BIOLOGY OF THE SWEETPOTATO WHITEFLY (HOMOPTERA: ALEYRODIDAE) ON TOMATO

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ABSTRACT

Development and oviposition of the sweetpotato whitefly, *Bemisia tabaci* (Gennadius), were studied on tomato leaflets under laboratory conditions (25°C and 65% R.H.). Three nymphal instars and a transitional form were noted. The duration in days of the egg, nymphs and transitional form was: egg 7.3 ± 0.5; first instar 4.0 ±1.0; second instar 2.7 ± 1.1; third instar 2.5 ± 0.7; fourth instar-pupa 5.8 ± 0.3. Total life cycle from egg to adult emergence was 22.3 days. Adult longevity was 19.0 ± 3.3 and 19.4 ± 5.8 for the females and males, respectively. Preoviposition lasted 1.4 ± 0.7 and oviposition 16.7 ± 3.2 days. Fecundity was 194.9 ± 59.1 eggs per female, while egg viability was 86.5%. Sex ratio was 1: 2.7 male-female. Virgin females were parthenogenetic, arrhenotoky type.

Key Words: Life cycle, *Bemisia tabaci*, developmental stages, tomato, Venezuela

RESUMEN

El desarrollo y la ovoposición de la mosca blanca de la batata, *Bemisia tabaci* (Gennadius), fueron estudiadas en foliolos de tomate *Lycopersicon esculentum* bajo condiciones promedios de 25°C de temperatura y 65% de humedad relativa, a nivel del laboratorio. La duración en días de las diferentes fases de desarrollo fue: huevo 7,3 ± 0,5; primer instar ninfal 4,0 ± 1,0; segundo instar 2,7 ± 1,1; tercer instar 2,5 ± 0,7; cuarto instar-pupa 5,8 ± 0,3. La duración total del ciclo de vida desde huevo hasta la formación del adulto fue de 22,3 días. Se determinaron tres instares ninfales y uno de transición (cuarto instar-pupa). La longevidad de las hembras y los machos fue de 19,0 ± 3,3 y 19,4 ± 5,8 días, respectivamente. El período de preovoposición fue de 1,4 ± 0,7 días, mientras que el de ovoposición fue de 16,7 ±3,2 días. La fecundidad fue de 194,9 ± 59,1 huevos/hembra, siendo la viabilidad de los huevos 86,5%. La proporción sexual fue 1: 2,7 macho-hembra. Las hembras mostraron una partenogenesis, tipo arrenotoquia.

The sweetpotato whitefly, *Bemisia tabaci* (Gennadius), is one of the most important agricultural insect pests in the Middle East, Europe, North and Central America, and the Caribbean Basin. In addition to feeding on more than 700 host plant species within 86 botanical families (Greathead 1986), *B. tabaci* has a high reproductive capacity and distinctive life habits that enable it to (1) cause severe damage through plant feeding and (2) transmit more than 90 types of virus diseases in commercial crops (Brunt 1986).

On a worldwide basis, but mainly in the Old World, *B. tabaci* has been recognized as a major agricultural pest for more than four decades (Byrne et al. 1990). In the New World, its presence as an economic pest has been reported from the 1930s through the 1960s, with population outbreaks in the 1970s and 1980s up to the present date (Brown 1990). In Venezuela, population explosions on melon plantings in the late 1980s caused economic damage; tomato, tobacco, sesame and other annual crops were also damaged in the early 1990s (unpublished data).

Several studies on the biology of *B. tabaci* have been done under diverse environmental conditions, (López-Avila 1986). Those studies reported that the life cycles varied mainly depending upon the temperature, relative humidity and the host plant. Russell (1975) compiled literature on the biology and morphology of *B. tabaci* and other whitefly species in legume crops. She reported finding much variability in the life cycle and other biological aspects that were strongly related to climatic factors and the host plant. This study was conducted to determine the development and ovipositional preference of *B. tabaci* under controlled climatic conditions on tomato, *Lycopersicon esculentum* Mill.

MATERIALS AND METHODS

Bemisia tabaci was determined by L.M. Russell from U.S.D.A., A.R.S., S.E.L., Beltsville, M.D., U.S.A. (Arnal et al. 1993). Voucher specimens have been deposited in the Entomology Museum at FONAIAP, CENIAP, Maracay, Venezuela. We believe that the strain involved in this study is strain A (cotton strain). Venezuelan strains of *B. tabaci* are actually under study by J. K. Brown from University of Arizona, U.S.A. So far, plant symptoms caused by the B or "silverleaf" strain on several vegetable crops have not been observed in Venezuela.

The research was conducted at the Entomology Laboratory of FONAIAP - Centro de Investigaciones Agropecuarias del Estado Lara, Venezuela, in 1993 under a mean

temperature of 25°C and 65% R. H. Initially, pupae of *B. tabaci* were collected from 'Rio Grande' tomato plantings located at Quíbor Valley, Estado Lara. Pupae were held in humidity chambers until the adults emerged. The adults were then placed on young healthy tomato plants (free of insects) which were kept inside of rearing and reproduction cages (50 × 40 × 40 cm) made of wood and organdy cloth.

Insect development was studied on 'Rio Grande' tomato leaves with at least three leaflets, which were placed inside glass vials 9.5 cm long and 2.5 cm wide. Ten to 20 adults were introduced into each vial and the vial was closed with a cotton plug. Subsequently, 84 eggs were observed to determine their incubation period. After hatching, 65 first instar nymphs were selected to study duration of that stadium; 30 of these were observed to determine the duration of the "crawling" period of the first instar. To determine the number and duration of each instar, we made direct observations of the molted exuviae with aid of scotch tape. The tape was placed carefully over nymphs located on the underside of the leaflets and just over the trichomes to avoid any injury to the nymphs. The nymphs and the scotch tape were checked daily to evaluate nymphal development and the presence of molted skins on the tape. These observations lasted until pupae were formed. Records were kept for the duration of each instar and the number of shed exuviae.

The duration of the transitional fourth instar-pupa stage was studied on 42 specimens showing combined morphological characteristics of nymph and pupa (typical "dome" shape of the nymph and the big red eyes of the pupa) through adult formation. Adult longevity was studied with 45 virgin males and 43 virgin females. They were placed individually inside the glass vials using tomato leaflets as food.

Preoviposition and oviposition periods and fecundity were studied with 40 virgin females sexed by body size and the shape of their abdomen. They were placed inside glass vials containing healthy tomato leaflets and the vials closed with a cotton plug. The petiole of each leaflet was inserted inside a small plastic container filled with water. The leaves were replaced daily. Viability was determined for 104 eggs laid by virgin females on 10 leaflets. Hatching was recorded daily. Sex was determined by the dissection of genitalia. Sexual structures were contrasted with the abdomen shape in every specimen. Sex ratio was observed and recorded for 220 adults of the same cohort based on dissection of genitalia. Parthenogenesis was studied on the offspring of 74 adults obtained from 20 previously isolated virgin females. Their sex was determined by dissection and observation of the genitalia.

Results and Discussion

Duration of the Developmental Stages

Mean duration of the egg and nymphal stage of *B. tabaci* is shown in Table 1. The egg incubation period, 7.3 ± 0.5 (S.D. is used throughout), was very similar to that reported by López-Avila (1986) for whiteflies reared on tomato and cotton at 25°C and 75% R.H., and Peña-Rojas et al. (1992) with common bean plants at temperatures ranging from 22 to 31°C and R.H.'s from 41.5 to 94%. This was different than that reported by Eichelkraut & Cardona (1989) for whiteflies reared on common bean plants grown in field (24°C, 70% R.H.) or greenhouse (26°C, 67% R.H.). A wide range in incubation period has been reported (3 to 33 d), depending mainly on temperature and relative humidity conditions (Husain 1931, Husain & Trehan 1933, Avidov 1956, El-Helaly et al. 1971, Azab et al. 1971, Butler et al. 1983).

The nymphal stage was separated into three well defined instars. A 4th-instar was considered as transitional and named 4th instar-pupa because the duration between these two stages was short and difficult to separate. The first instar lasted 4.0 ± 1.0 d

TABLE 1. MEAN DURATION OF THE DIFFERENT DEVELOPMENTAL STAGES OF *B. TABACI* REARED IN LABORATORY (25°C, 65% R.H.). 1993.

Stage	No. Tested	Duration (days)[2] Mean ± SD	Range
Egg	84	7.3 ± 0.5	6.8 - 8.7
Nymph			
1st instar[1]	65	4.0 ± 1.0	2.5 - 7.0
2nd instar	55	2.7 ± 1.1	1.5 - 6.0
3rd instar	47	2.5 ± 0.7	1.5 - 4.0
4th instar-pupa	42	5.8 ± 0.3	4.0 - 9.0
Adult			
Male	45	19.4 ± 5.8	14.5 - 29.0
Female	43	19.0 ± 3.3	12.8 - 29.0

[1]The mobile form (crawler) lasted 1 h, 48 min, and the fixed form 4.0 d.
[2]Total life cycle from egg to adult lasted 22.3 d.

with two forms, one mobile (crawler) that lasted 0.08 d (1 h,48 min) and a fixed one that lasted 3.96 d. Duration of the crawler form was similar to that found by Eichelkraut & Cardona (1989), but Avidov (1956) indicated that it could last several days. Azab et al. (1971) found that the duration of the first instar varied from 2 to 6 d on sweetpotato under conditions close to ambient. Sharaf & Batta (1985) reported that the duration at 25°C was 2.8 d, and 9.0 d at 14°C.

Second and third nymphal instars lasted 2.7 ± 1.1 and 2.5 ± 0.7 d, respectively. These observations are similar to those reported by El-Helaly et al. (1971) on sweetpotato and potato under a temperature of 24.5°C and a saturated atmosphere and Sharaf & Batta (1985) at 25°C. It was different than the results reported by Eichelkraut & Cardona (1989) who found a duration of 4.7 and 3.7 d (2nd instar), and 5.9 and 5.1 d (3rd instar) on field and greenhouse, respectively, and Peña-Rojas et al. (1992) 4.45 d (2nd instar) and 4.35 d (3rd instar). Azab et al. (1971) reported that these instars lasted from 1 to 7 d for each; however, others reported that the whole nymphal stage lasted from 9 to 84. They emphasized that temperature had an important effect on the duration (Husain 1931, Husain & Trehan 1933).

Some researchers consider the 4th instar separate from the pupa (Azab et al. 1971, El-Helaly et al. 1971, Sharaf & Batta 1985, López-Avila 1986), but others as a transitional stage (Husain 1931, Gill 1990, Bethke et al.1991, Byrne & Bellows 1991). We agree with the latter conclusion and regard its duration time as difficult to delineate, but morphologically distinct. Fourth instar-pupa lasted 5.8 ± 0.3 d being similar to the results of El-Helaly et al. (1971), but different from authors who considered this instar as two separate stages (Azab et al. 1971, López-Avila 1986, Peña-Rojas et al. 1992).

Life Cycle

The duration from egg to adult was 22.3 d, which is very similar to that reported by Eichelkraut & Cardona (1989) on common beans under the same temperature and relative humidity. Bethke et al. (1991) found that total development times were similar, ranging from 23.2 d (poinsettia population reared on poinsettia) to 25.6 d (cotton

population reared on poinsettia). Other authors have reported life cycles from 14 to 107 d, depending upon temperature, indicating that at 25-30°C the cycle was shortened (Husain 1931, El-Khidir 1965, Azab et al. 1971, Butler et al. 1983). Coudried et al. (1985) found that the time required for *B. tabaci* to complete the development from egg to adult at 26.7 ± 1°C was influenced by the host plant on which it was fed. For instance, mean duration in days varied among hosts: carrot (29.8), broccoli (29.7), tomato (27.3), pepper (23.4), cantaloupe (22.3), watermelon (22.3), common beans (21.8), cotton (21.7), squash (21.3), aubergine (20.9), cucumber (20.6), lettuce (19.4) and sweetpotato (18.6). Development was completed in 30% less time on lettuce, cucumber, aubergine, and squash than on broccoli or carrot. Based on our results, we suggest that under the tropical conditions of Venezuela, 10 to 16 generations per year may occur, which is similar to reports by Husain (1931), Avidov (1956), and Azab et al. (1971).

Nymphal Instars

Through direct observations, 3 shed nymphal skins were noted indicating that *B. tabaci* has 4 instars on tomato. No shed skins were observed between 4th instar and pupa, only morphological changes. Likewise, Husain (1931) on cotton and López-Avila (1986) on common beans, tobacco, cotton, and tomato reported a 4th instar, but El-Helaly et al. (1971) on sweetpotato and potato and Azab et al. (1971) on sweetpotato reported three instars. Byrne & Bellows (1991) stated that in the literature, whitefly 4th nymphal instar is commonly referred to as a pupa. Bethke et al. (1991) found 4 nymphal instars on different populations of *B. tabaci* reared on poinsettia and cotton leaves. They included 4th instars as a pupal stage. Lynch & Simmons (1993) reported 4 nymphal instars of *B. tabaci* strain B reared on peanut.

Preoviposition and Oviposition

Preoviposition was 1.4 ± 0.7 and ovipositional period 16.7 ± 3.2 d. These results are similar to those reported by López-Avila (1986) and Eichelkraut & Cardona (1989), but differ from Sharaf & Batta (1985) regarding preoviposition. They found a duration of 3.6 and 4.9 d at 25 and 14°C, respectively. The oviposition time we observed was similar to that of Husain & Trehan (1933), and the duration range similar to that of Eichelkraut & Cardona (1989), who stated that oviposition occurred within the first five days.

Fecundity and Viability

The mean number of eggs laid per virgin female was 194.9 ± 59.1 and the mean number per female per day was 11.7 ± 3.6. Azab et al. (1971) and Gameel (1974) reported an average of 161 eggs per female on sweetpotato and cotton, respectively. Avidov (1956) pointed out that 300 or more eggs were oviposited per female, however, other researchers found a much lower number, indicating the influence of the temperature on fecundity (Husain 1931, Husain & Trehan 1933, El-Khidir 1965, Butler et al. 1983, Sharaf & Batta 1985,Eichelkraut & Cardona 1989). Among 104 eggs observed, 86.5% hatched. Butler et al. (1983) reported a hatchability of 68 and 75% at 26.7 and 32.2°C, respectively.

Sex Ratio and Parthenogenesis

Among 220 dissected adult genitalia, 161 showed female structural parts, whereas 59 were male, resulting in a ratio of 1: 2.7 (male: female). These results are similar to those of López-Avila (1986) at the same temperature and agree with the statement of

Azab et al. (1971) that females are more numerous than males. However, our results differ from those of Sharaf & Batta (1985) who reported sex ratios of 1:1.8 and 1:3.1 (male:female) when temperature decreased from 25 to 14°C, increasing the number of females. Eichelkraut & Cardona (1989) found a sex ratio of 1:1 (n:600). Only males hatched from eggs laid by virgin females suggesting that the parthenogenesis observed was of the arrhenotoky type. These results are similar to others authors (Husain & Trehan 1933, Mound 1983, Sharaf & Batta 1985, Eichelkraut & Cardona 1989).

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References Cited

Arnal, E., L. M. Russell, E. Debrot, F. Ramos, M. Cermeli, R. Marcano, and A. Montagne. 1993. Lista de moscas blancas (Homoptera: Aleyrodidae) y sus plantas hospederas en Venezuela. Florida Entomol. 76: 365-381.

Avidov, Z. 1956. Bionomics of the tobacco whitefly (*Bemisia tabaci* Gennad.) in Israel. Ktavim. 7: 25-41.

Azab, A. K., M. M. Megahed, and H. D. El-Mirsawi. 1971. On the biology of *Bemisia tabaci* (Genn.) (Hemiptera-Homoptera: Aleyrodidae). Bulletin de la Société Entomologiqué d Egypte. 55: 305-315.

Bethke, J. A., T. D. Paine, and G. S. Nuessly. 1991. Comparative biology, morphometrics, and development of two populations of *Bemisia tabaci* (Homoptera: Aleyrodidae) on cotton and poinsettia. Ann. Entomol. Soc. America 84: 407-411.

Brown, J. K. 1990. An update on the whitefly-transmitted geminiviruses in the Americas and the Caribbean Basin. FAO Plant Prot. Bull. 39: 5-23.

Brunt, A. A. 1986. Transmission of diseases, pp. 43-50 *in* M.J. Cock [ed.] *Bemisia tabaci* A literature survey on the cotton whitefly with an annotated bibliography. London, International Institute of Biological Control, Chamaleon Press.

Butler, G. D. Jr., T. J. Henneberry, and T. E. Clayton. 1983. *Bemisia tabaci* (Homoptera: Aleyrodidae): development, oviposition and longevity in relation to temperature. Ann. Entomol. Soc. America 76: 310-313.

Byrne, D. N., T. S. Bellows, Jr., and M. P. Parrella. 1990. Whiteflies in agricultural systems, pp 227-262 *in* D. Gerling [ed.], Whiteflies:their bionomics, pest status and management. Intercept, Andover, U.K.

Byrne, D. N., and T. S. Bellows, Jr. 1991. Whiteflies biology. Annu. Rev. Entomol. 36: 431-457.

Coudriet, D. L., N. Prabhaker, A. N. Kishara, and D. E. Meyerdirk. 1985. Variation in development rate on different hosts and overwintering of the sweetpotato whitefly *Bemisia tabaci* (Homoptera: Aleyrodidae). Environ. Entomol. 14: 516-519.

Eichelkraut, K., and C. Cardona. 1989. Biología, cría masal y aspectos ecológicos de la mosca blanca *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae), como plaga del frijol común. Turrialba 39: 51-55.

El-Helaly, M. S., A. Y. El-Shazli, and F. H. El-Gayar. 1971. Biological studies on *Bemisia tabaci* Genn. (Homopt.: Aleyrodidae) in Egypt. Zeitschrift fur Angewandte Entomologie. 69: 48-55.

El-Khidir, E. 1965. Bionomics of the cotton whitefly, (*Bemisia tabaci* Genn.), in the Sudan and the effects of irrigation on population density of whiteflies. Sudan Agric. J. 1: 8-22.

Gameel, O. I. 1974. Some aspects of the mating and oviposition behavior of the cotton whitefly *Bemisia tabaci* (Genn.). Revue de Zoologie Africaine. 88: 784-788.

GILL, R. J. 1990. The morphology of whiteflies, pp. 13-46 *in* D. Gerling [ed.], Whiteflies:their bionomics, pest status and management. Intercept, Andover, U.K.

GREATHEAD, A. H. 1986. Host plants, pp. 17-25 *in* M. J. Cock [ed.] *Bemisia tabaci* A literature survey on the cotton whitefly with an annotated bibliography. London, International Institute of Biological Control, Chamaleon Press.

HUSAIN, M. A. 1931. A preliminary note on the white-fly of cottons in the Punjab. Agric. J. India. 25: 508-526.

HUSAIN, M. A., AND K. N. TREHAN. 1933. Observations on the life history, bionomics and control of the white-fly of cotton (*Bemisia gossypiperda* M.EL.). Indian J. Agric. Science. 3: 701-753.

LOPEZ-AVILA, A. 1986. Taxonomy and biology, pp. 3-11 *in* M. J. Cock [ed.] *Bemisia tabaci* A literature survey on the cotton whitefly with an annotated bibliography. London, International Institute of Biological Control. Chamaleon Press.

LYNCH, R. E., AND A. M. SIMMONS. 1993. Distribution of inmatures and monitoring of adult sweetpotato whitefly *Bemisia tabaci* (Gennadius) (Homoptera:Aleyrodidae), in peanut, *Arachis hypogea*. Environ. Entomol. 22: 375-380.

MOUND, L. A. 1983. Biology and identity of whitefly vectors of plant pathogens, pp. 305-313 *in* R. T. Plumb, and J. M. Thresh [eds.]. Plant virus epidemiology. The spread and control of insect-borne viruses. Oxford, U.K., Blackwell Scientific Publications.

PEÑA-ROJAS, E. A.; A. PANTOJA, AND J. S. BEAVER. 1992. Determinación de la pubescencia de cuatro materiales genéticos de frijol (*Phaseolus vulgaris* L.) y su efecto sobre el insecto *Bemisia tabaci* (Gennadius). Rev. Colombiana Entomol. 18: 41-48.

RUSSELL, L. M. 1975. Whiteflies on beans in the western hemisphere. In Workshop on Bean Protection (1975, Cali, Colombia). Cali, Colombia, CIAT: 21 p.

SHARAF, N., AND Y. BATTA. 1985. Effect of some factors on the relationship between the whitefly *Bemisia tabaci* Genn. (Homopt., Aleyrodidae) and the parasitoid *Eretmocerus mundus* Mercet (Hymenoptera., Aphelinidae). Zeitschrift fur Angewandte Entomologie 99: 267-276.