ECOLOGY, BEHAVIOR AND BIONOMICS

Life History Parameters of *Trialeurodes vaporariorum* (Westwood) (Hemiptera: Aleyrodidae) at Different Environmental Conditions on Two Bean Cultivars

Maria R Manzano[1], Joop C van Lenteren[2]

[1]*Depto. de Ciencias Agrícolas, Univ. Nacional de Colombia, sede Palmira, Cra. 32 Chapinero via a Candelaria, Colombia; mrmanzanom@palmira.unal.edu.co;* [2]*Lab. of Entomology, Wageningen University, PO Box 8031, 6700 EH Wageningen, The Netherlands; Joop.vanLenteren@wur.nl*

Edited by André L Lourenção - IAC

Neotropical Entomology 38(4):452-458 (2009)

Estadísticos Vitales de *Trialeurodes vaporariorum* (Westwood) (Hemiptera: Aleyrodidae) a Diferentes Condiciones Ambientales en Dos Cultivares de Fríjol

RESUMEN - Se determinaron los estadísticos vitales de la mosca blanca *Trialeurodes vaporariorum* (Westwood), una plaga importante del cultivo del fríjol en Colombia, en cámara ambiental en dos cultivares (cv.) de fríjol. La longevidad media de *T. vaporariorum* en el cv. Chocho fue mayor a 19°C (22.6 d), intermedia a 22°C (17.5 d) y menor a 26°C (5.9 d). En el cv. ICA-Pijao la longevidad media fue de 35.5 d a 19°C. La fecundidad media total fue 8.6, 32.6 y 33.3 huevos por hembra a 19, 22 y 26°C, respectivamente en el cv. Chocho. La fecundidad en el cv ICA-Pijao fue mucho más alta, 127. 2 huevos por hembra, a 19°C, que la del cv. Chocho. La tasa intrínseca de crecimiento poblacional (r_m) fue más alta a 22°C (0.061), intermedia a 19°C (0.044) y más baja a 26°C (0.035) en el cv. Chocho. Ella fue de 0.072 a 19°C en el cv. ICA-Pijao. Se comparan los estadísticos vitales de *T. vaporariorum* con los de su enemigo natural, el parasitoide *Amitus fuscipennis* MacGown & Nebeker y se zonifica la distribución del parasitoide en el Valle del Cauca, Colombia.

PALABRAS CLAVE: Mosca blanca de los invernaderos, fecundidad, *Phaseolus vulgaris*, *Amitus fuscipennis*

ABSTRACT - Life-history parameters of the greenhouse whitefly *Trialeurodes vaporariorum* (Westwood), an important pest of bean crops in Colombia, were determined in environmental control chambers on two dry bean (*Phaseolus vulgaris*) cultivars (cv.). *Trialeurodes vaporariorum* longevity on cv. Chocho decreased as temperature increased from 22.6 d at 19°C to 5.9 d at 26°C. Fecundity was significantly lower at 19°C (8.6 eggs/female), as compared to 22°C (32.6 eggs/female) and 26°C (33.3 eggs/female) on cv. Chocho. Fecundity on cv. ICA-Pijao was much higher (127.2 eggs/female) than on cv. Chocho (32.6 eggs/female) at 19°C. The intrinsic rate of population increase (r_m) was highest at 22°C (0.061), intermediate at 19°C (0.044) and lowest at 26°C (0.035) on cv. Chocho, and was 0.072 on cv. ICA-Pijao at 19°C. Life history parameters of *T. vaporariorum* are compared to those of one of its natural enemies, the parasitoid *Amitus fuscipennis* MacGown & Nebeker. Finally, data are presented on the distribution of the parasitoid related to the altitude for the Valle del Cauca, Colombia.

KEY WORDS: Greenhouse whitefly, fecundity, *Phaseolus vulgaris*, *Amitus fuscipennis*, IPM

The greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), is an important pest especially in vegetable and ornamental crops (van Lenteren & Martin 2000). Adults and nymphs feed on phloem sap, excreting large amounts of honeydew that favors the development of sooty mould, which reduces plant photosynthesis (Lindquist *et al* 1972). In Colombia, greenhouse whitefly is a key pest on dry and snap kidney beans (*Phaseolus vulgaris*) (Rodriguez & Cardona 2001, Quintero *et al* 2001). As a result, Colombian bean crops are heavily sprayed (average of 10 times per cropping season) with chemical insecticides to control this pest (Rodriguez & Cardona 2001).

The presence of three mountain ranges of the Andean mountain range in Colombia offers a landscape of kidney bean cultivation at different altitudes. Surveys in Colombia and Ecuador have shown that *T. vaporariorum*

is the dominant whitefly species distributed in the tropical highlands of the Andean region between 2000 m.a.s.l. and 2830 m.a.s.l. (meters above sea level) (Quintero *et al* 2001) where the average temperature and relative humidity (RH) are around 19°C and 80%, respectively. The pest is also present on crops established around 1000 m (inter-Andean valleys) in combination with other whitefly species (Quintero *et al* 2001), where average temperature ranges from 22°C to 24°C, with a relative humidity around 74%.

In Colombia, the greenhouse whitefly is parasitized by an endemic natural enemy, the parasitoid *Amitus fuscipennis* MacGown & Nebeker (Hymenoptera: Platygasteridae), which has been evaluated as a potential biological control agent of the greenhouse whitefly on kidney beans (Manzano *et al* 2000) and tomato in Colombia (De Vis *et al* 2002). One criterion used to evaluate the potential of natural enemies for controlling a pest is that the intrinsic rate of population increase (r_m) of the control agent has to be at least equal to the pest's population growth rate, thereby making biological control feasible (van Lenteren & Woets 1988).

At least 37 commercial kidney bean cultivars are grown in Colombia and more than 60 bean lines have been improved agronomically (Voysest 1983). To test the potential effect of host plant on the r_m value of *T. vaporariorum*, two different cultivars were used, cv. Chocho and cv ICA-Pijao. Chocho is an important commercial cultivar that is grown mainly in the hillside areas of Tenerife, Valle del Cauca, Colombia, while cv. ICA-Pijao is well adapted to greenhouse conditions and is less susceptible to microbial infections.

We measured the r_m values of *T. vaporariorum* in environmental control chambers, which were set to simulate the climate found at the hillside and lowland bean-cropping regions. The r_m values of the parasitoid and its host were compared to determine those altitudinal zones and kidney bean cultivars where *A. fuscipennis* is likely to be most efficient as a biological control agent of the greenhouse whitefly. The earlier published r_m values of *A. fuscipennis* were obtained under similar climatic conditions on cultivars ICA-Pijao and Chocho with *T. vaporariorum* as a host (Manzano *et al* 2002).

Material and Methods

Plant and whitefly cultures. Plants of the kidney bean *P. vulgaris* cv. Chocho and cv. ICA-Pijao were grown in a greenhouse at 25 ± 5°C, 40-80% RH and at least 12h light per day. Plants used were 15 days old and were not fertilized or sprayed with chemicals.

Trialeurodes vaporariorum adults were obtained from a colony established on kidney bean plants (cv. ICA-Pijao) at the Centro Internacional de Agricultura Tropical (CIAT). The whitefly colony at CIAT was originally collected from snap bean fields in Fusagasugá, Colombia. The whiteflies were reared at 23 ± 1°C, 40-80% RH and 12L:12D.

Adult longevity and reproduction. *Trialeurodes vaporariorum* newly emerged adults were sexed and caged by pairs in clip-cages (inner diameter = 2.5 cm). Every 48h, the clip-cage with the test insects was moved to a new leaf area until all the female insects died. Fecundity was estimated by counting the number of eggs laid in each period of 48h. The caged adults were kept in environmental control chambers under different temperature and humidity conditions. Cultivar Chocho was kept at 19°C, 75 ± 5% RH; 22°C, 72 ± 6% RH; 26°C, 75 ± 5% RH, and cv. ICA-Pijao was kept at 19°C, 75 ± 5% RH.

Immature development and survival. Approximately 40 adults of *T. vaporariorum* were placed in clip-cages (inner diameter = 2.5 cm), which were then put on leaves of each cultivar. After 10h, adults were removed and about 100 eggs coming from two or three different groups of *T. vaporariorum* females were allowed to develop under the same conditions as previously described. Developmental time, percentage immature survival and proportion of females of *T. vaporariorum* were recorded.

Demographic parameters. Immature developmental time, percentage of immature survival and proportion of females were combined with reproduction experimental data to estimate life table parameters for calculation of *T. vaporariorum* demographic parameters, as defined by Price (1997): net reproductive rate (*Ro*), which represents the number of female descendants that an average female produces in one generation, and generation time (T) that is equivalent to the mean period between the birth of parents and birth of offspring. The intrinsic rate of population increase (r_m) for *T. vaporariorum* at different climatic conditions was also calculated using the equation given by Carey (1993): $\sum exp(-r_m x)lxmx = 1$, in which x is the age, lx is the age-specific survival and mx is the proportion of females produced by a female at age x. According to Carey (1993), pivotal age, which is $x + 0.5$, was used in the calculation of r_m values.

The r_m values of *T. vaporariorum* were measured simultaneously for ICA-Pijao and Chocho cultivars at 19°C and 75 ± 5% RH. These conditions were chosen for ICA-Pijao in order to compare this r_m value with that of *A. fuscipennis* previously determined (Manzano *et al* 2002). For the *T. vaporariorum* experiment, the r_m value at 22°C, 72 ± 6% RH was calculated assuming 25% as the proportion of females based on the proportion of females reported at 19°C and 26°C.

Distribution of *T. vaporariorum* and *A. fuscipennis* in Valle del Cauca, Colombia. *Amitus fuscipennis* and *T. vaporariorum* were collected on dry and snap kidney beans in different areas of Valle del Cauca, Colombia. Based on tested life history parameters of *T. vaporariorum*, a zoning map was made for Valle del Cauca. Localities where *A. fuscipennis* was collected in Valle del Cauca were drawn in the map to match parasitoid-host climatic adaptation.

Data analyses. Differences between mean longevity and fecundity values were compared using the Kruskal-Wallis One Way Analysis of Variance (ANOVA) on Ranks followed by all pairwise multiple comparison procedures (Student-Newman-Keuls test). Oviposition rates were compared using one-way ANOVA followed by Student-Newman-Keuls test. Differences in developmental time were tested using the Kruskal-Wallis One Way ANOVA on Ranks followed by pairwise multiple

comparisons (Dunn's method). For comparison of survival rates, χ^2- tests were used.

Results

Adult longevity and fecundity. Longevity of *T. vaporariorum* females decreased as temperature increased. *T. vaporariorum* longevity on cv. Chocho was shortest at 26°C (5.7 d), and the longest longevity on cv. ICA-Pijao was observed at 19°C (35.5 d). Mean longevity differed significantly among temperatures and kidney bean cultivars, except for values on cv. Chocho at 19°C and 22°C ($P < 0.0001$) (Table 1, Fig 1).

Fecundity was affected by temperature and kidney bean cultivars ($P < 0.0001$), except for values on cv. Chocho at 19°C and at 22°C (Table 1, Fig 2). Differences in fecundity between cv. Chocho and cv. ICA-Pijao at 19°C can be clearly observed in the reproduction curves: oviposition on cv. ICA-Pijao is much higher and oviposition continues for a longer period of time (Fig 3). Oviposition rate was significantly different among treatments (one-way ANOVA, $P < 0.0001$), except for the comparison between females on cv. Chocho at 19°C and 26°C (1.4 for both conditions, $P > 0.05$) (Table 1).

Trialeurodes vaporariorum had similar longevity and fecundity at tropical highland conditions (19°C, 80% RH) as at inter-Andean valley conditions (22°C, 74% RH). However, at a constant temperature of 26°C, combined with a relative humidity of 75%, longevity, fecundity and survival rates were much lower than at 19°C and 22°C (Table 1).

Immature development and survival. *Trialeurodes vaporariorum* survival ($\chi^2 = 77.7$, df = 3, $P < 0.0001$) and development time (Kruskal-Wallis one way ANOVA on ranks $P < 0.0001$, followed by Dunn's method, $P < 0.05$) were affected by climatic conditions and the kidney bean cultivars tested (Table 2). Female emergence was only around 20% at 19°C on both cultivars, and a little higher (28%) at 26°C on cv. Chocho (Table 2).

Demographic parameters. There were no large differences between reproduction data on cv. Chocho at 19°C ($Ro = 6.2$) and at 22°C ($Ro = 8.3$). The r_m value was lower (0.044) at 19°C than at 22°C (0.061). Reproduction decreased for the same cultivar at 26°C with Ro and r_m values at 2.3 and 0.035, respectively. The main difference was found for values of cv. Chocho at 19°C ($Ro = 6.2$, $r_m = 0.044$) and those of cv. ICA-Pijao under the same environmental conditions ($Ro = 26.7$ and $r_m = 0.072$). Generation time (T) was highest (49.6) on cv. ICA-

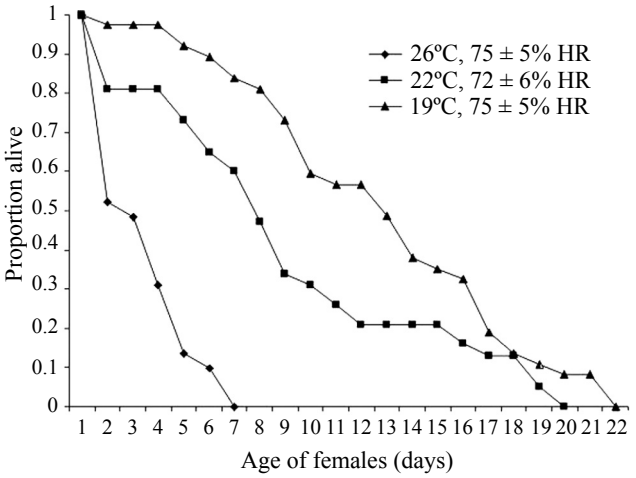

Fig 1 Survival of *Trialeurodes vaporariorum* on cv Chocho at different climatic conditions.

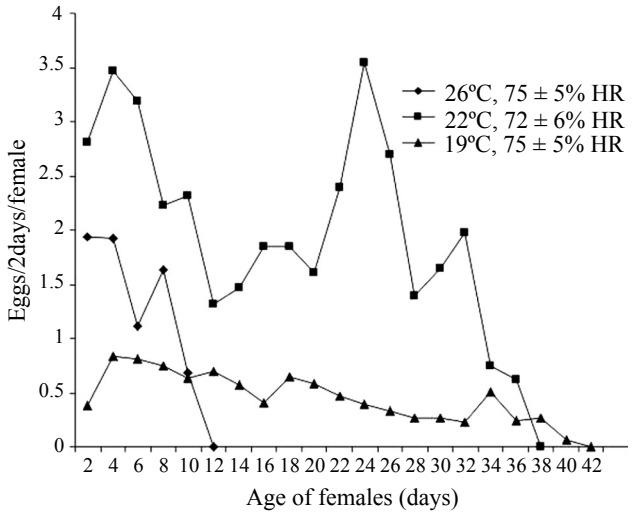

Fig 2 Reproduction of *Trialeurodes vaporariorum* on cv Chocho at different climatic conditions.

Table 1 Mean longevity (days), fecundity (eggs/female) and oviposition rate (eggs/female/2 days) of *Trialuerodes vaporariorum* at different temperatures (°C) and bean cultivars (cv).

Cultivar	Temperature	n	Longevity[1] (mean ± SE)	Fecundity[1] (mean ± SE)	Oviposition rate [2] (mean ± SE)
Chocho	19	36	22.6 ± 1.63 a (IV: 6-40)	32.6 ± 3.85 a (IV: 5-89)	1.4 ± 0.14 ac (IV:0.3-4.5)
	22	31	17.5 ± 1.76 a (IV: 6-36)	33.3 ± 4.28 a (IV: 8-94)	1.9 ± 0.19 b (IV: 0.6-3.7)
	26	27	5.9 ± 0.47 b (IV: 2-10)	8.6 ± 1.49 b (IV: 1-31)	1.4 ± 0.14 c (IV:0.3-3.3)
ICA-Pijao	19	31	35.5 ± 2.27 c (IV: 14-52)	127.2 ± 9.69 c (IV: 3-261)	3.6 ± 0.15 d (IV: 2.3-5.1)

[1]Kruskal-Wallis test $P < 0.0001$, followed by Student-Newman-Keuls test $P < 0.05$.
[2]One-way ANOVA $P < 0.0001$, followed by Student-Newman-Keuls test $P < 0.05$.
Averages followed by different letters within a column are significantly different.

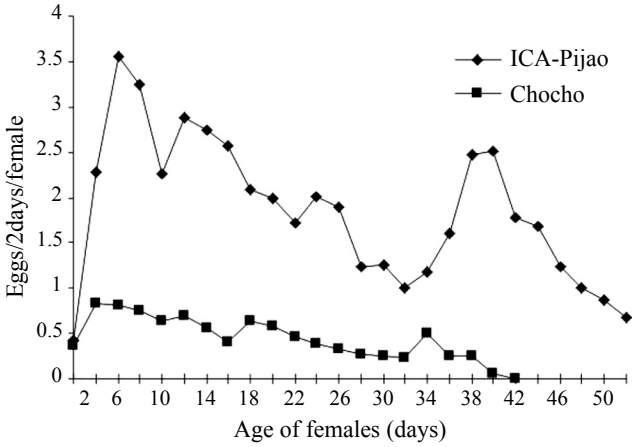

Fig 3 Reproduction of *Trialeurodes vaporariorum* on ICA-Pijao and Chocho bean cultivars at different climatic conditions.

Pijao and shortest (24.7) for cv. Chocho at 26°C (Table 2).

Distribution of *T. vaporariorum* and *A. fuscipennis* in Valle del Cauca, Colombia. Distribution of *A. fuscipennis* in combination with a temperature zone map for *T. vaporariorum* is shown in Fig 4. *Amitus fuscipennis* matches its distribution to 19-22°C except for Lomitas (Pradera) where average temperature is above 22°C. The average temperature of Tenerife is lower than 19°C, but the parasitoid is present.

Discussion

The temperature effects observed for *T. vaporariorum* follow the same trend of that reported by several authors, whom reported a negative effect on whitefly survival and adult longevity as temperature increased (Madueke 1979, Collman & All 1980, van Roermund & van Lenteren 1992). There are few data concerning the effects of kidney beans as a host on the reproductive capacity of *T. vaporariorum* at similar conditions as tested here (e.g., Madueke 1979), making any specific comparisons difficult. However, the drastic effect of different hosts on greenhouse whitefly reproduction and population growth potential can easily be observed when looking at the differences in r_m values for *T. vaporariorum* on different host plants (Zabudskaya 1989, Yano 1989, Romanow *et al* 1991).

Trialeurodes vaporariorum is well adapted to tropical highland conditions (19°C, 80% RH) as well as at inter-Andean valley conditions (22°C, 74% RH); an outcome supported by field surveys carried out by Quintero *et al* (2001). However at higher temperature and relative humidity conditions, survival of whitefly decreases. These latter climatic conditions are found in the northern coastal area of Colombia with tropical lowland conditions where RH can be higher than 80%. *Trialeurodes vaporariorum* is absent in this area but other whitefly species are present, like *Bemisia tabaci* (Gennadius) biotype B on vegetable crops (Rodriguez *et al* 2005), *Bemisia tuberculata* Bondar, *Trialeurodes variabilis* (Quaintance) and *Aleurotrachelus socialis* Bondar on cassava (Cardona *et al* 1998). Recently, it was found that *T. vaporariorum* possesses less tolerance to higher temperatures than *B. tabaci* biotype B, probably linked to the expression of heat shock protein genes (Wan *et al* 2009).

In our experiments, a strongly male-biased sex ratio was found for *T. vaporariorum*. We did not find the 'normal' sex ratio of 1:1 mentioned by van Lenteren & Noldus (1990). Our results cannot be easily explained because sex ratio in *T. vaporariorum* is thought to be independent of temperature and host-plant species (van Lenteren & Noldus 1990, van Roermund & van Lenteren 1992). Van Roermund & van Lenteren (1992) summarized several data from different authors on different host plants including kidney bean and reported an average value for sex ratio of *T. vaporariorum* of 0.538 (or 53.8% females).

Our results show considerable differences in life-history parameters between the kidney bean cultivars ICA-Pijao and Chocho. One possible explanation for this outcome is that whiteflies used in our experiments came from a colony established at CIAT for five years on cv. ICA-Pijao, and *T. vaporariorum* may have been adapted to this bean cultivar and, thus, performed better on cv. ICA-Pijao than on cv. Chocho.

Van Lenteren & Noldus (1990) found that a *T. vaporariorum* strain originating from tomato and reared for three generations on sweet pepper had a higher fecundity on

Table 2 Demographic parameters of *Trialeurodes vaporariorum* on bean cultivars ICA-Pijao and Chocho at different temperatures (ºC).

Cultivar	Temperature	N	Development time[1] (Mean ± SE)	Survival rate[2] (%)	Proportion of females (%)	r_m[3]	*Ro*[4]	T[5]
Chocho	19	77	29.3 ± 0.15 a	97.4 a	19	0.044	6.2	42.3
	22	131	24.7 ± 0.16 b	81 b	25[6]	0.061	8.3	36.1
	26	75	20.3 ± 0.18 c	52.3 c	28	0.035	2.4	24.7
ICA-Pijao	19	46	30.4 ± 0.18 d	74 d	21	0.072	26.7	49.6

[1] Kruskal-Wallis $P < 0.0001$ followed by Dunn`s test $P < 0.05$; [2] $x^2 = 77,7$, 3 df, , $P < 0.0001$; [3] Intrinsic rate of population increase; [4] Net reproductive rate; [5] Generation time (d); [6] Value assumed. Averages followed by different letters within a column are significantly different.

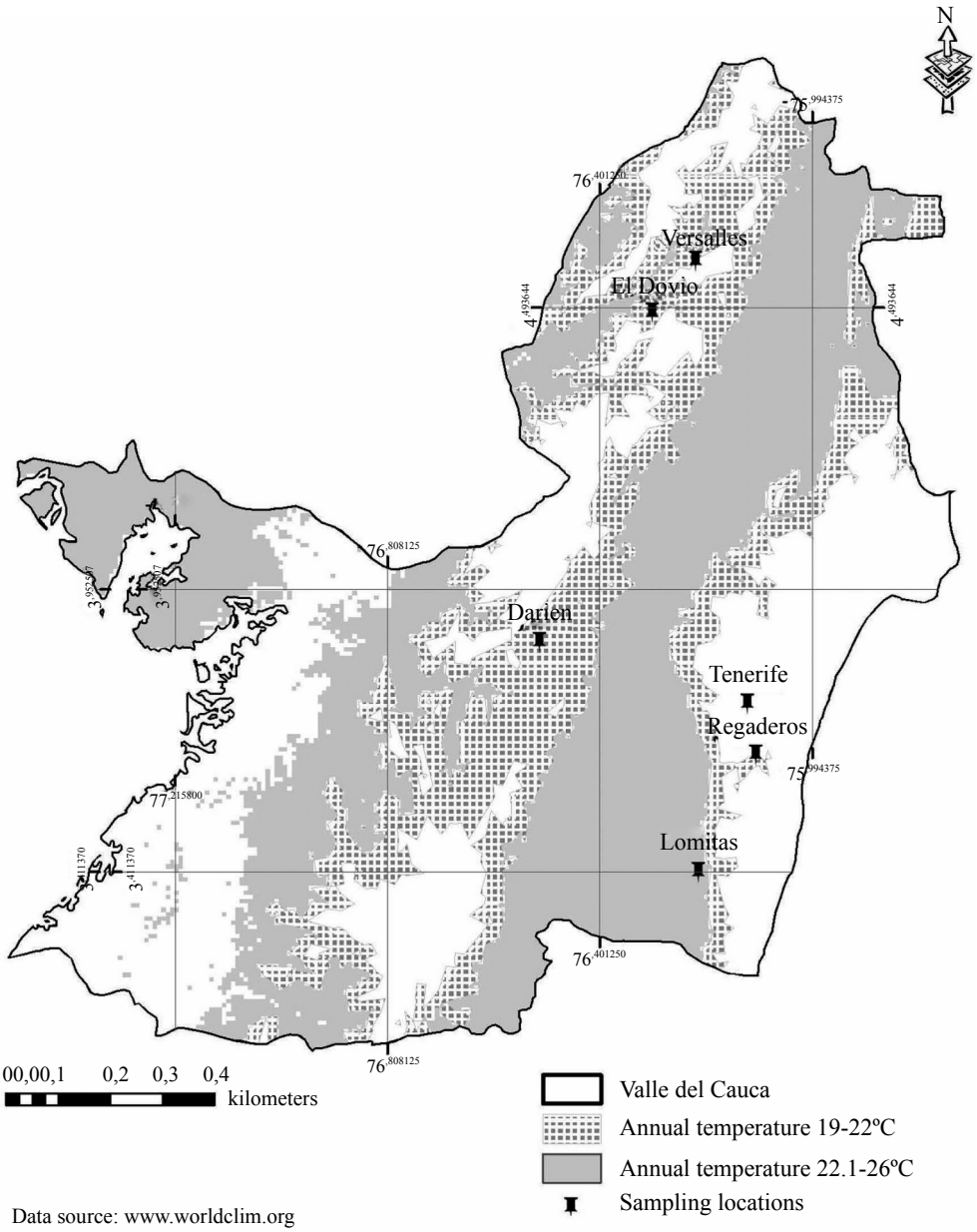

Fig 4 Distribution of *Amitus fuscipennis* in Valle del Cauca, Colombia. For the locations Darien, Regaderos, El Dovio and Versalles, and based on a kidnay bean cropping season of 120 days, 2.7 generations of *Amitus fuscipennis* and 2.4 generations of *Trialeurodes vaporariorum* are estimated to develop on cv ICA-Pijao. For cv Chocho, the estimates are 2.9 generations of *A. fuscipennis* and 2.8 of *T. vaporariorum*. For Lomitas, 4.4 and 3.3 generations are estimated for the parasitoid and its host respectively on cv Chocho. For Tenerife no estimates can be made with the available information.

sweet pepper than did the original strain. A different whitefly species, *B. tabaci* biotype B increased its oviposition rate after being reared for five generations on different host plants starting with bean and finishing with cassava passing through two Euphorbiaceae species (Carabali *et al* 2005). These results indicate that rearing for some generations on a host plant may facilitate the adaptation of whiteflies to a different host plant. Based on the above discussion concerning the possible adaptation of whitefly strains during exposure for several generations to a new cultivar, we propose further testing to find out if the poor performance found for *T. vaporariorum* on cv. Chocho is permanent or disappears within a few generations.

According to field surveys, parasitoid distribution in Valle del Cauca matches with areas along 19°C to 22°C where its host *T. vaporariorum* is also well adapted, corresponding to both inter-Andean and tropical highland conditions. Longevity of *A. fuscipennis* is negatively affected by dry or warm environments (Manzano *et al* 2000). As shown in the map localities as Lomitas (1180 m.a.s.l.) where average temperature is above 22°C, the parasitoid is scarce and *Encarsia nigricephala* Dozier is the dominant parasitoid

species of *T. vaporariorum* (Manzano *et al* 2003). On the other hand, in Tenerife, Valle del Cauca, located at tropical highland were average temperature is below 19°C, both the parasitoid and *T. vaporariorum* are abundant (Manzano 2000). Besides Valle del Cauca, *A. fuscipennis* has been collected in Rionegro (Antioquia) and Sumapaz (Cundinamarca) at altitudes above 1500 m in the tropical highlands (Manzano 2000).

We measured the r_m value of *A. fuscipennis* under the same experimental conditions and with the same kidney bean cultivars as in the present study, and found that the r_m values of the parasitoid were higher than the r_m values of *T. vaporariorum* (Manzano *et al* 2002). On cv. Ica-Pijao the parastioid's r_m value was 0.117; on cv. Chocho r_m values were 0.102 and 0.144 at 19°C and 22°C respectively. Van Lenteren & Woets (1988) proposed that an efficient parasitoid should have a potential maximum rate of population increase (r_m) equal to or larger than that of its host to keep up with growth of the pest population in inoculative or seasonal inoculative biological control programs.

Our results suggest that based on the reproductive parameters alone, *A. fuscipennis* may control *T. vaporariorum* populations at inter-Andean and tropical highland conditions.

Acknowledgments

We thank Cesar Cardona (CIAT) for allowing us to work at the Laboratory of Bean Entomology and to Hector Morales (CIAT) for his support in greenhouse activities. Thanks to Bregje Wertheim (Wageningen University) for her critical review that improved an early version of the manuscript. Thanks to John Selvaraj (UNAL sede Palmira) for preparing the map. Thanks to Takumasa Kondo (Corpoica, Palmira) and Fernando L Consoli (ESALQ/USP) for their comments and reviews. This research was financed by the Netherlands Foundation for the Advancement of Tropical Research (WOTRO).

References

Carabali A, Bellotti A C, Montoya-Lerma J, Cuellar M E (2005) Adaptation of *Bemisia tabaci* biotype B (Gennadius) to cassava, *Manihot esculenta* (Crantz). Crop Prot 24: 643-649.

Cardona C, Rendón F, Rodríguez I (1998) Chemical control and insecticide resistance of whiteflies in the Andean zone: a progress report. In International Workshop on *Bemisia* and Geminivirus, June 7-12, San Juan, Puerto Rico, L-70.

Carey J R (1993) Applied demography for biologists. New York, Oxford University Press, 206p.

Collman G L, All J N (1980) Quantification of the greenhouse whitefly life cycle in a controlled environment. J Georgia Entomol Soc 15: 432-438.

de Vis R M J, Fuentes L E, van Lenteren, J C (2002) Life history of *Amitus fuscipennis* (Hym., Platygastridae) as parasitoid of the greenhouse whitefly *Trialeurodes vaporariorum* (Hom., Aleyrodidae) on tomato as function of temperature. J Appl Entomol 126: 24-33.

Lindquist R K, Bauerle W L, Spadafora R (1972) Effect of the greenhouse whitefly on yields of greenhouse tomatoes. J Econ Ent 65:1406-1408.

Madueke E (1979) Biological control of *Trialeurodes vaporariorum*. PhD thesis, University of Cambridge, 114p.

Manzano M R (2000) Evaluation of *Amitus fuscipennis* as biological control agent of *Trialeurodes vaporariorum* on bean in Colombia. PhD thesis, Wageningen University, The Netherlands, 149p.

Manzano M R, van Lenteren J C, Cardona C (2002) Intrinsic rate of population increase of *Amitus fuscipennis* MacGown & Nebeker (Hym., Platygasteridae) according to climatic conditions and bean cultivar. J Appl Entomol 126: 34-39.

Manzano M R, van Lenteren J C, Cardona C (2003) Influence of pesticide treatments on the dynamics of whiteflies and associated parasitoids in snap bean fields. Biocontrol (Dordrecht) 48: 685-693

Manzano M R, van Lenteren J C, Cardona C, Drost Y C (2000) Developmental time, sex ratio, and longevity of *Amitus fuscipennis* MacGown & Nebeker (Hymenoptera: Platygasteridae) on the greenhouse whitefly. Biol Control 18: 94-100.

Price P (1997) Insect ecology. New York, John Wiley & Sons, 874p.

Quintero C, Rendón F, García J, Cardona C, López-Avila A, Hernández P (2001) Especies y biotipos de moscas blancas (Homoptera: Aleyrodidae) en cultivos semestrales de Colombia y Ecuador. Rev Colomb Entomol 27: 27-31.

Rodriguez I V, Cardona C (2001) Problemática de *Trialeurodes vaporariorum* y *Bemisia tabaci* (Homoptera: Aleyrodidae) como plagas de cultivos semestrales en el Valle del Cauca. Rev Colomb Entomol 27: 21-26.

Rodriguez I, Cardona C, Morales H, Bueno J M (2005) El biotipo B de *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae) adquiere mayor importancia en el Valle del Cauca. Rev Colomb Entomol 31: 21-28.

Romanow L R, de Ponti O M B, Mollema C (1991) Resistance in tomato to the greenhouse whitefly: analysis of population dynamics. Entomol Exp Appl 60: 247-259.

van Lenteren J C, Martin N A (2000) Biological control of whiteflies, p.202-214. In Albajes R, Gullino M, van Lenteren J C, Elad Y (eds) Integrated pest and disease management in greenhouse crops. Dordrecht, Kluwer Publishers, 568p.

van Lenteren J C, Noldus L (1990) Whitefly-plant relationships: behavioural and ecological aspects, p.47-89. In Gerling D (ed) Whiteflies: their bionomics, pest status and management. Andover, Intercept, 352p.

van Lenteren J C, Woets J (1988) Biological and integrated pest control in greenhouses. Annu Rev Entomol 33: 239-269.

van Roermund H J W, van Lenteren J C (1992) Life-history parameters of the greenhouse whitefly, *Trialeurodes vaporariorum*

and the parasitoid *Encarsia formosa*. Wageningen, Wageningen Agricultural University Paper 92-3, 147p.

Voysest O (1983) Variedades de frijol en América Latina y su origen. Cali, Centro Internacional de Agricultura Tropical (CIAT), 87p.

Yano E (1989) Factors affecting population growth of the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood) (Homoptera: Aleyrodidae). Jpn J Appl Entomol Zool 33: 122-127.

Wan F, Zhang G, Liu S, Luo C, Chu D, Zhang Y, Zang L, Jiu M, Lü Z, Cui X, Zhang L, Zhang F, Zhang Q, Liu W, Liang P, Lei Z, Zhang Y (2009) Invasive mechanism and management strategy of *Bemisia tabaci* (Gennadius) biotype B: Progress report of 973 Program on invasive alien species in China. Sci China Ser C- Life Sci 52: 88-95.

Zabudskaya I A (1989) Biological control of the greenhouse whitefly, *Trialeurodes vaporariorum* (Homoptera, Aleyrodidae). Acta Entomol Fenn 53: 73-76.

Received 13/II/07. Accepted 26/VI/09.