

Full Length Research Paper

Host plant selection and oviposition behaviour of whitefly *Bemisia tabaci* (Gennadius) in a mono and simulated polyculture crop habitat

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The host plant selection, oviposition behaviour and survivorship of whitefly (*Bemisia tabaci* (Gennadius)) was evaluated in green house. Three host plants cultivars namely: Brinjal (*Solanum malagna*), chilli (*Capsicum annum*) and tomato (*Solanum lycopersicum*) were placed in a multiple crop habitat at 34 - 36°C, 70 - 80% relative humidity (RH) in a normal day light. There was a variation of morphological characteristic among host plants (smooth and thick trichome leaves) where all developmental stages of pest were given free choice of foraging. Although the host plants genus *C. annum* and *S. lycopersicum* were also the potential host of *B. tabaci* but in the presence of *S. malagna*, the attack rate remains minimum on both the host plants. The feeding and egg laying was significantly higher on *S. malagna* L. leaves as compare to other two host plants in the open arena. *S. malagna* L. was also preferred when pest was tested in confined cages for free choice probing on capsicum and *S. malagna* L. There was no significant but a slight difference in survivorship of all developmental stages of whitefly when Brinjal and Chilli and then Brinjal and tomato from two different experimental arenas were compared. There was no host plant varietal effect on the overall developmental time from egg eclosion to the adult. The leaves of *S. malagna* with thick trichomes were chosen significantly more higher for egg laying compared to other host plants. The morphological characters and plant architecture contribute to higher densities of adult whitefly (wf) compared to new leaves. No symptoms of viral infection has been observed on the chilli with Brinjal, whereas, the same variety of chilli was reasonably infected with virus in chilli monocrop arena.

Key words: Multiple cropping, host plant selection, oviposition fecundity, intrinsic rate of increase.

INTRODUCTION

The whitefly *Bemisia tabaci* (Gennadius) Homoptera, Aleyrodidae has been a problem in greenhouses for many years, It is an insect pest capable of reducing plant productivity and longevity, as well as a virus vector (Bourland et al., 2003). It is the most devastating pest in tropical countries, both nymphs and adults feed by piercing the leaf surface and extracting phloem sap from sieve tubes with their sucking mouthparts (Chu et al., 1995). High population of the whiteflies *B. tabaci* drains

out enough nutrients by consuming so much sap to obtain scarce amino acids and this activity also lead to the production of great quantities of honey dew. This honey dew becomes a substrate for sooty mold that reduces the photosynthetic capacity of the foliage (Bethke et al., 1991). *B. tabaci*-vectored viruses can cause losses that are much more economically damaging than those resulting from feeding alone (Perring, 2001). Frequent use of pesticides on whitefly has raised environmental concerns and produced resistance in whitefly population (Prabhaker et al., 1985). As a result, whitefly became a major problem for the green houses and many field crops of commercial importance.

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The use of natural enemies for bio-control of whitefly is safest but very slow, and still not been proved as a substitute for chemical pesticides (van Lenteren et al., 2006). Some kind of oils and surfactants are the alternatives to broad spectrum insecticides but their activity is dependent on the direct contact with the targeted organism. The efficacy of pesticides is always very poor if there is no thorough coverage. To improve the target insecticide spray and apply the ecological based management of the pest, we need to understand first, the behavior of the pest such as the host plant preference, oviposition and switching behaviour (shifting to next host) of the pest (Andow, 1991; Simmon, 1994). The host plant selection by herbivore arthropod is a major theme in ecology which provides base lines for developing any pest control strategy (Maria et al 2003), (Nomiku et al., 2003).

The previous studies on the feeding behaviour of *B. tabaci* were concentrated on limited host plants in close environment. In the present experiment, the host plant preference and oviposition behaviour of whitefly is investigated in a green house by creating a simple and simulated multiple cropping environments. The result of the study is expected to help in developing a simulated ecological based plan of pest management through habitat manipulation.

MATERIALS AND METHODS

This study was conducted at the University Kebangsaan Malaysia (UKM). A culture of *B. tabaci* was maintained in a green house on the *Solanum mellegna* cultivar raised in pots before starting the actual experiment. Seedlings of three kinds of host plants namely: *Capsicum annum*, *S. mellegna* and *Solanum lycopersicum* L. (solanaceae) were raised in a separate isolated compartment of the green house at (34 - 36°C, 70 - 80% RH) and placed in the experimental arena at 3 - 4 leaf stage. Twenty individual plants of each species were arranged in the demarcated plot shape covered area measuring 50 x 30 ft in a green house. The treatments were arranged in a template of complete randomized designed (CRD). Each plot consists of 3 rows with half meter space and 1.5 ft apart. Treatments with each three replicates were brinjal chilli and tomato (BCT), chilli brinjal, tomato (CBT) and tomato chilli and brinjal (TCB).

Regular irrigation was given at 10.00 in the morning and no pesticide was sprayed before the experiment and throughout the duration of experiment. In a free choice test, the arrival of adult *B. tabaci* in the experimental arena was kept accessible. The whitefly were released at the beginning of the experiment and three weeks after the start of 1st experiment (free choice tests), randomly selected host plants from individual species were tagged on three strata's of the canopy (upper middle and lower). Population density and stage specific count (after 10.AM) of all developmental stages of pest were made on both sides of leaf in each stratum (abaxial and adaxial).

Ten pots of chilli plants only were placed in the compartment (mono crop habitat) of the green house (34 - 36°C, 70 - 80% RH) for no choice test to compare the attack rate on chilli monocrop versus multiple plant cultivars. For close observation of the foraging activity, the wooden frame cages of 2 x 2 m sizes (fine mesh) were used to isolate the whitefly couples (one male/one female) cage plant on individual chilli plant for 30 days. The whiteflies tested in cage arena were one day old crawler raised in separate small

chambers from same cohort. The observation and counting was made before 10 am usually, when the adults were less active. Stage specific survival of all developmental stages was studied on each caged host plant brinjal and chilli to evaluate the effect of host plant on longevity. The number of trichomes in a 4 mm² area on the abaxial surface of each leaflet of brinjal and chilli were counted at 10 am and 4 pm (Kisha, 1981), using a stereoscopic microscope (50x) equipped with an ocular micrometer.

The area was located near the main leaf vein and between the second and third adjacent veins to evaluate the oviposition preference. Observations pertaining to the major aspects like data on host plant preference, oviposition behavior and monocrop versus multiple crops were analyzed statistically with analysis of variance (ANOVA) and the means were separated using the Least Significant Difference (LSD) test (Steel and Tori, 1980) and was run through Minitab- 14 computer based statistical package.

RESULTS AND DISCUSSION

The results of the present study show that the highest attack rate of whitefly (wf) on brinjal is more than tomatoes and chilli for both feeding and oviposition in a multiple crop experimental arena (Figure 1). The mean population density of eggs were highly significant showing a stronger preference for oviposition ($F = 147.04$, $Df = 1$; $P = 0.001$) on brinjal among two hostile pant varieties. There was a significant difference ($F = 52.2$, $df = 1$ $P = 0.001$) for all developmental stages and mean number of eggs laid were 829.00 ± 38.00 in a free choice test (Table 1) when a comparison was made between brinjal and chillies (409.00 ± 31.00). Similarly, the cumulative distribution of various life stages of *B. tabacci* also showed a clear preference of host plant selection in a free choice test among the comparison of three crops (brinjal, tomato and chilli) (Figure 1). Although, chilli was the least preferred crop in a multiple choice test, there was a uniform distribution of all developmental stages of wf when placed in a monocrop habitat where the pest was not given any other choice for feeding. It indicates that in the absence of primary host plant, whitefly can switch its foraging activity on second option and start feeding there as it was on the primary host (Figure 2).

The host plant architecture may contribute in host plant selection by the wf. It was reported that soybean whitefly has a strong preference for hairy-leaf varieties of cotton and less preference for glabrous-leaf varieties (McAuslane, 1996). It might be the reason of the presence of trichomes on the leaf surface of the host plant. Both the brinjal and tomato leaves were furnished with trichomes on both abaxial and adaxial surfaces when compared to chilli leaves (Table 3). During the course of the present study, it has also been observed that adult wf preferably oviposit on brinjal *S. malagna* leaves which were furnished with more and thick trichomes. Our results are in accordance with Berlinger (1986) and Tsai and Wang (1996) who concluded that white fly is mainly attracted to the external and physical characteristics of the leaf surface (hairiness, leaf shape, leaf architecture). However, without biochemical analysis of the functions of trichomes

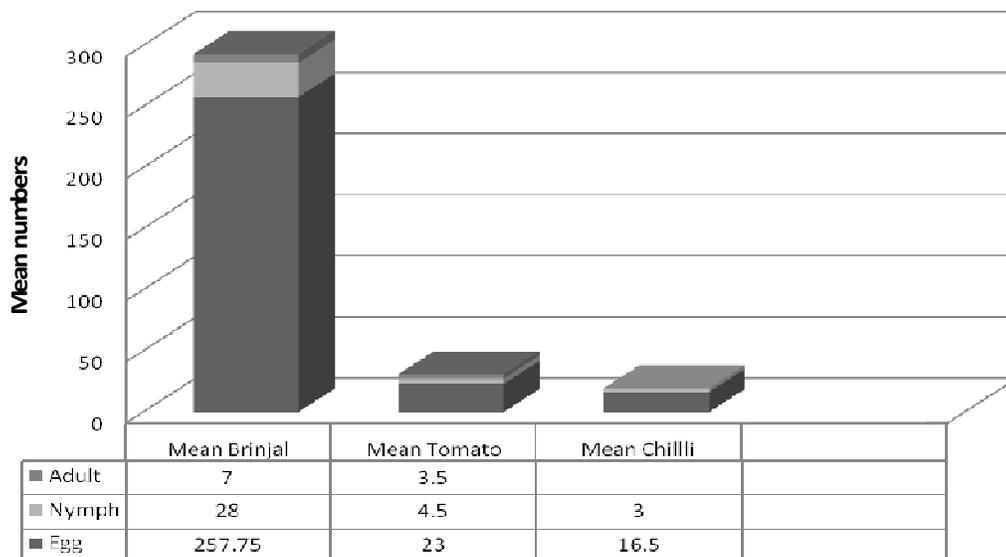


Figure 1. Mean population density of various life stages of *B. tabbaci* on three host plant varieties in a simulated multiple crop habitat measured on per 3 sq. cm of each strata.

Table 1. Adult feeding and oviposition preferences of *B. tabbaci* on brinjal and chilli measured on the average of three leave strata/plant in multiple environment.

Plant species	Adult <i>B. tabbaci</i> attracted (\pm SE)	Number of eggs laid (\pm SE)
Brinjal	134.50 \pm 7.50 a	829.00 \pm 38.00 a
Chilli	65.50 \pm 6.50 b	409.00 \pm 31.00 b
F	73.58	52.2
P	0.0012	0.0001

Means in column with the same letter are not significantly different at P > 0.05 (LSD)

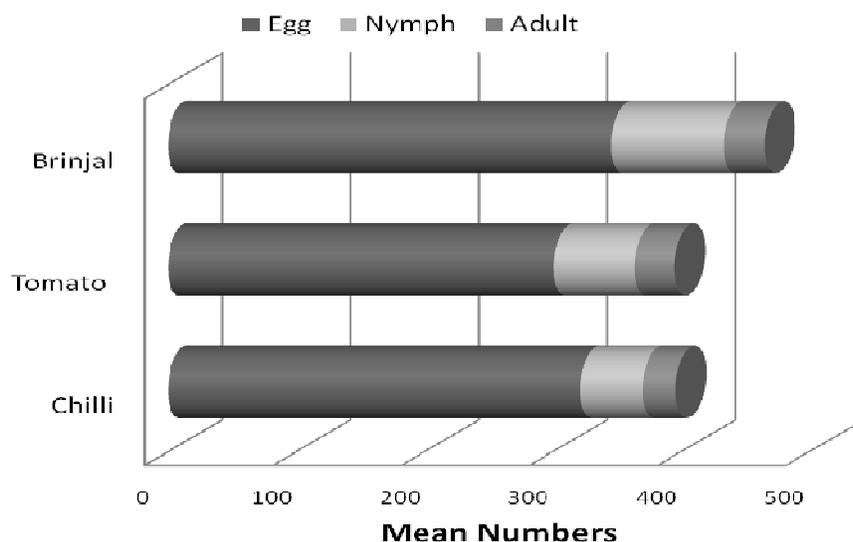


Figure 2. Cumulative mean of distribution of various life stages of whitefly in an individual simple crop habitat.

Table 2. Stage-specific survival of *B. tabacci* on brinjal and chilli in green house.

Stage	Chilli	Brinjal	F	P
Egg	7.6667 ± 0.195	7.333 ± 0.255	0.50	0.519
1st instar	1.1667 ± 0.096	3.333 ± 0.1924	33.80	0.004
2nd instar	1.8333 ± 0.0962	3.166 ± 0.0962	32.00	0.005
3rd instar	2.0000 ± 0.666	4.166 ± 0.025	16.90	0.015
4th instar	1.6667 ± 0.555	2.666 ± 0.889	7.20	0.055
Pupa	2.5000 ± 0.166	2.166 ± 0.0962	1.00	0.374

Table 3. Stage-specific survival of *B. tabacci* on tomato and brinjal in green house.

Stage	Brinjal	Tomato	F	P
Egg	8.00 ± 0.4666	7.66 ± 0.1859	0.25	0.643
1st instar	2.83 ± 0.0962	1.166 ± 0.0962	50.00	0.002
2nd instar	1.500 ± 0.000	1.833 ± 0.2929	4.00	0.116
3rd instar	1.83 ± 0.256	2.000 ± 0.166	0.10	0.768
4th instar	2.166 ± 0.0962	1.66 ± 0.0962	4.50	0.101
Pupa	2.33 ± 0.962	2.500 ± 0.166	0.25	0.643

and the profile of leaf containing essential amino acids, we cannot have a definite conclusion about the internal and chemical characteristics of the leaf (pH or leaf sap).

The stage-specific survival of all developmental stages of the whitefly when compared to two host plants chilli versus brinjal, the longevity of most developmental stages was slightly higher on brinjal (Table 2). In parallel to that, there was also significant difference of longevity of all developmental stages when compared between brinjal and tomato. (Table - 3). However, the egg stage was same on each host plants. Earlier, 7 - 11 days was reported by Berlinger (1986) but in the present study, almost 7 - 8 days on each substrate shows no significant effect on particular host plant only on eggs longevity (Table 2). Butler and Wilson (1984) reported some other aspects of host plant like pH of the leaf which act as repellent rather than only morphological character.

A thick density of trichomes on both upper and lower leaves of the brinjal were seen when scanned under (T.M -1000 table top scanner) and with the aid of stereoscope. Because of these trichomes, the crawlers do not move any significant distance from their eclosion site, thus, immature stages tend to be distributed vertically on the adaxial surface of the leaf with older stages found on progressively older leaves. During the fourth week of the study, the egg density per 3 sq.cm on brinjal was found to be 829 ± 50 and can go up to the extent of 1200/3 sq cm as it was previously reported for the same *Bemesia* genus by Baker (1978) and Dingle (1978) on other plant varieties in various green houses. Differences in plant infestation was thus a combination of host plant preferences for feeding, suitability of oviposition as part of parental care prior to trichomes and for better development

of various life stages.

According to Nomiku et al. (2003), the host plant preference cannot be because of only the quality of the host plant for the whitefly, it can learn to avoid even the plants on which her offspring would run a high risk of being eaten by predators. Thus, host plant selection of herbivores can depend on the presence of predators as well as on the experience of the herbivores (Scheirs and De Bruyn, 2002). The morpho-taxonomic features of the three host plants show the various densities of the trichomes on the leaf blades and the lamina (Figures 3, 4 and 5). The variation in population density of the whitefly was an obvious factor of leaf structures.

The nutritional profile of individual plant is yet to be researched through chemical analysis, therefore, some earlier workers carried out a partial study on effect of various nitrogen doses showing very positive correlation with host plant selection (Bentz et al., 1995). In most of the early studies, the host plant finding abilities of white flies and other insect species were carried out in various flight chambers (Southwood, 1960, 1962) focused on flight activity which concluded that insects vary in their intrinsic level of flight and host finding. According to Berlinger (1986), whiteflies have two different flight patterns: Short-distance and long-distance flights. Short-distance flights remain within the plant canopy and the insect travels from plant to plant within a field. The short flights are less than 15 ft in distance and mainly involve the flight from the lower leaves, whereas, the long flights is from border to border of the chamber in search of suitable host plant where they prefer to lay eggs. In the present study, the marked adults showed no long-distance flights, they just remain consistent within experimental arena whether it

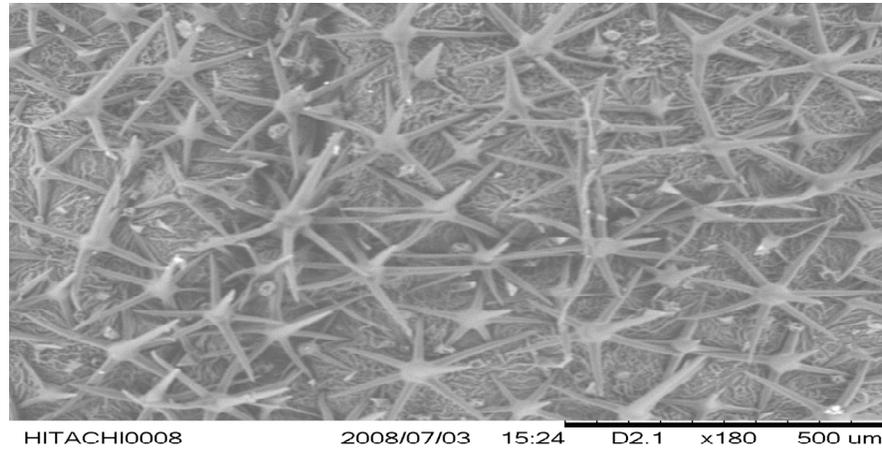


Figure 3. Trichome density of brinjal Terung Bulat MJK cultivar.

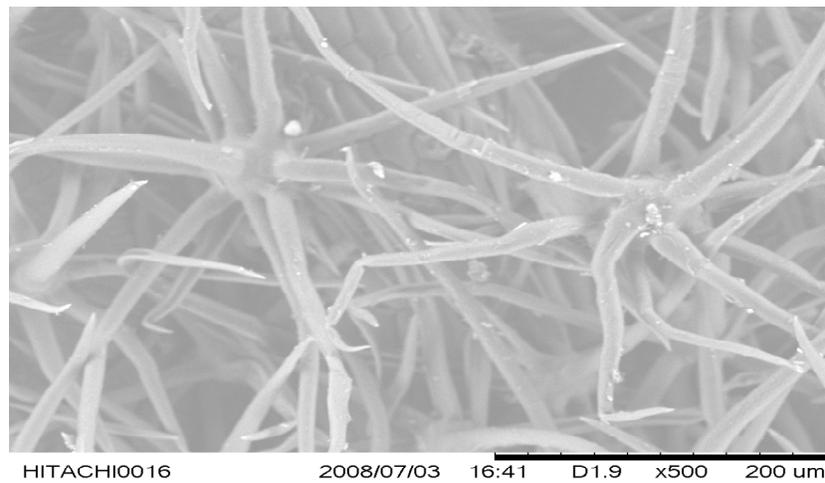


Figure 4. Trichome density of brinjal plant, Terung Panjang Unggu cultivar.

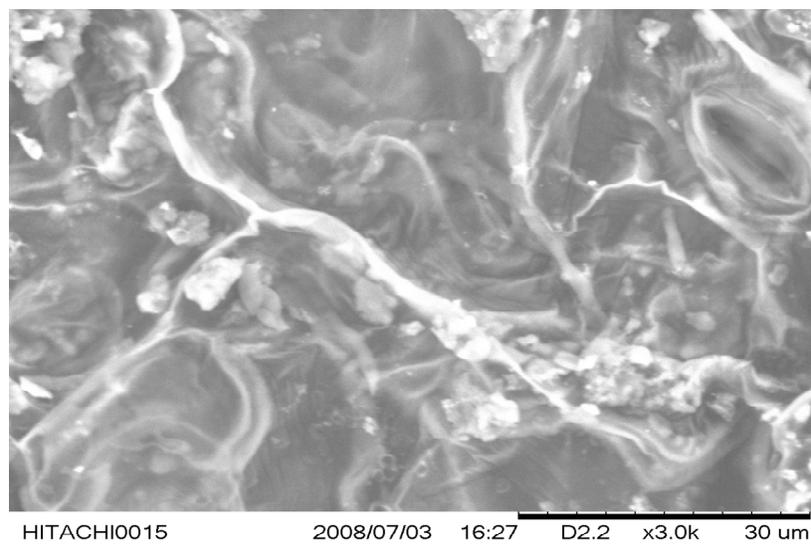


Figure 5. The trichome density on egg plant, Terung pipit cultivar.

was simple or multiple.

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REFERENCES

- Andow DA (1991). Vegetational diversity and arthropod population response. *Annu. Rev. Entomol.* 36: 561-586.
- Baker RR (1978). *The Evolutionary Ecology of Animal Migration*. Hodder and Stoughton, London, p. 1012.
- Bentz J, Reeves II, Barbosa P, Francis B. (1995). Nitrogen fertilizer effect on selection, acceptance and suitability of *Euphorbia pulcherrima* (Euphorbiaceae) as host plant to *Bemisia tabaci* (Homoptera: Aleyrodidae). *Environ. Entomol.* 24: 40-45.
- Bethke JA, Paine TD, Nuessley GS (1991). Comparative biology, morphometrics, and development of two populations of *Bemisia tabaci* (Homoptera: Aleyrodidae) on cotton and poinsettia. *Ann. Entomol. Soc. Am.* 84(4): 407-411.
- Berlinger MJ (1986). Host Plant Resistance to *Bemisia tabaci*. *Agric. Ecosystems Environ.* 17: 69-82.
- Bourland FM, Hornback JM, Calhoun SD (2003). A rating system for leaf pubescence of Cotton. *J. Cotton Sci.* 7: 8-15.
- Butler GD Jr, Wilson FD (1984). Activity of Adult Whiteflies (Homoptera: Aleyrodidae) Within Plantings of Different Cotton Strains and Cultivars as Determined by Sticky-Trap Catches. *J. Econ. Entomol.* 77(5): 1137-1140.
- Chu CC, Henneberry TJ, Cohen AC (1995). *Bemisia argentifolii* (Homoptera: Aleyrodidae): Host preference and factors affecting oviposition and feeding site preference. *Environ. Entomol.* 24(2): 351-360.
- Dingle H (1978). *Evolution of Insect Migration and Diapause*. ed Springer-Verlag, New York, Heidelberg, Berlin: p. 284.
- Kisha JSA (1981) Observations on the trappings of the whitefly *Bemisia tabaci* by glandular hairs on tomato leaves. *Ann. Appl. Biol.* 97: 123-127.
- McAuslane HJ (1996). The influence of pubescence on ovipositional preference of *Bemisia argentifolii* (Homoptera: Aleyrodidae) on soybean. *Environ. Entomol.* 25: 834-84.
- Perring TM (2001). The *Bemisia tabaci* species complex. *Crop protection* 20: 725-737.
- Prabhaker ND, Coudriet DL, Meyer-dirk DE (1985). Insecticide resistance in the sweet potato whitefly *Bemisia tabaci* (Homoptera, Aleyrodidae). *J. Econ. Entomol.* 78: 748-752.
- Simmons AM (1994). Oviposition on Vegetable by *Bemisia tabaci* (Homoptera, Aleyrodidae): Temporal and leaf surface factors. *Environ. Entomol.* 23: 381-389.
- Steel RGD, Torrie JH (1980). *Principles and procedures of Statistics a biological approach*. 2nd ed. McGraw Hill book Co., New York.
- Scheirs J, De Bruyn L (2002). Temporal variability of top-down forces and their role in host choice evolution of phytophagous arthropods. *Oikos*, 97: 139-144
- Southwood TRE (1960). The flight activity of Heteroptera. *Trans. R. Ent. Soc. Lond.* 32: 173-220.
- Southwood TRE (1962). Migration of terrestrial arthropods in relation to flight. *Biol. Rev.* 32: 171-214.
- Tsai JG, Wang KH (1996). Development and reproduction of *Bemisia argentifolii* (Homoptera: Aleyrodidae) on five host plants. *Environ. Entomol.* 25: 810-816.
- Van Lenteren JC, Bale J, Bigler F, Hokkanenand HMT, Loomans mAJM (2006). Assessing the risks of biological control agents of arthropod pests. *Annu Rev. Entomol.* 51: 609-634.