DRIFT PATTERN OF TROPICAL STREAM INSECT: UNDERSTANDING THE AQUATIC IINSECTS MOVEMENT

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ABSTRACT

An investigation to determine the drift pattern of aquatic insects in an upstream river in Perak, Malaysia was carried out. Drift was sampled by collecting drifting insects using drift sampler at every six hourly intervals within 24-hours period. A total of 3147 individuals of drifting aquatic insects was collected represented by 9 orders, 49 families and 81 genera. There was a significant difference in the temporal drifting pattern in aquatic insects (Kruskal-Wallis test, P =0.00). Greatest drift abundance occurred at night time, which approximately 40 % higher than during the daytime samples, signifying diel periodicity of aquatic insect drift. In addition, nights without moonlight exhibited more drift rate as compared to bright, full-moonlit nights and differed significantly (P<0.05). Drifting aquatic insects displayed alternant pattern with the greatest abundance at 0200 to 0800 h interval, and the least was at 1400 to 2000 h interval.

Keywords: Diel periodicity, nocturnal, aquatic insects, river.

ABSTRAK

Satu kajian untuk menentukan pola hayutan serangga akuatik di hulu sungai di Perak, Malaysia telah dijalankan. Hayutan diperolehi dengan mengumpul serangga hanyut dengan menggunakan ‘drift sampler’ pada selang waktu enam jam bagi tempoh 24 jam. Sejumlah 3147 individu serangga akuatik hanyut dikumpulkan daripada 9 order, 49 famili dan 81 genera. Terdapat perbezaan yang signifikan bagi corak hanyut temporal dalam serangga akuatik (ujian Kruskal-Wallis, P =0.00). Kelimpahan hayutan terbesar berlaku pada waktu malam, kira-kira 40% lebih tinggi daripada sampel siang hari, menandakan pergerakan serangga akuatik adalah secara perkalaan harian. Di samping itu, malam tanpa cahaya bulan memperlihatkan kadar hayutan yang tinggi berbanding dengan malam terang dan bulan penuh dan terdapat perbezaan dengan nyata (P <0.05). Hayutan serangga akuatik memaparkan corak alternatif dengan kelimpahan terbesar pada waktu antara 0200 hingga 0800, dan paling sedikit pada waktu 1400 hingga 2000h.

Kata kunci: Perkalaan harian, nocturnal, serangga akuatik, sungai.

INTRODUCTION

Drift is defined as a temporary movement of bottom dwellers during phases of their life cycle. Drift and drift pattern of aquatic insects are very important activities for their colonisation of new areas that contribute significantly to the community richness and diversity in specific environments. For that matter, they have been studied widely in the temperate regions (Fenoglio et al. 2005). Drift is an important event in dispersal and colonisation of aquatic insects (Dudgeon 1992) generally to survive from their potential predators, or unsuitable or changed abiotic conditions (Koetsier & Bryan 1995).

The number of drifting invertebrates usually peaks either during the day or at night. Various studies have proven that aquatic insect drift is strongly influenced by temporal pattern, with nocturnal drift is higher than diurnal drift (Elliot 2002). The drift diel pattern becomes more complex in different instars of similar or different taxa (Saltveit et al. 2001). Night-time drift disperses the invertebrates more effectively due to larger-sized individuals are more vulnerable to predation risk. Conversely, smaller-bodied insects display fewer periodic drift patterns as they face lower risk of vulnerability, due to their smaller body size. Unfortunately, there was a gap in the knowledge of this process in the tropical countries including Malaysia. Therefore, this study was carried out to further examine this process with the following objectives: to study the insect composition during the drift activity and to determine the diel periodicity in aquatic insect drift at Batu Kurau River in a 24-hours-period.

MATERIALS AND METHODS

Study Area

The study site was located in upstream of Batu Kurau River, Perak, Malaysia, at N 04^{o} 54' 17.4" E 100^{o} 49' 59.9". Batu Kurau River was chosen for the drift study because it was a less disturbed river, situated far inside Bintang Hijau Forest Reserve and far from undesirable artificial light disturbances. According to Henn et al. (2014) additional light would interfere with natural drift behaviour of aquatic insects. More importantly, this river can be accessed easily as this study required to collect aquatic insect larvae sample during day and night within 24-hours period per day.

Aquatic Insects Drift Monitoring

Sampling was conducted six times, three nights with full-moonlight night and three nights where moonlight was totally precluded by cloud cover. Six drift net samplers of 10 cm x 10 cm frame size attached with 100 cm cone sack of 500 mm mesh were set up randomly in the Batu Kurau River. The opening of the sampler was positioned against the water current to collect drifted aquatic insect larvae. The nets were set from 1400 h on the first day until 1400 h on the next day, on all sampling events. The nets were emptied at six hourly intervals over 24 hour periods at 2000, 0200, 0800 and 1400. The first collection was at 2000 h, and the subsequent collections followed this scheduled time until the 24-hours period was completed; giving 24 samples each day. Samples were sorted instantaneously after collection to avoid predation. All insects were preserved in 75% ethanol prior to identification and counting. Aquatic insect identification based on morphological characters was done under a stereomicroscope, Olympus Leica EZ4 (Olympus, Tokyo) up to lowest taxa possible using keys provided by Morse et al. (1994), Yule and Yong (2004) and Orr (2005).

Data Analysis
Species Diversity and Richness IV software (Pisces Conservation Ltd, 2007) was used to calculate ecological indices for this study. The diversity of drifting aquatic insects was determined by Shannon Index. Their richness was calculated by Menhinick's Index. The patterns of drifted aquatic insects were confirmed by the Pielou's Evenness Index. Statistical analysis of drift data was analysed using SPSS version 22 software with normality assumptions confirmed using Kolmogorov-Smirnov test at 95% confidence interval (P=0.05) for not normally distributed data. Differences of drift abundance during each time intervals were analyzed using the non-parametric Kruskal-Wallis test at P=0.05. Mean comparison of various time intervals was carried out using Mann-Whitney U-test with Bonferroni correction at P<0.0083. The box-plot analysis was used to illustrate the abundance of drifted aquatic insects during four time intervals and moonlighted nights. Boxes in the graph displayed the interquartile ranges and bars in the boxes represented medians. Whiskers indicated the minimum and maximum variability outside the upper and lower quartiles.

RESULTS

Diel Periodicity in Drift
Throughout the study period of five months, a total of 3,147 individuals of drifting aquatic insects were collected, represented by nine orders, 49 families and 81 genera. In general, the dominant groups of drifting aquatic insects were Ephemeroptera (45.7%), of which 78.9% of them were from the family of Baetidae, followed by Trichoptera (13.2%), Coleoptera (12.6%) and Diptera (11.3%) (Table 1). These were found in all sampling periods, which made them the most frequently occurring aquatic insects in this study.

Table 1. List of drifted aquatic insects in Batu Kurau River.

Order	Family	Genus
Ephemeroptera	Baetidae	*Baetis*
		Platybaetis
	Caenidae	*Caenis*
	Ephemerellidae	*Crinitella*
		Drunella
	Ephemeridae	*Ephemera*
	Heptageniidae	*Campsoneuria*
		Thalerosphyrus
	Leptophlebiidae	*Choroterpes*
		Habrophlebiodes
		Thraulus
	Potamanthidae	*Rheonanthus*
	Tricorythidae	*Neurocaenis*
Odonata	Calopterygidae	*Echo*
		Neurobasis
	Chlorocyphidae	*Rhinocypha*
	Euphaeidae	*Euphaea*
	Gomphidae	*Acrogomphus*
		Gomphidictinus
		Megalogomphus
	Libellulidae	*Zygonyx*
	Plastystictidae	*Drepanosticta*

Plecoptera	Peltoperlidae	*Cryptoperla*
	Perlidae	*Kamimuria*
		Phanoperla
Hemiptera	Aphelocheiridae	*Aphelocheirus*
	Corixidae	*Micronecta*
	Gerridae	*Cryptobates*
		Limnogonus
		Metrocoris
		Ptilomera
		Rheumatogonus
	Helotrephidae	*Helotrephes*
	Naucoridae	*Ctenipocoris*
	Nepidae	*Ranatra*
	Veliidae	*Pseudovelia*
		Rhagovelia
Trichoptera	Hydropsychidae	*Ceratopsyche*
		Cheumatopsyche
		Hydropsyche
		Potamyia
	Lepidostomatidae	*Lepidostoma*
	Leptoceridae	*Oecetis*
		Ceraclea
		Setodes
		Triaenodes
	Molannidae	*Molanna*
	Odontoceridae	*Psilotreta*
	Philopotamidae	*Chimarra*
	Psychomyiidae	*Psychomyia*
		Tinodes
	Sericostomatidae	*Gumaga*
	Stenopsychidae	*Stenopsyche*
Coleoptera	Dryopidae	*Helichus*
	Dytiscidae	*Hyphydrus*
		Neptosternus
	Elmidae	*Ordobrevia*
		Potamophilus
		Stenelmis
		Zaitzevia
	Eulichadidae	*Eulichas*
	Gyrinidae	*Orectochilus*
	Hydrophilidae	*Berosus*
		Helochares
		Laccobius
	Lampyridae	*Lampyridae*
	Noteridae	*Canthydrus*
	Psephenidae	*Eubrianax*
	Scirtidae	*Cyphon*
Diptera	Athericidae	*Atrichops*
		Suragina

	Blephariceridae	*Blephariceria*
	Ceratopogonidae	*Bezzia*
	Chironomidae	*Tanypodinae*
	Simuliidae	*Simulium*
	Tipulidae	*Hexatoma*
		Tipula

The daytime drifters (0800–1400 and 1400–2000) comprised of 59 aquatic insect genera while 75 genera were observed drifted during night time (Figure 1). The greatest number of individual collections was at 0200–0800 time interval with 1357 individuals from 63 genera. Whereas the least number of individuals collected were during 1400–2000 time interval with 369 individuals from 52 genera. By mean, the aquatic insects drifted in 0200–0800 period was the greatest with 37.8±5.3 individuals, followed by 2000–0200 timeframe with 23.6±4.5 individuals. The least drift activity was at 1400–2000 interval with 10.3±1.7 individuals. Mann-Whitney test proved that there was a significant difference of aquatic insects drifted among the time intervals between [1400–2000 and 0200–0800] and [0200–0800 and 0800–1400] (*P*>0.0083). In fact, Mann-Whitney test demonstrated that other time intervals showed no significant different of drifting aquatic insects with *P*>0.0083.

Members of orders Hemiptera, Lepidoptera and Plecoptera drifted in low numbers with percentages of 6.9%, 6.4% and 3.2% respectively of the total drifted community, while the odonates were occasionally drifted (0.7%) (Figure 2). Kruskal-Wallis test showed that there was significant difference in aquatic insect drift in between four time intervals (P=0.00; χ^2=25.7; df=3).

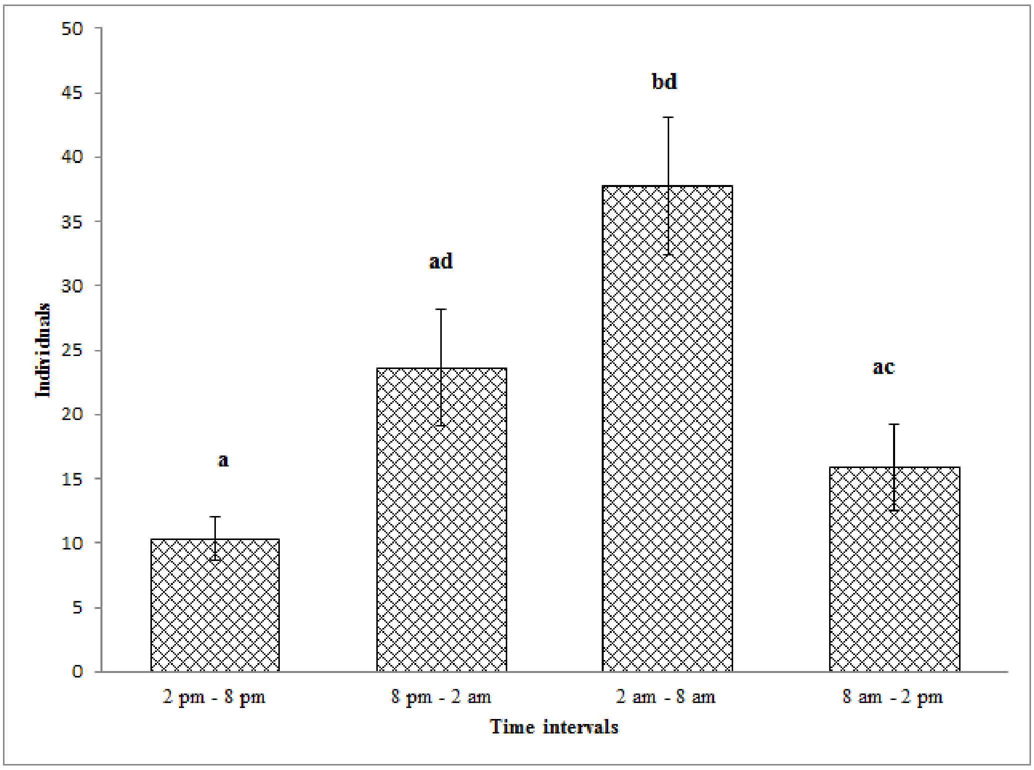

Figure 1. Mean number of individuals in each time intervals. Small letters signify differences of mean at P >0.0083.

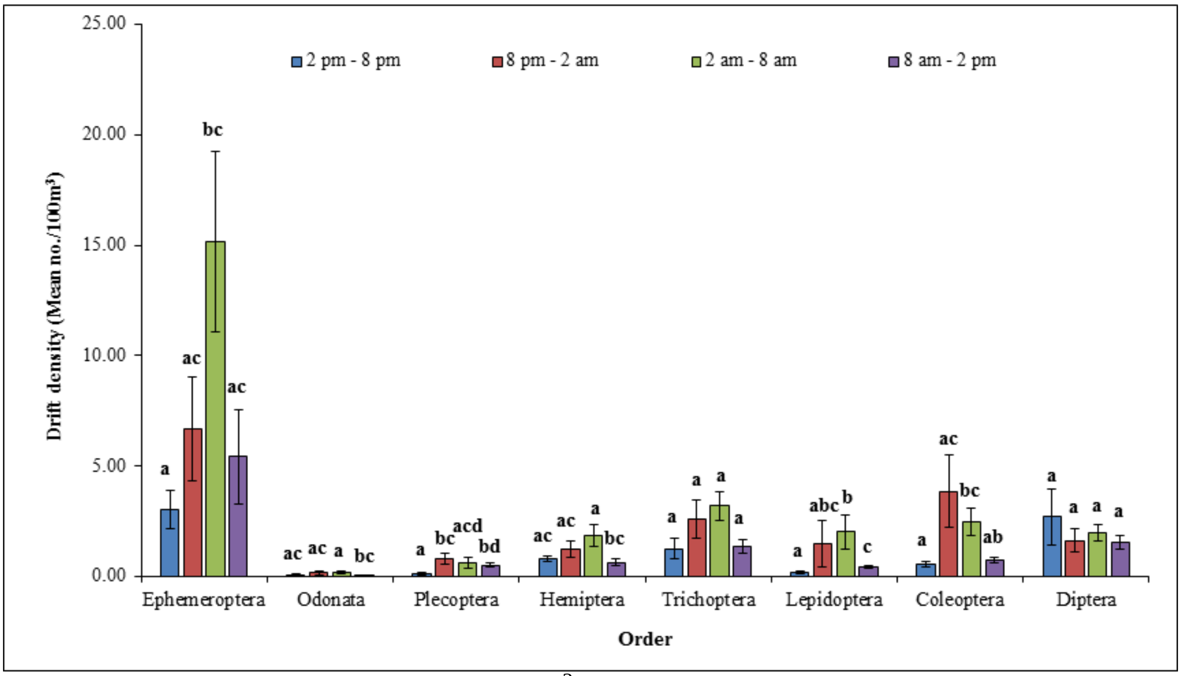

Figure 2. Drift density (mean no./100m^3 ± SE) of aquatic insects in four time intervals.

Score of several ecological indices implied that diversity, richness and evenness of drifted aquatic insects were similar in all time intervals. However, the most diverse aquatic insect community drifted at 2000–0200 interval (H'=3.311), while the least was during 0800–1400 interval (H'=2.640). Nevertheless, the Menhinick's Index indicated 1400–2000 interval had the highest richness (R_2=2.707) among all periods. Time interval of 2000–0200 recorded the highest evenness of drifting aquatic insect community (J'=0.753). The Kruskal-Wallis test showed there was no statistical significance (P>0.05) among indices in all time intervals.

Influence of Moonlight in Night Drift

Generally, all aquatic insects drifted more actively at night (from 2000 to 0800) compared to daytime. Among all the collections, 2,203 of them were night time drifters. The largest groups of drifted aquatic insects from order Ephemeroptera (45.5%), in which 76.8% of them were Baetidae, Coleoptera (15.0%) and Trichoptera (12.98%). Mean difference showed that aquatic insects that drifted with ambient moonlight were 38.6±29 individuals, while nights with full-moonlight recorded 22.8±18.7 individuals. High diversity of drifting aquatic insects was presented in both moonlight conditions however, nights with total darkness showed a slightly more diverse community (H'=3.099) than nights with moonlight (H'=3.091). Drifted aquatic insects in dark nights (without moonlight) showed comparatively evenly distributed (J'=0.7222) with night with moonlit (J'=0.7205). Nevertheless, Kruskal-Wallis test proved that among the ecological indices were not significantly different (P>0.05) in both night conditions. A box-and-whisker plot was used to exemplify the median abundance of drifted aquatic insect larvae under two moonlight conditions (Figure 3). In general, more larvae were drifted under poor light condition as compared to nights with bright moonlit. The distribution range for poorly lit nights was at least one individual drifted and at most 125 individuals drifted during darker nights. The skewness of drifted larvae's distribution was positive (mean=38.58).

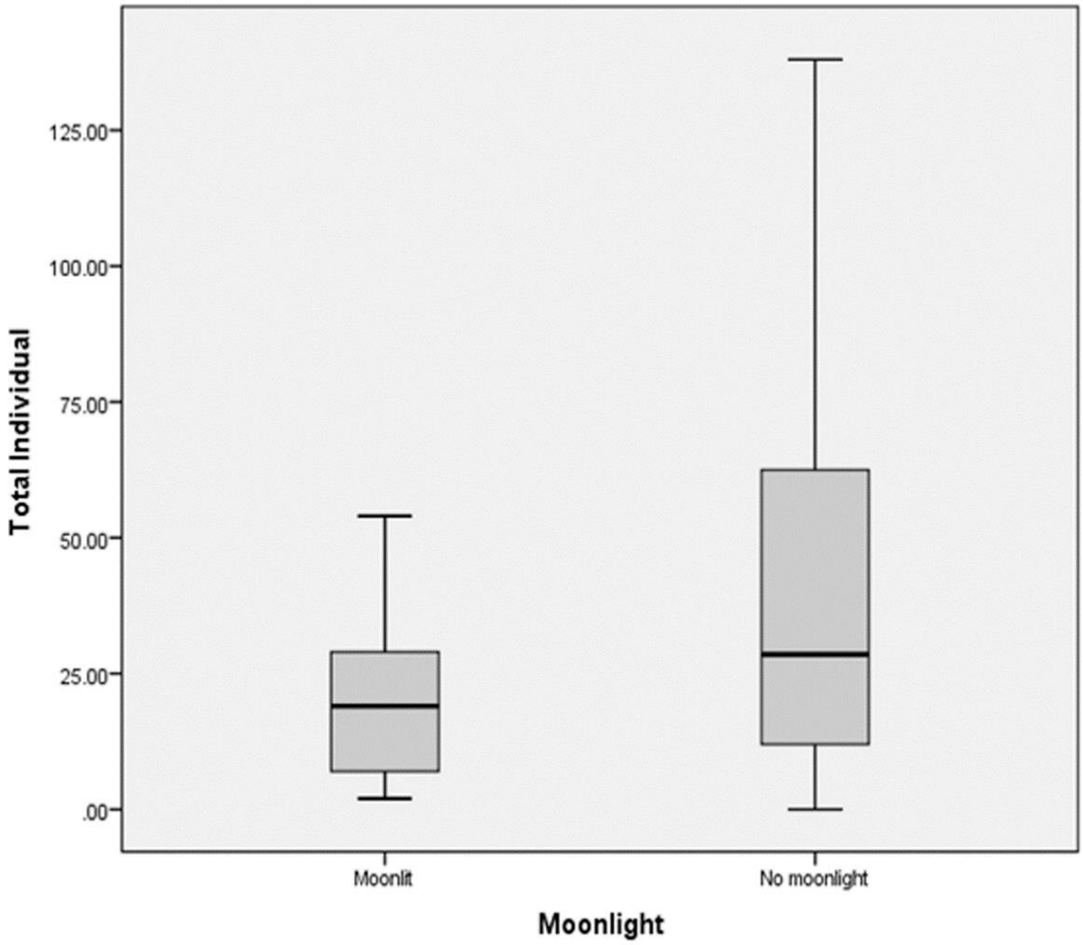

Figure 3 Box-and-whisker plot of abundance of drifted macroinvertebrate under two moonlight conditions.

DISCUSSION

Aquatic insects drift seemed to occur in Batu Kurau River during the 24-hour period. The number of individuals captured in the collected samples at night was approximately 40% higher than in daylight samples. Likewise, the scores of diversity and richness indices were higher during the dark nights. The greatest drift occurred during the time interval of 2000 to 0200, recorded the most diverse drifted aquatic insect larvae (H'=3.311). Apparently, aquatic insect from orders Ephemeroptera, Hemiptera, Trichoptera and Lepidoptera was observed drifted following alternant pattern as seen significantly in large numbers from 0200 to 0800 h. Although the results presented that insect drift was proved to be more active during night-time, results documented from bright, full moonlight nights need consideration. This study resulted in higher drift activities during nights with total darkness, as compared to nights with bright, full-moonlit. There were 54 aquatic insect genera drifted in brightly lit nights, while 63 genera drifted in total darkness. Light is the most essential clue that control diel behavioral cycles in organisms (Schloss 2002). In this study, Baetidae was found to have drifted in larger number in moonless nights, as compared to brightly-moonlit nights. *Baetis* recorded 13.9% of drift activity in total darkness, while nights with bright moonlight recorded 10.8%, and *Platybaetis* recorded 22.8% and 21.2% in nights without and with moonlight, respectively. In addition, Henn et al. (2014) supported, there was reduction of Baetidae and Simuliidae abundance in drift under artificial light. Baetids decreased from 92% to 5.5% while simuliids decreased from

102% to 0% under brightest light intensity treatment (8.8 lx) (Henn et al 2014). Since many faunas function under a circadian rhythm, light pollution would affect distribution, predation and communication of aquatic insects, fish and even marine and terrestrial animals (Davies et al. 2012). Present study was carried out in the field/ river using only natural moonlight instead of using artificial simulated light source in the laboratory.

According to Warrant and Dacke (2016), insects drift at night to avoid vision dependent predators, lowering the risk of predation and thus increasing the chance of survival. The risk of predation as a reason of nocturnal drift is hard to test directly because behavioral traits interact at the levels of genes (York 2018). A study by Ramírez and Gutiérrez-Fonseca (2014) discovered that collector-gatherers such as baetids collect accumulated particles on the stream bottom mostly in darkness for feeding Statistical test of present study showed that drifted scrapers and collector-gatherers (mostly from families Pyralidae and Baetidae) displayed significant difference in four time intervals (P=0.000).

Scouring effects dislodged many insects due to large water discharge and thus explains why the drift nets were empty after heavy rain during the third sampling of night without the presence of moonlight. According to Suhaila et (2018), the flow of the water current lead away the aquatic insects during the rainy season. In present study, water level increased from 16 cm to 18 cm on average (personal observation), after the heavy rain, while water velocity had already recovered to normal velocity before the rain. In this study, the time interval just before the heavy rain (1400–2000) recorded only 34 individuals drifted, while after the rain, the number hiked to 216 drifted individuals in one-time interval (0200–0800). The rain might have reduced insects’ densities especially *Baetis*, however more information on the movements during flow disruptions are needed.

CONCLUSION

Aquatic insect drift in Batu Kurau River displayed a light-differential pattern with 40% more individuals were drifted at night while fewer individuals drifted during the day, in other terms, they exhibit alternant pattern, with the greatest drift activity occurred at 0200 to 0800 intervals. Furthermore, nights without moonlight showed slightly greater drift activities than nights with full-moonlight. Greater drift abundance at darker times probably was influenced by low light intensity, spates and the presence of predator. Aquatic insect from order Ephemeroptera, specifically family Baetidae (*Platybaetis* spp.), showed the most incredible drift activity within a 24-hours period.

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