SPATIAL AND TEMPORAL DYNAMICS OF PREDATION OF ROBBER FLIES (INSECTA: DIPTERA: ASILIDAE) ON INSECT FAUNA ACROSS THE DRY DECIDUOUS FOREST LANDSCAPE

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[**Naskar, A., Maity, A., Homechaudhuri, S. & Banerjee, D.** 2020. Spatial and temporal dynamics of predation of robber flies (Insecta: Diptera: Asilidae) on insect fauna across the dry deciduous forest landscape. Munis Entomology & Zoology, 15 (1): 180-188]

ABSTRACT: The stability of the landscape depends on the prey predator's relationship on that ecosystem. So, our present model of two most abundant asilid predator and their predation dynamics in response to varied diversity of different prey groups is the main aim of the present study. *P. femoralis* and *M. aurata* found to predate upon nine insect orders and Arenae (spiders). It revealed that slightly better prey capturing frequency of *P. femoralis* (0.68, $p<0.05$) in comparison to *M. aurata* (0.67, $p<0.05$). Sperman's rank correlation study further confirmed maximum prey capturing efficacy of *P. femoralis* in comparison to *M. aurata* as evident from maximum positive values of correlation (41) and positive slopes (6) at $p<0.05$. Present study also established pre-monsoon as most preferred season to influence maximum predation dynamics of these asilid predators in comparison to other season as their feeding activities increased by 2.3-4 folds in case of *P. femoralis* and 1.5-1.9 folds in case of *M. aurata* respectively. It may also seem to be due to most of the insect orders (Diptera-21; Hymenoptera-11; Hemiptera- 10; Coleoptera-9) available in greater abundance during pre-monsoon, thus affecting predatory activities of asilid fauna ultimately. Different vegetation pattern in two different forest patch (dense vegetation patch with large forest undergrowth vs. thin vegetation without forest undergrowth) influenced predatory dynamics of two asilid species from 25 to 44 in case of *P. femoralis* and from 18 to 31 in case of *M. aurata*. Present study also indicated that differences in diet among the habitats can be attributed to differences in the abundance of the dipterans, and other abundant prey groups rather than to the co-existence of two distinct robber fly populations in prey preference. From the best of the knowledge, it will probably require long term and more detailed field studies under conditions of spatially and temporally variable prey community composition and relative abundance at much broader range to better understand trophic interactions and predatory dynamics of theses model asilid fauna at finer level.

KEY WORDS: Prey preference, predation, capture efficiency, robber flies, dry deciduous forest

The study of trophic relationships is fundamental to understand the structure and function of floral and faunal communities in a particular landscape (Juen & Traugott, 2005). The stability of that landscape depends on the prey predator's relationship on that ecosystem.

Some generalized predators are able to exploit a wide variety of prey, they can respond to fluctuations in the relative abundances of alternative prey and occupy habitats with different prey communities. Populations of such predators may appear to be specialists if they switch to near exclusive use of the most abundant prey type (Hansson, 1989). Therefore to determine the overall impact on prey communities of predators in heterogeneous environments, it is essential to understand the integrate prey use over an entire landscape, where resource availability changing over time (O' Neill, 1992).

The robber flies (Diptera: Asilidae) is a large and diverse family of formidable aerial predatory dipterans. They are mostly generalist predators, although some species show more specialized feeding habits. Robber flies (Insecta: Diptera: Asilidae) are also opportunistic predators that also can be found in many similar habitats. Some robber flies can successfully capture dangerous prey such as stinging bees and wasps (Londt, 1993; Dennis & Lavigne, 2007).

Most of the work done by the eminent scientist is recording the prey utilized by the asilids (Oldroyd, 1980; Lehr et al., 2007 and Hayat et al., 2008). More than 2000 prey species of the asilids are also recorded from the Afro-tropical region (Londt, 2006). But there is a scatter representation of the interaction of asilids with their prey and how they change the trophic level by interacting. Moreover all the studies done in a particular prey group, but there is no overall studies done on the prey insect communities. Therefore the present study thus help to understand the impact of predation done by the asilids in the arid region.

To understand this relationship over time within a limited anthropogenic factor, we chose two species of asilids namely *Michotamia aurata* (Fabricius, 1794) and *Philodicus femoralis* (Ricardo, 1921) as they are the most abundant species in this dry deciduous landscape. Moreover they are generalized as well as specialized predators. Thus our study aimed to understand the overall trophic relationship, over short time intervals and small distances in a dry deciduous landscape with limited anthropogenic factor.

MATERIALS AND METHODS

(i) Study area

Study area in and around Sonamukhi protected forest area has been designed in such a way to divide it into 24 stations for present study on predation dynamics of Asilidae.

(ii) Collection & preservation techniques

The collection of asilids from several study sites is mainly done by insect sweep net after close observation and video recording their predatory activities. In several instances 6 modified large malaise traps were used to capture large amount of asilid fauna in short time. After capturing the fauna, they were sacrificed in killing jar filled with cotton sopping benzene. Then most abundant asilid fauna were sorted separately and transferred in dry envelope with locality label. After they were brought to the laboratory, temporary locality label were replaced followed by their proper identification using Leica EZ4 stereo microscope and Leica stereoiso microscope M205A fitted with Leica software 3.0 were used for their photographic documentation.

(iii) Statistical analysis

Several graphs, Speramnn's rank correlation were performed using multiple softwares like Past 3.0, Microsoft excel 2013 and Xlstat 2014. Maps were generated in Google earth Pro version 7.3.0.3830.

RESULTS

(i) Species abundance

Population size of two highly abundant species i.e. *Michotamia aurata* (Fabricius, 1794) and *Philodicus femoralis* (Ricardo, 1921) are 117 and 76 respectively as revealed from the present study in dry deciduous landscape of Sonamukhi forest. List of two asilid species is given below.

Family ASILIDAE
Subfamily ASILINAE
Tribe Ommatini

1. *Michotamia aurata* (Fabricius, 1794)
   1794, *Michotamia aurata* Fabricius, *Ent. Syst.* 4: 387 (sex-? *Asilus*)
   Type-locality: East India
   Distribution: India [W. Bengal, Uttar Pradesh]
   Elsewhere: Burma, Celebes, Formosa, W. Pakistan
2. *Philodicus femoralis* (Ricardo, 1921)
   1921, *Philodicus femoralis* Ricardo, *Ann. Mag. nat. Hist.*, (9)8: 190 (♂; ♀).
   Type-locality: Okkyl, Schwegu, Burma
   Distribution: India
   Elsewhere: Burma

(ii) List of prey species recorded from present study

Prey Records from present results exhibited that two species of Asilidae was recorded as most abundant and frequently predate upon preys (Table 1). Nine insect orders and Arenae also recorded as prey of the Asilidae. The order Diptera however are mostly targeted pray for Robber flies. Hymenoptera, Coleoptera and Hemiptera are the next targeted group of Insect Order (Fig. 1). More abundant species was *Philodicus femoralis* (Ricardo, 1921) followed by *Michotamia aurata* (Fabricius, 1794) under subfamily Asilinae (Fig. 2).

(iii) Prey capture efficiency

Prey capturing frequency of asilid predators were mainly measured from auto-correlation analyses of the collected data from field. It revealed that at lag 2, *P. femoralis* (0.29, $p<0.05$) clearly won the competition as far as the prey capture efficiency is concerned in comparison to *M. aurata* (0.22, $p<0.05$). Similarly at final lag (lag 4), *P. femoralis* established itself as more efficient predator (0.68, <0.05), in comparison to *M. aurata* (0.67, $p<0.05$) (Fig. 3).

(iv) Prey capturing efficacy

Prey capturing efficacy is another term to talk about the capturing accuracy of predators. Here prey capturing efficacy was measured in terms of Sperman's rank correlation between number of respective asilid species and number of prey individuals captured of different insect orders and araneae as the case may be. It revealed clearly that maximum positive values of correlation (41) and positive slopes (6) were formed in case of *P. femoralis*, in comparison to *M. aurata* (Fig. 4).

(v) Seasonal influence on prey capture efficiency

Seasonal effect on prey capture: is quite common and evident. Asilid fauna also followed a definite trend as far as interplay among different seasonal parameters like temperature, relative humidity, rainfall etc. and predation dynamics are concerned. Present study revealed that their prey capturing efficiency increased by 2.3 folds and 4 folds during pre-monsoon in comparison to monsoon and post monsoon respectively in case of *P. femoralis*. While in case of *M. aurata* the prey capturing efficiency during pre-monsoon increased by 1.5 folds and 1.9 folds in comparison to monsoon and post monsoon respectively (Fig. 5).

(vi) Seasonal variation in prey size

Seasonal variation in available prey size: is pretty known and well documented and evident from the previous literatures (Dennis et al., 2012). Present study also produced similar results and it depicted that number of individuals of most of the insect orders varied seasonally and thereby affect predatory activities frequency of their encounter seasonally. However most of the insect orders available in greater abundance during pre-monsoon, thus affecting predatory activities of asilid fauna eventually (Fig. 6).

(vii) Spatial variation in prey capture efficiency

Relative study sites and prey capture are always inter-related as evident from few old literatures (Hansson, 1989, O'Neill, 1992). Our present study also supported by the previous findings as the present study also revealed that vegetation pattern wise there was a certain variation in prey population affecting their ability to escape the predatory activity as evident from the figures given below (Fig. 7). It also therefore resulted that in less dense vegetation area around dense forest without and / or with low forest understory might cause difficulties of prey populations of different insect orders and preyed upon more frequently by the predatory asilids.

DISCUSSION

Two most abundant asilid can prey on arthropods from widely different taxa and size classes they can (i) respond rapidly to diet fluctuations in the abundance of specific prey within a patch and (ii) forage in different patches that vary in relative abundance of specific prey groups, similar with the findings of Oneill, 1992. Short-term temporal variation in diet was observed when surges in the abundance of dipterans, hymenopterans and coleopterans resulted in a rapid increase in the number of robber flies feeding and a decrease in the proportion of non-dipteran / non-hymenopteran / non-coleopteran prey in their diets. This change occurred on the same time scale as the changes in these prey activity. During non-swarm periods and non-swarm days (specially late monsoon and post monsoon), both the asilid used alternative prey taxa (Orthopterans and lepidopterans) and a wider range of prey sizes. A less pronounced increase in predation upon dipterans was observed on the day that swarms of dipterans of the family Stratiomyidae appeared at the site. Because the flies exploited both large (Tabanidae) and small (Sepsidae) dipterans, it is quite obvious that prey abundance, not only prey size, determined asilid predator's diet composition as already evident from similar results (Oneill, 1992).

In the second part of the study, differences in the abundance of dipterans, hymenopterans, coleopterans and other prey insect orders between native (core dense vegetation zone of forest with high amount of forest understory) and reseeded habitats (less dense planted habitat at the periphery of dense forest zone) were correlated with differences in the proportion of these insect orders in the diet of two asilid predators. On native rangeland, the more varied diet of the these two asilid fauna reflected their ability to exploit a wide range of prey when no single group was extremely abundant. Because of the relatively large home ranges of *P. femoralis* in comparison to shorter home range of *M. aurata* (Londt, 2006) and the small spatial scale over which the study was conducted, it seems likely that differences in diet among the habitats can be attributed to differences in the abundance of the dipterans, and other abundant prey groups rather than to the co-existence of two distinct robber fly populations in prey preference.

Rees & Onsager (1985) estimated the impact of a robber fly with a varied diet on a local community by experimentally controlling *E. bicaudata* densities in the field and in cages and found that heavy predation by the robber flies on the parasitoid flies (Sarcophagidae) reduced the impact of the latter upon grasshoppers. However, it would be grim to extrapolate these results to other times and sites in case of *P. femoralis* and *M. aurata*. Thus, without comprehensive knowledge of the response of the robber flies to spatial and temporal variation in the relative abundance of dipterans and other prey groups, the role of either of the asilid predator in different prey community dynamics cannot be predicted. Such knowledge will only come from more detailed field studies under conditions of spatially and temporally variable prey community composition and relative abundance at much broader range and needed perhaps long term monitoring too.

ACKNOWLEDGEMENTS

The survey for the study was conducted by Diptera Section, Zoological Survey of India (ZSI), Head Quarters, M Block, New Alipore, Kolkata -700 053. The authors acknowledge, Director, Dr. Kailash Chandra. The authors also acknowledge the help of Mr. P. Parui, former scientist, Diptera Section and all the present staff members of the section. The help of DFO and all the forest staffs, is also deeply acknowledged for providing accommodation and necessary facilities.

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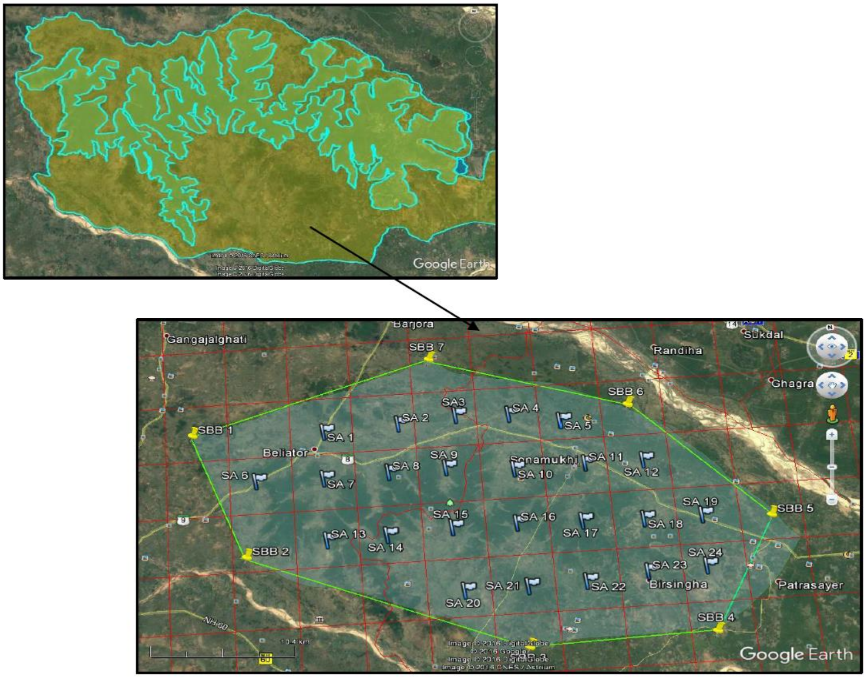

Map 1. Showing 5 Km X 5 Km grid satellite map of study area in and around Sonamukhi protected forest, pop out from satellite map showing actual core forest area of Sonamukhi.

Table 1. Showing combined predatory activities of two most abundant asilid species on 10 different insect orders.

Prey Order	Total No.	*Philodicus femoralis* (Ricardo, 1921)	*Michotamia aurata* (Fabricius, 1794)
Araneae	6	11	0
Coleoptera	15	19	10
Diptera	35	31	40
Hemiptera	14	2	10
Hymenoptera	16	12	4
Isoptera	4	6	0
Lepidoptera	11	18	8
Odonata	3	0	0
Orthoptera	12	18	4
Thysanoptera	2	0	0
Total	118	117	76

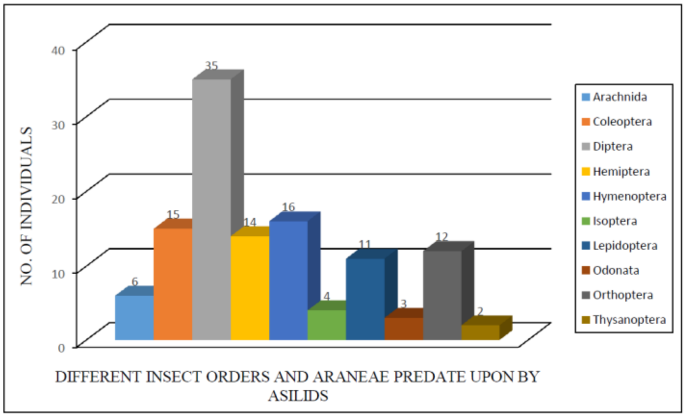

Figure 1. Showing range of predatory activities of two asilid species predated on different insect orders and order Araneae.

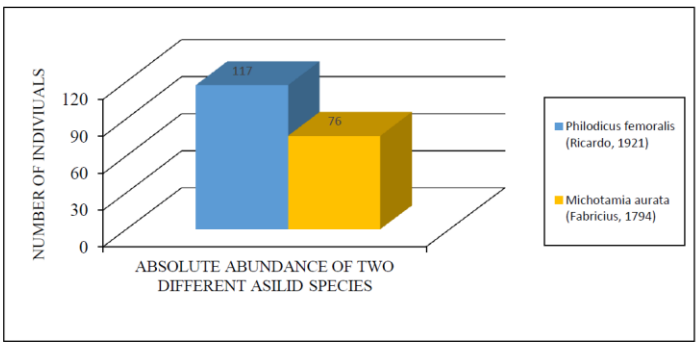

Figure 2. Showing absolute abundance of two asilid species predated on different insect orders.

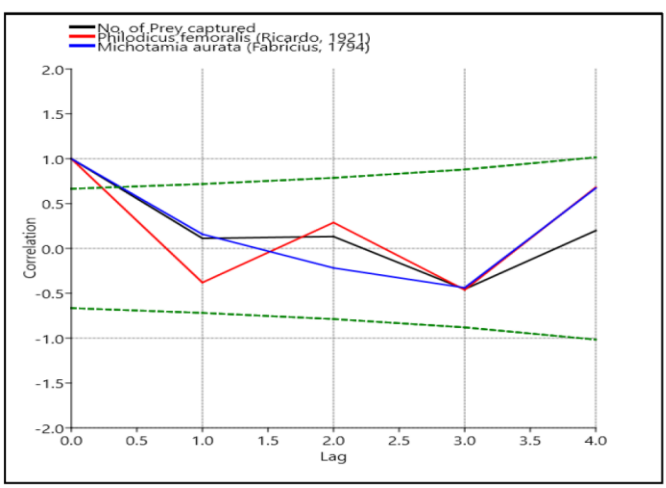

Figure 3. Auto correlation study exhibited graph showing predation dynamics of two asilid species in terms of prey capture efficiency.

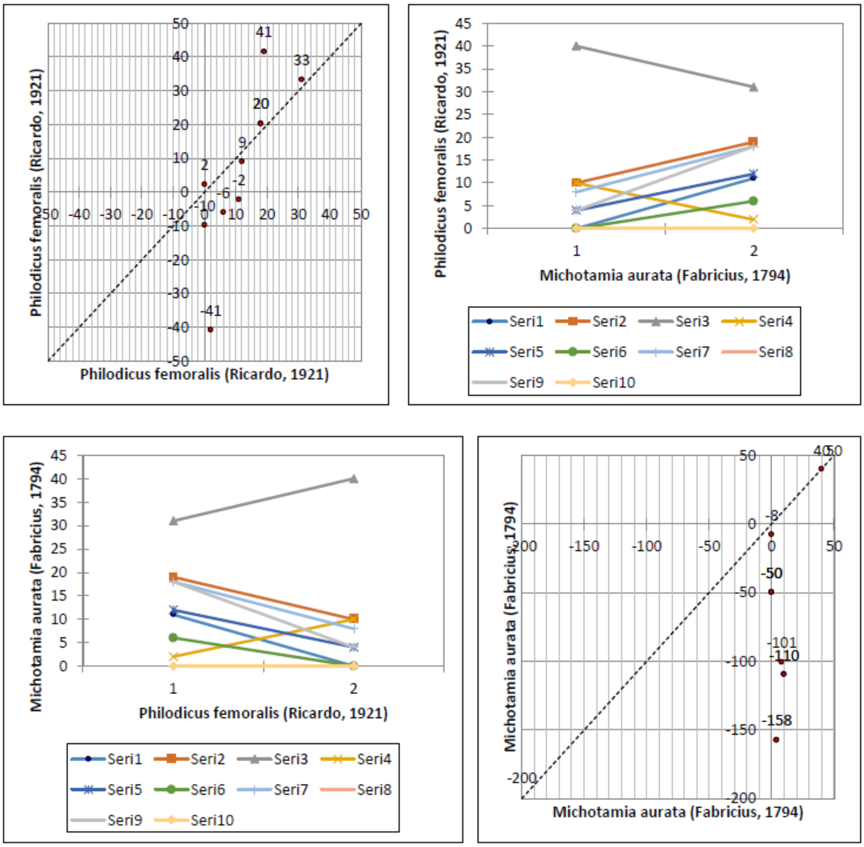

Figure 4. Line diagram and Q-Q plot showing the results of Sperman's rank correlation between *P. femoralis* and the prey captured and *M. aurata* and the prey captured respectively.

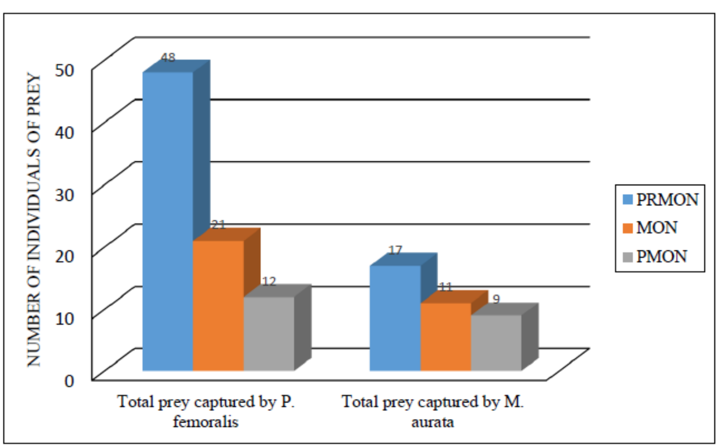

Figure 5. Clustered column showing the effect of season on prey capturing ability of two asilid predators.

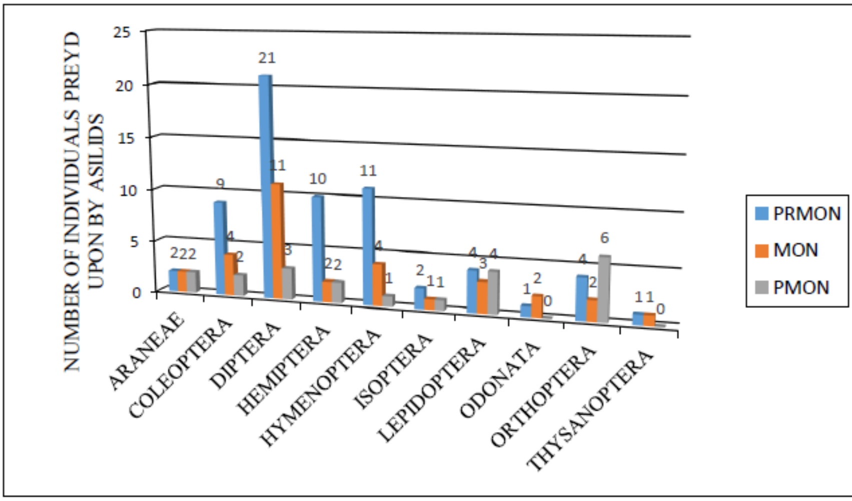

Figure 6. Clustered column diagram showing individual insect order wise seasonal variation in their availability and predated upon by asilid flies.

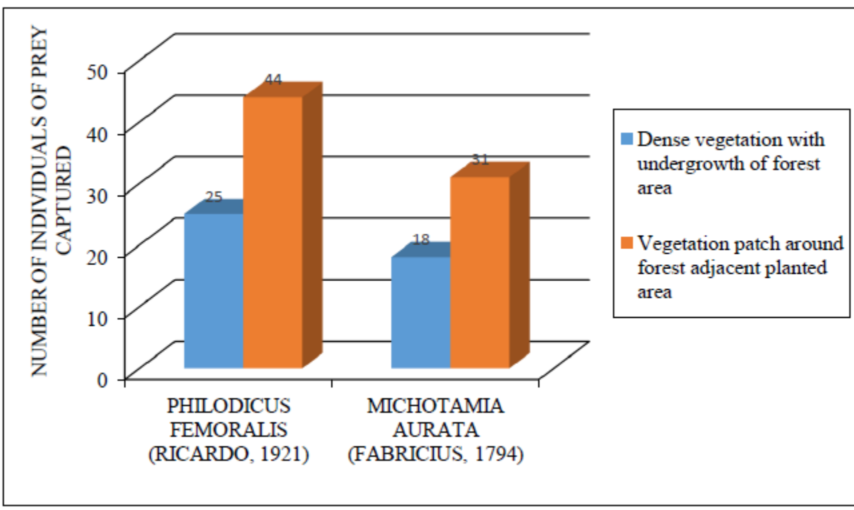

Figure 7. Clustered column showing comparative predatory activities of two asilid flies in varied vegetation patch in and around the Sonamukhi protected forest area.