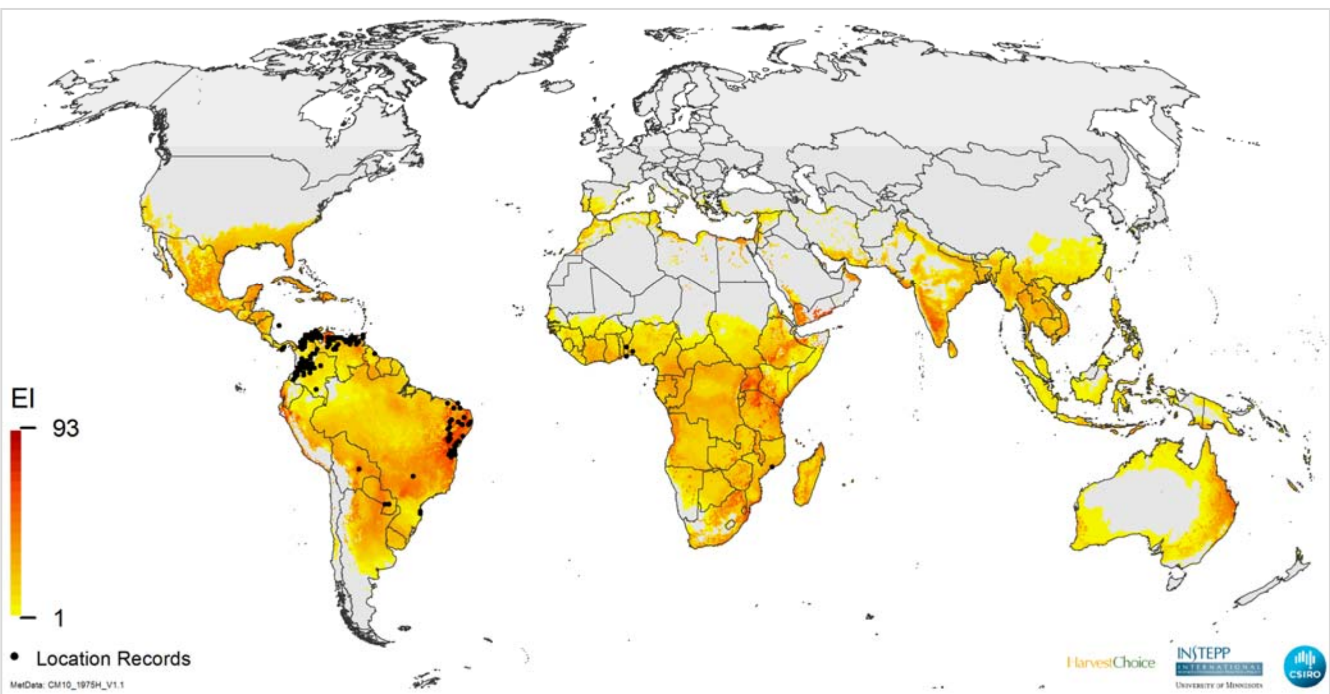

Figure 4. Modelled global climate suitability for *Mononychellus tanajoa* as a composite of natural rainfall and irrigation based on the irrigation areas identified in Siebert et al. (2005). Location records were provided by B.V.H. Campo and G.G. Hyman of CIAT.

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ABOUT HARVESTCHOICE

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Revision History

In the October 2014 publication, the third paragraph of the Known Distribution section originally read:

> More recently, *M. tanajoa* was introduced to Asia. It was reported in China in 2010, and has since become a major pest in the cassava regions of Hainan (Lu et al. 2012). Machi et al. (2014) indicate that *M. tanajoa* was first reported in Asia (Thailand) in 2008, but now also occurs in Cambodia, Indonesia, Laos, Malaysia, Myanmar, New Guinea, and Vietnam.

This revised April 2016 version updated the above paragraph with additional information from recent publications and personal communication.

The reference list has been expanded in this version to include the following:

Flechtmann, C.H. (2013). A new species of *Neotetranychus* Trägårdh (Acari, Prostigmata, Tetranychidae) from Thailand with a key to world species. *Persian Journal of Acarology* 2:35-40.

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