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Butterflies and locality predict the occurrence of larger day-flying moths in Dehing Patkai landscape, Assam

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Abstract
This paper deals with a survey of day-flying moths from Dehing Patkai landscape, Assam covering a period from 2014 to 2017. 10 species belonging to 10 genera from 6 families were encountered in the study. The moths were sighted more in the morning hours, in the month of October, in the forested land and roadsides. Multiple logistic regression analysis revealed that presence of day-flying moths were positively related to the abundance of butterflies, for 5 out of 7 moth species analysed. Test for moth abundance showed significant difference between the categories of locality (X^2, p=78.034, 0.000); sighting hour (X^2, p=8.67, 0.03); distance to forest (U, p= 844.5, 0.00); distance to industries (U, p= 1249, 0.007) and distance to human settlements (U, p=1031.5, 0.02). Day-flying moths and butterflies overlap in time, locality, resource requirements and susceptible to similar threats. Both the groups may play surrogate role in conservation alternately for each other.

Keywords: day-flying, moths, Assam, butterflies, Dehing Patkai

1. Introduction
The insect order Lepidoptera contains the butterflies and moths. Presently highlight in this group is prominent due to their surrogate roles in conservation [1, 2]. The day-flying group of moths is mostly active carrying out their activities during the daylight hours, co-occurring with the other diurnal insects, especially with the sympatric butterfly species in terms of active hours, resource requirements and exposure to similar threats [3].
Human activities increasingly bring forth change to pristine environments by transforming the quantity, quality, and arrangement of the natural resources. These forms of disturbance can have enormous influence on biodiversity and a common backdrop throughout the world [4, 5]. The relationship between butterfly communities and disturbance regimes has been widely studied, relatively few reports on the factors that regulate the occurrence of nocturnal and day-flying moths in disturbed habitats [6, 7].
The occurrence of a species in a locality is potentially influenced by attributes of the location, time and season of occurrence [8, 9]. Numerous studies on insect fauna reveal site attributes such as habitat heterogeneity, isolation from natural vegetation, proximity to disturbed area may have an influence on species composition [10, 11, 12, 13, 14]. Further, insects can exhibit perception on resource availability and display specific response in variation to the seasons they occur, disturbance regimes of any locality may not always be the determiner of species occurrence, focus on seasonal variation is yet another factor to be regarded as an additional aspect in studies related to distribution and community ecology [15, 16]. Moreover considering the influence of sympatric species might as well be an interesting attribute towards determining species composition of a target community.
This study aims at testing the relationship between presence-absence of day-flying moth species with few factors assumed to be responsible. Two questions were addressed:
(1) What species comprise the day-flying moth group of the landscape? (2) Do sympatric species (butterflies), locality attributes, time and seasonality predict the occurrence of day-flying moth?

2. Materials and methods
2.1 Study area
The present study was undertaken in the localities of Tinsukia district and Dibrugarh district constituting the Dehing Patkai landscape, extending from 27°14 to 27°30 North and 95°23 to 96°08 East. Being one of the few intact natural landscapes of Assam, it is also renowned for its petroleum and coal resources. Moths were observed in the natural forests within the forested lands of Digboi Forest Division covering locations from Digboi reserve East Block, DR West Block, Upper Dehing RF, Lekhapani RF, Kotha RF and Tirap RF and in the Dehing Patkai Wildlife Sanctuary, sharing a portion with Joyepore RF of Dibrugarh Division. Residential areas from Digboi, Margherita, Ledo, Jagun, and Joyepore were composed of sites associated with the direct expansion of human settlements, portraying modest concern on biodiversity, in these locations few remnant semi-natural areas such as the plantations, gardens, and lawns showed a presumable vegetation presence. Moths were looked around the roadsides of the roads connecting Digboi-Jagun via. Margherita; Digboi-Joyepore via. Bhadoipanchali and Ushapur, these roads that pass across and adjacent to forests were retained by characteristics of a pristine environment, however, these locations are perpetually disturbed due to busy human connectivity. Few water features were surveyed consisting of river/stream banks, mineral licks inside forests.

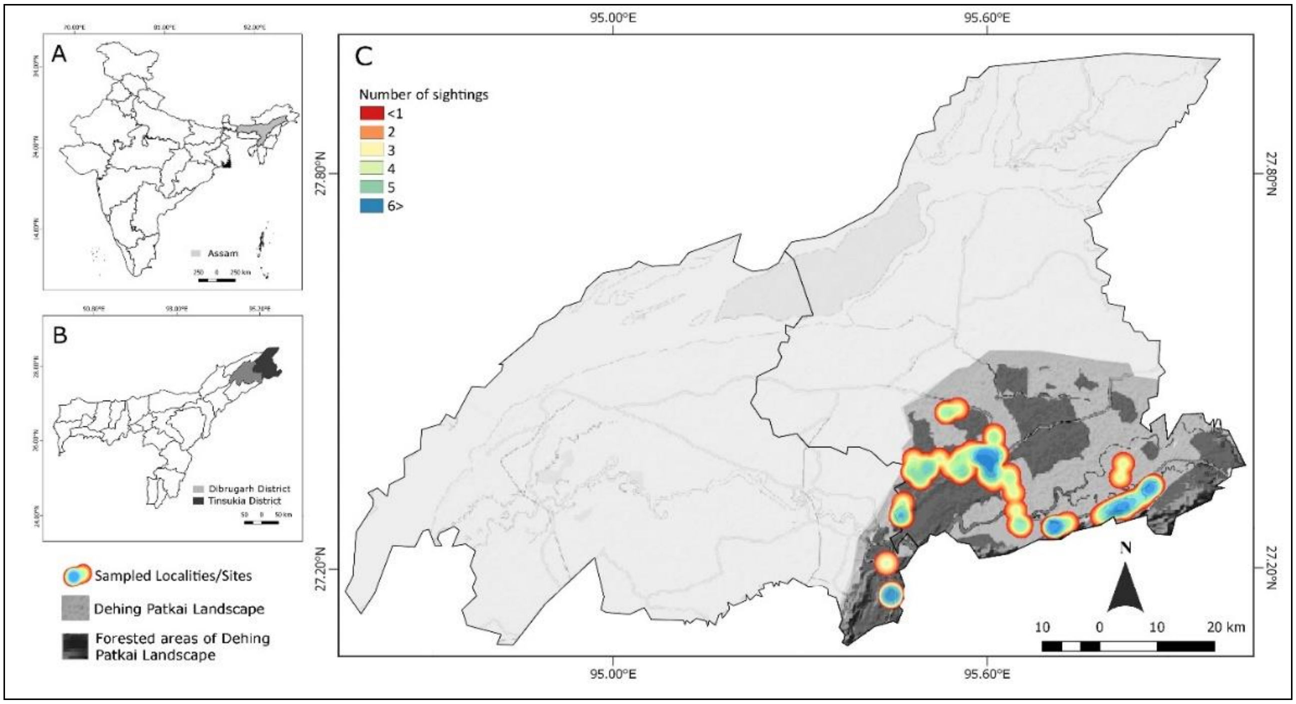

Fig 1: Map of (A)India (B)Assam; (C) Tinsukia & Dibrugarh district, a heatmap on the number of day-flying moth sightings showing the sampled localities/sites.

2.2 Data collection

Data on presence-absence and abundance of the day-flying moths were taken from 147 locations, surveying occasionally from August 2014 to December 2017.

Photographs of the study species were taken by digital still camera and identified by referring available literature, Hampson [17, 18, 19] and Kendrick [20].

Record on species presence (1) was made at a location when moths were sighted, and absence (0) for no sighting. For each observation, coordinates were noted with time, type of locality, season and the locality attributes. The locality variables were (1) locality type (*residential areas, water feature such as pond or river bank, agricultural land, roadsides and forested land*), (2) Distance to human settlements, (3) Distance to industries, (4) Distance to forest (in kilometers), (5) Abundance of sympatric species (butterflies were counted on each surveyed site). The temporal variables were: (5) Sighting hour (*morning: 6am-9am; forenoon: 9am-12am; afternoon: 12pm-3pm and evening 3-6pm*) and (6) Month of observation.

Table 1: Variables and categories

Variable	Details/Categories	Variable Type
Locality type	Residential areas, water feature, agricultural land, roadsides and forested land	Categorical
Distance to forest, Distance to human settlements, Distance to industries	Aerial distance from the sampled location to the nearest industrial area; to the human settlements and; forested areas measured in GIS (in kilometers)	Continuous
Butterfly abundance (sympatric species)	Count on butterflies on each locality (irrespective to species)	Continuous
Sighting hour and; month of occurrence	Hours of observation: morning, forenoon, afternoon and evening; Months	Categorical

2.3 Statistical analysis

Data were analysed using the program R 3.3.0 [21]. To test the differences in accumulation of moths (abundance per locality) in relation to independent variables (table 2), mean abundance of moth were tested against the categorical variables (with two categories) using Mann-Whitney-U test; and variables with more than two using Kruskal Wallis-X^2 test.

To predict the relationship between the sympatric species, locality and temporal attributes (predictor variables) with the day-flying moths, presence-absence of each species (as response variable) were regressed with the independent variables using multiple logistic regression, the logistic regression was performed through fitting a binomial GLM (generalized linear model) with "logit link" function, where GLM deals with observations that do not meet the normal distribution assumption and the logit link function ensure the predicted values exist in range between 0 and 1. Further, odds ratio(s) were calculated by exponentiating the coefficients, and confidence intervals were obtained, McFadden R^2 index was used to explain the % variation caused by the variables.

3. Results

3.1 Frequency of day-flying moths

A total of 298 sightings of 10 dayflying moth species belonging to 10 genera and 6 families were encountered in the study, 15 butterfly species coincided their occurrence (Table 2).

Of the species occurred in the study *Dysphania militaris* was sighted highest number of times (26.5% of T.S, total sightings), it was observed more than once per month and was present on all the localities along with *Episteme sp.* (18.1% of T.S) *and Cyclosia papilionaris* (12.8% of T.S). C*ephonodes hylas* was active throughout the sighting hours (21.1% of T.S). *Typhanophora semihyalina*, *Callidula sp.* and *Chatamla sp.* *w*ere sighted once in forested site and were not considered for further analyses (0.3 % of T.S respectively).

of the months sampled, highest sightings were from the October month and the least from June, Morning sightings were higher and afternoon hours were less. The forested lands and roadsides had a higher number of sightings compared to the others.

Table 2: A list of Day-flying moth species and sympatric butterfly species encountered in the study.

Sl.	Day-flying moth species	Family	Common name
1	*Dysphania militaris*	Geometridae	False tiger moth
2	*Cephonodes hylas*	Sphingidae	Pellucid hawk moth
3	*Chatamla sp. (close to C. flavescens)*	Epicopeiidae	Oriental swallowtail moth
4	*Tryphanophora semihyalina*	Zygaenidae	-
5	*Callidula sp. (close to C. erycinoides)*	Callidulidae	Callidulid butterfly moth
6	*Episteme sp.*	Noctuidae	-
7	*Cyclosia papilionaris*	Zygaenidae	Drury's jewel moth
8	*Milionia basalis*	Geometridae	-
9	*Gynautocera papilionaria*	Zygaenidae	-
10	*Tetragonus catamitus*	Callidulidae	Callidulid butterfly moth
	Butterfly species		
1	*Graphium sarpedon*	Papilionidae	Common Bluebottle
2	*Papilio polytes romulus*	Papilionidae	Common Mormon
3	*Eurema hecabe contubernalis*	Pieridae	Common Grass Yellow
4	*Delias thysbe pyramus*	Pieridae	Redbreast Jezbel
5	*Catopsilia pomona*	Pieridae	Common Emigrant
6	*Catopsilia pyranthe minna*	Pieridae	Mottled Emigrant
7	*Leptosia nina nina*	Pieridae	Psyche
8	*Pieris canidiaindica*	Pieridae	Indian Cabbage White
9	*Argynnis hyperbius*	Nymphalidae	Indian fritillary
10	*Parantica aglea*	Nymphalidae	Glassy Tiger
11	*Danaus chrysippus*	Nymphalidae	Plain Tiger
12	*Melanitis leda ismene*	Nymphalidae	Common Evening Brown
13	*Cyrestis thyodamas indica*	Nymphalidae	Common Map
14	*Acraea issoria*	Nymphalidae	Yellow Coaster
15	*Tanaecia lepidea*	Nymphalidae	Grey Count

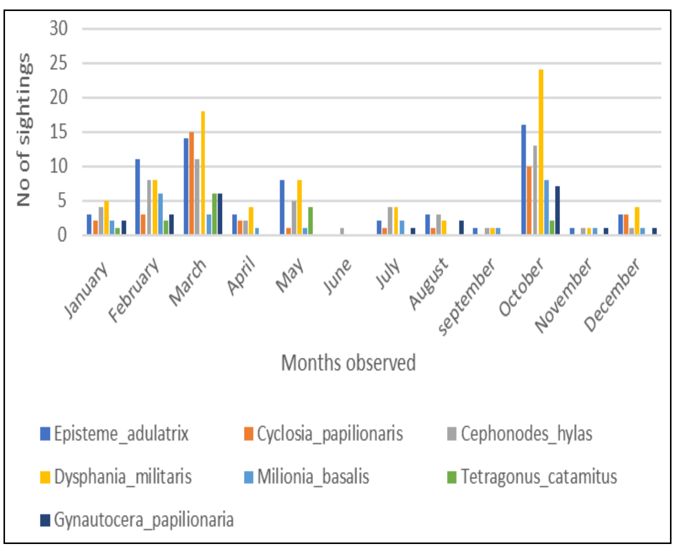

Fig 2: Month-wise sightings

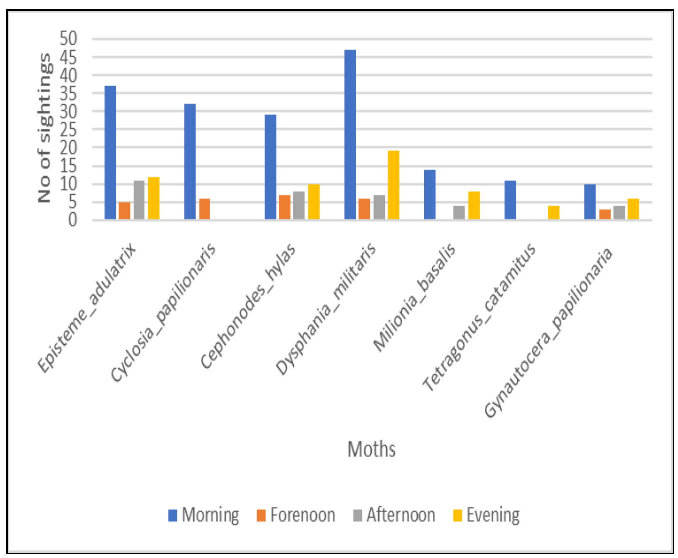

Fig 3: Hour-wise sightings

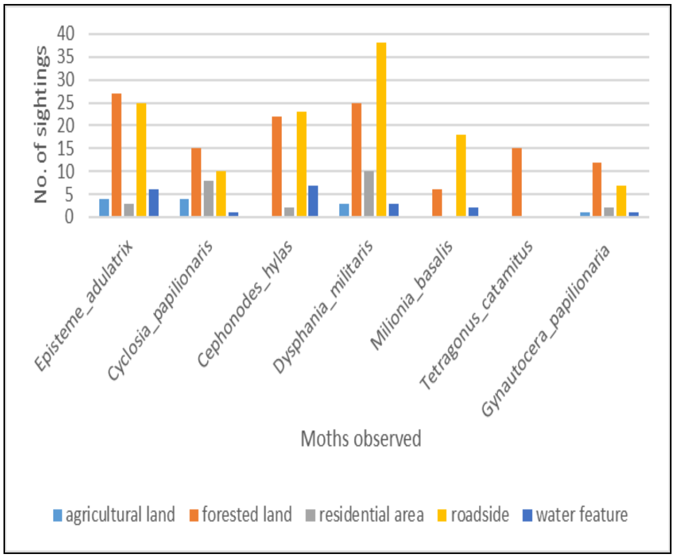

Fig 4: Locality-wise sightings

3.2 Mean abundance of moths in relation to independent variables

Test for moth abundance against the independent variables showed significant difference between the categories of locality (Kruskal-Wallis X^2, p=78.034, 0.000); sighting hour (X^2, p=8.67, 0.03), butterfly abundance (Mann-Whitney-U, p=176, 0.00); distance to forest (U, p= 844.5, 0.00); distance to industries (U, p= 1249,0.007); distance to human settlements (U, p=1031.5, 0.02). The abundance of moths between the observed month did not show significant difference (Table: 2).

Table 3: Mean abundance of moths in relation to independent variables (*U = Mann Whitney-U statistic, X^2 = Kruskal Wallis statistic.)

Variables	Categories	Moth Abundance mean ± SE (N)	U or X^2 (p)
Locality/Site type	Agricultural land	0.85 ± 0.23 (14)	78.034 (0.000)
	Forested land	4.5 ± 0.20 (27)	
	Residential area	0.6 ± 0.17 (40)	
	Roadside	2.2 ± 0.19 (53)	
	Water feature	1.4 ± 0.38 (14)	
Month	January	2.1 ± 0.7 (9)	26.264 (0.08)
	February	1.7 ± 0.3 (23)	
	March	2.3 ± 0.4 (31)	
	April	0.7 ± 0.2 (17)	
	May	2.7 ± 0.4 (10)	
	June	1 ±. (1)	
	July	2.3 ± 0.8 (6)	
	August	11 ± 0.5 (1)	
	September	4 ±. (1)	
	October	2.7 ± 0.3 (29)	
	November	5 ±. (1)	
	December	1.444 ± 0.6 (9)	
Sighting hour	Morning	2.4 ± 0.2 (74)	8.67 (0.03)
	Forenoon	2.1 ± 0.4 (13)	
	Afternoon	1.6 ± 0.4 (21)	
	Evening	1.5 ± 0.3 (40)	
Butterfly abundance	More (5<)	4.6 ± .21 (13)	176 (0.00)
	Less (<5)	1.7 ± .14 (135)	
Distance to forest	Far (2<)	0.7 ± 0.1 (51)	844.5 (0.00)
	Near (<2)	2.7 ± 0.2 (97)	
Distance to industries	Far (2<)	2.2 ± 0.2 (117)	1249 (0.007)
	Near (<2)	1.4 ± 0.3 (31)	
Distance to human settlements	Far (2<)	3.2 ± 0.2 (62)	1031.5 (0.02)
	Near (<2)	1.2 ± 0.2 (86)	

3.3 Factors influencing the occurrence of day-flying moths
(a) Logistic regression
Logistic regression on presence-absence of each moth species against multiple independent variables were analyzed as separate models (Table 3); (model-1) *C. hylas*, showed the variables Butterfly abundance (Pr(>|z|)=0.008) and distance to forest (Pr(>|z|)=0.006) as significant predictors, exponentiating the coefficients and confidence intervals, the odds ratio obtained for this model shows that with increase in number of butterfly abundance, the presence of moths will increase by a factor of 4.5, ranging a confidence interval of 1.7 to 17, while for distance to the forest odds ratio shows 1.5E-03, a negative effect. The two variables explained 79% (McFadden's R^2) variance in the presence-absence of the species; (model-2) *C. papilionaris* was shown to have positively influenced by butterfly abundance and distance to human settlements, these two variables showed 0.62 % (McFadden's R^2) variance, here the odds ratio for both the variables were positive; (model-4) *Episteme sp.* was found to be influenced by 4 variables that explained 86% i.e. highest variation among all the models; (model-3) Distance to human settlements significantly influenced the presence-absence of *M. basalis*, explaining 49 % (McFadden's R^2) variance, lowest among the models.

C. hylas, C. papilionaris, *D. militaris*, *Episteme sp. and G. papilionaria* were positively associated with abundance of butterflies, while for *T. catamitus* it was negative; presence of *C. hylas* and *Episteme sp.* were more near the forests; occurrence of *C. papilionaris and G. papilionaria* increased as the sighting locations moved farther from human settlement area, while for *Milionia basalis* sightings decreased*; D. militaris* showed higher sightings as distance to industries increased; *D. militaris* occurred more in forested land and roadsides, it decreased in the February month, and; sightings of *Episteme sp.*. decreased along the roadsides.

Table 3: Logit model: Estimates for the variables and odds ratios predicting the presence-absence of day-flying moths.

Species/model	Included variables	B (SE)	Pr(>|z|)	Odds Ratio	CI Low	CI Upper
Cephonodes hylas	Intercept	-11.5(17908.74)	0.999	9.7E-06	1.5E-214	6.40E+20
	Butterfly abundance	1.4 (0.56)	0.008	4.5	1.9	17.2
	Distance to forest	- 6.4 (2.36)	0.006	1.5E-03	0.0	0.1
AIC= 87.87; R^2(McFadden)=0.79						
Cyclosia papilionaris	Intercept	-25.4(29232.43)	0.999	8.8E-12	-	-
	Butterfly abundance	0.8(0.26)	0.002	2.3	1.4	4.1
	Distance to human settlements	0.3(0.19)	0.043	1.5	1.0	2.2
AIC=111.48; R^2(McFadden)= 0.62						
Dysphania militaris	Intercept	-21.0(3956.1)	0.996	0.0	-	-
	Butterfly abundance	0.7(0.20)	0.000	2.2	1.5	3.4
	Distance to industries	0.35(0.11)	0.003	1.4	1.1	1.8
	Site type-forested land	4.2(1.96)	0.017	68.2	4.3	5.27E+03
	Site type-roadside	4.4 (1.86)	0.017	84.7	3.4	5797.9
	Month-February	-4.5(1.69)	0.007	1.1E-02	2.3E-04	0.2
AIC=124.43; R^2(McFadden)= 0.62						
Episteme sp.	Intercept	25.1(29232.44)	0.999	8.06E+10	0.00	-
	Butterfly abundance	4.3 (1.42)	0.002	79.2	8.5	2.77E+03
	Distance to forest	-5.9(1.92)	0.002	0.0	0.0	0.0
	Site type _residential area	-13.6(5.53)	0.014	1.95E+07	0.0	0.0
	Site type-roadside	-8.7(3.73)	0.020	1.7E-04	1.1E-08	0.1
AIC=78.84; R^2(McFadden)= 0.86						
Gynautocera papilionaria	Intercept	-46.9(29682.82)	0.999	0.0	-	-
	Butterfly abundance	2.7(1.12)	0.013	16.0	0.5	0.5
	Distance to human settlements	1.9(1.01)	0.050	0.1	6.3E-03	0.6
AIC=66.73; R^2(McFadden)= 0.84						
Milionia basalis	Intercept	-4.231E01(3.01E04)	0.999	-	-	-
	Distance to human settlements	4.854E-01 (1.669E-01)	0.004	-	-	-
AIC=118.11; R^2 (McFadden)= 0.49						
Tetragonus catamitus	Intercept	-7.9(85221.61)	1.000	3.6E-04	-	-
	Butterfly abundance	-1.1(0.52)	0.050	0.4	0.1	0.8
AIC=63.60; R^2(McFadden)=0.83						

4. Discussion
Research aimed at the ecology of this day-flying moths is scanty. Williams worked on day-flying moths and butterflies in an urban landscape of Western Australia, he compared the moth and butterflies with the extent of the area of sites, connectivity with disturbance, vegetation and habitat resources, where he ascertained that the species are determined by the extent of site area and vegetation condition [4]. Franzén & Ranius studied the occupancy of day-flying Zygaenids of southeastern Sweden in relation to habitat characteristics, grazing pressure, species composition of butterflies and plants, they found the day-flying species positively correlated with butterfly abundance and highly associated with the larger size of pastures (grasslands) and those that are lesser grazed [27]. Cowley, examined the spatial distribution of day-flying moths and butterflies in a

fragmented landscape of north-west Wales, he designed habitat based statistical models using logistic approaches to predict the relationship between species distribution and density across spatial scales considering independent attributes such as larval-host plant distribution for moths and butterflies, habitat types, habitat extent, percentage of landscape, concluding significant relationships between probability of occurrence of species at modeled scales and species occupancy across sampled scales [28]. Binzenhofer *et al*. used habitat connectivity models in relation to moth occurrence and habitat parameters, including the influence of landscape context to predict potential habitat for burnet moth *Zygaena carniolica* and the nymphalid butterfly *Coenonympha arcania* in Northern Bavaria, German based on logistic regression, where they found the presence of the burnet moths depended mainly on the presence of nectar plants [29].

Previous studies on lepidopteran community of this landscape report butterflies, nocturnal moths and few diurnal moths belonging to different families as checklists [22, 23]. This study was a very basic approach towards understanding diurnal moths in relation to their locality regimes, disturbance levels and co-occurrence with sympatric species. Although this study used logistic models to predict the relationship between species occurrence and independent variables, occupancy and distribution across spatial scales were not considered, thus were not comparable with other studies. Among the moths encountered in this study; *Cyclosia papilionaris, Gynautocera papilionaria, Tryphanophora semihyalina* belongs to the widely studied family, Zygaenidae, these moths exhibit a large number of specializations; time of activity, weak flight, limited mobility and avoidance by predators due to aposematic colouration of wings and cyanogenic in nature, making them successful diurnal competitors. *Tetragonus catamitus* and *Callidula sp.* from Callidulidae, a family with moths strikingly similar to butterflies showing upright resting position [3]. The moths from the family Geometridae are nocturnal, but few species are primarily diurnal, *Dysphania militaris* one of the commonly sighted geometrid moths mostly confused for a butterfly [22]. Some hawk-moths (family: Sphingidae) are diurnal likely to be sighted around flowers during morning and evening hours, *Cephonodes hylas* is one such that is active throughout the day-light.

The localities differed in the occurrence of species; the forested lands defined by the department boundaries, also includes degraded forest patches with human disturbance, invasive shrublands developed in some locations due to past felling of trees. However, due to greater habitat heterogeneity of the surroundings and greater distance from the human and industrial effluence, these areas harbored much of the species. Seeking for day-flying species in forested lands offered sightings of the most cryptic species as moths from Callidulidae, that is unusual to be sighted outside forests. The roadsides being the prime connectivity between different localities become an important place for sighting day-flying moths, as in course of adult moths dispersing for resource acquisition. However, variation in species occurrence is universal between the roadsides close to forests and those that connect semi-natural and urban residential sites. During early morning hours, *Dysphania* was common to encounter in the roadsides, likely to be predated by foraging birds and often stamped (road-killed) by wheels in large numbers. Around the water features such as the stream bank inside the forested lands, bank of ponds and mineral licks, moths such as *Milionia* and *Dysphania* could be sighted mud-puddling in the morning and forenoon hours. In residential areas, the habitat/sites are very different from natural forests; some species that occur in this locality are benefitted by non-native species and few native host plants growing in smaller patches. It can be assumed that the early stages of these moths are nourished in these patches, but due to massive intraspecies competition and dispersal in later stages, these moths are able to find necessary resources in the residential area and adapted to feed on introduced plant species as preference host, also greater distance make these day-flying species unmanageable to reach the natural forests and to procure principal hosts.

Butterfly abundance is found to be positively correlated with the occurrence of most of the day-flying moths. Belonging to the same order Lepidoptera, these two groups have similar life history attributes except for the nocturnal moths that have a difference in time of activity, the day-flying group overlaps with the butterflies in time, locality, resource requirements, and are susceptible to similar disturbance possessed by environmental and human activity.

At the present scenario, residential areas with residual natural land adjoining forest-edges may encompass a variety of disturbance that is vulnerable to further alteration over time. Resulting loss of herbivore insect species that directly depend on them. Conservation of these taxa marks the necessity to determine factors that influence their presence in those habitats and ascertain resources that nourish species in various aspects of their life history.

5. Conclusion

This study was a prefatory approach towards understanding diurnal moths, where the occurrence of moths were observed to be influenced by a number of factors. Of the seven moth taxa considered for analyses, occurrence of *C. hylas, C. papilionaris*, *D. militaris*, *Episteme sp. and G. papilionaria* shown to have positive correlation with butterfly abundance, that demonstrates the relation between their co-occurences, which might be because of spatio-temporal and resource overlap. More systematic research needs to be followed up related to occupancy and resource overlap based on habitat complexity, which is expected to predict competetion between these sympatric species. Also, in perspective of conservation both the groups can be studied in a way that they can be used as surrogate taxa alternately for each other, such that conserving butterflies can help day-flying moths from declining or vice. Versa. Most importantly both the groups can be quantitatively studied as indicators of habitat/site and vegetation quality.

Greater vegetation complexity in the forested land and the other localities proximal to natural land provides ample resource for the target species leading the number of sightings to be higher. Conservation of these pristine natural habitats, particularly assessment on the level of disturbance will provide better management implication to protect the habitats and species from further disturbance. In residential area the moths are benefitted by non-native plant species and few native hosts growing in smaller patches, restoration of remnant vegetation in these areas may assist in redeeming the lepidopteran species from local extinction.

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7. References

1. Brown Jr KS, Freitas AV. Atlantic forest butterflies: indicators for landscape conservation. Biotropica. 2000; 32(4):934-56.
2. Kitching RL, Orr AG, Thalib L, Mitchell H, Hopkins MS, Graham AW, *et al*. Moth assemblages as indicators of environmental quality in remnants of upland Australian rain forest. Journal of Applied Ecology. 2000; 37(2):284-97.
3. Capinera John L., ed. Encyclopedia of Entomology. Springer Science & Business Media, 2008; 1: 4411
4. Williams MR. Habitat resources, remnant vegetation condition and area determine distribution patterns and abundance of butterflies and day-flying moths in a fragmented urban landscape, south-west Western Australia. Journal of Insect Conservation. 2011; 15(1-2):37-54.
5. Warren MS, Hill JK, Thomas JA, Asher J, Fox R, Huntley B, *et al*. Rapid responses of British butterflies to opposing forces of climate and habitat change. Nature. 2001; 414(6859):65.
6. Williams MR. Assessing diversity of diurnal Lepidoptera in habitat fragments: testing the efficiency of strip transects. Environmental Entomology. 2008; 37(5):1313-22.
7. Didham RK, Tylianakis JM, Gemmell NJ, Rand TA, Ewers RM. Interactive effects of habitat modification and species invasion on native species decline. Trends in ecology & evolution. 2007; 22(9):489-96.
8. Gardner TA, Barlow J, Chazdon R, Ewers RM, Harvey CA, Peres CA, *et al*. Prospects for tropical forest biodiversity in a human-modified world. Ecology Letters. 2009; 12(6):561-82.
9. Hanski I, Thomas CD. Metapopulation dynamics and conservation: a spatially explicit model applied to butterflies. Biological Conservation. 1994; 68(2):167-80.
10. Samways MJ. Implementing ecological networks for conserving insect and other biodiversity. Insect conservation biology. 2007; 127-43.
11. Dennis RL, Hardy PB. Targeting squares for survey: predicting species richness and incidence of species for a butterfly atlas. Global Ecology and Biogeography. 1999; 8(6):443-454.
12. Ramírez-Restrepo L, MacGregor-Fors I. Butterflies in the city: a review of urban diurnal Lepidoptera. Urban Ecosystems. 2017; 20(1):171-82.
13. Baz A, Garcia-Boyero A. The effects of forest fragmentation on butterfly communities in central Spain. Journal of Biogeography. 1995; 129-40.
14. Giuliano WM, Accamando AK, McAdams EJ. Lepidoptera-habitat relationships in urban parks. Urban Ecosystems. 2004; 7(4):361-70.
15. Summerville KS, Crist TO. Contrasting effects of habitat quantity and quality on moth communities in fragmented landscapes. Ecography. 2004; 27(1):3-12.
16. Summerville KS, Crist TO. Determinants of lepidopteran community composition and species diversity in eastern deciduous forests: roles of season, eco-region and patch size. Oikos. 2003; 100(1):134-48.
17. Hampson GF. Fauna of British India: Moths 1. Dr. W Junk BV. Publishers, The Hague. 1892; 1:527.
18. Hampson GF. Fauna of British India: Moths 2, Dr. W Junk BV. Publishers, The Hague. 1894; 2:528.
19. Hampson GF. Fauna of British India: Moths 3, Dr. W. Junk BV. Publishers, The Hague. 1895; 3:517.
20. Kendrick RC. Moths (Insecta: Lepidoptera) of Hong Kong. Ph.D. Thesis. Hong Kong: University of Hong Kong. 2002; 1:622pp
21. Core R, Team R. A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria, 2003. URL http://www.R-project.org/.
22. Gogoi M. A Preliminary Checklist of Butterflies Recorded from Jeypore-Dehing Forest, Eastern Assam, India. Journal of Threatened Taxa. 2013; 5(2):3684-96.
23. Arandhara S, Barman S, Tanti R, Boruah A. Macro moths of Tinsukia district, Assam: A provisional inventory. Journal of Entomology and Zoology Studies. 2017; 5(6):1612-1621.
24. Bourn, Nigel AD. The ecology, conservation and population genetics of three species of Zygaenid moths, Zygaena lonicerae, Zygaena purpuralis and Zygaena filipendulae in north-west Scotland. Ph.D. diss., University of Aberdeen, 1995; 267 pp.
25. Naumann CM, Tarmann GM, Tremewan WG. The Western Palaearctic Zygaenidae (Lepidoptera). Apollo books; 1999; 304 pp.
26. Yousheng W, Zesheng G. Preliminary reports on the bionomics of Dysphania militaris Linnaeus. Forest Pest and Disease. 2004; 23(5):25-6.
27. Franzén M, Ranius T. Habitat associations and occupancy patterns of burnet moths (Zygaenidae) in semi-natural pastures in Sweden. Entomologica Fennica. 2004; 15(2):91-101.
28. Cowley MJ, Wilson RJ, León-Cortés JL, Gutierrez D, Bulman CR, Thomas CD, *et al*. Habitat-based statistical models for predicting the spatial distribution of butterflies and day-flying moths in a fragmented landscape. Journal of Applied Ecology. 2000; 37(s1):60-72.
29. Binzenhöfer B, Schröder B, Strauss B, Biedermann R, Settele J. Habitat models and habitat connectivity analysis for butterflies and burnet moths–the example of Zygaena

arniolica and Coenonympha arcania. Biological Conservation. 2005; 126(2):247-59.
30. Arandhara S. Hawkmoths of Dehing Patkai Region, Assam. Jorhat, Assam: Sabda Prakashan. 2017; 1:82.
31. Arandhara, Subhasish, Rajib Rudra Tariang. Drivers Regulating Species Composition of the Larger Nocturnal Moths in Tinsukia District, Assam. Journal of Entomology and Zoology Studies. 2018; 6(2):748-55.
32. Sanyal AK, Dey P, Uniyal VP, Chandra K, Raha A. Geometridae Stephens, 1829 from Different Altitudes in Western Himalayan Protected Areas of Uttarakhand, India (Lepidoptera: Geometridae). SHILAP Revista de Lepidopterología, 2017; 45(177):195.
33. Tremewan W Gerald. Zygaenidae. The moths and butterflies of Great Britain and Ireland, 1985; 74-123.
34. Arandhara S. A Preliminary Checklist on Hawkmoths of Digboi, Assam (Lepidoptera: Bombycoidea: Sphingidae). Global Journal for Research Analysis. 2016; 5(10):348-9.