



Research Article

SEASONAL VARIATIONS IN THE DIVERSITY OF AMPHIBIANS AND REPTILES IN WESTERN TERAI ARC LANDSCAPE, INDIA

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ABSTRACT

Amphibian and reptiles are weather sensitive, poikilothermic group of animals, and their occurrence varies with the change in seasons. Present study was conducted in Ramnagar Forest Division of Uttarakhand state of India. Ramnagar Forest Division is the western part of Terai Arc Landscape which is an important ecoregion of the world. Sampling was done with Visual Encounter Surveys along with other methods, in all the seasons of a year. A total of 47 species of herpetofauna was recorded in the study, including 10 species of frogs, 13 species of lizards, 20 species of snakes and 4 species of testudines. The maximum number of herpetofauna species was observed during monsoon season, while the least number species were found in winters. The general pattern of herpetofauna species richness that observed in Ramnagar Forest Division was, found to be highest in monsoons, which then started decreasing in autumns and a rapid decrease was noticed in pre-winter and reached minimum in winters. In springs it started rising again and continue to rise in summers to reached maximum in monsoons.

Keywords: Herpetofauna, Species richness, Visual Encounter Survey, Ecoregion, Weather.

INTRODUCTION

Season is the yearly and expected change in weather, ecology and hours of day light (Pramod *et al.*, 2012; Singh *et al.*, 2012). It is a cyclic climatic pattern of any region, which is repeated every year. Season is known as 'Ritu' in Uttarakhand. Ritus are differentiated by observing the changes in surrounding. Ritu contributes various changes in nature (Baghel *et al.*, 2018). The Ritu concept is based on the changes in vegetation phenology like flowering, fruiting and leaf shedding (Thakkar *et al.*, 2011), as well as on the temperature, climate, movement of sun in celestial sphere and the day length. Whole year is divided in six Ritus (seasons) (Krishnan, 2020) and each Ritu is approximately consist of two months (Singh *et al.*, 2012a) Table.1. This concept of seasons is followed by the various countries of Indian subcontinent, such as Nepal, India, Bangladesh and Sri Lanka. The seasonal change in the climatic and environmental factors not only effect

vegetation but also the animal physiology (Singh *et al.*, 2012), which leads the changes in their seasonal behavior.

Amphibians and reptiles are poikilothermic group of animals which are sensitive to the seasonal changes in environment. Amphibians and reptiles get affected by seasonal changes in temperature and rainfall (Bickford *et al.*, 2010). Their physiological functions are affected by the external influences of environment. The seasonal patterns of changes in temperature and humidity have significant impact on the occurrence pattern of herpetofauna species (Gonzalez, 2021; Pradhan *et al.*, 2014). Their biological cycles such as hibernation, aestivation and reproduction remain synchronized with the seasonal changes in environment (Rastogi *et al.*, 2011). Season affects the physiology and behavior of herpetofauna, such as thermoregulation (Huey & Pianka, 1977) haematology (Hernández Marrero *et al.*, 2017) and diet (Simic *et al.*,

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1992), it also effects the sensitivity to infections (Ruggeri *et al.*, 2015) and mortality (Berger *et al.*, 2004).

During extreme temperatures the occurrence of herpetofauna usually reduced, in extremely warmer months they go for summer sleep or aestivation (Secor & Lignot, 2010), while in extreme colder months of the year they enter into winter sleep or hibernation (Halime *et al.*, 2019). The occurrence of herpetofauna fluctuates with the season, but in the areas of moderately warm temperature they remain active for whole year (Fair & Henke, 1997). Terai Arc Landscape (TAL) is the highly biodiverse region in the Himalayan foot plains of India and Nepal. It is enlisted among 200 important ecoregions of the world (Olson & Dinerstein, 1998). The total area of TAL is 49,500 km², out of which 30,000 km² areas falls in India and 19500 km² is in Nepalese territory (Semwal, 2005). Eight protected areas in India (Semwal, 2005) and six protected areas in Nepal (Ministry of Forests and Soil Conservation, 2015) are situated in TAL region. The present study was performed in western part of TAL named

Ramnagar Forest Division (RFD) which falls in Uttarakhand state of North India. RFD is located in the western part of TAL with an area of 593 km² and contains good biodiversity and shares its western boundary with Cortbett national park (Ahmad *et al.*, 2018). In spite of its great importance of this region, being a part of TAL, there is very limited information is available about the amphibian and reptiles of this area (Bhattara *et al.*, 2017).

MATERIALS AND METHODS

Study Area

RFD is located in Uttarakhand state in North India. The coordinates of the study area lies between latitude 29°33'10" to 29°13'40" N and longitude 79° 5'50" to 79° 32'40" E (Figure.1). Temperature varies from 5°C in winters to 40°C in summers. Yearly average precipitation in the region is around 2000 mm, mostly rainfall occurs during monsoon season. Sampling was done whole year round and in all seasons of the year.

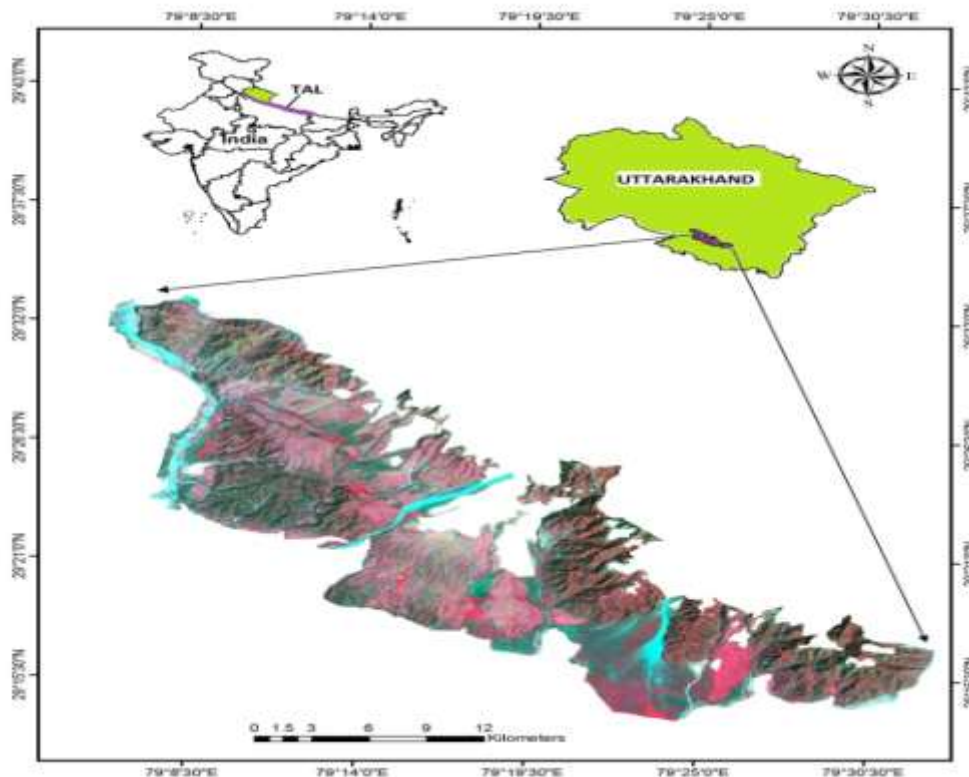


Figure 1. Study area located in Uttarakhand state in North India.

Sampling Methods

Data was collected mainly by Visual Encounter Survey (VES) method (Heyer *et al.*, 2014; Sutherland, 2006), by following the transect. No animal was killed or harmed in the study; only photographs shows were taken for the

identification. Data collection was also done by using additional methods, such as opportunistic observation (Behangana, 2004), road kill survey (Langen *et al.*, 2009), night searches (Bennett, 1999), rescue and release program. Identification of species was done with the help of field guides and identification keys (Ahmed *et al.*, 2018; Daniel

& Society, 2002; Vasudevan & Sondhi, 2010; Whitaker *et al.*, 2004).

RESULTS AND DISCUSSION

In this study we reported a total of 47 species of herpetofauna from three different orders, viz., Anura, Squamata and Testudinata. Ten species of toads and frogs were reported from four different families of the Order Anura. Thirty three species of squamates were reported, which includes 13 species of lizards from four families and 20 species of snakes from six families. Four species of tortoise and turtles were recorded from three families of Order Testudinata. Occurrence of herpetofauna species in various seasons was as follows. January- In the month of January, only one species of frog, viz.; *Euphlyctis cyanophlyctis* was encountered (Table 2). One species out of total 47 species of herpetofauna (1/47) meaning only 2.12% of total herpetofauna species was encountered in this month (Table 3 and 4).

February- In February total four species of herpetofauna encountered belonging two orders. In which three species of frogs and one species of lizards were

reported, but no species of snakes and testudines was found (Table 3). Out of total 47 species, only 8.51% of total herpetofauna species was encountered in this month (Table 4). March- Total 12 species from two orders of herpetofauna were recorded in March, which means 25.53% of total herpetofauna species was encountered (Table 4). Two species of frogs, 7 species of lizards and two species of snakes and one species of Testudinata were found (Table 3). April- Total 10 species from all three orders of herpetofauna were encountered in this month, meaning 21.27% of total herpetofauna species was encountered (Table 4). Two species of frogs, five species of lizard, two species of snakes and one species of testudines were found (Table 3). May- Total 12 species of herpetofauna were encountered in the month of May. It means 25.53% of total herpetofauna species was encountered (Table 4). In these four species of frogs, six species of lizards and two species of snakes were found (Table 3). June- Total 19 species from all three orders of herpetofauna were encountered in June (Table 3). In these five species of frogs, six species of lizards, seven species of snakes and one species of testudines were recorded. It comprised 40.42% of total herpetofauna species (Table 4).

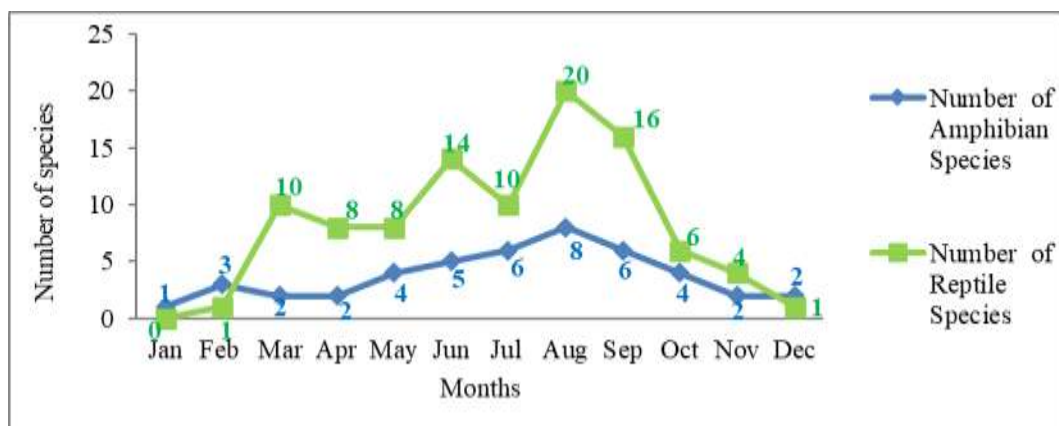


Figure 2. Monthly variations in the pattern of occurrence amphibian and reptile species in Ramnagar Forest Division (RFD).

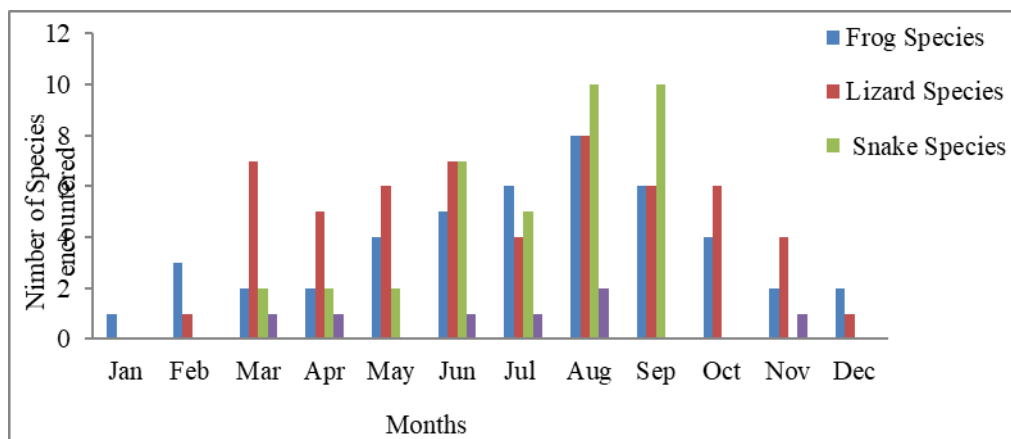


Figure 3. Number of species encountered during various months of the year in Ramnagar Forest Division (RFD).

July- Total 16 species of herpetofauna were encountered, six species of frogs, four species of lizards and five species of snakes were found but no species of testudines was found (Table 3). The percentage of total herpetofauna species encountered in this month was 34.04% (Table 4). August - Total 28 species encountered, in which eight species of frogs and eight lizards, 10 snakes and two species of testudines were reported (Table 3). It was 59.57% of total herpetofauna species (Table 4). September- Total 22 species were encountered in this month, in which six species of frogs and six species of lizards and ten species of snakes were found (Table 3). In September 46.80% of total herpetofauna species was encountered (Table 4).

October- Total 10 species encountered, in which four species of frogs and six species of lizards were found (Table 3). In this month 21.27% of total herpetofauna species was encountered. November- Total six species of herpetofauna encountered it means 14.89% of total herpetofauna species was reported (Table 4). In these two species of frogs, three species of lizards and one species of testudinata were found (Table 3). December- Only three species of herpetofauna were encountered; it means total 6.38% of total herpetofauna species was encountered in this month (Table 4). In which one species of lizard and two

species of frogs and were found incepted in (Table 3). In this study, maximum number of species found in monsoons season and minimum number of species were encountered in winter season. While in springs and autumns the moderate number of species was encountered shows in the (Table 1).

The highest number of herpetofauna species was encountered in August during the monsoons, followed by July and September, respectively. In August, 29 species out of total 47 species were encountered. Least number of species was found in winter season in month of January when only one species was recorded (Table 3). Maximum number of frog species encountered in August, eight species of frogs out of 10 species were encountered in this month. While least number of frog species was encountered in the months of January when only single species, viz., *Euphlyctis cyanophlyctis* was encountered (Table 3). The highest number of lizard species was also encountered in August, eight species out of total 13 species were encountered in this month. While in the month of January no species of lizard was encountered (Table 3). Maximum number of snake species was encountered in the month of August, ten species out of total 20 species were found. While in the months of January, February, October, November and December, no species of snakes was encountered (Table 3).

Table 1. Season profile of Ramnagar Forest Division (RFD), India.

Local Seasons	Months	Forest phenology of RFD	Average day length (Hrs.)*	Average temperature (°C)*	Number of Amphibian species encountered	Number of Reptilian species encountered	Total number of Herpetofauna species
Shisir (Winter)	January-February	Dormancy	10.51.33	14	4	1	5
Vasanth (Spring)	March-April	Budding	12.52.05	23	4	18	22
Greeshm (Summer)	May-June	Flowering	13.46.27	29.5	9	16	25
Varsha (Monsoon)	July-August	Shoot lengthening	13.27.56	27.5	14	30	44
Sharad (Autumn)	September-October	Senescence	11.53.33	24.5	10	22	32
Hemant (Pre-winter)	November-December	Fall	10.31.59	17	4	5	9

(*www. timeanddate.com)

Table 2. Seasonal variation in occurrence of herpetofauna species in different months of the year in Ramnagar Forest Division (RFD).

Species	Common Name	Seasons	Months
Anurans			
<i>Duttaphrynus melanostictus</i>	Common Indian toad	Summer, Monsoon, Autumn	May, Jun, Jul, Aug, Sep
<i>Duttaphrynus stomaticus</i>	Marbled toad	Summer, Monsoon	Jun, Jul, Aug
<i>Sphaerotheca breviceps</i>	Indian burrowing frog	Monsoon, Autumn	Aug, Sep
<i>Fejervarya limnocharis</i>	Paddy field cricket frog	Winter, Spring, Summer, Monsoon, Autumn	Feb, Mar, Apr, May, Jun, Aug, Sep, Oct, Nov
<i>Euphlyctis cyanophlyctis</i>	Indian skipper frog	Winter, Spring, Summer, Monsoon, Autumn, Pre-winter	Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec
<i>Hoplobatrachus tigerinus</i>	Indian bull frog	Winter, Monsoon, Autumn, Pre-winter	Feb, Jul, Aug, Sep, Oct
<i>Hoplobatrachus crassus</i>	Jerdon's bull frog	Autumn, Pre-winter	Oct, Dec
<i>Microhyla nilphamairensis</i>	Nilphamari narrow mouthed frog	Summer, Monsoon, Autumn	May, Jul, Aug, Sep
<i>Uperodon systoma</i>	Marbled balloon frog	Summer	Jun
<i>Polypedates maculatus</i>	Common tree frog	Monsoon	Jul, Aug
Lizards			
<i>Varanus bengalensis</i>	Indian monitor lizard	Spring, Summer, Monsoon, Autumn	Mar, May, Jul, Aug, Oct
<i>Laudakia tuberculata</i>	Himalayan rock lizard	Spring, Summer, Monsoon	Mar, Apr, May, Aug
<i>Calotes versicolor</i>	Oriental garden lizard	Spring, Summer, Monsoon, Autumn, Pre-winter	Mar, Apr, May, Jun, Sep, Oct, Nov
<i>Cyrtodactylus fasciolatus</i>	Banded bent toad gecko	Monsoon	Aug
<i>Hemidactylus kushmorensis</i>	Kushmore's house gecko	Spring, Summer, Monsoon, Autumn	Apr, May, Jun, Jul, Aug, Sep, Oct
<i>Hemidactylus leschenaultii</i>	Leschenault's house gecko	Summer, Autumn, Pre-winter	Jun, Sep, Nov
<i>Hemidactylus flaviviridis</i>	Northern house gecko	Spring, Summer, Monsoon, Autumn	Mar, Apr, May, Jun, Jul, Aug, Sep, Oct
<i>Eutropis carinata</i>	Keeled grass skink	Spring, Summer, Monsoon, Autumn, Pre-winter	Mar, Apr, Jun, Aug, Sep, Oct, Nov, Dec
<i>Eutropis dissimilis</i>	Striped grass skink	Summer	May
<i>Eutropis macularia</i>	Bronze grass skink	Summer	Jun
<i>Lygosoma punctata</i>	Dotted garden skink	Spring, Monsoon,	Mar, Jul, Aug
<i>Lygosoma albopunctatum</i>	White spotted supple skink	Monsoon	Aug
<i>Asymblepharus himalayanus</i>	Himalayan rock skink	Winter, Spring, Summer, Autumn, Pre-winter	Feb, Mar, Jun, Sep, Oct
Snakes			
<i>Daboia russelii</i>	Russell's Viper	Monsoon	Aug
<i>Trimeresurus septentrionalis</i>	Indian green pit viper	Autumn	Sep
<i>Bungarus caeruleus</i>	Common Indian krait	Summer, Monsoon, Autumn	Jun, Jul, Sep
<i>Naja naja</i>	Indian cobra	Monsoon, Autumn	Aug, Sep
<i>Ophiophagus hannah</i>	King cobra	Summer, Autumn	May, Sep
<i>Ptyas mucosa</i>	Rat snake	Monsoon, Autumn	Jul, Aug, Sep
<i>Oligodon arnensis</i>	Common kukri	Monsoon, Autumn	Jun, Aug, Sep
<i>Dendrelaphis tristis</i>	Common bronze back	Spring, Summer, Monsoon	Mar, Jun, Aug
<i>Coelognathus helena</i>	Common trinket	Monsoon, Autumn	Aug, Sep
<i>Boiga trigonata</i>	Common cat snake	Summer, Monsoon,	Jun, Aug
<i>Boiga forsteni</i>	Forstain's cat snake	Autumn	Sep

<i>Coelognathus radiata</i>	Copper headed trinket	Monsoon	Aug
<i>Lycodon aulicus</i>	Common wolf snake	Monsoon	Aug
<i>Lycodon jara</i>	Spotted wolf snake	Monsoon	Jul
<i>Sibynophis sagittarius</i>	Cantor's black headed snake	Summer	Jun
<i>Amphiesma stolatum</i>	Striped keel back	Spring, Summer, Monsoon, Autumn	Apr, Jun, Jul, Aug, Sep
<i>Xenochrophis piscator</i>	Checkered keel back	Summer, Autumn	Jun, Sep
<i>Indotyphlops braminus</i>	Common blind snake	Monsoon	Jul
<i>Argyrophis diardii</i>	Diard's blind snake	Spring	Mar
<i>Python bivittatus</i>	Burmese python	Spring, Summer	Apr, May
Testudines			
<i>Indotestudo elongata</i>	Elongate tortoise	Spring, Monsoon	Mar, Jul, Aug
<i>Melanochelys tricarinata</i>	Indian black turtle	Summer	Jun
<i>Melanochelys trijuga</i>	Indian flap shell turtle	Pre- winter	Nov
<i>Lissemys punctata</i>	Tricarinate hill turtle	Spring, Monsoon	Apr, Aug

Table 3. Number of herpetofauna species reported in different months of the year in Ramnagar Forest Division (RFD).

	Number of Anuran Species	Number of Lizard Species	Number of Snake Species	Number of Testudine Species	Total Number of Herpetofauna Species
Jan	1	0	0	0	1
Feb	3	1	0	0	4
Mar	2	7	2	1	12
Apr	2	5	2	1	10
May	4	6	2	0	12
Jun	5	7	7	1	20
Jul	6	4	5	1	16
Aug	8	8	10	2	28
Sep	6	6	10	0	22
Oct	4	6	0	0	10
Nov	2	3	0	1	6
Dec	2	1	0	0	3

Table 4. Percentage of herpetofauna species encountered in different months of the year in Ramnagar Forest Division (RFD).

	Anuran Species (Total =10)		Lizards Species (Total =13)		Snakes Species (Total =20)		Testudine Species (Total =4)		Herpetofauna Species (Total=47)	
Jan	1/10	10%	0	0	0	0	0	0	1/47	2.12%
Feb	3/10	30%	1/13	7.69%	0	0	0	0	4/47	8.51%
Mar	2/10	20%	7/13	53.84%	2/20	10%	¼	25%	12/47	25.53%
Apr	2/10	20%	5/13	38.46%	2/20	10%	¼	25%	10/47	21.27%
May	4/10	40%	6/13	46.15%	2/20	10%	0	0	12/47	25.53%
Jun	5/10	50%	7/13	53.84%	7/20	35%	¼	25%	20/47	42.55%
Jul	6/10	60%	4/13	30.76%	5/20	25%	¼	25%	16/47	34.04%
Aug	8/10	80%	8/13	61.53%	10/20	50%	2/4	50%	28/47	59.57%
Sep	6/10	60%	6/13	46.15%	10/20	50%	0	0	22/47	46.80%
Oct	4/10	40%	6/13	46.15%	0	0	0	0	10/47	21.27%
Nov	2/10	20%	3/13	23.07%	0	0	¼	25%	6/47	12.76%
Dec	2/10	20%	1/13	7.69%	0	0	0	0	3/47	6.38%

Also maximum number of species of Testudinata was recorded in the month of August, when two out of four species of testidines were encountered. No testudine species was encountered in, six months Viz.; January, February, May, September, October and December (Table 3). *Euphlyctis cyanoflyctis* was found whole the year round, in all seasons and every month of the year (Table 2). In this study the maximum number of herpetofauna species was reported in monsoon season in the month of August. Similar results were observed in seasonal variation of herpetofauna assemblage in eastern part of India i.e., in West Bengal state, where maximum number of species was found in monsoon season, (in the month of July) (Pradhan *et al.*, 2014). More number of species in monsoons may be due to availability of food in this season (Pal *et al.*, 2012), also may be due to availability of ideal conditions for breeding.

In another study done in the south eastern part of India in Odisha, also reveals similar findings, where, maximum number of species was recorded in rainy season in the month of July (Pradhan *et al.*, 2014). They further said that the activity of herpetofauna is found to be maximum during moderate temperature and high precipitation (Pradhan *et al.*, 2014). In central Amazonia (Brazil), in the starting and end of the rainy season less number of frog species were recorded, while in the middle of the rainy season highest number of species were recorded (Menin *et al.*, 2008). Further it is observed, in coastal island of Nigeria, in rainy season more number of amphibian species were encountered while in dry season more reptile species were recorded (Akani *et al.*, 2010). In our study the number of species of amphibian as well as reptiles was found maximum during rainy season (month of August) (Table 3). Similar results of the seasonal variations in herpetofauna occurrence were obtained in coastal wetlands of Ghana, Africa, where more number of herpetofauna species were encountered in wet season in comparison with dry season (Musah *et al.*, 2019). In Nigeria, Africa also more number of amphibian species were recorded in wet season in comparison to dry season, but there was no significant difference in the occurrence of reptile species (Akani *et al.*, 2010).

The seasonal impact in occurrence pattern of snakes also affects the number of snake bites. The seasonal variations in the number of snake bites in Himachal Pradesh state of North India is observed, with a peak in the monsoon season, while there was no bite recorded in the winters (Bhardwaj & Sokhey, 1998). It again indicates the higher occurrence of snakes in monsoons in comparison to winters. In RFD the least number of species were recorded in winter season in month of January, when temperature was low. Similar result were obtained from East India (Pal *et al.*, 2012) and South east India (Pradhan *et al.*, 2014), in both the studies they get least number of species in the winter month of December. While evaluating the weather effect on the western rat snakes (*Pantheropsis obsoletus*) in central Missouri USA, least number was found in mid

summers (George *et al.*, 2015). In winter season, only anurans were reported and no species of reptile was found in January. In south Texas plain (USA) also, least number of species were reported in winters, where they found no species of snakes in winters, but reported few species of lizards and frogs (Ruthven *et al.*, 2002). In another study in southern Brazil, less number of anuran species were encountered in colder seasons of autumn and winter while there were more number of anuran species was found in warmer seasons of spring and summer (Luza *et al.*, 2018). Less number of species in winters may be due to the hibernation, which is the response to cold temperature and low resource availability (Bickford *et al.*, 2010).

In this study, we found, after winters the number of herpetofauna species started increasing in spring season. In spring season, the total number of herpetofauna species in RFD was increased in comparison to the species number in winters (Table 1). In springs percentage of lizards was maximum (Table 4). The number of reptiles rose from one species to 18 numbers of species especially the encounter of lizard species boomed up in summers (Table 3). In South Texas plains, USA, most species of frogs and some species of snakes were found in spring season (Ruthven *et al.*, 2002). In this study in RFD we also found similar results. In summer season, in the months of May and June, species of lizards were again found maximum (Table 1) in RFD. While in Greece, also number of lizards increased in months of April and May (Zogaris & Economou, 2017). But the total number of herpetofauna species slightly reduced in summers in comparison to the number of species in the springs (Table 1). This decrease in number of species during summers may be due to aestivation activity of the herpetofauna (Pradhan *et al.*, 2014). In autumns the number of herpetofauna species started decreasing, in this season the number of anuran species was found maximum and number of lizard species was found minimum. In Western Australia also less number of species were encountered in autumn season in comparison to springs (Thompson & Thompson, 2005). In RFD during pre-winter season the total number of herpetofauna species further reduced but still the number of lizard species were more and the number of anuran species was minimum among all species encountered.

CONCLUSION

Maximum species richness found in monsoons in the month of August followed by September, while least species richness was found in winter season in the month of January. August is found to be the most suitable month, when maximum number of species was encountered. It is found that monsoon is the best season for the observation of herpetofauna species in this region, compare to winter and summers. It is expected that this study will be helpful as baseline information in further studies in this area, in relation to the effect of ecophysiological conditions on assemblage of herpetofauna.

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