



PREDATORY PERFORMANCE OF *MICROVELIA DOUGLASI* SCOTT (HEMIPTERA: VELIIDAE) WITH REFERENCE TO DIEL PERIODICITY

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ABSTRACT

The present work centers on the predatory performance of *Microvelia douglasi* adults with reference to diel periodicity. This experiment attempts to determine on whether the foraging efficiency was more at diurnal or nocturnal period, and was there an endogenous rhythm available within them to activate foraging response. The study was conducted in the laboratory for 24 hr with an interval of every three hr. The experiment was divided into Phase I (LD 12:12) and Phase II (DL 12:12). The predatory efficiency of *M. douglasi* adults was investigated on the first and second instars of *Anopheles stephensi* at prey densities of 25 and 50, and the experiment was conducted separately for male, female, and for both male and female, in 500 ml and 1000 ml containers. The bugs showed predatory activity both in diurnal and nocturnal periods. In LD cycle, maximum predatory activity was at 15:00 hr by the female bugs, and a total of 350.0 *An. stephensi* larvae were predated with 144.6 and 205.4 prey predated at 25 and 50 prey density, respectively. The male bugs predated 110.4 prey, and their response was less than that of females, which showed the highest rate of predation as they predated 129.4 prey. The prey predated when both male and female were put together was 110.2. In DL cycle, maximum predatory activity occurred at 24:00 hr again by the female bugs, and a maximum of 327.8 larval instars were predated with 153.4 and 174.4 prey predated at 25 and 50 prey density, respectively. Female bugs predated (121.2) more prey than male (99.4). However, the prey predated when both male and female were put together was 107.2, which was higher than prey predated by male. In LD cycle, the bugs predated more first instar (186.0) than the second instar (164.0), and in DL cycle, there was not much difference as 163.2 and 164.6 first and second instar, respectively were predated. Overall, the bugs showed more predatory activity during light than in dark, though natural light was changed to dark and dark to light. Predator's sex, prey size, and different photoperiods testified the predatory performance of *M. douglasi*, and it was noted that the cumulative interactions of these three parameters were significant. The photoperiods were highly significant. Relatively high statistical significance was also derived in the interaction between the prey size and photoperiod. There was no statistical significance between predator's sex and prey size and predators' sex and photoperiod, and when all three parameters interacted, very less significance occurred.

Key words: *Microvelia douglasi*, *Anopheles stephensi*, diel periodicity, photoperiod, predator's sex, prey size, prey density, predator efficiency, diurnal variations

Insects across all platforms of life make biologically based decisions such as, when to mate, search for food, and when to be active based on the climate around them. Three vital abiotic cues in the environment that drive insect decision making are temperature, humidity, and light, as well as the 24-hour oscillations between these cues (Liu and Meng, 1999; Doge et al., 2015). Dawn and dusk periods are significant in terms of environmental stimuli due to the presence of twilight (Evans et al., 2017). The importance of photoperiod for synchronizing the life history in a given habitat depends on the insect's ability to perceive and measure

the absolute and the relative changes in day length and the availability of their environmental signals. Few studies are reported on the diel variations of food intake in insects (Walde and Davies, 1985; Cloarec, 1988; Shearer et al., 1996; Schloss, 2002; Krupke et al., 2006). Since aquatic insects respond to very low light levels, light detection is perhaps not a problem for them in the aquatic environment. However, it is not the same in semi-aquatic insects. Experimental studies on semi-aquatic insects are needed to broaden the information concerning the effects of photoperiod, and much work remains to be done on the feeding rhythms

of semi-aquatic insects. *Microvelia*, a semi-aquatic bug inhabits the water surface, and plays a vital role in the aquatic ecosystem (Dunbar et al., 2010), as they are predaceous on mosquito larvae (Miura and Takahashi, 1988; Ohba et al., 2011; Arivoli et al., 2023a, b). The effect of nutritional status and sex on circadian variation in predation of *Diplonychus indicus* on modelling predator-prey cycles by Venkatesan and Rao (1980) paved way for investigation with reference to diel periodicity. The present work centers on the predatory performance of *Microvelia douglasi* adults on the larval instars of *Anopheles stephensi* as prey with reference to diel periodicity, and attempts to determine whether the foraging efficiency was more at diurnal or nocturnal periods, and was there an endogenous rhythm available within them to activate foraging response.

MATERIALS AND METHODS

***Microvelia douglasi*:** Adults of *M. douglasi* collected from the water surface of paddy fields from Vellore, Tamil Nadu, India using an insect net were transported to the laboratory and reared in glass aquariums (30" x 20" x 20") filled with rice field water (10L). To recreate natural settings, *Azolla* leaves were dusted within the aquarium. The insects were maintained at room temperature (30± 2°C) with a photoperiod of 12 hr light: 12 hr dark cycle, and were fed with *An. stephensi* larvae on a regular basis. After copulation, the eggs laid were isolated from the aquarium and transferred to small troughs for the emergence of nymphs.

***Anopheles stephensi*:** *Anopheles* adults collected from cattle sheds with the aid of an aspirator were transferred to one feet mosquito cage, and transported to the laboratory, where they were identified with the help of a mosquito identification key, and species of *An. stephensi* were confirmed before rearing (Tyagi et al., 2015; World Health Organization, 2020). Subsequently, their cyclical generations were provided a blood meal, and maintained separately in two feet mosquito cages (27± 2°C, 70-80% RH) inside an insectary. Ovitrap placed inside the mosquito cages collected the oviposited eggs, which were shifted to the larval rearing room in enamel larval salvers, and the larvae on hatching were provided larval feed (yeast and dog biscuits in ratio of 1:3). The larvae, on turning into pupae, were moved to another mosquito cage in enamel bowls for adult emergence.

Diel periodicity: To investigate the test hypothesis of this study, this experiment was designed. The study was conducted in the laboratory for 24 hr with an interval of every three hr. The number of larvae killed was taken as

an indication of their predatory activity. The photophase period was from 06:00 to 06:30 hr and remained active upto 18:00 to 18:30 hr, whereas the scotophase period was from 18:00 to 18:30 hr, and continued upto 06:00 to 06:30 hr. During the experimental period, dawn and dusk were recorded between 05:55 and 06:15 hr, and from 18:15 to 18:45 hr, respectively. Since the aim of the present study was to study the diel periodicity of *M. douglasi* adults, the experiment was divided into two phases. Phase I: The male and female bugs were starved from 18:00 to 20:00 hr, and during this phase, the LD 12:12 was maintained. The bugs were fed with prey from 06:00 to 06:00 hr (for 24 hr). The experiment was repeated throughout the day and night with the interval of three hr in order to assess the predatory performance. The experimental set up was placed near a window facing east in order to get exposed to a natural photoperiod. It is to be noted that this experimental set up received no artificial light. The nocturnal activity was observed with the aid of torches to minimize the effect of light. Phase II: Another group of bugs were starved from 18:00 to 06:00 hr, and the LD cycle was reversed as DL 12:12, and was maintained. The bugs were fed with prey from 06:00 to 06:00 hr (for 24 hr). In this phase, the day light was converted to dark (06:00 to 18:00 hr) by covering with thick black plastic containers, and the dark period was converted to day light (18:00 to 06:00 hr) with the aid of table lamps.

To reduce the level of satiation as variable in the test, and in order to control the level of hunger, the bugs were fed to satiation at the beginning of the experiment. Thereafter, the prey was removed, and the bugs were starved for 12 hr. Prior to the start of each experiment, the required number of prey in each size were counted and placed in the experimental container at room temperature. The predatory efficiency of *M. douglasi* adults was investigated on the first and second instars of *An. stephensi* at prey densities of 25 and 50, and the experiment was conducted separately for male, female, and for both male and female, in 500mL and 1000mL containers. Control lacked predators to ensure mortality does not occur in any prey. At the end of every three hr, the dead prey were counted. A total of five trials were performed. Data obtained were subjected to statistical analysis, via, ANOVA (SPSS, 2021) to find out the significance of the photoperiodic effect on diel predation in *M. douglasi* adults.

RESULTS AND DISCUSSION

No prey mortality was reported in any of the control sets. The number of prey killed by *M.*

douglasi adults irrespective of its sex, prey size, and at various photoperiods are presented in Table 1 and 2. The bugs showed predatory activity both diurnally and nocturnally. In LD cycle, the bugs started their predatory activity early in the morning, and maximum predatory activity was at 15:00 hr by the female bugs, and a total of 350.0 *An. stephensi* larvae were predated. Prey predated by the bugs at 25 and 50 prey density in 500 and 1000mL was 74.8, 69.8, 101.2 and 104.2, respectively. At 25 prey density in 500 mL, 22.4 and 26.8 prey were predated by male and female bugs, and in 1000 mL it was 20.2 and 28.0, respectively. At 50 prey density, it was 34.8 and 36.6 in 500 mL, and 33.0 and 38.0 in 1000 mL, respectively. In DL cycle, maximum predatory activity occurred at 24:00 hr again by the female bugs, and a total of 327.8 larval instars were predated. Prey predated by the bugs at 25 and 50 prey density in 500 and 1000 mL was 80.8, 72.6, 82.8 and 91.6, respectively. At 25 prey density in 500 mL, 23.4 and 33.2 prey were predated by male and female bugs, and in 1000 mL it was 21.0 and 27.0, respectively. At 50 prey density, it was 25.8 and 29.5 in 500mL and 29.2 and 31.6 in 1000 mL, respectively. The trend in predation was directly proportional to the increase in prey density. In LD cycle, 144.6 and 205.4 prey were predated at 25 and 50 prey density, and in DL cycle, it was 153.4 and 174.4, respectively.

In LD cycle, the male bugs predated 110.4 prey, and their response was less than that of females, which showed the highest rate of predation as they predated 129.4 prey. The prey predated when both male and female were put together was 110.2. In DL cycle, the same trend followed as female bugs predated (121.2) more prey than male (99.4). However, the prey predated when both male and female were put together was 107.2, which was higher than prey predated by male. In LD cycle, the bugs predated more first instar (186.0) than the second instar (164.0), and in DL cycle, there was not much difference as 163.2 and 164.6 first and second instar, respectively were predated. Overall, the bugs showed more predatory activity during light than in dark, though natural light was changed to dark and dark to light. Interaction of parameters/factors in foraging response involved predator's sex (male, female, both male and female), prey size (first and second instar), and different photoperiods which testified the predatory performance of *M. douglasi* via ANOVA (Table 3). It may be noted that the cumulative interactions of the three parameters were significant at $P < 0.05$ level. The photoperiods were highly significant. Relatively high statistical significance was also derived in the

interaction between the prey size and photoperiod. There was no statistical significance between predator's sex and prey size and predators' sex and photoperiod. However, when all three parameters interacted, very less significance occurred.

Insects exhibit daily and annual cycles of activity and development, and some may be nocturnal and diurnal, and some have evolved with the periodicity close to 24 hr (circadian). Photoperiodic sensitivity exists in *M. douglasi* under various photoperiodic conditions and has had effect on their oviposition (Muraji and Nakasuji, 1990). Light plays a vital role to perform a particular activity in relation to environmental periodicity. Variations of light intensity influence the diel distribution of food intake though in presence of surplus food. In the experimental phase I and II, there was not much behavioural difference in the activity. A difference in their predation was mainly attributed to the fluctuations of light and temperature. Besides, variation in the predatory activity could have also been due to the absence of vegetation, other physiological and environmental factors or due to laboratory conditions, where the room temperature is high. Significant interaction occur between photoperiod and temperature (Murarji et al., 1989). The daily rhythm of food intake in semi-aquatic insects are biphasic and peak feeding occur after dusk and before dawn (Blois and Cloarec, 1983).

The results of the present study indicate that *M. douglasi* presented a biphasic feeding rhythm. Peaks in feeding activity are influenced by light (from LD 12:12 and DL 12:12). These results agree with Cloarec (1988). This type of predatory activity both in day and night may be referred to as nycthemeral periodicity in contrast with most of the semi aquatic bugs which are either diurnal or nocturnal. The present study suggested that the discontinuity between predator and prey habits may not severely limit the role of *M. douglasi* as a predator because mosquito larvae came to the surface of water at high densities. When a single predator attacked prey, the probability of successful attacks was rather low, but increased greatly for plural attacks (Nakasuji and Dyck, 1984). The successful attacks of the predator on hunting first and second instars was in balance point despite the increase in the density of the prey, and the first instar was more preferred, as the predator is very small. Analyzing the feeding span between the sexes of *M. douglasi*, the male took longer time that the female to consume the prey, and this difference was significant, which are due to exogenous factors. In nature, female veliids ripple

Table 1. Predatory performance of *M. douglasi* on *An. stephensi* in LD cycle

Predator sex	Instar	LD cycle (12:12) in hr							
		9:00	12:00	15:00	18:00	21:00	24:00	03:00	06:00
(25 prey density; 500 ml)									
♂	I	1.20± 1.30	2.60± 1.34	2.00± 1.41	2.00± 1.58	1.20± 0.83	1.20± 1.30	1.00± 1.00	0.60± 0.54
	II	2.40± 0.89	3.00± 1.58	1.20± 0.83	1.00± 1.00	1.00± 0.70	1.00± 0.70	0.40± 0.54	0.60± 0.89
♀	I	1.60± 1.34	2.20± 0.44	4.40± 2.50	2.20± 1.64	1.20± 1.30	1.60± 0.54	1.60± 1.14	0.60± 0.89
	II	1.60± 0.89	2.40± 1.14	1.60± 0.54	1.20± 0.83	0.60± 0.54	1.40± 0.89	1.40± 1.14	0.60± 0.89
♂+♀	I	2.80± 1.92	2.40± 1.14	3.60± 2.07	1.60± 0.89	2.00± 0.70	0.80± 0.83	1.80± 0.83	0.40± 0.54
	II	1.60± 0.89	2.40± 0.89	1.60± 1.14	1.60± 1.67	0.60± 0.89	1.00± 1.00	0.60± 0.54	0.80± 0.83
(25 prey density; 1000 ml)									
♂	I	1.40± 0.54	2.60± 1.67	1.40± 1.14	1.00± 0.70	1.80± 1.20	1.60± 0.55	1.00± 1.00	0.60± 0.89
	II	1.80± 0.83	1.40± 0.54	1.20± 0.83	1.40± 0.89	0.40± 0.54	1.20± 1.30	0.80± 0.83	0.60± 0.54
♀	I	1.40± 2.07	1.80± 0.83	3.40± 2.19	1.80± 2.49	2.20± 2.16	2.40± 2.30	2.60± 1.51	2.40± 1.14
	II	1.80± 0.83	1.20± 0.83	2.80± 1.92	1.20± 0.89	0.60± 0.89	1.00± 0.70	0.60± 0.89	0.80± 0.83
♂+♀	I	3.00± 2.12	2.00± 1.22	0.80± 0.83	1.40± 1.14	1.40± 1.34	1.00± 1.22	1.00± 0.70	1.00± 1.00
	II	2.40± 1.14	1.80± 0.83	1.20± 0.83	1.20± 0.83	0.60± 0.54	1.00± 0.70	0.80± 1.09	1.00± 0.70
(50 prey density; 500 ml)									
♂	I	1.60± 0.54	2.20± 1.78	2.60± 1.34	4.60± 2.40	2.00± 2.00	1.40± 1.40	1.20± 1.30	1.60± 1.51
	II	3.80± 0.83	3.40± 1.51	4.80± 3.34	1.60± 1.14	0.80± 1.09	1.00± 0.70	1.20± 0.83	1.00± 1.00
♀	I	2.20± 1.30	2.40± 1.67	4.00± 1.87	3.40± 1.14	1.40± 1.14	0.80± 0.83	1.60± 0.89	1.20± 0.83
	II	3.60± 1.81	4.00± 1.22	5.40± 1.67	2.20± 2.28	1.40± 0.89	1.00± 0.70	1.00± 0.70	1.00± 0.70
♂+♀	I	2.40± 1.10	1.80± 1.48	3.60± 1.81	2.80± 0.83	1.60± 0.89	1.60± 0.89	1.80± 0.83	1.00± 0.70
	II	2.80± 0.83	2.20± 0.83	2.60± 0.89	1.60± 0.89	0.80± 0.83	0.80± 0.70	1.00± 0.83	1.40± 0.89
(50 prey density; 1000 ml)									
♂	I	2.40± 0.89	2.00± 1.22	4.00± 1.22	4.80± 1.48	1.60± 0.54	1.80± 0.83	1.20± 0.83	0.80± 0.83
	II	2.80± 0.83	3.20± 1.78	2.20± 0.44	1.80± 0.83	0.60± 0.54	1.00± 0.70	1.80± 1.48	1.00± 0.70
♀	I	2.60± 1.51	2.00± 0.70	4.40± 1.14	3.80± 1.64	0.80± 0.83	1.60± 1.81	0.80± 0.83	1.00± 0.70
	II	4.20± 1.30	3.80± 1.92	5.60± 1.81	1.80± 1.09	1.00± 0.70	1.00± 0.81	2.20± 1.48	1.40± 0.54
♂+♀	I	2.00± 0.70	2.60± 1.14	3.60± 2.30	3.20± 1.09	1.20± 1.64	1.20± 1.30	1.40± 0.54	0.80± 0.83
	II	4.40± 2.19	3.20± 2.28	4.20± 3.27	1.60± 0.89	1.00± 0.70	0.80± 0.83	1.20± 0.83	0.80± 0.83

Table 2. Predatory performance of *M. douglasi* on *An. stephensi* in DL cycle

Predator sex	Instar	DL cycle (12:12) in hr							
		9:00	12:00	15:00	18:00	21:00	24:00	03:00	06:00
(25 prey density; 500 mt)									
♂	I	1.20± 1.64	2.20± 2.16	2.00± 1.73	1.00± 1.00	1.80± 1.48	3.00± 1.22	2.40± 1.51	0.40± 0.89
	II	1.00± 0.70	1.60± 1.34	1.00± 1.22	0.60± 0.89	0.80± 0.44	1.40± 0.89	1.80± 1.09	1.20± 1.09
♀	I	3.40± 2.88	2.00± 1.41	2.80± 2.28	3.00± 2.12	4.00± 3.53	1.40± 1.14	1.60± 1.51	0.40± 0.89
	II	0.40± 0.54	3.40± 0.89	1.20± 1.30	0.40± 0.54	1.40± 0.54	4.60± 3.05	2.20± 0.83	1.00± 0.70
♂+♀	I	1.20± 0.83	3.00± 2.00	1.40± 1.14	1.20± 1.30	1.00± 1.41	1.60± 2.30	2.80± 2.38	0.60± 0.89
	II	0.40± 0.54	0.60± 0.89	1.20± 1.09	0.40± 0.54	1.20± 0.83	4.20± 2.68	2.20± 0.44	1.20± 0.83
(25 prey density; 1000 mt)									
♂	I	0.80± 1.30	2.00± 1.73	1.00± 1.41	1.40± 2.19	1.00± 1.22	2.20± 1.48	1.00± 1.22	1.80± 0.44
	II	1.20± 0.44	1.80± 0.83	1.60± 1.14	0.40± 0.89	0.80± 0.44	1.80± 0.83	1.20± 1.30	1.00± 1.00
♀	I	2.40± 1.30	1.40± 1.14	2.60± 1.34	1.00± 1.22	1.20± 1.64	3.20± 3.27	1.40± 1.94	1.00± 1.41
	II	0.80± 0.83	1.80± 1.64	0.20± 0.44	1.00± 1.73	1.80± 0.83	4.80± 2.77	1.40± 0.54	1.00± 0.70
♂+♀	I	1.40± 1.34	2.00± 1.41	2.00± 1.58	0.80± 0.44	2.20± 2.16	1.60± 1.14	2.00± 2.73	1.40± 0.54
	II	1.20± 0.44	0.80± 0.83	1.40± 0.89	1.00± 1.22	0.80± 0.44	3.40± 1.14	1.40± 0.54	1.20± 0.83
(50 prey density; 500 mt)									
♂	I	1.00± 1.00	0.80± 0.83	1.40± 0.89	1.00± 0.70	2.40± 0.54	2.00± 1.22	2.20± 1.48	2.00± 1.58
	II	1.20± 0.83	0.60± 0.54	2.00± 1.22	1.00± 1.22	1.80± 1.48	2.00± 1.00	2.20± 1.09	2.20± 0.44
♀	I	0.80± 0.83	1.20± 1.30	1.20± 0.83	1.60± 0.89	2.20± 1.14	2.40± 0.83	2.80± 1.92	2.40± 1.14
	II	2.20± 0.83	1.00± 0.70	1.60± 1.14	2.00± 1.58	2.20± 2.16	2.20± 0.44	1.60± 0.54	2.00± 0.70
♂+♀	I	1.00± 0.70	1.20± 0.83	0.80± 0.83	0.60± 0.54	2.20± 1.09	2.00± 0.54	2.20± 1.30	1.60± 0.54
	II	1.60± 1.51	1.00± 0.70	2.20± 1.51	2.00± 1.41	2.80± 1.48	1.80± 0.83	2.20± 1.09	2.40± 1.14
(50 prey density; 1000 mt)									
♂	I	0.80± 0.83	1.40± 0.89	1.00± 0.70	1.00± 0.70	2.00± 0.70	3.00± 1.73	1.80± 0.83	2.60± 0.89
	II	1.60± 1.89	1.80± 1.64	2.40± 0.54	1.60± 0.89	2.20± 1.09	2.20± 1.09	2.60± 0.89	2.20± 1.09
♀	I	0.80± 0.83	1.00± 0.70	1.60± 0.54	1.40± 1.67	2.20± 0.83	2.60± 0.89	2.40± 1.14	2.20± 1.09
	II	1.80± 1.09	2.60± 0.54	2.00± 1.22	2.40± 0.89	1.80± 1.09	3.20± 1.09	1.80± 0.44	1.80± 0.83
♂+♀	I	1.20± 0.83	0.80± 0.83	1.40± 1.67	0.80± 0.83	2.00± 0.70	3.20± 1.09	2.40± 1.51	1.40± 1.14
	II	1.60± 0.54	1.40± 0.89	2.80± 1.92	2.20± 0.83	2.00± 0.70	2.80± 0.83	2.40± 1.14	2.40± 1.14

Table 3. ANOVA for diel periodicity of *M. douglasi* predation on *An. stephensi* larval instars

Parameters	Sum of squares	Degree of freedom	Mean squares	F value	LD cycle (12:12)			
					(25 prey density; 500 m ℓ)		(25 prey density; 1000 m ℓ)	
Predator's sex	2.608	2	1.304	0.575	10.808	2	5.404	5.829*
Prey size	12.604	1	12.604	4.683	15.504	1	15.504	8.259*
Predator's sex x Prey size	2.908	2	1.454	0.540	7.408	2	3.704	1.973
Photoperiod	94.596	7	13.514	17.627*	35.796	7	5.114	3.650*
Predator's sex x Photoperiod	17.192	14	1.228	1.602	16.592	14	1.185	0.845
Prey size x Photoperiod	24.696	7	3.528	2.468*	14.462	7	2.066	1.324
Predator's sex x Prey size x Photoperiod	14.892	14	1.064	0.744	16.525	14	1.180	0.756
					(50 prey density; 500 m ℓ)		(50 prey density; 1000 m ℓ)	
Predator's sex	7.275	2	3.638	1.353	5.008	2	2.504	1.403
Prey size	4.150	1	4.150	2.170	0.104	1	0.104	4.034*
Predator's sex x Prey size	5.358	2	2.679	1.401	10.858	2	5.429	2.103
Photoperiod	214.929	7	30.704	16.454*	274.496	7	39.214	24.048*
Predator's sex x Photoperiod	18.258	14	1.304	0.698	23.592	14	1.685	1.033
Prey size x Photoperiod	55.963	7	7.995	5.434*	69.663	7	9.952	6.419*
Predator's sex x Prey size x Photoperiod	25.775	14	1.841	1.263	16.675	14	1.191	0.768
					DL cycle (12:12)			
					(25 prey density; 500 m ℓ)		(25 prey density; 1000 m ℓ)	
Predator's sex	17.733	2	8.867	3.837*	5.700	2	2.850	1.736
Prey size	10.004	1	10.004	2.317	2.604	1	2.604	1.193
Predator's sex x Prey size	1.733	2	0.867	0.244	0.133	2	0.066	3.053
Photoperiod	82.529	7	11.789	5.697*	68.329	7	9.761	5.514*
Predator's sex x Photoperiod	19.333	14	1.381	0.667	25.033	14	1.788	1.010
Prey size x Photoperiod	47.096	7	6.728	3.122*	14.496	7	2.071	0.874
Predator's sex x Prey size x Photoperiod	79.067	14	5.648	2.621*	36.067	14	2.576	1.087
					(50 prey density; 500 m ℓ)		(50 prey density; 1000 m ℓ)	
Predator's sex	2.033	2	1.017	0.935	0.174	2	8.749	0.111
Prey size	2.604	1	2.604	2.490	10.838	1	10.838	14.135*
Predator's sex x Prey size	4.033	2	2.017	1.928	0.525	2	0.262	0.342
Photoperiod	51.029	7	7.289	6.018*	50.496	7	7.214	6.075*
Predator's sex x Photoperiod	5.033	14	0.359	0.290	8.692	14	0.620	0.522
Prey size x Photoperiod	11.629	7	1.661	1.279	15.529	7	2.218	1.933
Predator's sex x Prey size x Photoperiod	8.633	14	0.617	0.475	13.008	14	0.929	0.809

*Values significant at $p < 0.05$

bugs are the strongest individuals and show the best foraging activity (Wilson et al., 1978), and the present research supports this statement. Nevertheless, the male and female bugs when put together showed lesser rate of predation. This may be due to the coexistence of male and female, where they were found to copulate or chase one another, and the male tend to enjoy a free ride by sitting on the back of a female. This showed that they are governed by factors like copulation of

intraspecific interference. The present study reports the fact that *M. douglasi* adults predation was governed by the photoperiods and also in the interaction between the prey size and photoperiod. However, above all, diel periodicity could have been produced in possible ways like, a direct response by the predator to the light-dark regime, predator's response to temperature change, diel changes in prey behaviour activity, and an internal clock or endogenous rhythm.

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AUTHOR CONTRIBUTION STATEMENT

All authors equally contributed to this study.

CONFLICT OF INTEREST

No conflict of interest.

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