BASKING BEHAVIOUR IN SOME NYMPHALID BUTTERFLIES OF BANGLADESH

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Abstract

A through study was conducted on the basking behaviour of some nymphalid butterflies in the fields of Bhawal national park, Rema-Kalenga, Zoological and Botanical Gardens of the University of Dhaka. The time budget and the wing-posture activities of butterflies during basking period were studied butterfly species under the family Nymphalidae. The experimental species were *Junonia atlites, J. almana, J. iphita, Neptis soma, Labadea martha, Ergolis ariadne, Phalantha phalantha, Hypolimnas bolina* and *Athyma perius.* Different types of wing postures (viz. appressed, horizontal, angled and closed type) were also recorded. It is found that butterflies take more time for their basking during winter season. Most of them prefer the month of November and December for their basking. The observations reveal that thermal basking increases the temperature in the butterfly body. It directly implies how thermoregulation associated with behavioural activities in different abiotic conditions. The results also showed the importance of wing postures for thermoregulation.

Key words: Basking, posture, thermoregulation, time budget.

INTRODUCTION

Ectotherms or "cold-blooded" animals, such as invertebrates, amphibians, reptiles, and fish regulate their internal body temperature (ITB) externally primarily through behavioral mechanisms that alter heat exchange between their bodies and the environment (Norris and Kunz 2012). As butterflies are cold blooded, they need the sun to warm their wing muscles so that they can fly (Kleckova and Klecka 2016). In butterflies, basking is the process of sun-bathing that increases temperature in the wing muscles to bring the insects in a physiological condition which makes them able for taking off to their flight. Butterfly flies at their very best ecological condition when the air temperature ranges from 24°C to 32°C. The reason for this is that they don't have to stop and warm their wings up. If the winds are cooler, many butterflies perch on flowers and leaves in the sun, usually laying them flat down and facing upward at the sun, so they can get the best exposure. When temperature rises butterflies seek shade places (Bashar 2015).

Thermoregulation is an important component to initiate behavioural activities of butterflies. Although the physical structures, such as wing size and thorax, ultimately limit thermoregulatory capacity, behavioral changes (e.g., basking, body postures) can greatly affect heat gain and loss and allow butterflies to keep their body temperature close to the optima for flight, foraging, etc. (Heinrich 1972, Kingsolver and Moffat 1982, Kingsolver and Wiernasz 1991, Kleckova *et al*. 2014). Through basking and adjusting body posture, butterflies increase internal temperature by absorbing solar radiation or by conducting heat through body parts placed onto warmer substrates (Heinrich 1993, Huey *et al.* 2003). Wing flapping or increased exposure to wind decreases body temperatures through convective cooling. Because butterflies are not able to change their colouration, wing colour is thermally limiting in that darker colouration absorbs more solar radiation than lighter colouration (Berwaerts *et al.* 2001, Watt 1968).

Butterfly basking can be categorized into three types. These are lateral, dorsal and reflectance basking. Lateral basking occur when butterfly wings are folded and facing the sun. When the wings are fully open at 180° (or 90° with respect to the direct solar, radiation) the behaviour is called dorsal basking (Casey 1981). Dorsal basking is the most common type of basking. The third type basking is called reflectance. In this case, the wings are used to reflect the sun light to the butterfly's body rather than absorb it (Bashar 2015). A reflectance basker opens its wings at 5-90° angles to the incident solar

radiation (Kingsolver 1988). Dorsal basker typically perch on the ground or other substratum, and the baskers achieve a high temperature because of the direct solar radiation striking the thorax, as well as, the reduced convective cooling as a result of warm air trapped under their spread wings (Wasserthal 1975). Reflectance baskers, unlike dorsal baskers, typically do not hug the substratum. Instead, they perch on vegetation near the ground where they are exposed to turbulent and unpredictable air currents. During the basking, the butterflies exhibit various postures. Posture is known as the position or bearing of the body at a given time especially with respect to capability in particular circumstances (Kingsolver 1988, Henrich 1990, Shreeve and Dennis 1992, Shreeve *et al.* 2009).

Under relatively cool conditions (in the early morning, late afternoon, or immediately after extended overcast spells), many nymphalid butterflies perch in the sun with their wings fully spread and angled downwards so that the distal edges are appressed to the substrate (the appression posture). This posture creates a tent-like area between the wing surface and the perch substrate. It has been observed that when ambient temperature increases, male *Hypolimnas bolina* butterflies continue to select perches in the sun, but adopt wing postures ranging from horizontally spread to completely close (Clench 1966, Kemp and Krockenberger 2002). Under hotter conditions, males perch in the shade with closed wings. In all cases, the most common perching substrate is tree/shrub foliage (Rutowski 1992), but individuals may occasionally select structures such as tree stumps, or perch on the ground (McCubbin 1971).

The Nymphalidae is a family of about 5,000 species of butterflies distributed throughout the world (Parmesan *et al.* 1999). Some are brilliantly coloured and the range of pattern and wing shape is extensive. They are usually very brightly coloured, often with wing margins sharply indented or angled, many predominately patterned black spots and streaks on a tawny background (Strauss 1990).

The present study has made investigations mainly on the basking behaviour of nymphalid butterflies. The investigations were also detailed on categorizations and time budget in different categories of the basking behaviour of the nymphalid butterflies.

MATERIAL AND METHODS

Basking behaviour of nymphalid butterflies viz. *Junonia atlites* (Johanssen 1763), *J. almanac* (Linnaeus 1758), *J. iphita* (Cramer 1869), *Neptis soma* (Moore 1872), *Labadea martha* (Fabricius, 1775), *Ergolis ariadne* (Johanssen 1764), *Phalantha phalantha* (Drury 1770), *Hypolimnas bolina* (Linnaeus 1758) and *Athyma perius* (Linnaeus 1758) were observed in the Bhawal National Park, Rema-Kalenga forest, Zoological and Botanical Gardens of the University of Dhaka from June 2016 to July 2017. Basking behaviour was mostly observed in the months of Octover, November and December. The butterfly specimens were identified following Bashar (2014) and Ek-Amnuay (2006). Observation, date, time, weather condition and study area were recorded according to Bashar *et al.* (2006a and 2006b). Basking behaviour and other behavioural activities, like foraging, mating, host plant searching and pollinating activities were observed and recorded following Bashar (2015).

In the field, butterflies were observed using the transect method followed by Pollard and Yates (1993) and Latin square method by Rao and Richard (2006). Identification of plants was done following Ahmed *et al.* (2009). Observations were made during the time period between 8.00 a.m. and 4.00 p.m. A "constant walk" for 10-15 minutes was engaged as 'preparatory performance' in the study areas to start examining the butterflies while they were on basking.

During the study period, the duration of their basking in different posture was attentively recorded. A time frame was made in ranging from 1-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71-80,81-90, 91-100, 101-110 and 111-120 seconds. The number of basking in different categories as 'appressed', 'horizontal', 'angled' and 'closed' were counted and these were based on the time ranges.

RESULTS AND DISCUSSION

In the studied butterflies (Table 1) the principal way that butterflies regulate their heat gain by behavioural orientation and posture relative to the sun was absorbed and recorded. The butterflies in the present investigation belonged to the family Nymphalidae. Four different basking postures were traced and identified. These postures were appressed, horizontal, angled, and closed (Fig. 1). The postures were used by the butterflies to the sun for regulating temperature in their thoracic muscles. In appressed posture, wings tips are downwards to the ground; in horizontal posture, wings position were flat (equal to 180°); in angled posture, wing tips were opposite to the ground (less than 180°); and in closed posture, wings were closed together at 90° angle from the ground.

a b c d

Fig. 1. Different basking postures of butterfly (e.g. *Junonia atlites*): a. Appressed, b. Horizontal, c. Angled, d. Closed.

The species which exercised all the recorded four categories of the behaviour (appressed, horizontal, angled and closed) were *Junonia atlites, J. almana*, *Neptis soma*, *Hypolimnas bolina* and *Athyma perius*; and those shown only three categories (horizontal, angled and closed) were *Junonia iphita*, *Labadea martha*, *Ergolis ariadne* and *Phalantha phalantha*. It is found that 'appressed' type of the basking behaviour of category was only present in the nymphalid butterflies not even in the butterflies belonging to the rest of the butterfly families. And furthermore, it is also noticed that the 'appressed' behaviour is also poorly exercised by the butterflies even of the family Nymphalidae. The basking time budget of nymphalids is shown in Table 1.

Table 1. Basking time budget of nymphalid butterflies when their different postures are examined in field conditions.

Selected butterfly		Individual number (n)	Basking postures	Basking number	Duration of basking (second)		
Genus	Species				Min.	Max.	Av.±SD
Junonia	*J. atlites*	17	Appressed	21	2	59	26.65±18.93
			Horizontal	42	2	50	23.69±13.2
			Angled	35	2	45	19.21±13.14
			Closed	38	5	71	29.92±16.55
	J. almana	25	Appressed	22	5	70	25.82±19.42
			Horizontal	35	2	45	12.77±10.14
			Angled	47	2	80	27.39±20.59
			Closed	29	2	91	32.72±29.3
	J. iphita	9	Horizontal	21	3	39	15.95±9.68
			Angled	27	2	48	18.00±14.48
			Closed	19	3	51	22.11±14.96
Neptis	*N. soma*	5	Appressed	14	7	35	21.71±9.343
			Horizontal	26	4	39	14.96±8.87
			Angled	22	2	40	13.68±11.81
			Closed	22	5	45	18.59±12.42
Labadea	*L. martha*	3	Horizontal	33	3	62	20.52±14.21
			Angled	20	3	54	20.40±13.92
			Closed	18	3	59	27.72±18.11

Ergolis	*E. ariadne*	2	Horizontal	28	3	65	24.46±16.99
			Angled	15	4	42	22.76±14.51
			Closed	15	2	49	23.39±16.56
Phalantha	*P. phalantha*	6	Horizontal	19	7	31	17.42±7.14
			Angled	19	3	23	11.21±6.43
			Closed	18	3	49	22.11±16.14
Hypolimnas	*H. bolina*	5	Appressed	11	6	39	19.00±9.68
			Horizontal	14	5	33	13.86±8.51
			Angled	25	3	40	16.38±8.70
			Closed	21	7	57	25.38±15.55
Athyma	*A. perius*	3	Appressed	12	3	20	10.75±5.83
			Horizontal	16	6	31	18.13±7.25
			Angled	20	2	27	14.65±7.67
			Closed	22	7	37	14.65±7.67

Species-wise statements are made accordingly as stated below-

Junonia atlitis

Junonia atlites was found to exercise basking behaviour on plant leaves. This species basks at the temperature of 28°C and with 49% relative humidity. Four types of basking postures (viz. appressed, horizontal, angled and closed) were recorded in this butterfly. During basking it spent minimum 2 and maximum 59 seconds in appressed position, minimum 2 and maximum 50 seconds in horizontal position, minimum 2 and maximum 45 seconds in angled position, and minimum 5 and maximum 71 seconds in close position The time budget of *J. atlities* for its basking was 26.65±18.93 seconds in appressed position; 23.69±13.2 seconds in horizontal position; 19.21±13.14 seconds in angled position, and 29.92±16.55 seconds in closed position. This species was found foraging, pollinating and mating after basking (Table 1). *Junonia atlites* basks 14 times within the range of 1-10 seconds of duration in angled position; fourteen times within 11-20 seconds on horizontal; only one time within 71-80 seconds on closed position (Fig. 2a).

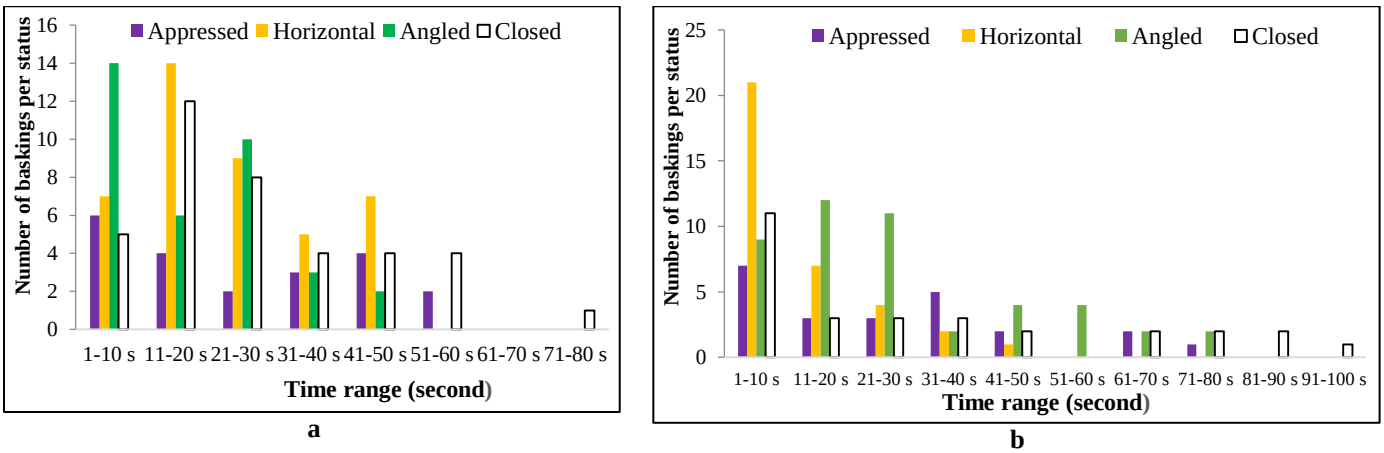

Fig. 2. Basking time budget (staying on basking) of **a**. *Junonia atlites* and **b**. *J. almana* during observation in the fields from June 2016 to July 2017.

Junonia almana

Junonia almana basks on plant leaves mainly. This butterfly species basks at the temperature of 27°C and humidity of 52%. Four types of basking postures (viz. appressed, horizontal, angled and closed) were observed in this butterfly. It spent minimum 5 and maximum 70 seconds in appressed position; minimum 2 and maximum 45 seconds in horizontal position; minimum 2 and maximum 80 seconds in angled position; minimum 2 and maximum 91 seconds in closed position (Fig. 2b). The time

budget of *J. almana* for its basking was noted as 25.82±19.42 seconds in appressed position; 12.77±10.14 seconds in horizontal position; 27.39±20.59 seconds in angled position and 32.72±29.3 seconds in the closed position. This species was found very dynamic in pollinating, foraging and mating behaviours after basking is over. Basking in *J. almana* was highest 21 times occurring within 01-10 seconds in horizontal position; lowest only one time within 41-50 seconds in horizontal position and within 91-100 seconds in closed position (Fig. 2b).

Junonia iphita

Junonia iphita was found basking on plant leaves at 27.9°C and 47% RH. Three types of basking posture were observed in this butterfly. This species spent minimum 3 and maximum 39 seconds in horizontal position; minimum 2 and maximum 48 seconds in angled position; minimum 3 and maximum 51 seconds in closed position. The time budget of *J. iphita* for these three basking postures (viz. horizontal, angled and closed) was 15.95±9.68, 18.00±14.48 and 22.11±14.96 seconds, respectively. This species showed foraging, mating and pollinating behaviour after basking (Table 1). It was also found that *J. iphita* basking was highest 14 times occurring within 1-10 seconds in angle position and lowest only one time within 51-60 seconds in closed position (Fig. 3a).

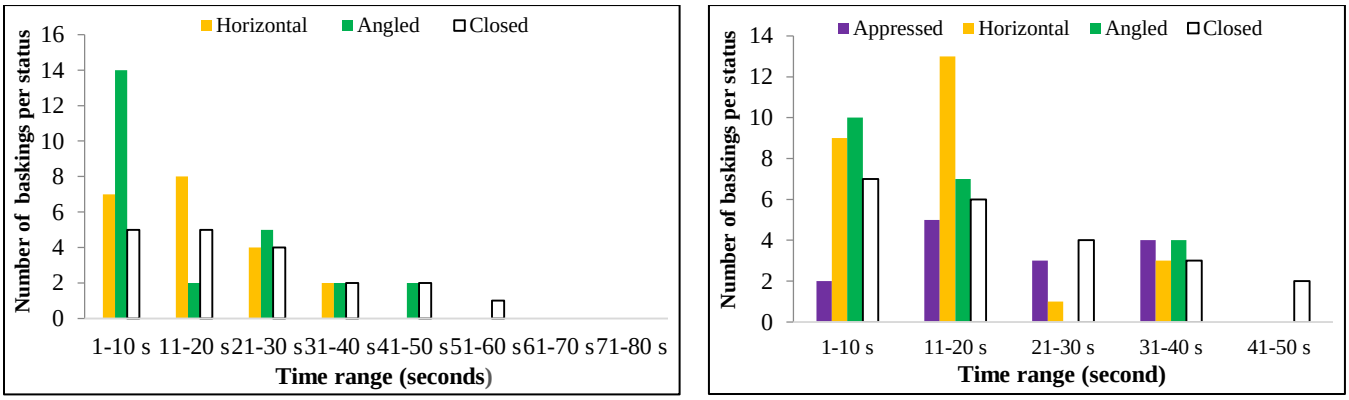

Fig. 3. Basking time budget (stay on basking) of **a**. *Junonia iphita* and **b**. *Neptis soma* during observation in the fields from June 2016 to July 2017.

Neptis soma

During the observation period *N. soma* was found basking on plant leaves at 30°C and 67% RH. Four types of basking posture were observed in this butterfly. This species spent minimum 7 and maximum 35 seconds in appressed position; minimum 4 and maximum 39 seconds in horizontal position, minimum 2 and maximum 40 seconds in angled position, minimum 5 and maximum 46 seconds in close position. The time budget of *N. soma* for four basking postures was 21.71±9.343 seconds in appressed position; 14.96±8.87 seconds in horizontal position; in 13.68±11.81 seconds angled position and 18.59±12.42 seconds in closed position. This species were found foraging and pollinating after basking (Table 1). *N. soma* basking was highest 13 times occurring within 11-20 seconds in horizontal position; lowest only one time within 21-30 seconds in horizontal position (Fig. 3b).

Labadea martha

The basking of *L. martha* was found on plant leaves at 29.5°C and 51% RH. Three types of basking posture were observed in this butterfly. Those postures were horizontal, angled and closed. This butterfly spent minimum 3 and maximum 62 seconds in horizontal position, minimum 3 and maximum 54 seconds in angled position, and minimum 3 and maximum 59 seconds in closed position. The time budget of *L. Martha* for its basking was 20.52±14.21 seconds in horizontal position, 20.40±13.92

seconds in angled position, and 27.72±18.11 seconds in closed position. This species took more time for basking because of its larger size and basking was highest 11 times occurring within 11-20 seconds in horizontal position and lowest only one time within 61-70 seconds in horizontal position (Fig. 4a). The butterfly was found foraging after basking.

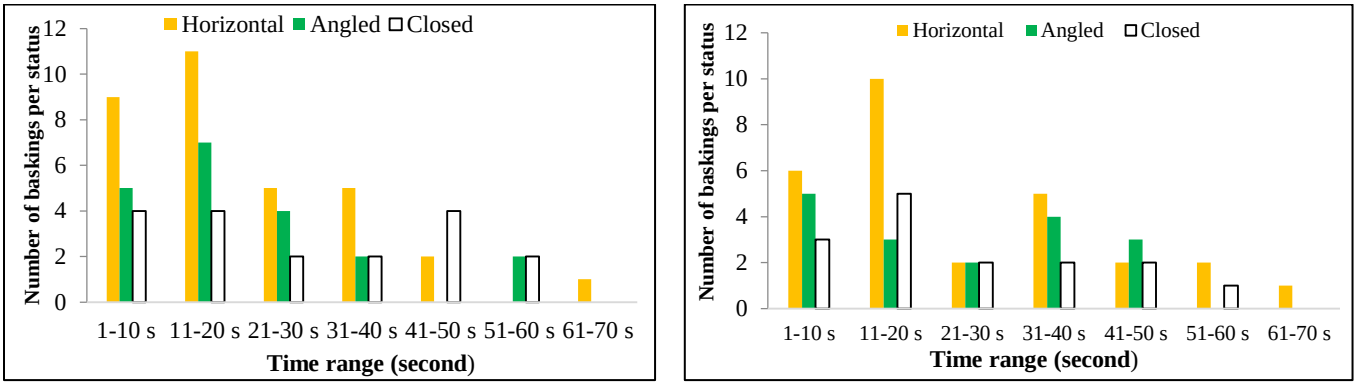

Fig. 4. Basking time budget (stay on basking) of **a**. *L. martha* and **b**. *E. ariadne* during observation in the fields from June 2016 to July 2017.

Ergolis Ariadne

Ergolis ariadne was found basking on plant leaves at 30°C and 58% RH. It spent minimum 3 and maximum 65 seconds in horizontal position, minimum 4 and maximum 42 seconds in angled position, and minimum 2 and maximum 49 seconds in closed position. The time budget of *E. ariadne* for its basking was 24.46±16.99 seconds in horizontal position, 22.76±14.51 seconds in angled position, and 23.39±16.56 seconds in closed position. This species showed foraging behaviour after basking (Table 1). *E. ariadne* basking highest 10 times occurring within 11-20 seconds in horizontal position, lowest only one time within 61-70 seconds in horizontal position and 51-60 seconds in closed position (Fig. 4b).

Phalantha phalantha

During the observation period, *P. phalantha* was found basking on plant leaves at 29°C and 39.8% RH. It spent minimum 7 and maximum 31 seconds in horizontal position, minimum 3 and maximum 23 seconds in angled position, minimum 3 and maximum 49 seconds in closed position.

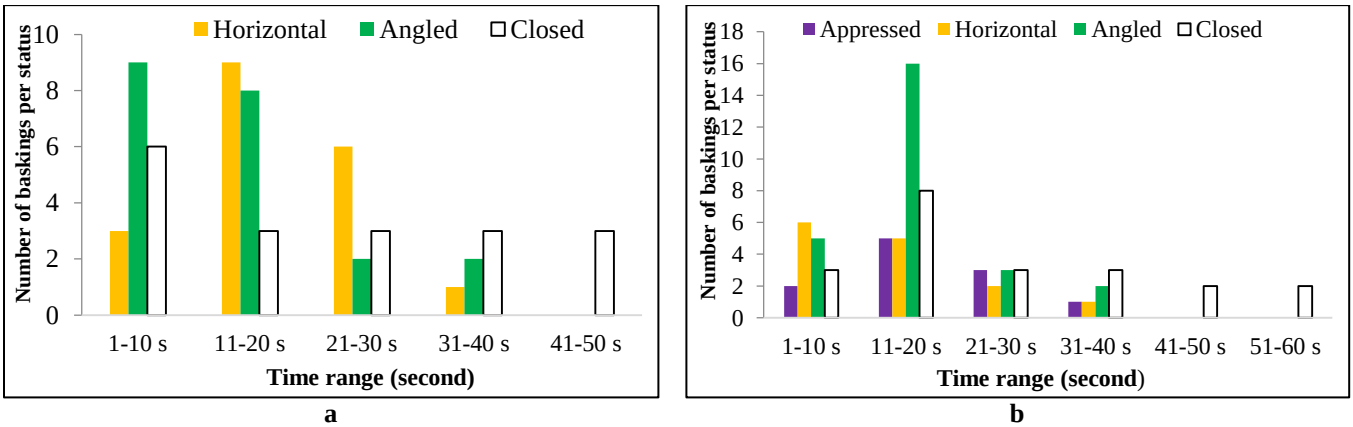

Fig. 5. Basking time budget (stay on basking) of **a**. *P. phalantha* and **b**. *H. bolina* during observation in the fields from June 2016 to July 2017.

The time budget of *P. phalantha* for its basking was 17.42±7.14 seconds in horizontal position; 11.21±6.43 seconds in angled position and 22.11±16.14 seconds in closed position. This species was

found foraging, mating and pollinating after basking (Table 1). The basking of *P. phalantha* was highest nine times occurring within 11-20 seconds in horizontal position and 1-10 seconds in angled position, lowest only one time within 31-40 seconds in horizontal position (Fig. 5).

Hypolimnas bolina

When thermoregulation in *H. bolina* is studied, it is seen that both male and female adults exhibit the 'appression' posture (Kemp and Krockenberger 2002). In the present study, during the observation period *H. bolina* was found basking on plant foliage and stem at 27.1°C and 32.7% RH in a cloudy day. This butterfly species spent minimum 7 and maximum 39 seconds in appressed position, minimum 5 and maximum 33 seconds in horizontal position, minimum 3 and maximum 40 seconds in angled position, and minimum 7 and maximum 57 seconds in close position. The time budget of *H. bolina* for basking was 19.00±9.68 seconds in appressed position, 13.86±8.51 seconds in horizontal position, 16.38±8.70 seconds in angled position, and 25.38±15.55 seconds in closed position.

This species was found in foraging and mating after basking was over (Table 1). Basking of *H. bolina* was highest 16 times occurring within 11-20 seconds in angled position, lowest only one time within 31-40 seconds in appressed position and 31-40 seconds in horizontal position (Fig. 5b).

Athyma perius

Athyma perius was found basking on plant leaves at 31.1°C and 67% RH. The species spent minimum 3 and maximum 20 seconds in appressed position, minimum 6 and maximum 31 seconds in horizontal position, minimum 2 and maximum 27 seconds in angled position, and minimum 7 and maximum 37 seconds in close position. The time budget of *A. perius* for basking was 10.75±5.83 seconds seconds in appressed position, 18.13±7.25 seconds in horizontal position, 14.65±7.67 seconds in angled position, and 14.65±7.67 seconds in closed position. This species was found in foraging after basking.

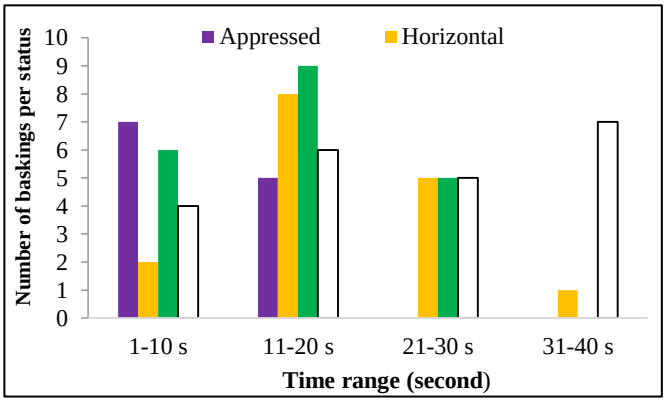

Fig. 6. Basking time budget of *A. perius* during observation in the fields from June 2016 to July 2017.

The basking of this species was nine times occurring within 11-20 seconds in angled position, lowest only one time within 31-40 seconds in horizontal position (Fig. 6).

Among the observed Nymphalid species, *J. almana* and *J. atlites* were seen to express all the four postures in higher frequency. Apressed and angled postures were the most frequent in *J. almana*; and horizontal and closed postures were mostly seen in *J. atlites. J. iphita, P. phalantha, L. Martha and E. ariadne* didn't exhibit any appressed posture, but showed moderate to higher frequency in horizontal, angled and closed postures (Fig. 7).

Among the observed nymphalid butterflies, all the species were found basking mostly in the ranges between 1-15 and 16-30 seconds. In appressed posture, only *J. almana* was basking in the range of 61-75 seconds. In horizontal posture, *L. martha* and *Ergolis ariadne* were basking in the range of 61-75 seconds. In angled posture, *J. almana* was basking in the range of 76-90 seconds. In closed posture, *J. almana* was basking in the range of 91-105 seconds. In this observation, *J. almana* was seen to take more time to bask than other species of nymphalid butterflies (Fig. 7).

The association of nymphalid butterflies with plants as their basking support was also recorded during study the period. Some nymphalid butterflies were associated with few plants, such as Rongon, Joba, Bristle grass, Jangli Ghagra, Bhat, Katamehadi, Harinalata, Kata mehedi, Motkila etc. The plants are usually herb, shrub and vine. Nymphalid butterflies mostly used top leaves of those plants, but

sometimes they used other parts of plants. It was found that nymphalid butterflies utilized the following plant families as their basking support: Rubiaceae, Malvaceae, Gramineae, Verbenaceae, Viticeae, and Rutaceaeetc (Table 2).

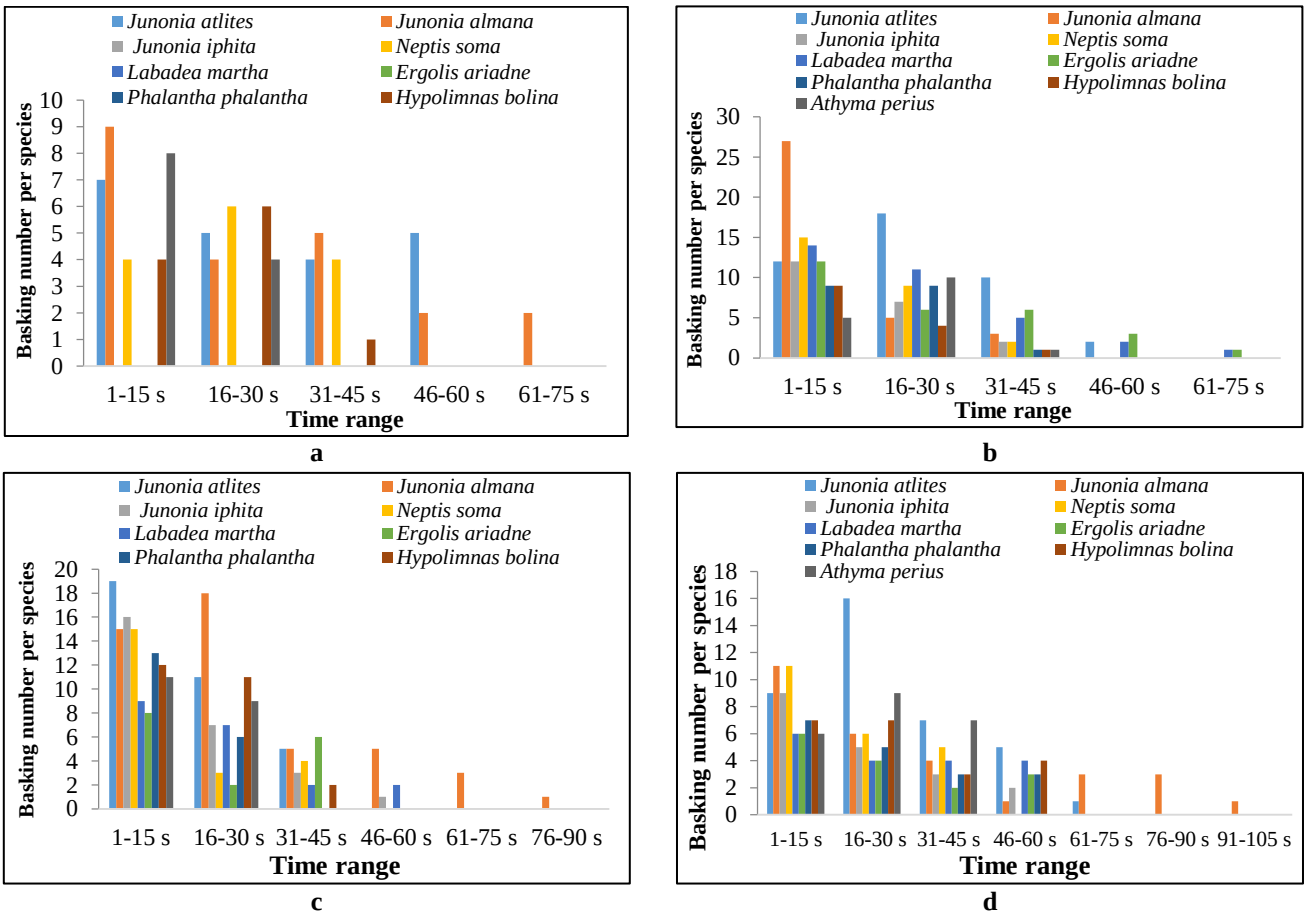

Fig. 7. Basking number and their range in various postures: **a**. appressed, **b**. horizontal, **c**. angled and **d**. closed found in studied nymphalid butterflies during the period from June 2016 to July 2017.

Total 75 individuals of nine species under the family Nymphalidae were found in basking behaviour. About 17 individuals of *J. atlites*, 25 individuals of *J. almana*, 9 individuals of *J. iphita*, 5 individuals of *N. soma*, 3 individuals of *L. martha*, 2 individuals of *E. ariadne*, 6 individuals of *P. phalantha*, 5 individuals of *H. bolina* and 3 individuals of *A. perius* were found basking on the leaves of herbs and shrubs during observation period. Most of the species were found basking during morning time (Fig. 8).

Table 2. The nymphalid butterflies utilized following plants as their basking support.

Scientific name	Local name	Family	Type of plants
Ixora coccinea	Rongon	Rubiaceae	Shrub
Hibiscus rosa-sinensis	Joba	Malvaceae	Shrub
Urena lobata	Jangli Ghagra	Malvaceae	Shrub
Setariaverticillata	Bristle grass	Gramineae	Herb
Clerodendrum infortunatum	Bhat	Verbenaceae	Shrub
Duranta repens	Kata mehadi	Verbenaceae	Shrub
Duranta indica	Kata mehedi	Verbenaceae	Shrub
Glycosmis pentaphylla	Motkila	Rutaceae	Shrub
Vitis lanceolaria	Harina lata	Viticeae	Vine

Basking behaviour regulates the body temperature of butterflies. Different wing postures in response to different abiotic conditions found significant in this behaviour. Temperature is a major constraint on activities in almost all butterflies. Large butterflies, when they produce appreciable quantities of endothermic heat in flight, may dissipate the excess heat physiologically (Heinrich 1974), or they must stop flying periodically to cool off. Small butterflies, on the other hand, precluded from endothermic warm-up because of their unfavourable surface/volume ratio, and at low ambient temperatures they may stop flying and periodically warm up by basking (Casey 1981). The nymphalids took much time to bask because of their larger body size. When the temperature was very low they took appressed posture. With the increases of temperature they took horizontal, angled and closed posture accordingly.

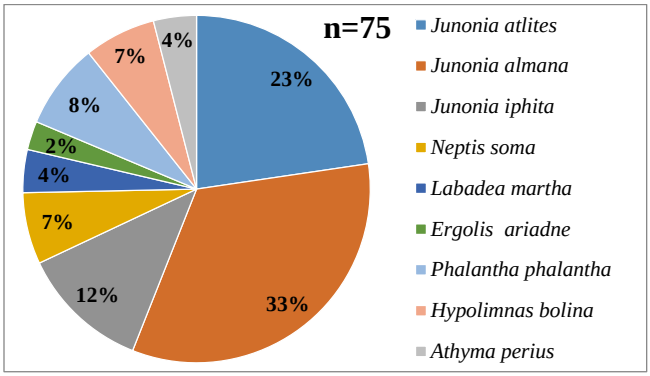

Fig. 8. Nymphalid butterflies during observation period.

The butterfly diversity of different families varied from station to station and species to species. The butterflies were found to use all types of plant, such as vines, herbs, shrubs and other substratum of plant for basking. Butterfly-plant interaction is a subject of the highest degree of specialization. It is essential for the diversification of living beings in nature. Basking behaviour with different wing posture could be used to assess the status of butterflies as the indicators of climatic change and its impact on biodiversity.

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