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COMMUNICATION

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The worrisome conservation status of ecosystems within the distribution range of the Spectacled Bear *Tremarctos ornatus* (Mammalia: Carnivora: Ursidae) in Ecuador

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Abstract: The distribution range of Spectacled Bear in Ecuador has been strongly fragmented owing to human activities, thus studying the conservation status of the remaining patches in which this species inhabits is essential to ensure its conservation. We performed a descriptive analysis of the conservation status of the ecosystems that form part of the Spectacled Bear distribution range in Ecuador, using values of five indicators (fragmentation, connectivity, threat, vulnerability and fragility) provided by the Ecuadorian Ministry of Environment. Moreover, we compared the conservation status between scrubland & pastures and evergreen forest ecosystem according to the five indicators. Overall, the Spectacled Bear distribution in Ecuador is covered by a greater surface area of ecosystems classified with a medium level of fragmentation (58.8%), low connectivity (45.1%), high fragility (45.6%), high (38.2%) and medium threat (39.2%), as well as high (33.7%) and medium (33.1 %) vulnerability. Scrubland and pastures ecosystems had worse conservation status than evergreen forests, with 98% of their surface classified as having low or very low connectivity, 77.3% as high fragility and 77.4% as high threat. These results showed the worrisome conservation status of the ecosystems shaping the distribution range of Spectacled Bear in Ecuador, particularly the scrubland and pastures, and therefore, a wider national strategy (inside and outside the limits of the bear distribution range) should be applied to ensure the preservation of these ecosystems.

Keywords: Andean Bear, conservation, ecosystem, endangered species, habitat loss, human activities, species distribution.

Resumen. El área de distribución del oso de anteojos en Ecuador ha sido fuertemente fragmentada debido a actividades antropogénicas, y por lo tanto, estudiar el estado de conservación de los parches remanentes en los cuales esta especie habita es esencial para asegurar su conservación. Se realizó un análisis descriptivo del estado de conservación de los ecosistemas que forman parte del área de distribución del oso de anteojos en Ecuador, usando valores de cinco indicadores (fragmentación, conectividad, amenaza, vulnerabilidad y fragilidad) proporcionados por el Ministerio del Ambiente de Ecuador. Además, se comparó el estado de conservación entre los ecosistemas de matorral & pastizal y bosques siempreverdes de acuerdo con los cinco indicadores. En general, el área de distribución del oso de anteojos está cubierta por una mayor superficie de ecosistemas clasificados con un nivel medio de fragmentación (58.8%), baja conectividad (45.1%), alta fragilidad (45.6%), alta (38.2%) y media (39.2%) amenaza, así como alta (33.7%) y media (33.1%) vulnerabilidad. Los ecosistemas de matorral y pastizales tuvieron peor estado de conservación que los bosques siempreverdes, con un 98% de su superficie con baja o muy baja conectividad, 77.3% con alta fragilidad, y 77.4% con alta amenaza. Los resultados muestran el preocupante estado de conservación de los ecosistemas que conforman el área de distribución del oso de anteojos en Ecuador, particularmente los ecosistemas de matorral y pastizal, y por lo tanto, una estrategia nacional más amplia (dentro y fuera de los límites de área de distribución del oso) deberían ser aplicados para asegurar la preservación de estos ecosistemas.

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INTRODUCTION

Habitat loss and degradation are major threats for the world's mammals (Brooks et al. 2002; Fahrig 2003; Dobson et al. 2006). Apart from constraining the distribution range of mammal species, habitat loss entails the fragmentation and isolation of remaining populations, increasing the risk of extinction as a consequence of the loss of genetic flow and adaptive genetic variation (Ernest et al. 2011), inbreeding (Keller & Waller, 2002), demographic and environmental stochastic phenomena (Shaffer 1981; Crooks et al. 2011), and lower colonization rate (Fahrig 2003). Large mammals are most vulnerable to habitat loss and fragmentation owing to their extensive home ranges, lower densities, and lower population growth rates (Cardillo et al. 2005). Furthermore, large mammals are more prone to poaching and direct persecution, and are often implicated in various kinds of human-wildlife interactions such as damage to agriculture or attacks on livestock (Woodroffe et al. 1998; Kinsky & Knight 2014), which are more frequent in smaller populations surrounded by a human-dominant matrix (Michalski & Peres 2005).

As a large mammal, the Andean Bear or Spectacled Bear *Tremarctos ornatus* F.G. Cuvier, 1825 needs large areas to fulfil its biological requirements (Cuesta et al. 2003; Castellanos 2011). This species is endemic to the Tropical Andes and was formerly distributed widely across the mountain range (Peyton et al. 1998; Kattan et al. 2004; Velez-Liendo & García-Rangel 2017), however, its current populations are distributed in fragmented areas from Bolivia to Venezuela, which led to the species being assessed as Vulnerable (VU) on the IUCN Red List (Velez-Liendo & García-Rangel 2017). In Ecuador, this species is listed as Endangered (EN) in the Red Book of Mammals of Ecuador (Castellanos et al. 2011), owing to a reduction in both population size and distribution as a consequence of habitat alteration (Peyton et al. 1998; Kattan et al. 2004; Peralvo et al. 2005), thus affecting strongly the viability of the species (Kattan et al. 2004). Therefore, it is important to assess the remaining patches in terms of threat, vulnerability, and fragmentation, to establish measures favouring bear conservation. Most studies in Ecuador have been conducted to assess habitat preferences at small scales (Suarez 1988; Cuesta et al. 2003; Peralvo et al. 2005; Clark 2008; Castellanos 2011; Demay et al. 2014; Filipczykova et al. 2017), but none have characterized the remaining fragments at national scale in which this species inhabits. The aim of this study was to characterize all the remaining

fragments of Andean Bears in Ecuador, taking into account five indicators of the conservation status of the ecosystems (fragmentation, connectivity, vulnerability, threat, and fragility) provided by the Ecuadorian Ministry of Environment, in order to comprehensively assess the conservation status of ecosystems in which the Spectacled Bear inhabits in Ecuador.

MATERIAL AND METHODS

Species distribution range

The geo-referenced current range of the bear within Ecuador was obtained from the IUCN Red List webpage (Velez-Liendo & García-Rangel 2017; Figure 1). An area is considered as extant if the species is known or thought very likely to occur there presently, which encompasses localities with current or recent (data updated in 2017) records where suitable habitat at appropriate altitudes remain (IUCN 2018).

Ecosystem features

Geo-referenced shapefiles were obtained from the Ecuador Ministry of Environment (available at <http://ide.ambiente.gob.ec/mapainteractivo/>) wherein the ecosystems of mainland Ecuador are classified into 91 types according to biotic and abiotic factors (Ministerio del Ambiente del Ecuador 2013). This shapefile also contains information concerning fragmentation, connectivity, vulnerability, threat, and fragility of each ecosystem. The rate of fragmentation was calculated using three variables: the number of patches, their mean size, and the coefficient of variation of the size of the patch (Ministerio del Ambiente del Ecuador 2015b). These variables were used to rank the fragmentation of each ecosystem on four levels (very high, high, medium, and low) according to the method of Jenks' natural breaks (for more details see the previous reference). Connectivity was measured by the equivalent connected area index, which is defined as the size of a single habitat patch (maximally connected) that would provide the same value of the probability of connectivity than the actual habitat pattern in the landscape (Saura et al. 2011). Using also Jenks' natural breaks, the connectivity rates of the ecosystems were classified into four categories: high, medium, low, and very low (Ministerio del Ambiente del Ecuador 2017). The vulnerability index was calculated at species level by using the number of species listed in CITES, the number of endemic species, the number of plants with a commercial value, and the number of endangered plant species according



Figure 1. Andean Bear distribution range (green shapes) in Ecuador according to the IUCN Red List.

to the IUCN Red List in Ecuador. At the landscape level, vulnerability was calculated by the degree of representativeness, fragmentation, and connectivity. The threat to ecosystems was assessed by five variables: climate change, water resource use, forest exploitation, extraction of natural resources, and the probability of land conversion. Vulnerability and threat were classified in three categories (high, medium, and low) by using quantiles, and both indicators were combined to get five levels of fragility (very high, high, medium, low, and very low; Ministerio del Ambiente del Ecuador 2015a). No values were assigned to areas identified as non-natural ecosystems, such as crops, urban areas, or planted forests. These indexes provided by the Environmental Ministry have been used in previous scientific papers (e.g. Rivas et al. 2020).

Three different descriptive analyses were performed. Firstly, the proportions of each level (e.g., high, medium, low) of each of the five indicators (fragmentation, connectivity, vulnerability, threat, and fragility) were calculated in the whole bear distribution range, which was done by adding the surface area of every ecosystem with the same level of each indicator. Secondly, these proportions were calculated separately in each of 17 distribution patches, which allows us to estimate the mean values and the variation among patches. Thirdly, the ecosystems were grouped into the two main habitats of Andean Bears in Ecuador (Peralvo et al. 2005):

forests and scrubland & pastures (including paramo), to compare the conservation status between both habitats in accordance with the five indicators.

RESULTS

According to the IUCN data, Spectacled Bears in Ecuador are located in 17 different patches (Figure 1) covering an area of 19,940km², with a mean patch size of 1,172km² (\pm 890). This distribution range includes 42 distinct ecosystems: 14 natural pastures and/or scrublands covering 35.7% of the range, 28 different forest ecosystems covering 57.4%, and the remaining 6.9% classified as non-natural areas. Overall, in the whole distribution range, the bear distribution contains a higher proportion of ecosystems classified as medium fragmented (58.8%), with low connectivity (45.1%), high fragility (45.6%), high (38.2%), and medium threat (39.2%), as well as high (33.7%) and medium (33.1%) vulnerability (Figure 2). The mean values obtained in the 17 patches in which the Andean Bear inhabits showed greater average values of medium level of fragmentation, low connectivity, high fragility, medium threat, and high vulnerability (Table 1).

Finally, the comparison between forests and scrublands & pastures, showed that the latter ecosystem type has a poorer conservation status (Figure 3). For instance, 98% of the area covered by scrublands & pastures are classified as having low or very low connectivity, 77.3% with high fragility, and 77.4% with high threat (Figure 3).

DISCUSSION

Habitat fragmentation and its consequent isolation of populations is one the main conservation problems for the majority of large mammals (Crooks et al. 2011), including the Spectacled Bear (Castellanos et al. 2005). The development of the road network, land-use changes, and the establishment of human settlements (Armenteras et al. 2003; Kattan et al. 2004; Peralvo et al. 2005) have fragmented continuous populations into smaller and isolated patches (Figure 1), which could jeopardize bears population viability. It is, therefore, important to understand the features of these fragments, such as the conservation status of the ecosystems shaping the distribution range of the Spectacled Bear, which could help to establish remedial measures to conserve its habitats. In this work, however, we have

Table 1. Mean values \pm standard deviation (SD) of the percentage of surface area of the different levels of the five indicators for the 17 distribution patches in which the Andean Bear inhabits in Ecuador.

Indicator	Mean	\pm SD
Fragmentation		
Very High	7.94	6.77
High	17.43	25.6
Medium	55.28	27.28
Low	9.35	15.46
Connectivity		
High	10.83	17.47
Medium	27.17	22.84
Low	43.96	25.6
Very Low	8.24	12.01
Fragility		
Very High	15.28	29.13
High	49.77	31.06
Medium	6.21	8.47
Low	10.81	15.6
Very Low	8.14	12.54
Threat		
High	32.11	25.1
Medium	45.54	26.76
Low	12.55	13.65
Vulnerability		
High	43.2	32.3
Medium	29	27.22
Low	17.99	23.55

shown that the ecosystems occupied by this species are not always the best preserved, since a great proportion of the potential distribution range of the Spectacled Bear in Ecuador are ecosystems with some degree of threat.

Overall, a large proportion of the distribution range of the Spectacled Bear in Ecuador is covered by ecosystems catalogued as fragmented, poorly connected, fragile, threatened, and vulnerable (Figure 2). This relatively poor conservation status has important implications for the Spectacled Bear if no measures are applied to conserve these ecosystems. A fragmented and poorly connected ecosystem under high human pressure is vulnerable to reduction in surface area or even complete disappearance. Therefore, the ecosystems in Andean Bear's range could be replaced by other land uses that are less suitable as Andean Bear habitats.

Several scientific works have suggested that connectivity among patches still inhabited by Andean Bear is essential to ensure the conservation of its

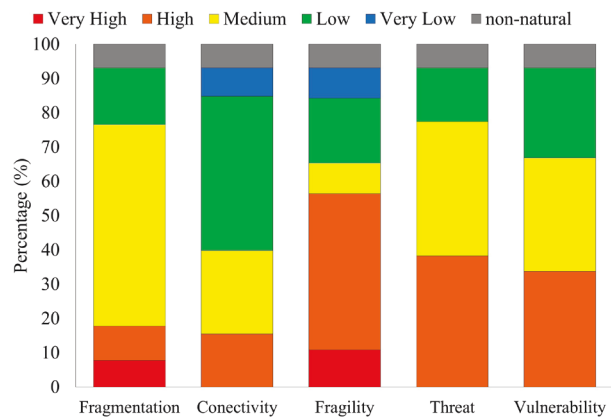


Figure 2. Proportion of the area covered by the different categories of the five ecosystems indicators within the distribution range of the Spectacled Bear. The five indicators were divided in five, four or three categories (see methods for more details), and therefore, some categories are missing for some indicators.

populations (Kattan et al. 2004; Velez-Liendo et al. 2014). According to our results, however, apart from connecting the reaming patches, a wider strategy (inside and outside of the distribution range) aimed at boosting the conservation status of the important ecosystems for this species is also necessary. One strategy could be to use the Andean Bear as an umbrella species (Crespo-Gascón & Guerrero-Casado 2019) in order to conserve those ecosystems with a high degree of threat that this species inhabits.

Furthermore, our results show that scrublands and pastures (including paramo or moorland) which are an important part of the Andean Bear's distribution range are more threatened than evergreen forests. The paramo in Ecuador has been extensively replaced by other land uses (e.g., pine plantations, crops or artificial pastures) (Ross et al. 2017) and although it covers a large area in the Andes region, it is highly threatened by anthropogenic activities (Ministerio del Ambiente del Ecuador 2015b). Therefore, since the paramo is an important ecosystem for the Andean Bear (Demay et al. 2014), it covers an important proportion of its distribution, and is a fragile ecosystem, conservation efforts should be also targeted at preserving this ecosystem at the national scale, which in turn could help to conserve the Spectacled Bear habitats.

Evergreen montane forests are the main habitats for the Spectacled Bear in Ecuador (almost 60 % according to our data), and as we have shown in this study, almost 50% of the distribution range of the Spectacled Bear is covered by forests considered as high or very high fragility (Figure 3). These ecosystems have a high alpha diversity and they are well represented in

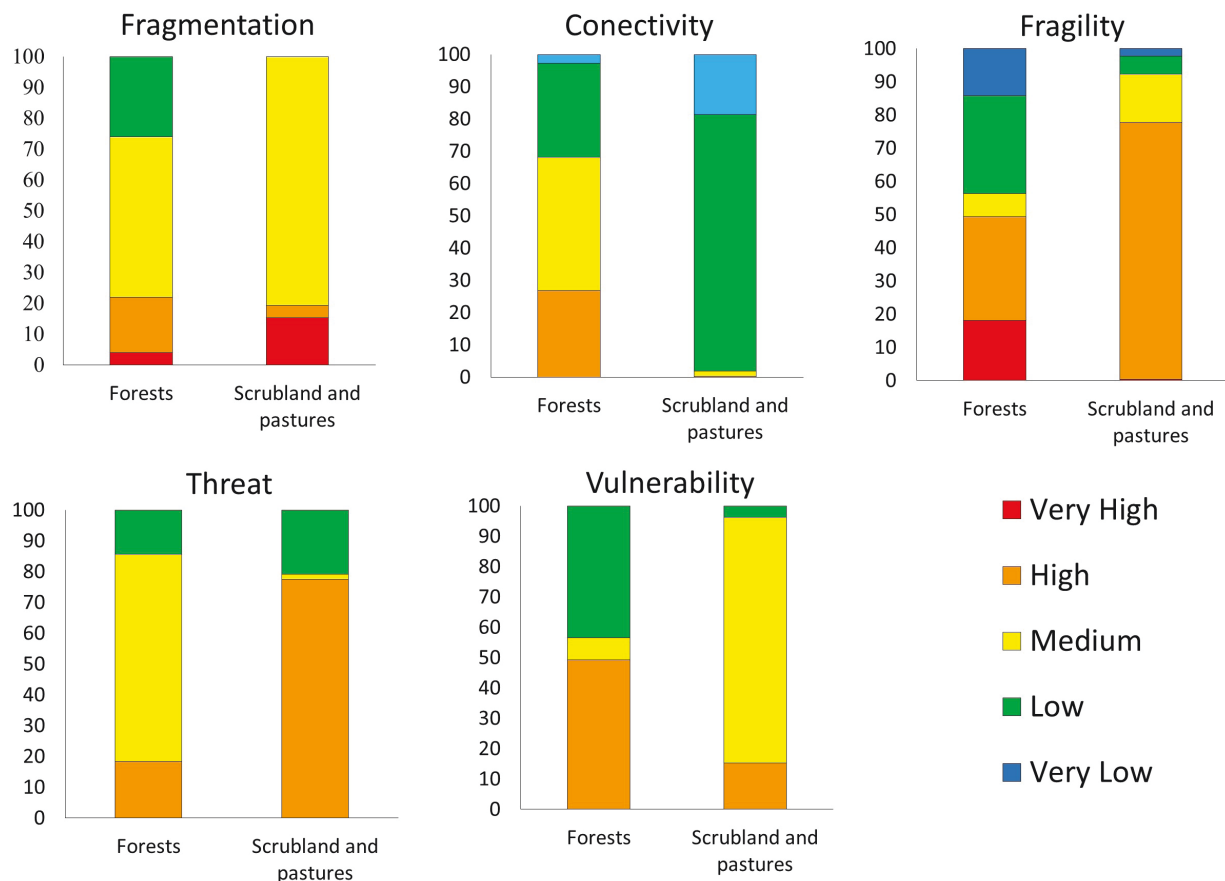


Figure 3. Proportion of the area covered by the different categories of the five ecosystem indicators for forest and scrublands & pastures separately. The five indicators were divided in five, four or three categories (see methods for more details), and therefore, some categories are missing for some indicators.

protected areas (Sierra et al. 2002), although they have been intensely deforested, thus, they are very fragile ecosystems. Therefore, conserving the larger blocks which this species inhabits (Kattan et al. 2004) as well as smaller patches of evergreen forests to promote the connectivity (Peralvo et al. 2005) should be implemented to ensure the preservation of these ecosystems and the habitat of the Andean Bear.

CONCLUSION

In summary, our results show that the ecosystems in which the Spectacled Bear inhabits have a poor conservation status, with an important proportion of the distribution range covered by ecosystems classified as fragmented, poorly connected, vulnerable, threatened, and fragile. Therefore, a national conservation strategy should be developed to enhance the conservation status of these ecosystems, which should include actions performed not only in areas where bears are present, but

also in areas where they are not. This would contribute to the conservation of these ecosystems at a national scale, which would effectively preserve Spectacled Bear habitats.

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Editorial

Pakshirajan Lakshminarasimhan: a plant taxonomist who loved plants and people alike
– Mandar N. Datar, Pp. 16195–16203

Communications

The worrisome conservation status of ecosystems within the distribution range of the Spectacled Bear *Tremarctos ornatus* (Mammalia: Carnivora: Ursidae) in Ecuador
– José Guerrero-Casado & Ramón H. Zambrano, Pp. 16204–16209

Living with Leopard *Panthera pardus fusca* (Mammalia: Carnivora: Felidae): livestock depredation and community perception in Kalakkad-Mundanthurai Tiger Reserve, southern Western Ghats
– Bawa Mothilal Krishnakumar, Rajarathinavelu Nagarajan & Kanagaraj Muthamizh Selvan, Pp. 16210–16218

An updated checklist of mammals of Odisha, India
– Subrat Debata & Himanshu Shekhar Palei, Pp. 16219–16229

Negative human-wildlife interactions in traditional agroforestry systems in Assam, India
– Yashmita-Ulman, Manoj Singh, Awadhesh Kumar & Madhubala Sharma, Pp. 16230–16238

Prevalence and morphotype diversity of *Trichuris* species and other soil-transmitted helminths in captive non-human primates in northern Nigeria
– Joshua Kamani, James P. Yidawi, Aliyu Sada, Emmanuel G. Msheliza & Usman A. Turaki, Pp. 16239–16244

Detection of hemoparasites in bats, Bangladesh
– Shariful Islam, Rakib Uddin Ahmed, Md. Kaisar Rahman, Jinnat Ferdous, Md. Helal Uddin, Sazed Akter, Abdullah Al Faruq, Mohammad Mahmudul Hassan, Ausraful Islam & Ariful Islam, Pp. 16245–16250

Ecology of the Critically Endangered Singidia Tilapia (Teleostei: Cichlidae: *Oreochromis esculentus*) of lake Kayanja, Uganda and its conservation implications
– Richard Olwa, Herbert Nakiyende, Elias Muhumuza, Samuel Bassa, Anthony Taabu-Munyaho & Winnie Nkalubo, Pp. 16251–16256

Length-weight relationships of two conservation-concern mahseers (Teleostei: Cyprinidae: *Tor*) of the river Cauvery, Karnataka, India
– Adrian C. Pinder, Rajeev Raghavan, Shannon D. Bower & J. Robert Britton, Pp. 16257–16261

The identity and distribution of *Bhavana annandalei* Hora, 1920 (Cypriniformes: Balitoridae), a hillstream loach endemic to the Western Ghats of India
– Remya L. Sundar, V.K. Anoop, Arya Sidharthan, Neelesh Dahanukar & Rajeev Raghavan, Pp. 16262–16271

Records of two toads *Duttaphrynus scaber* and *D. stomaticus* (Amphibia: Anura: Bufonidae) from southeastern India
– S.R. Ganesh, M. Rameshwaran, Naveen A. Joseph, Ahamed M. Jerith & Sushil K. Dutta, Pp. 16272–16278

Some rare damselflies and dragonflies (Odonata: Zygoptera and Anisoptera) in Ukraine: new records, notes on distribution, and habitat preferences
– Alexander V. Martynov, Pp. 16279–16294

Floristic diversity of Anjaneri Hills, Maharashtra, India
– Sanjay Gajanan Auti, Sharad Suresh Kambale, Kumar Vinod Chhotupuri Gosavi & Arun Nivrutti Chandore, Pp. 16295–16313

A checklist of macrofungi (mushroom) diversity and distribution in the forests of Tripura, India
– Sanjit Debnath, Ramesh Chandra Upadhyay, Rahul Saha, Koushik Majumdar, Panna Das & Ajay Krishna Saha, Pp. 16314–16346

Short Communications

A threat assessment of Three-striped Palm Squirrel *Funambulus palmarum* (Mammalia: Rodentia: Sciuridae) from roadkills in Sigur Plateau, Mudumalai Tiger Reserve, Tamil Nadu, India
– Arockianathan Samson, Balasundaram Ramakrishnan & Jabamalainathan Leonaprinay, Pp. 16347–16351

Impact of vehicular traffic on birds in Tiruchirappalli District, Tamil Nadu, India
– T. Siva & P. Neelamarayanan, Pp. 16352–16356

Ichthyofaunal diversity of Manjeera Reservoir, Manjeera Wildlife Sanctuary, Telangana, India
– Kante Krishna Prasad, Mohammad Younus & Chelmala Srinivasulu, Pp. 16357–16367

New distribution record of the endemic and critically endangered Giant Staghorn Fern *Platycerium grande* (Fee) Kunze (Polypodiaceae) in central Mindanao
– Cherie Cano-Mangaoang & Charissa Joy Arroyo Gumban, Pp. 16368–16372

Notes

First photographic record of the Dhole *Cuon alpinus* (Mammalia: Carnivora: Canidae) from the Sirumalai Hills in Tamil Nadu, India
– B.M. Krishnakumar & M. Eric Ramanujam, Pp. 16373–16376

Tracing heavy metals in urban ecosystems through the study of bat guano - a preliminary study from Kerala, India
– Jithin Johnson & Moncey Vincent, Pp. 16377–16379

Population dynamics and management strategies for the invasive African Catfish *Clarias gariepinus* (Burchell, 1822) in the Western Ghats hotspot
– Kuttanellloor Roshni, Chelapurath Radhakrishnan Renjithkumar, Rajeev Raghavan, Neelesh Dahanukar & Kutty Ranjeet, Pp. 16380–16384

First records of the black widow spider *Latrodectus elegans* Thorell, 1898 (Araneae: Theridiidae) from Nepal
– Binu Shrestha & Tobias Dörr, Pp. 16385–16388

First report of the assassin bug *Epidius wangi* (Heteroptera: Reduviidae: Harpactorinae) from India
– Swapnil S. Boyane & Hemant V. Ghate, Pp. 16389–16391

Observations of the damselfly *Platylestes cf. platystylus* Rambur, 1842 (Insecta: Odonata: Zygoptera: Lestidae) from peninsular India
– K.J. Rison & A. Vivek Chandran, Pp. 16392–16395

***Herminium longilobatum* (Orchidaceae), a new record for Bhutan**
– Ugyen Dechen, Tandin Wangchuk & Lam Norbu, Pp. 16396–16398

Recent record of a threatened holoparasitic plant *Sapria himalayana* Griff. in Mehao Wildlife Sanctuary, Arunachal Pradesh, India
– Arif Ahmad, Amit Kumar, Gopal Singh Rawat & G.V. Gopi, Pp. 16399–16401

Eleven new records of lichens to the state of Kerala, India
– Sonia Anna Zachariah, Sanjeeva Nayaka, Siljo Joseph, Pooja Gupta & Scaria Kadookunnel Varghese, Pp. 16402–16406

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