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# Ontogeny and Chaetotaxy of Mononychellus Tanajoa Bondar Infesting Cassava Crops in Rivers State, Nigeria

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**A B S T R A C T**

The ontogeny of body setae in the immature stages of Mononychelust anajoa in Rivers state, Nigeria was studied. Setal counts on the life stages (larva, protonymph, deutonymph and adult) from laboratory cultured specimens showed a constant number of 13 pairs of setae on the dorsal idiosoma from larval to adult instars, while there was a progressive addition of setae on both the ventral idiosoma and leg segments. Complete setal formulae for the leg segments for all the instars are presented.



**Key words:** *cassava; cassava green mites (CGM); chaetotaxy; deutonymph; larva; Mononychellus tanajoa; ontogeny; protonymph, setae; tetranychidae;*



## Introduction

According to Montaldo (1973), cassava (Manihotesculenta (Crantz)) (family Euphorbiceae) originated in the Venezuelan savannah. It was introduced in the delta of the Congo River by the Portuguese during the latter part of the sixteenth century and in the early nineteenth century in East Africa (IITA, 1986). Most cassava in Africa including Nigeria grows between latitude 15N and 15S of the equator. It is now extensively grown from humid to semi-humid region of tropical Africa, covering 80 million hectares in about 34 countries (IITA 1985). Montaldo (1973) reported that, over nine million hectares are sown worldwide, the main producers being Brazil with more than two million hectares, followed by Indonesia and Nigeria with more than one million each. Over 200,000 ha of cassava is planted in Nigeria with yields between 7 and 12 tons/ha (Zwankhvizen, 1962). The crop is used for both food and industrial purposes. It is a staple carbohydrate food source for 300-500 million inhabitants of Africa and Nigeria in particular (Byrne et al; 1983). It is used as raw material for the production of alcohol and adhesives and also principal starch source. The leaves serve as green vegetable in many areas (Lima, 1977, Lii and Chany1978).

In Africa, the arthropod pest status on cassava was not considered to be of economic importance until the accidental introduction of cassava mealy bug and cassava green mite (CGM) (Girling et al, 1977). Flechtmann (1977, 1981) and Doreste (1981) stated that, there are about 40 different species of tetranychids on cassava all over the world. Out of these, the most frequent and most important being Mononychellus tanajoa (Bondar). The host range of CGM is also limited within the family Euphorbiaceae and is restricted almost entirely to the genus Manihot. Nyiira (1977); Mendonca et. al.(2011) reported that the mites feed and breed on Manihotesculenta, M. psuglaziovii, M. dichotoma and M. pauyensi. This narrow host range indicates specifically leading to high buildup of pest population to damaging levels.

Mites in general, are minute chelicerate arthropods. The adult size ranges from 150-700um in length. They belong to the Acari (= Acarina), a subclass in the Arachnida. They have neither distinct body division nor segmentation, while chelicerae replace mandibles for mouth parts. Body is covered with setae (hairs). They have four pairs of legs at nymphal and adult stages. Development of mites goes through four active stages: a six-legged larval stage, two nymphal stages (protonyymph and deutonymph) and an adult stage with quiescent periods before each moult (Gutierrez 1987, Yaninek and Herren 1988, Yaninek et al., 1989). Mites though small as individuals, usually occur in large numbers which rank them among some of the most dangerous organisms attacking plants. Although systematic studies of the Acari began in the past century, it is probable that only a small portion of the fauna has been discovered. Inspite of this, studies of phytophagous mites in the family Tetranychidae (spider mites) and others have made steady progress because of their agricultural importance. The spider mites are of particular interest because of their cosmopolitan nature as well as their abundance and damage done to many plant species of economic importance. Identification of tetranychid mites to genus and species level has received considerable attention. Most recent are those of the genus Mononychellus feeding on

cassava plants in Africa. They are commonly referred to as "Cassava Green Spider Mites" (CGM). The CGM in Africa, first described as Mononychellus tanajoa (Bondar) is an exotic species from South America. It was first recorded from Uganda, in 1971. Since then it has been found in almost all cassava growing countries of Africa. Dorest (1981) described Monoychellus progressivus (Doreste) in Venezuela which has also been reported in Africa (Flechtmann, 1982, Macfarlane,1984). The occurrence of both species: M .tanajoa and M. progresivus in Africa raised some doubts (Yaninek and Herren, 1985), it is now accepted 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).

M.tanajoa attacks the ventral surface of young cassava plants, especially 2-8 months old leaves near the terminal shoots (Girling et. al. 1977). Byrne et al. (1983);Yaninek et al. (1987) and Yaninek et. al. (1989a) described the feeding mechanism of M. tanajoa. They feed by piercing individual cells of the leaf parenchymatous tissue with their elongated, paired, needle-like stylets, extracting cell contents. The damage systems as a result of this, is first observed as irregular whitish spots on the leaf surface which later become yellowish (Chlorotic spots) due to chlorophyll depletion in the leaves. Complete chlorosis occurs depending on the population of CGM feeding actively. Heavy infestation leads to stunted growth of the plant and leaf drop producing a "candle stick" symptom followed by complete defoliation particularly under drought stress conditions.

There has been a decline in yield all over the world ever since the mite pest infestation on cassava became apparent. Root yield losses due to M. spp. have been estimated at 10-80% (Bondar, 1938 and Shukla, 1978). The value of annual losses of tubers due to mite infestation was estimated at 860 million U.S dollars, which excludes the loss of leaf vegetation and planting materials (IITA, 1986). Control method of M. tanajoa generally in Africa emphasized classical biological control methods since both the pest and the host plant are exotic to Africa (Yaninek and Herren, 1988; Herren and Neuensschwander, 1991; Yaninek and Hanna, 2002). While this is ongoing, severe occurrences of cassava pests and diseases were reported in Rwanda (Night et.al. 2011). Also, M.tanajoa was reported to have been introduced in Asia. It was reported in China in 2010 and has since become a major pest in cassava growing regions of Hainan (Lu et. al. 2012). Machi et. al. (2014) indicated 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 is worrisome. One major requirement of a successful biological control programme is accurate identification of both pest and the natural enemies. Although considerable work has been done on the identity of M. tanajoa a reliable description of the species based on immature stages will not be out of place. Studies on immature stages may be justified when one considers that not only structural characters but data from other aspects of the organisms biology, including life history and immature stages could be used in the development of classification scheme and others. Van Emden (1959) and Manton (1964) emphasized the taxonomic significance of the characters of immature insects. This is the position of this study.

## Materials And Methods

### Specimen Collection

Adult males and females teleochyrysalis (virgin females) reared for immature stages were collected from infested cassava leaves in the field, from five cassava growing local government areas of Rivers State, namely: Ikwerre, Etche, Ahoada East, Ahoada West and Khana. Collection was carried out at every 15 kilometers (km) interval along a transect. At every point, infested leaves (leaves 6-10) from the terminal shoot were collected into cellophone bags. The largest number of CGM was usually present on these leaves (Yaseen, 1975). Adult male and female mites were transferred with the aid of a fine camel hair brush with dampened bristles onto a leaf disk for rearing.

### Rearing

The leaf disk method described by Helle and Overmeer (1985) was employed. Contamination by alien species was avoided by washing and inspecting the leaves under the microscope before use. The leaves were changed within a maximum of four days to avoid fungal growths. The trays carrying the Petri dishes of the leaf disk were placed on galvanized water trough, acting as a barrier to all crawling foreign agents for possible contamination. A 60w incandescent bulb illuminated the chamber and also provided the necessary warmth required. Temperature and Relative Humidity were regulated at $26^0$-$28^0$C and 65-75% R. H. under these conditions, the mites mated and females oviposited. The eggs hatched into larvae and subsequently moulted into protonymphs, deutonyphs and adults. At each instar, enough specimens were removed for mounting and examination.

### Mounting

CGM specimens for the study were mounted in Hoyer's medium as recommended by Pritchard and Baker (1955). A drop of the Hoyer's solution was placed at the centre of a clean microscope slide and individual adult and immature were deposited in the medium and orientated dorso-ventrally with legs well spread out and covered with a cover slip. To expand and clear the specimen, it was gently heated over a spirit lamp and left to dry at $50^0$C for 5-7 days. Dried slides were ringed with neutral nail polish and were labeled indicating the locality, date of collection, specimen sex, and others and then stored in slide boxes.

### Setal scores

All observations were made with a Leitz phase contrast microscope at 40x objective and all illustrations were made with Leitz camera lucida. The nomenclature of the body parts and the different setae are as illustrated by Gutierrez, 1985. Ten replicates per location were used because greater degree of accuracy is expected with large sample size. The characters examined were based on some general morphological characters often used in the identification of tetranychid mites. These are:

**Body Setae**
Number of Prodorsumal setae: P1-3
Number of Dorso-central Setae: D1-5
Number of Humeral Setae: H
Number of Dorso-lateral Setae: L1-4
Number of Idiosomal Mid-venter Setae: MV1-3
Opisthosomal venter:
Number of Pregenital Setae: PrG
Number of Genital Setae: G1-2
Number of Anal Setae: A1-2
Number of Para-anal Setae: PaA1-2

**Leg Setae**
Number of Setae on Coxistenal Plate, Legs 1-4: Cx1-4
Number of Setae on Trochanter segment, Legs 1-4: Tr 1-4
Number of Setae on Femur segment, Legs 1-4: Fm 1-4
Number of Setae on Genu segment, Legs 1-4: Gn 1-4
Number of Setae on Tibia segment, Legs 1-4: Tb 1-4
Number of Setae on Tarsus segment, Legs 1-4: Ts 1-4
(Larvae: Legs 1-3).

**Results**

Changes during setal ontogeny involve changes in number, length, shape and position of the setae. In this study the number, shape and position were considered. It should be noted that in interpreting these changes, it was assumed that once a seta appeared it was always retained in the subsequent instars. The body setae under examination were classified as dorsal idiosomal, ventral idiosomal and setae on the leg segments. Dorsal idiosomal setae comprise the prodorsumal and opisthosomal setae while opisthosomal is further differentiate as humeral, central and lateral setae.

**Dorsal Idiosomal Setae**

In the larval stage, three pairs of Prodorsumal setae P1, P2 and P3were observed. These were observed without addition or reduction through to protonymph, dectonymph and adult stage. The Opisthosomal dorsum showed 10 pairs of setae in the larva and again all through the life stages. These comprised a pair of humeral (H), 5 pairs of Dorso-central (D1- D5) and 4 pairs of Dorso-lateral (L1- L4) setae. Figures 1-4 illustrate their position, shape and total number of 13 pairs. All the setae on this striated cuticle appeared similar in length, except the L4 and D5 series which were shorter and shortest respectively, all through the stages. From larva to deutonymph, setae L1- L4 and D1- D5 were longest or as long as the distances between their bases. In the adult, the above mentioned setae were shorter than the distances between their bases. All the setae were similar in shape showing serrations and non-tapered ends.

**Ventral Idiosomal Setae**

Ventral idiosomal setae are distributed within the prodorsumal and opisthosomal ventral portions. In the larva, 2 pairs of setae, often referred to as Mid-ventral setae, Mv1- Mv2 were observed (Figure1). Protonymph retained this number (Figure2), but in the deutonymph a third pair (Mv3) was added (Figure3). The deutonymph number was retained in the adult stage (Figure4).

In the opisthosomal venter, 2 pairs of Anal setae (A1- A2) appeared around the anal opening in the larva and also 2 pairs of Para-anal setae (PaA1- PaA2) (Figure1) these numbers were retained in the protonymp with the addition of a pair of Pregenital setae (PrG) (Figure2). In the deutonymph a pair of Genital setae (G1) was added to the protonymhal number (Figure 3). At adult stage, a second pair of Genital setae (G2) was observed. A summary of the total number of ventral idiosomal setae for the instars is given in Table 1. Unlike the dorsal setae, the ventral setae were all short, smooth, slender and setiform on membranous cuticle.

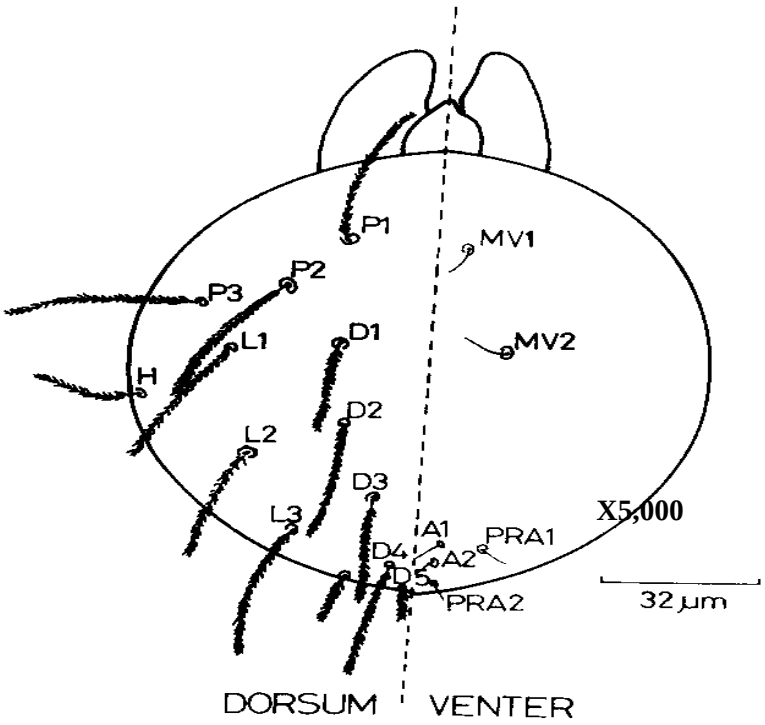


Figure 1: Dorsovestral aspect of larva of Monoychllus tanajoa showing idiosomal body setae. P1-3= prodorsumal satae; H=Humeral seta; D1-5= Dorso-central setae; L1-4= Dorso-lateral setae; MV1-2 = Mid-ventral setae; PRG= Pre-genital seta; A1-2= Anal setae; PRA1-2 = Para-anal setae.

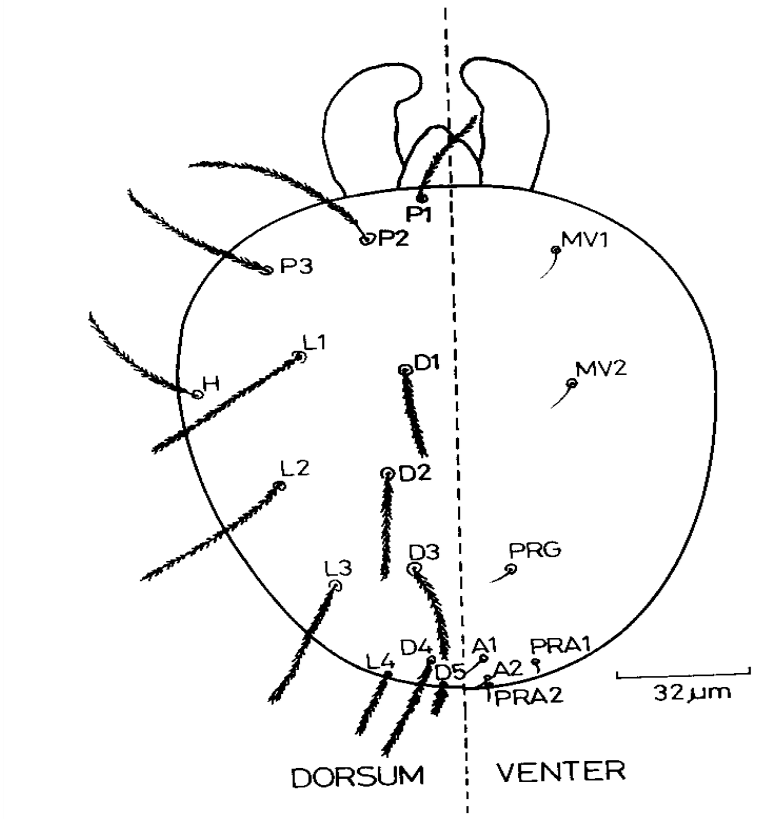


Figure 2: Dorsovestral aspect of protonymph of Mononychllus tanajoa showing idiosomal body setae. P1-3= prodorsumal satae; H=Humeral seta; D1-3= Dorso-central setae; L1-4= Dorso-lateral setae; MV1-2 = Mid-ventral setae; A1-2= Anal setae; PRA1-2 = Para-anal setae.

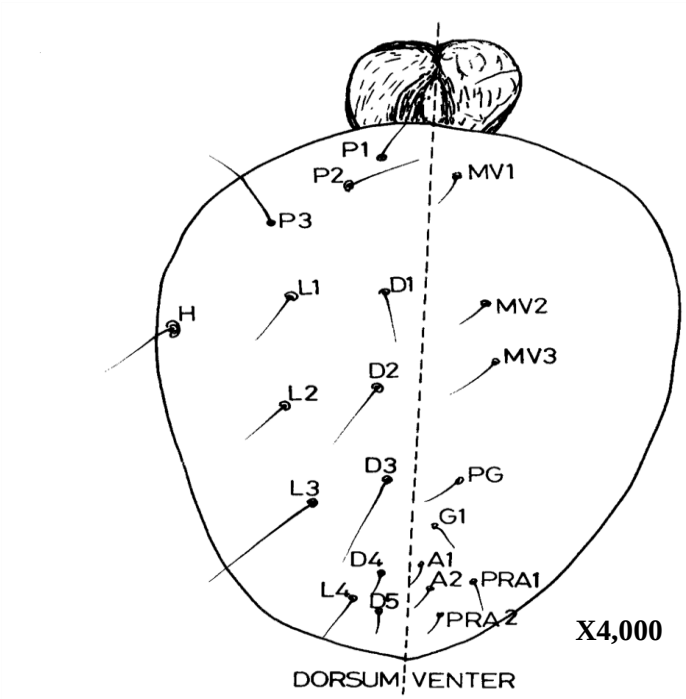


Figure 3: Dorsovestral aspect of duetonymph of Monoychllus tanajoa showing idiosomal body setae. P1-3= prodosomal satae; H=Humeral seta; D1-5= Dorso-central setae; L1-4= Dorso-lateral setae; MV1-3 = Mid-ventral setae; PRG= Pre-genital seta; G1-2= Genital setae A1-2=Anal setae; PRA1-2 = Para-anal setae.

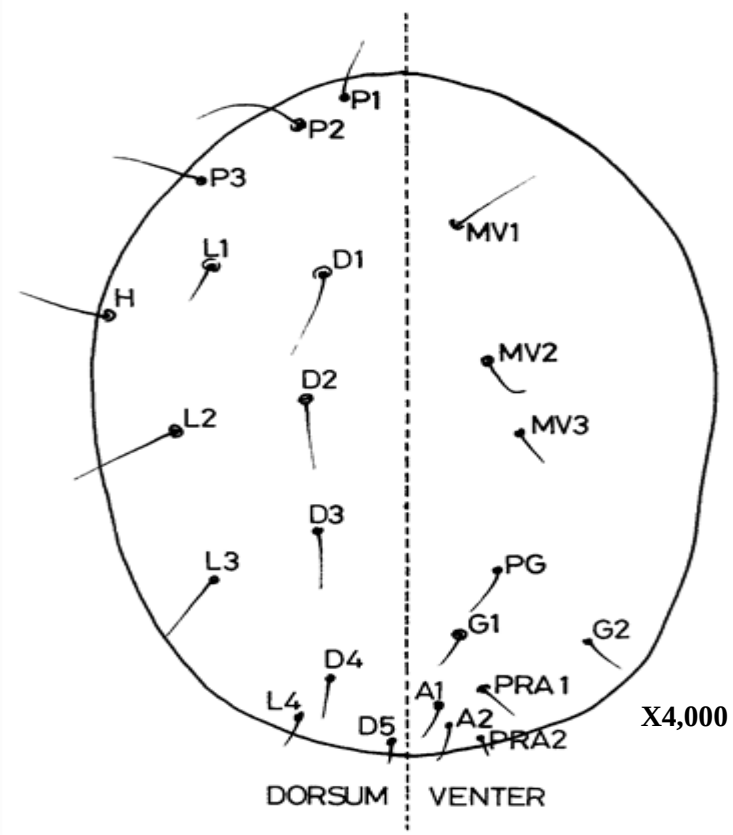


Figure 4: Dorsovestral aspect of adult female of Monoychllus tanajoa showing idiosomal body setae. P1-3= prodosomal satae; H=Humeral seta; D1-5= Dorso-central setae; L1-4= Dorso-lateral setae; MV1-2 = Mid-ventral setae; PRG= Pre-genital seta; A1-2= Anal setae; PRA1-2 = Para-anal setae.

Table 1: Ontogeny of the veatralidiosomal body setae of Mononychellus tanajoa.

| INSTAR | MV1 | MV2 | MV3 | PrG | G1 | G2 | A1 | A2 | PaA1 | PaA2 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Larva | + | + | - | - | - | - | + | + | + | + | 6pairs |
| Protonymph | + | + | - | + | - | - | + | + | + | + | 7pairs |
| Deatonymph | + | + | + | + | + | - | + | + | + | + | 9pairs |
| Adult | + | + | + | + | + | + | + | + | + | + | 10pairs |

(-) = absent; (+) = presence.

**Leg segments**

In all active instars of Mononychellus tanajoa, each leg had 5 articulating segments namely: trochanter, femur, genu, tibia and tarsus. The trochanter attached basally to a coxisternal plate which was delimated laterally but not medially from the rest of the prodorsumal surface.

**Coxisternal Plate**

In the larva, only a pair of setae appeared on platel, none on plates II and III and plate IV was absent (Figure 5). In the protonymph, with the larval setae retained a pair was added to plate I, bringing the number to 2 pairs and a pair each on plates II and III. There was none on plate IV (Figure 6). To the protonymphal number, a pair was added to plates II and IV in the deutonymph (Figures 7 & 8). The deutonumphal expression was retained in the adult stage (Figures 9 & 10). Table 2 shows the summary of numbers.

Table 2: Ontogeny of setae on Coxisternal plate of M. tanajoa

| INSTAR | Leg I | Leg II | Leg III | Leg IV |
|---|---|---|---|---|
| Larva | 1 | 0 | 0 | X |
| Protonymph | 2 | 1 | 1 | 0 |
| Deutonymph | 2 | 2 | 1 | 1 |
| Adult | 2 | 2 | 1 | 1 |

(0) = sate absent; (X) = leg not in existence

**Trochanter Segment**

The setation on this segment was the simplest. No setae were observed on all the legs of both larva and protonymph. Figures 5&6). In the deutonymph, a pair each appeared on legs I-III, none on leg IV (Figures 7 &8). The adult stage had the appearance of a pair on leg IV in addition to the deutonymphal numbers (Figures 9 & 10). Table 3 gives the number of setae on this segment.

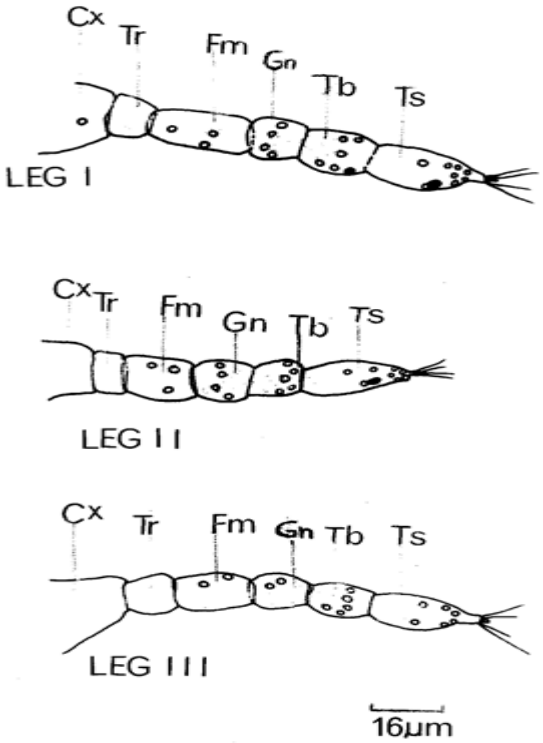


Figure 5: The setation of legs I-III of larva of Mononychellus tanajoa. Cx=Coxisternal plate; Tr=Trochanter; Fm=Femur; Gn= Genu; Tb= Tibia; Ts=Tarsus; (0) = tactile setae (0) = sensory seta; (c0) = duplex setae.

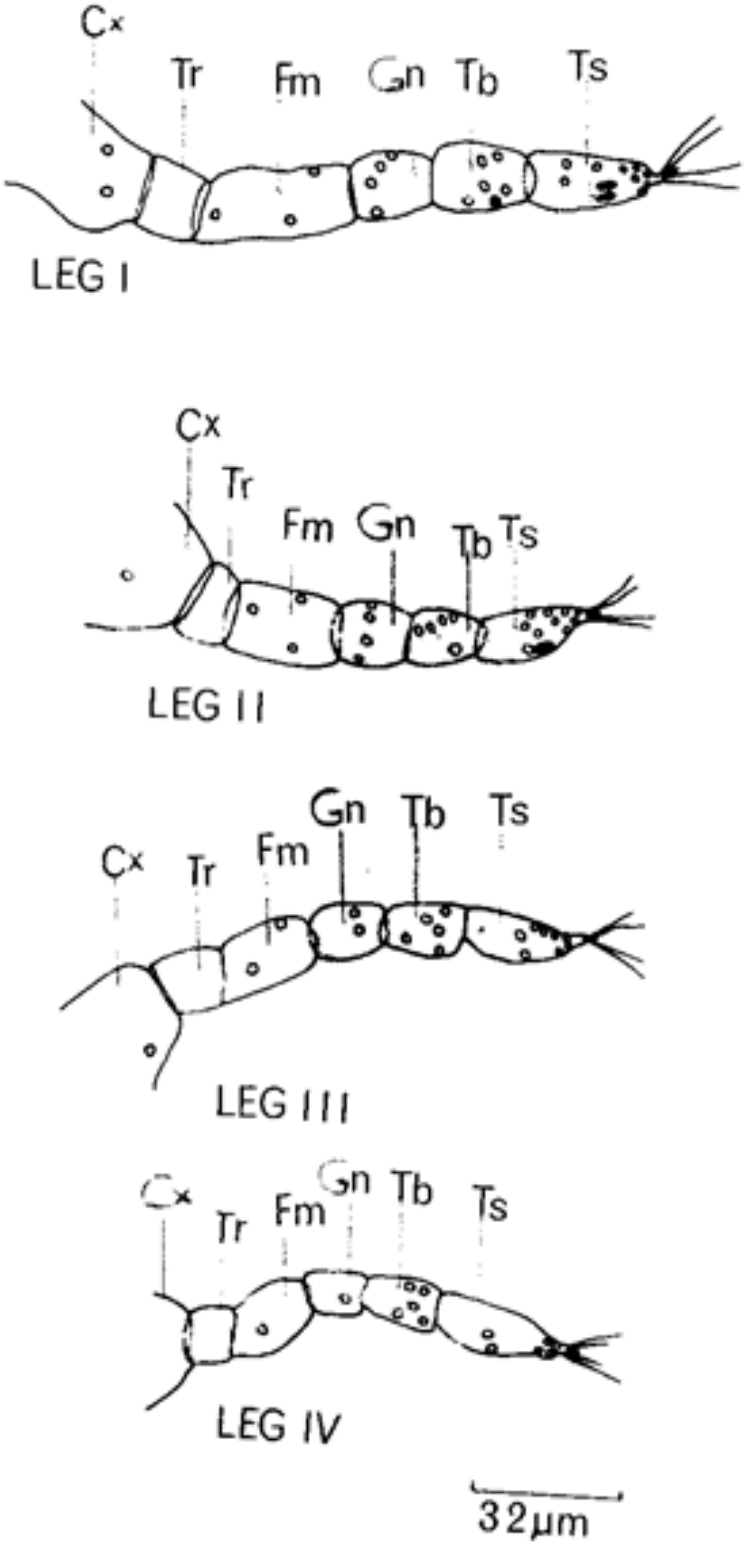


Figure 6: The setation of legs I-IV of protonymph of Mononychellus tanajoa. Cx=Coxisternal plate; Tr=Trochanter; Fm=Femur; Gn= Genu; Tb= Tibia; Ts=Tarsus; (0) = tactile setae (0) = sensory seta; (0) = duplex setae.

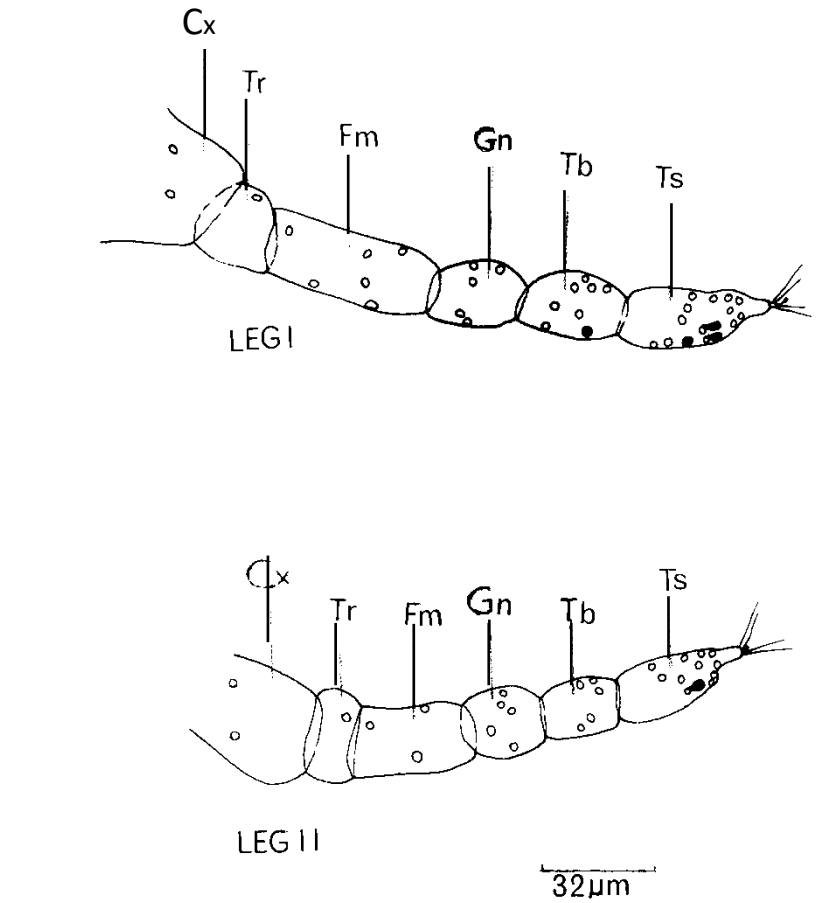


Figure 7: The setation of legs I & II of deutonymph of Mononychellus tanajoa. Cx=Coxisternal plate; Tr=Trochanter; Fm=Femur; Gn= Genu; Tb= Tibia; Ts=Tarsus; (0) = tactile setae (0) = sensory seta; (0) = duplex setae.

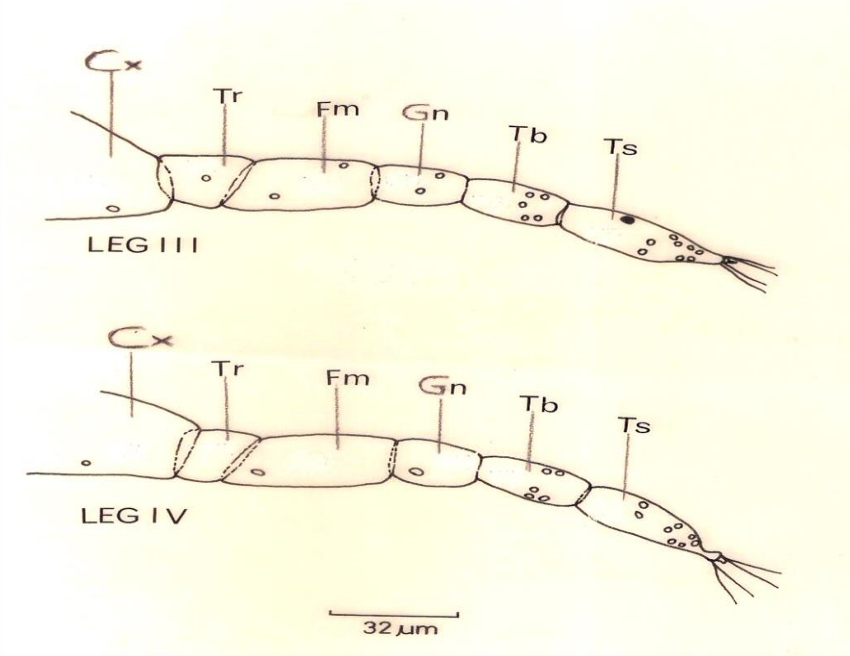


Figure 8: The setation of legs III & IV of adult female Mononychellus tanajoa. Cx=Coxisternal plate; Tr=Trochanter; Fm=Femur; Gn= Genu; Tb= Tibia; Ts=Tarsus; (0) = tactile setae (0) = sensory setae. (0) = duplex setae.

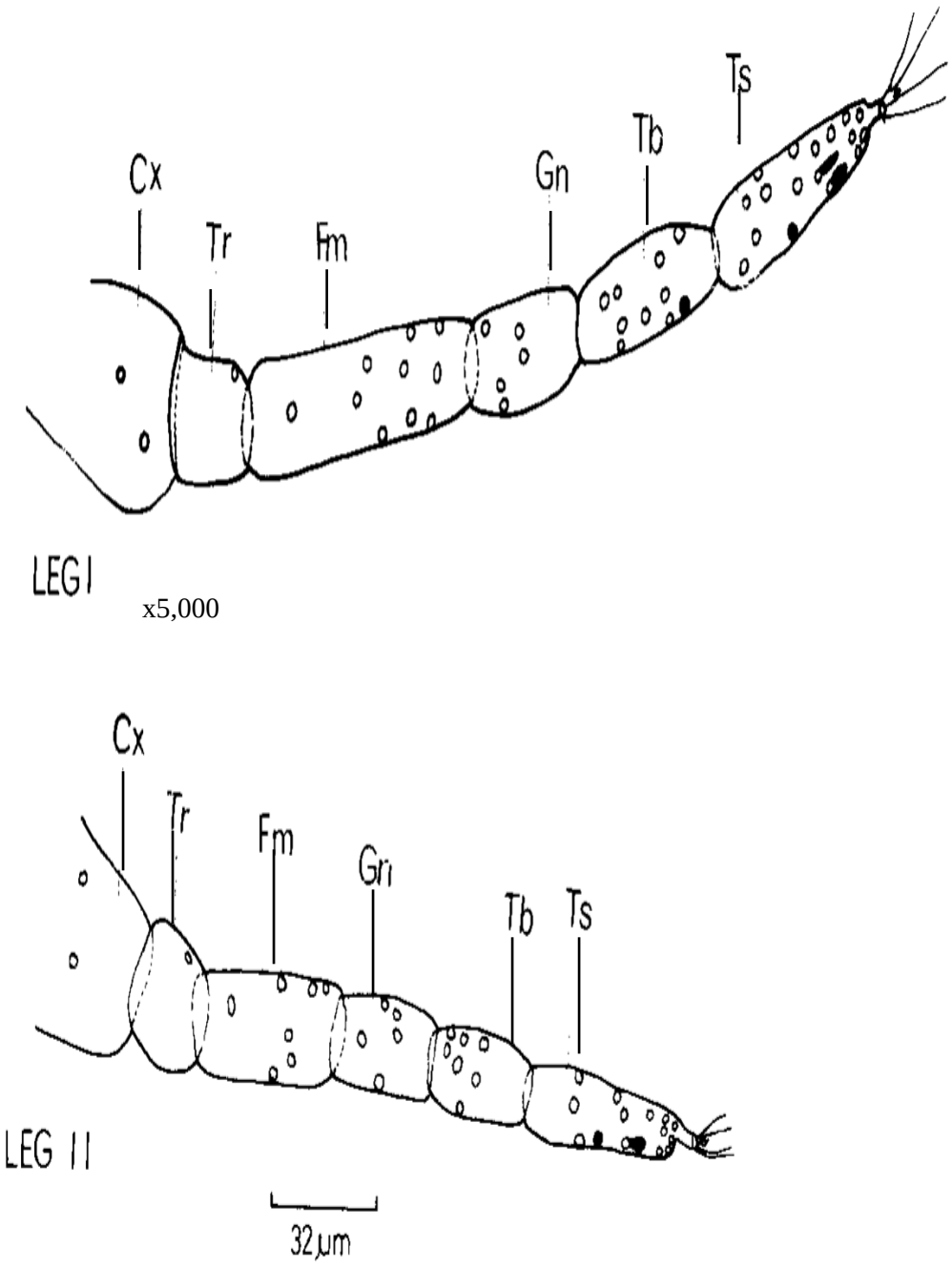


Figure 9: The setation of legs I & II of adult female Mononychellus tanajoa. Cx=Coxisternal plate; Tr=Trochanter; Fm=Femur; Gn= Genu; Tb= Tibia; Ts=Tarsus; (0) = tactile setae (0) = sensory setae. (0) = duplex setae.

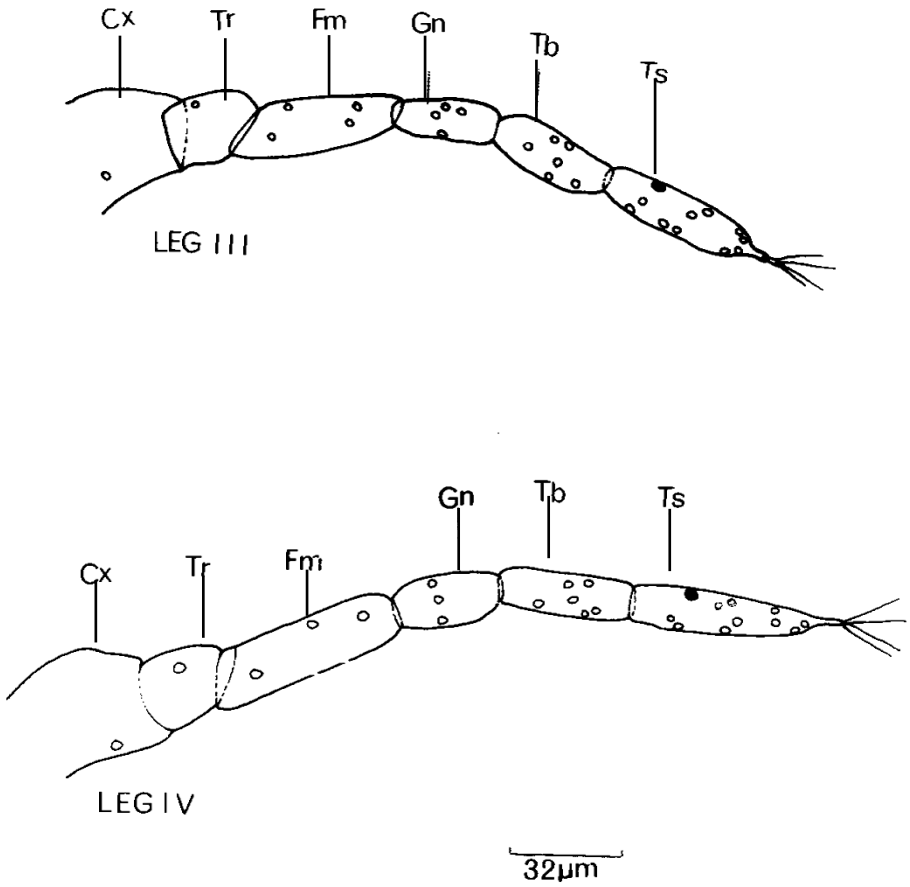


Figure 10: The setation of legs III & IV of deutonymph of Mononychellus tanajoa. Cx=Coxisternal plate; Tr=Trochanter; Fm=Femur; Gn= Genu; Tb= Tibia; Ts=Tarsus; (0) = tactile setae (0) = sensory setae.

Table 3: Ontogeny of setae on Trochanter segment of M. tanajoa

| INSTAR | Leg I | Leg II | Leg III | Leg IV |
|---|---|---|---|---|
| Larva | 0 | 0 | 0 | X |
| Protonymph | 0 | 0 | 0 | 0 |
| Deutonymph | 1 | 1 | 1 | 0 |
| Adult | 1 | 1 | 1 | 1 |

(0) = sate absence; (X) = leg not in existence

**Femur Segment**

In the larva, 3 pairs of setae appeared on leg I, 3 pairs on leg II and 2 pairs on leg III. The protonymph had a pair on leg IV (Figures 5 & 6). In the deutonymph, 3 pairs were added on leg I only. The rest remained unchanged (Figures 7 & 8). At adult stage, there were additions all through the legs as follows: 4 pairs on leg I, 4 pairs on leg II, 2 pairs on leg III and 2 pairs on leg IV. These brought the numbers to 10-7-4-3 on legs I-IV, respectively (Figures 9 & 10).
Table 4 shows the summary of the femoral setation

Table 4: Ontogeny of setae on Femur segment of M. tanajoa

| INSTAR | Leg I | Leg II | Leg III | Leg IV |
|---|---|---|---|---|
| Larva | 3 | 3 | 2 | X |
| Protonymph | 3 | 3 | 2 | 1 |
| Deutonymph | 6 | 3 | 2 | 1 |
| Adult | 10 | 7 | 4 | 3 |

(X) = leg not in existence

**Genu segment**

The genualsetal development in the larva was the appearance of 4 pairs of setae on leg I, 4 pairs of setae on leg II, 4 pairs on leg II and 2 pairs on leg III (Figure 5). The protonymph had an additional pair of setae on leg IV (Figure 6). In the deutonymph one set each was added to legs I and II, none on legs III and IV. The number was then increased to 5-

5-2-1. In the adult stage additions were only on legs III and IV (Figures 9 & 10) and the number increased to 5-5-4-2. A summary of the setal numbers on this segment is given in Table 5.

Table 5: Ontogeny of setae on Genu segment of M. tanajoa

| INSTAR | Leg I | Leg II | Leg III | Leg IV |
|---|---|---|---|---|
| Larva | 4 | 4 | 2 | X |
| Protonymph | 4 | 4 | 2 | 1 |
| Deutonymph | 5 | 5 | 2 | 1 |
| Adult | 5 | 5 | 4 | 3 |

(X) = leg not in existence

**Tibial segment**

In the larva and protonymphal stages, tibialsetation on legs I-IV were given as 5(+1 sensory) -5-5-5 (Figures 5 & 6). In the deutonymph, changes were only on leg I with the addition of setae all through the legs in the adult. These brought the number of 9(+1 sensory) -7-6-6 (Figures 9 & 10) Ontogenetic changes in this segment are summarized in Table 6.

Table 6: Ontogeny of setae on Tibial segment of M. tanajoa

| INSTAR | Leg I | Leg II | Leg III | Leg IV |
|---|---|---|---|---|
| Larva | 5t+1s | 5 | 5 | X |
| Protonymph | 5t+1s | 5 | 5 | 5 |
| Deutonymph | 7t+1s | 5 | 5 | 5 |
| Adult | 9t+1s | 7 | 6 | 6 |

(X) = leg not in existence; (t)-tactile setae; (S)=sensory setae

**Tarsal Segment**

Larval setation in this segment was 7(+1 duplex) – 7(+1 duplex)-6 (Figure 7) Protonymph had 9(+2 duplex) – 9(+1 duplex)-8-6 (Figure 8). In the deutonymph, there were additions of both tactile and sensory setae all through the legs; the numbers then became 11(+1s+2 duplexes)-10(+1d)-8(+1s)-8. Adult expression was also increased to 14(+1s+2d)-12(+1s+1d)-10(+1s)-10(+1s). Full tarsal notation for the whole instars is given in Table 7. It was noted that, in this segment, the addition of setae were from the distal to the proximal end of the body.

Table 7: Ontogeny of setae on Tarsal segment of M. tanajoa

| INSTAR | Leg I | Leg II | Leg III | Leg IV |
|---|---|---|---|---|
| Larva | 7t+1d | 7t+1d | 6 | X |
| Protonymph | 9t+2d | 9t+1d | 8 | 6 |
| Deutonymph | 11t+1s+2d | 10t+1d | 8t+1s | 8 |
| Adult | 14t+1s+2d | 12t+1s+1d | 10t+1s | 10t+1s |
| | (5t+1s)* | (3t+1s)* | (2t+1s)* | (2t+1s)* |

(t) = tactile setae; (S)=sensory setae; (d)-duplex setae; (X)=leg not in existence; *=proximal setae

The full complements of setal formulae for the legs of all the life stages are given in Tables 8-11.

Table 8: Leg chaetotaxy in Larva of M. tanajoa

| LEG | Cx | Tr | Fm | Gn | Tb | Ts |
|---|---|---|---|---|---|---|
| I | 1 | 0 | 3 | 4 | 5t+1s | 7t+1d |
| II | 0 | 0 | 3 | 4 | 5 | 7t+1d |
| III | 0 | 0 | 2 | 2 | 5 | 6 |

(t)=tactile setae; (S)=sensory setae; (d)=duplex setae; (o)=setae absent

Table 9: Leg chaetotaxy in Protonymph of M. tanajoa

| LEG | Cx | Tr | Fm | Gn | Tb | Ts |
|---|---|---|---|---|---|---|
| I | 2 | 0 | 3 | 4 | 5t+1s | 9t+2d |
| II | 1 | 0 | 3 | 4 | 5 | 9t+1d |
| III | 0 | 0 | 2 | 2 | 5 | 8 |
| IV | 0 | 0 | 1 | 1 | 5 | 6 |

(t)=tactile setae; (S)=sensory setae; (d)=duplex setae; (o)=setae absent

Table 10: Leg chaetotaxy in Deutonymph of M. tanajoa

| LEG | Cx | Tr | Fm | Gn | Tb | Ts |
|---|---|---|---|---|---|---|
| I | 2 | 1 | 6 | 5 | 7t+1s | 11t+1s+1d |
| II | 2 | 1 | 3 | 5 | 5 | 10t+1d |
| III | 1 | 1 | 2 | 2 | 5 | 8t+1s |
| IV | 1 | 0 | 1 | 1 | 5 | 8 |

(t)=tactile setae; (S)=sensory setae; (d)=duplex setae; (o)=setae absent

Table 11: Leg chaetotaxy in Adult female of M. tanajoa

| LEG | Cx | Tr | Fm | Gn | Tb | Ts |
|---|---|---|---|---|---|---|
| I | 2 | 1 | 10 | 5 | 9t+1s | 14t+1s+2d |
| II | 2 | 1 | 7 | 5 | 7 | 12t+1s+1d |
| III | 1 | 1 | 4 | 4 | 6 | 10t+1s |
| IV | 1 | 1 | 3 | 3 | 6 | 10t+1s |

(t)=tactile setae; (S)=sensory setae; (d)=duplex setae

**Discussion**

The prodorsumal setal number of 3 pairs observed in all instars was not unusual. It was observed by Lindquist (1985) in his general work on spider mites that, a number of 3 pars of setae throughout life were consistent. The 10 pairs evident on the opisthosomal dorsum were also within the range of numbers found in other tetranychid mites (Lindquist, 1985). The setal numbers of 6, 7, 9 and 10 pairs for the larva, protonymph, deutonymph and adult female, respectively on the ventral idiosoma also conform with those on other tetranychid mites (Lindquist, 1985). Among these, were 2 pairs of para-anal setae which were evident from larval to adult stages. These have been described as unique features among the Tetranychidae and have been used as a diagnostic character of the genus (Nyiira, 1977 and Flechtmann, 1977). The number of the ventrally placed short setae on the coxisternal plates agrees with the maximum number observed in the family Tetranichidae for all the instars (Robaux and Gutrierrez, 1973 and Lindquist, 1985). The ontogenetic pattern in the trochanter segment as observed in this study is common to the Tetranychidae, as was also observed by Lindquist (1985) who reported that, in the adult only a pair of setae are present on each leg. It was also noted that these setae were absent on all the legs in the larva and protonymph. In the deutonymph they were absent only on leg IV. This observation makes distinction easier between this instar and the protonymph of M. tanajoa.

The pattern of setation observed in the femoral segment did not tally completely with those of other tetranychid mites. According to Quiros and Baker (1984) the correct notation in this segment in tetranychids had not been determined but in the adult, they observed that there are generally additions of about 4 pairs of setae each to the deutonymphal numbers on legs I and II and 3 pairs each on legs III and IV. These additions were observed on legs I and II but only 2 pairs each were observed on legs III and IV. Grandjean (1965) however, stated that, generally, spider mites also show varying degrees of setal additions and reductions on this segment. The femoral numbers of 10-7-4-3 on the four legs indicated addition on legs I and II and reductions on legs III and IV. Meyer (1974) on the other hand, described Mononychelleslippiae with reductions all through the legs except for leg II with the numbers given as 9-7-3-3.

Addition of setae in the genual segment of adult spider mites is also variable in the Tetranychinae. In this sub-family, generally, no setae are added on legs I and II (Lindquist, 1985). This is in agreement with the present findings in adult female M. tanajoa retaining the deutonyphal numbers of 5-5 on legs I and II. There are usually additions and reductions on legs III and IV of the adult. A reduction giving a formula of 5-5-4-2 in the adult was used in the description of M. lippiae (Meyer, 1974), while there was setal addition in M. tanajoa giving a formula of 5-5-4-3. These conditions in different species of Mononychellus could be influenced by some genetic factors which determine the species types.

The findings of 9 tactile and I sensory setae and 7 tactile setae on tibiae I and II, respectively tally with observations of Nyiira (1977), Flechmann (1977) and Rogo, et. al. (1987). These are already used as diagnostic features of M. tanajoa. Other observations on the larva, protonymph and deutonymph for legs I-IV and the distal tarsal setae in the adult female are original findings of the present study specific to M. tanagoa. Based on this, it would be worthwhile to re-describe M. tanajoa to include the complete setal formulae of the immature stages. These characters have often been used in systematic studies of species in the Acari in general and Tetranychidae in particular.

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