

BIOLOGICAL ASPECTS AND LIFE TABLE OF *Uroleucon ambrosiae* (THOMAS, 1878) AS A FUNCTION OF TEMPERATURE

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ABSTRACT: The aphid *Uroleucon ambrosiae* (Thomas) is considered a pest of hidroponically-grown lettuce, but basic and applied information on its control are scarce in Brazil. The aim of this study was to determine the effect of different temperatures on biological aspects and life history of *U. ambrosiae* (Thomas) developing on hydroponic lettuce (*Lactuca sativa* L.) crop. Newly emerged nymphs were placed on 4-cm discs of hydroponic lettuce, var. Verônica, which were maintained on 5-cm Petri dishes, at temperatures of 15, 20 and 25°C and 14 h photophase, and inside a greenhouse, within micro-cages at room temperature. The duration of development in all nymphal stages varied inversely to temperature. Nymphs maintained at 20°C and 25°C, had similar development period. However, at fluctuating greenhouse temperatures (daily mean = 21°C), different results were obtained, which was also true for the pre-reproductive, reproductive and post-reproductive periods. Daily and total fertilities at 20°C were better in comparison to the other treatments. The highest mortality rate of aphids occurred under greenhouse conditions. The production of 1.28 nymphs per female per day, the time needed for the population to double in size (TD=2.77days), and the intrinsic rate of population increase ($r_m=0.25$), were similar for insects maintained at 20 and 25°C. On the other hand, time interval between generations (T) and the net reproductive rate (R_o) were higher at 20°C. In the greenhouse, even though T was similar to laboratory conditions at 20 and 25°C, the R_o , r_m and λ parameters were lower and TD was higher. Based on biological aspects, fertility and life expectancy tables, constant temperature of 20°C is the most suitable for *U. ambrosiae*.
Key words: insecta, aphids, biology, climatic factors

ASPECTOS BIOLÓGICOS E TABELA DE VIDA DE *Uroleucon ambrosiae* (THOMAS) EM FUNÇÃO DA TEMPERATURA

RESUMO: O afídeo *Uroleucon ambrosiae* (Thomas) é considerado praga em alface de cultivo hidropônico, mas conhecimentos básicos e aplicados que auxiliam no seu controle, são escassos no Brasil. O objetivo do trabalho foi determinar o efeito de diferentes temperaturas a biologia e tabela de vida de *U. ambrosiae* em alface (*Lactuca sativa* L.) hidropônica. Ninfas recém-emergidas foram colocadas em discos com 4 cm de diâmetro de folhas de alface hidropônica cv. Verônica, mantidas em placas de Petri de 5 cm, nas temperaturas de 15, 20 e 25°C, com 14 h de fotofase e em casa-de-vegetação em microgaiolas com temperatura ambiente. A duração do desenvolvimento de todos os estágios ninfaís variou em razão inversa à temperatura. Quando as ninfas foram mantidas em temperaturas de 20°C ou 25°C, os períodos de desenvolvimento foram similares; no entanto, na temperatura ambiente de casa-de-vegetação (média diária = 21°C), diferentes resultados foram observados. A mesma tendência foi observada para os períodos pré-reprodutivo, reprodutivo e pós-reprodutivo. A fertilidade diária e total a 20°C foi melhor quando comparada com as temperaturas constantes de 15°C e 25°C e a da casa-de-vegetação. A maior mortalidade do afídeo foi constatada em condições de casa-de-vegetação. A produção de 1,28 ninfas por fêmea por dia, o tempo necessário para duplicar em número (TD=2,77dias) e capacidade inata de aumentar em número ($r_m=0,25$), foram similares quando esses insetos foram mantidos a 20 e 25°C. No entanto, a 20°C valores superiores foram observados para o tempo decorrido entre gerações (T) e para a taxa líquida de reprodução (R_o). Na casa-de-vegetação, apesar do valor de T ter sido próximo ao observado em condições de laboratório, a 20 e 25°C, os parâmetros taxa reprodutiva líquida (R_o), taxa intrínseca de aumento de população (r_m) e taxa finita de aumento (λ) foram inferiores, e TD foi superior. Pelos aspectos biológicos e tabela de fertilidade e esperança de vida, a temperatura de 20°C é a mais favorável para a espécie *U. ambrosiae*.
Palavras-chave: insecta, afídeos, biologia, fatores climáticos

INTRODUCTION

Lettuce (*Lactuca sativa* L.) is one of the most common and easily found vegetables in Brazilian homes

(Darold et al., 1993). The aphid *Uroleucon ambrosiae* (Thomas), a pest of various cultivated and wild plants of the family Asteraceae (Peña-Martines, 1992) is among the factors that may cause economical damage to this crop.

This insect is not only an important vector of the lettuce mosaic virus, but also cause qualitative damage, because excretes and deposit the "honeydew" over the leaves, which encourages the development of the sooty mold, and undervalue the product.

Temperature is one of the factors that conditions the size of *U. ambrosiae* populations. Highest population densities for this aphid in the hydroponic lettuce condition occur between 16.4 and 19.2°C (Auaud et al., 2002). Negative correlation between temperature and relative humidity and population density of *U. compositae* (Theobald) was verified by Akashe et al. (1995). This fact indicates that investigating the interaction between temperature and development rate of aphids is essential to understand their population dynamics (Liu & Meng, 2000).

Because of the great economical importance of *U. ambrosiae* for hydroponic lettuce cultivation in Brazil (Auaud et al., 2002), this study was set up to obtain information on biological aspects and on the life table of this aphid under different temperatures, aiming to estimate parameters related to its population growth potential which may back up integrated management programs for the control of this pest under protected cultivation.

MATERIAL AND METHODS

Nymphs and adults of *U. ambrosiae* were collected from hydroponically-grow lettuce plants. Biological aspects of the aphid were studied in the laboratory by placing 4-cm lettuce leaf discs (cv. Verônica), on 5-cm Petri dishes containing an agar layer (1%); Leaf discs were replaced every three days. Recently-emerged nymphs were placed on the dishes and maintained in BOD incubators at temperatures of 15, 20 and 25°C, and 14 h photophase. Samples were observed daily under a stereoscopic microscope. Evaluations included: the number of instars, duration of each instar, duration of the nymphal period, duration of the pre-reproductive, reproductive and post-reproductive periods, longevity, and daily and total nymph production. These aspects were also evaluated in the greenhouse on recently-emerged nymphs placed on hydroponic lettuce plants and individualized in microcages built with transparent PVC tubes, 3 cm in diameter and 1.5 cm height, with one end covered by voile fabric and the rim of the other end padded with foam. Cages were attached to the lettuce leaves by aluminum clips. Data on temperature and relative humidity inside the greenhouse were recorded on a thermo-hygrograph. The experiment was set up in a completely randomized design, with 40 replicates per temperature. Data were submitted to analysis of variance differences between means were detected by Tukey test ($P = 0.05$).

The life table calculations were based on Silveira Neto et al. (1976), from laboratory data at 15, 20 and 25°C

and in the greenhouse, with minimum, mean and maximum temperatures equal to 14, 21 and 31°C. The life expectancy table included: number of survivors (L_x); number of dead individuals (d_x); age structure (E_x); life expectancy (e_x); and probability of dying at age x ($100q_x$), where: $E_x = [L_x + (L_{x+1})]/2$; $e_x = T_x/L_x$; $100q_x = (d_x/L_x) \times 100$. The fertility table included the net reproductive rate (R_0), time interval between generations (T), intrinsic rate of population increase (r_m), finite rate of increase (λ) and time needed for the population to double in size (TD), by means of the age intervals (x), age-specific fecundity (m_x) and age-specific survivorship (l_x), where: $R_0 = \sum (m_x l_x)$; $T = (\sum m_x l_x x) / \sum (m_x l_x)$; $r_m = \log_e R_0 / T = \ln R_0 / T$; $\lambda = e^{r_m}$; $TD = \ln(2) / r_m$.

RESULTS AND DISCUSSION

Biological aspects in the nymphal stage

Similarly to aphid species in general, *U. ambrosiae* went through four instars, (Dixon, 1987; Blackman, 1987). The time required for nymphal development, in all instars, was greater at 15°C (Table 1), varying inversely with the temperature. This has also been demonstrated for other aphid species by Elliott & Kieckhefer (1989), Van Steenis & El-Khawass (1995); and Bueno & Foureaux (1998).

Second and 3rd instar nymphs, regardless of being reared in the laboratory (20°C) or in the greenhouse, needed the same time to reach the next stage (Table 1). However, the duration was greater for those nymphs in the 1st and 4th instars submitted to variable temperatures in the greenhouse.

No changes in nymphal developmental period were observed at 20°C and 25°C for all instars. However, when the greenhouse data (21°C) were compared with the 25°C data, a decrease in duration was observed (Table 1). At similar temperatures, this variation can be attributed to temperature oscillations under greenhouse conditions, but that did not occur in the laboratory. Different responses in *Lipaphis erysimi* (Kaltenbach) nymphs maintained under constant or variable temperatures were demonstrated by Liu & Meng (2000), who reported that nymphs reared at constant temperatures of either 8°C or 35°C did not reach the adult stage. However, when maintained under a variable temperature regime, which included those temperatures at certain times of day, the aphids were able to attain the adult stage. The development of aphids at extreme temperatures under variable regimes has also been demonstrated for *Myzus persicae* (Sulzer) by Liu & Meng (1999).

As the temperature increased, the mean duration of the nymphal stage of *U. ambrosiae* was reduced from 16.03 (15°C) to 7.33 days (25°C) (Table 1), resulting in a smaller time interval between each generation (T) at higher temperatures (Table 2), similarly to what has been

Table 1 - Mean duration, in days, for 1st, 2nd, 3th and 4th instar nymphs to develop, pre-reproductive, reproductive and post-reproductive periods, daily and total fertility, and longevity of nymphs and adults of *Uroleucon ambrosiae*, under three constant temperatures, and under greenhouse conditions. n=40.

	Nymphal stage			
	Laboratory			Greenhouse
	15°C	20°C	25°C	
1 st instar	3.80 ± 0.13 a	2.07 ± 0.06 c	1.73 ± 0.09 c	2.70 ± 0.09 b
2 nd instar	4.07 ± 0.17 a	2.27 ± 0.14 bc	1.93 ± 0.11 c	2.47 ± 0.13 b
3 rd instar	4.00 ± 0.14 a	1.90 ± 0.06 b	1.77 ± 0.12 b	2.13 ± 0.01 b
4 th instar	4.17 ± 0.14 a	2.27 ± 0.08 c	2.17 ± 0.11 c	3.20 ± 0.12 b
Nymphal Stage	16.03 ± 0.38 a	8.47 ± 0.15 c	7.33 ± 0.23 d	10.47 ± 0.18 b
	Adult stage			
Pre-Reproductive	3.90 ± 0.18 a	1.77 ± 0.09 b	2.16 ± 0.15 b	2.07 ± 0.10 b
Reproductive	15.57 ± 1.10 a	12.23 ± 0.57 b	8.47 ± 0.62 c	8.87 ± 0.92 c
Post-Reproductive	2.07 ± 0.29 ab	1.50 ± 0.19 b	2.93 ± 0.44 a	1.17 ± 0.09 b
Longevity	21.60 ± 1.98 a	15.50 ± 0.63 b	13.50 ± 0.69 bc	12.10 ± 0.94 c
Biological Cycle (nymph + adult)	37.50 ± 1.25 a	23.97 ± 0.60 b	21.10 ± 0.73 b	22.50 ± 0.97 b
	Fertility (Number of nymphs produced)			
Total	52.47 ± 4.46 b	83.30 ± 4.49 a	29.27 ± 3.10 c	37.07 ± 3.51 c
Daily	3.24 ± 0.11 c	6.76 ± 0.19 a	3.40 ± 0.24 c	4.34 ± 0.24 b

Means followed by a common letter in the rows did not differ by Tukey test at 5%.

Table 2 - Fertility table for *Uroleucon ambrosiae* in the laboratory and in the greenhouse.

Parameters evaluated	Fertility			
	Laboratory			Greenhouse
	15°C	20°C	25°C	
T	27.66	16.88	13.38	16.99
R ₀	39.56	70.02	26.93	25.79
r _m	0.13	0.25	0.25	0.19
λ	1.13	1.28	1.28	1.21
TD	5.33	2.77	2.77	3.65

T: Time interval between each generation; R₀: Net reproductive rate; r_m: Intrinsic rate of population increase; λ: Finite rate of increase; TD: Time necessary to double in population size (days).

reported observed for *Aphis gossypii* Glover (Kocourek et al., 1994) and *L. erysimi* (Godoy, 1999). Nymphs of *U. ambrosiae* maintained at 25°C attained the adult stage in half the time necessary for those maintained at 15°C, which resulted in greater population growth potential.

Biological aspects in the adult stage

The duration of the pre-reproductive period was longer when females were maintained at 15°C. A decrease in the reproductive period was verified at higher temperatures: from 15.57 days at 15°C to 8.47 days at 25°C. The post-reproductive period was shorter at 20°C than at 25°C, but not at 15°C (Table 1). Not only temperature influences these periods, but also the number of offsprings produced during these time intervals should also be considered. For

females kept in the greenhouse, shorter reproductive and longevity periods were observed, while no significant differences were verified for the pre-reproductive and post-reproductive periods and for the biological cycle, when compared to the results observed at 20°C. Therefore, data obtained at the constant temperatures (laboratory) can be utilized to estimate development time for those insects in the adult stage under room conditions (greenhouse), and that would provide supporting information for management strategies against this pest.

Longevity of *U. ambrosiae* was greater at 15°C (21.60 days), decreasing to 13.50 days at 25°C. The biological cycle was longer at 15°C, when compared to the constant temperatures (20 and 25°C) and to the room temperature prevailing in the greenhouse (Table 1).

The total number of nymphs of *U. ambrosiae* produced at 20°C was 83.30 nymphs (Table 1) with a mean value of 7.94 nymphs per female; at 15°C a total of 52.47 nymphs was recorded; at temperature 25°C, 29.27 nymphs; in the greenhouse, 37.07 nymphs. The greater daily *U. ambrosiae* nymph production was verified at 20°C. These differences, i.e., a greater number of offspring at the 20°C temperature, may lead to a greater growth potential and, since under field conditions this species has to face changing conditions, even when the mean temperature is close to 20°C, the number of offsprings might be reduced.

Life expectancy table

The greater longevity of *U. ambrosiae* on lettuce plants was observed when the individuals were main-

tained at 15°C (48 days), followed by those maintained in the greenhouse (30 days) and in the laboratory at 20°C and 25°C (29 and 26 days, respectively) (Figure 1).

The greatest life expectancies (e_x) for *U. ambrosiae* were 29.95, 19.98, 17.15, and 17.93 days at the nymphal stage; and 19.47, 12.18, 11.10, and 9.89 days at the adult stage (Figure 1). These values were recorded on the 2nd, 1st, 2nd, and 3rd observation days for nymphs, and on the 17th, 9th, 9th and 12th days for adults, when maintained at temperatures of 15, 20 and 25°C in

the laboratory, and in the greenhouse, respectively. The probability of death occurring ($100q_x$) for these individuals before the established time was null, except for the adult stage at 20°C and for the nymphal stage at 25°C, with values of 2.70 and 5.41%, respectively.

The duration of the nymphal stage was 16, 9 and 8 days at temperatures of 15, 20 and 25°C, respectively, and 11 days for those individuals maintained in the greenhouse (Table 1). The highest mortality rate of this aphid

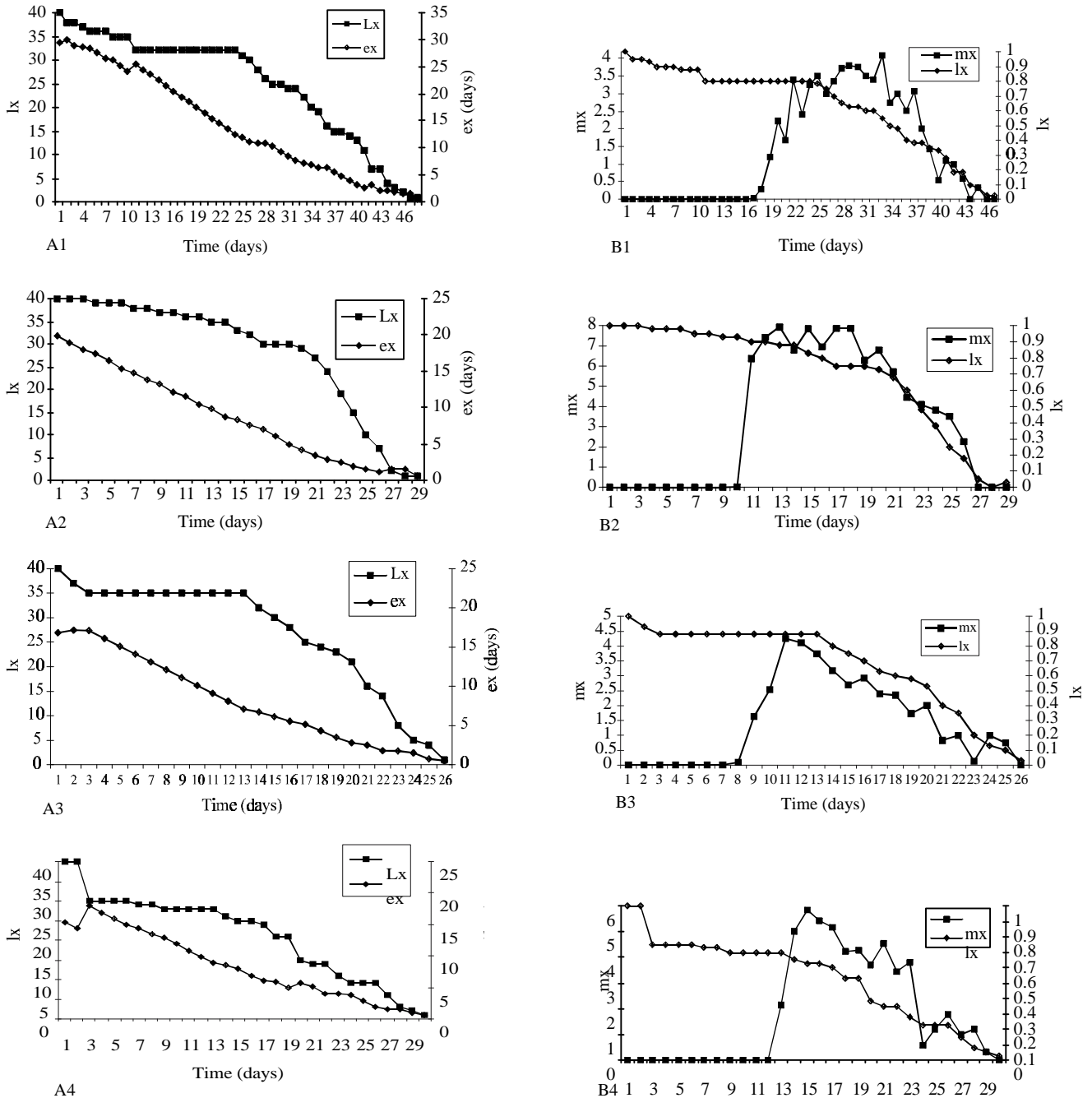


Figure 1 - Survivorship (L_x) and life expectancy (e_x) (A1, A2, A3, A4), mean number of nymphs/female (m_x) and percentage of survival (l_x) (B1, B2, B3, B4) of *Uroleucon ambrosiae* at constant temperatures of 15, 20, and 25 °C, and in the greenhouse at a mean temperature of 21 °C, respectively.

species at the nymphal stage was verified when they were under greenhouse conditions. In the laboratory, the highest mortality occurred at 15°C (Figure 1). The influence of temperature on the life table parameters of *Toxoptera aurantii* (Boyer de Fonscolombe) was mentioned by Wang & Tsai (2001) and followed the same trend observed in the present study.

Fertility table

At 15°C the greatest age-specific fertility (m_x) occurred between 32 and 35 days (4.09 nymphs per female per day) (Figure 1). The age-specific survival (l_x) started to decline beginning on day 1.5, stabilizing above 80% until day 22.5. From this evaluation forth, gradual decreases were observed, reaching 50% on day 32.5 (Figure 1). The mean duration of *U. ambrosiae* generations (T) was 27.66 days, with a net reproductive rate (R_0) of 39.56. The finite rate of increase (λ) was 1.13 nymphs per female per day. The lowest intrinsic rate of population increase ($r_m=0.13$) was verified at 15°C (Table 2). Even though the aphids maintained at this temperature had greater increase in population density from one generation to the next, they had a lower growth potential when compared to kept aphids at 25°C and at room temperature (greenhouse), manifested by their intrinsic rate of population increase. Similar values were verified by Wang & Tsai (2001) while studying the life table for *T. aurantii* at a constant temperature of 15°C.

The production of 1.28 nymphs per female per day, the time necessary for the population to double in size (2.77 days) and the intrinsic rate of population increase (0.25), were the same when insects were maintained at 20 and 25°C (Table 2). Therefore, the optimal temperature for the best increase in population density of *U. ambrosiae* is within this interval. In reports of Van Steenis & El-Khawass (1995) with *A. gossypii*, Godoy (1999) with *L. erysimi*, and Wang & Tsai (2001) with *T. aurantii*, an increase in r_m was recorded for aphids with increasing temperature, but the opposite was observed by Goel & Singh (1994) for *L. erysimi*. These differences can be attributed to the intrinsic characteristics of the aphid species investigated or to differences in the experimental conditions. However, at 20°C, higher values were verified for the interval between generations (T) and for the net reproductive rate (R_0). Nowierski et al. (1995) recorded a higher R_0 value (42.08) for *Diuraphis noxia* (Nowierski) at 25°C, as compared to temperatures of 10°C (15.89) and 30°C (9.16).

The time necessary for the population to double in size was shorter at 20 and 25°C (2.77 days), in comparison to the other temperatures. Females maintained at 15°C spent twice as long, on average 5.33 days, to double their population (Table 2).

In the greenhouse, in spite of the fact that the interval between generations was similar to that ob-

served in the laboratory at 20 and 25 °C, parameters R_0 , r_m and λ were lower and TD was higher. The net reproductive rate (R_0) allowed to determine that *U. ambrosiae* has, an increased capacity of 25.79 fold from one generation to the next, quite lower than the value verified in the laboratory at a constant temperature of 20°C, i.e., 70.02 (Table 2). Auad et al. (2002) mentioned that the highest *U. ambrosiae* population densities in the greenhouse on hydroponic lettuce were recorded when the temperature was between 16.4 and 19.2°C.

From the biological aspects, fertility and life expectancy tables, the constant temperature of 20°C is the most suitable for *U. ambrosiae*, and some differences can be observed when the nymphs are reared in the greenhouse, under a mean temperature near 21°C, although with marked variation. This information is important for studies involving population dynamics of this aphid, allowing the estimation of aspects related to its population growth potential, in order to provide background knowledge for management strategies against this pest insect on hydroponic lettuce.

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