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References

BirdLife International 2016. *Anthracoceros albirostris*. The IUCN Red List of Threatened Species 2016: e.T22682437A92945575. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22682437A92945575.en. Downloaded on 23 January 2020.

BirdLife International 2018a. *Buceros bicornis*. The IUCN Red List of Threatened Species 2018: e.T22682453A131870948. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T22682453A131870948.en. Downloaded on 23 January 2020.

BirdLife International 2018b. *Rhyticeros undulatus*. The IUCN Red List of Threatened Species 2018: e.T22682528A132400385. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T22682528A132400385.en. Downloaded on 23 January 2020.

BirdLife International 2018c. *Aceros nipalensis*. The IUCN Red List of Threatened Species 2018: e.T22682510A131867116. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T22682510A131867116.en. Downloaded on 23 January 2020.

BirdLife International 2018d. *Anorrhinus austeni*. The IUCN Red List of Threatened Species 2018: e.T22731941A131871758. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T22731941A131871758.en. Downloaded on 23 January 2020.

Datta, A., 2009. Observations on Rufous-necked *Aceros nipalensis* and Austen's Brown *Anorrhinus austeni* Hornbills in Arunachal Pradesh: natural history, conservation status, and threats. *Indian Birds* 5 (4): 108–117.

Datta, A., & Rawat, G. S., 2003. Foraging patterns of sympatric hornbills during the nonbreeding season in Arunachal Pradesh, northeast India. *Biotropica* 35 (2): 208–218.

Datta, A., Naniwadekar, R., Rao, M., Sreenivasan, R., & Hiresavi, V., 2018. Hornbill Watch: A citizen science initiative for Indian hornbills. *Indian BIRDS* 14 (3): 65–70.

Jain, A., 2019. Website URL: https://ebird.org/view/checklist/S60385237. [Accessed on 23 January 2020.]

Pratim, M., 2018. Website URL: https://ebird.org/checklist/S58101566. [Accessed on 23 January 2020.]

Holbrook, K. M., Smith, T. B., & Hardesty, B. D., 2002. Implications of long-distance movements of frugivorous rain forest hornbills. *Ecography* (Cop.). 25 (6): 745–749.

Kannan, R., & James, D. A., 1999. Fruiting phenology and the conservation of the Great Pied Hornbill (*Buceros bicornis*) in the Western Ghats of Southern India. *Biotropica* 31 (1): 167–177.

Kinnaird, M. F., & O'Brien, T. G., 2007. The ecology and conservation of Asian hornbills: farmers of the forest. University of Chicago Press.

Kitamura, S., 2011. Frugivory and seed dispersal by hornbills (Bucerotidae) in tropical forests. *Acta Oecologica* 37 (6): 531–541.

Naniwadekar, R., Chaplod, S., Datta, A., Rathore, A., & Sridhar, H., 2019. Large frugivores matter: Insights from network and seed dispersal effectiveness approaches. *Journal of Animal Ecology* 88 (2): 1250–1262. D.O.I.: http://10.1111/1365-2656.13005

Pawar, P. Y., Naniwadekar, R., Raman, T. R. S., & Mudappa, D., 2018. Breeding biology of Great Hornbill *Buceros bicornis* in tropical rainforest human-modified plantation landscape in Western Ghats, India. *Ornithological Science* 17 (2): 205–216. D.O.I.: https://doi.org/10.2326/osj.17.205

Poonswad, P., 1995. Nest site characteristics of four sympatric species of hornbills in Khao Yai National Park, Thailand. *Ibis* 137 (2): 183–191.

Poonswad, P., Sukkasem, C., Phataramata, S., Hayeemuida, S., Plongmai, K., Chuailua, P., Thiensongrusame, P., & Jirawatkavi, N., 2005. Comparison of cavity modification and community involvement as strategies for hornbill conservation in Thailand. *Biological Conservation* 122 (3): 385–393.

Raman, T. R. S., & Mudappa, D., 2003. Correlates of hornbill distribution and abundance in rainforest fragments in the southern Western Ghats, India. *Bird Conservation International* 13: 199–212.

Sharma, N., Madhusudan, M. D., Sarkar, P., Bawri, M., & Sinha, A., 2012. Trends in extinction and persistence of diurnal primates in the fragmented lowland rainforests of the Upper Brahmaputra Valley, north-eastern India. *Oryx* 46 (2): 308–311.

Is the Indian Peafowl *Pavo cristatus* moving higher up in the mountains?

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The depletion of natural habitat, driven by human activities, and changes in climatic conditions are the most pronounced threat to biodiversity, resulting in massive range contractions and extinction of species (Pimm *et al.* 2014; He *et al.* 2018). The natural habitat of the Indian Peafowl consists of scrub-jungle of forest edges in sub-tropical and semi-arid regions (Ali & Ripley 1989). The birds are also abundant in agricultural fields, near streams, and water bodies (Padmanabhan 2007), and around human habitation in a semi-feral state (Johnsgard 1986). The species is well known for its ability to adapt and thrive in non-forested areas and agricultural lands; therefore, it is progressively becoming abundant in urban and semi-urban areas (Burton & Burton 2002). It occurs commonly in lowlands around 500 m asl (Baker 1930), but is frequently recorded up to 1,200 m asl in Nepal (Baral & Inskipp 2013). Its reported altitudinal range is up to 2,000 m asl (Dodsworth 1912; Ramesh & Mcgowan 2009), extending upwards from the Himalayan foothills.

Here, we have compiled the high altitudinal record of the Indian Peafowl, in the Himalayas and the Western Ghats, from data available on www.ebird.org, and a single camera trap image captured at 2,622 m asl in Darjeeling (26.99°N, 88.29°E), West Bengal, on 09 April 2019, which last record prompted this analysis.

Of the 18 high altitude (>2,000 m asl) records of the Indian Peafowl listed in Table 1, ten were from the Himalayan region, with 3,532 m asl being the highest elevation at which this bird was sighted, in Lantang National Park, Nepal (Gurung 2013). Whereas, eight sight records were from the Western Ghats, with 2,613 m asl (Plans 2015; Modi 2018) being the highest elevation recorded (Figs. 1, 2).

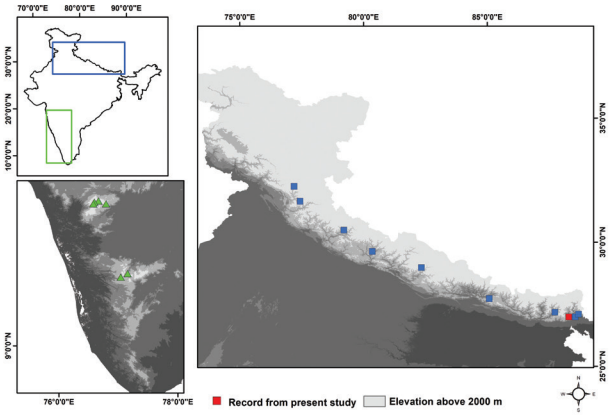

Fig. 1. Map showing the location of Indian Peafowl recorded above 2000 m asl in Himalayas and Western Ghat landscape.

A comparison of the occurrence of the species, in the two landscapes, in different months, does not reveal a clear pattern (Fig. 2; Table 1). Though sightings were in all the months, in both landscapes, (mostly in the 2,000–3,000 m elevation zone), the

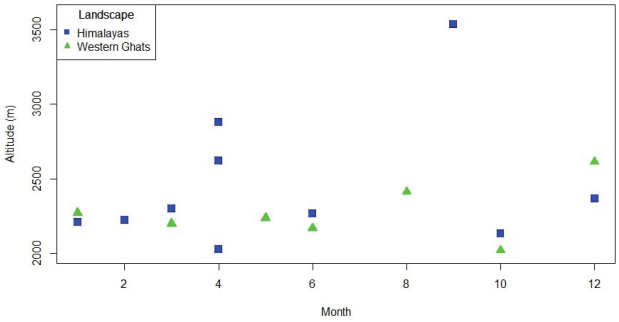

Fig. 2. Sightings of Indian Peafowl in the Indian Himalayas (blue squares) and the Western Ghats (green triangles) marked against altitude (m asl) across different months in a year.

majority of the sightings from higher elevations were from recent times, not earlier than 2010; the only exception being Fletcher's (1987) record, above 2,000 m asl, in 1987 (Fig. 3). While an increase in birdwatcher footfalls, and better coverage, could be one of the reasons for these altitudinal records, we feel that an iconic species like the Indian Peafowl would not have been missed by birders prior to 2010. Hence, there is a likelihood that the species is responding to rapid changes in climatic conditions, which have accelerated in the present century (Ross *et al.* 2018).

Jose V & Nameer (2020) predicted that the potential suitable habitat (dryland, scrub jungles, and semi-arid biomes) of the Indian Peafowl in the Kerala Western Ghats, under current conditions, is only 19.15%. Their species distribution model based on environmental and topographical conditions in the study predicted that distribution range of the species will increase

Table 1. Records of Indian Peafowl from the Himalayas, and the Western Ghats

Indian State/Nepal	Locality	Altitude (m)	Reference	Sighted on	Season
Himalayas					
Uttarakhand	Chopta	2877	Moteria (2017)	09-04-2017	Summer
Himachal Pradesh	Van Vihar	2133	Dookia (2017)	11-10-2017	Autumn
Himachal Pradesh	Sarahan	2267	Kumar (2013)	03-06-2013	Monsoon
West Bengal	Darjeeling	2222	Fletcher (1987)	10-02-1987	Winter
West Bengal #	Darjeeling	2622	Thapa (2019)	09-04-2019	Summer
West Bengal	Lava	2026	Bhoumik (2019)	15-04-2019	Summer
West Bengal	Neora Valley	2210	Das (2013)	10-01-2013	Winter
Karnali, Nepal	Barekot Area	2275	Bhusal (2016)	03-03-2016	Summer
Province 3, Nepal	Lantang	3532	Gurung (2013)	21-09-2013	Monsoon
Province 3, Nepal	Shivapuri-Nagarjun	2367	Barrett (2018)	26-12-2018	Winter
Western Ghats					
Kerala	Eravikulam	2020	Pakaravoor (2014)	15-10-2014	Autumn
Tamil Nadu	Dodabetta	2613	Modi (2018)	24-12-2018	Winter
Tamil Nadu	Dodabetta	2613	Plans (2015)	08-12-2015	Winter
Tamil Nadu	Gori Shola, Ooty	2411	Kumar (2016)	01-08-2016	Monsoon
Tamil Nadu	Carin Hills, Ooty	2270	Guthrie (2004)	19-01-2004	Winter
Tamil Nadu	Parsons Valley	2167	Jagadeesan (2016)	11-06-2016	Monsoon
Tamil Nadu	Porthimund Dam	2236	Kumar (2015)	23-05-2015	Summer
Tamil Nadu	Nanjanad	2264	Rajarajan V (2016)	03-03-2016	Summer

Observation from the present study

up to 41.44 % and 55.33% during 2050s and 2070s respectively whereas the habitat range may decline by 22.09% to 32.22% by the 2070s. They also report that the shift in the range is mostly seen due to increasing drought and aridity because of reduced non-monsoon precipitation in the mid- and low land regions of southern Kerala.

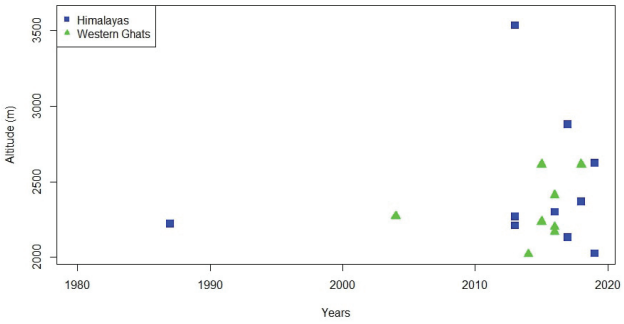

Fig. 3. Sightings of Indian Peafowl before and after 2000 indicating the observational records (present study and eBird.org) of Indian Peafowl at altitudes above 2,000 m asl.

Guhathakurta & Rajeevan (2008), IMD (2015), and IPCC (2018) all reported that due to global climate change, the temperature and rainfall pattern in India had been affected. A century ago, the mean annual temperature of Darjeeling was 13.4°C, which has now gone up by 1.05°C, to 14.5°C. The rise in mean annual temperature of adjacent districts in the plains (Jalpaiguri, Cooch Behar, and Malda) has been only 0.4°C to 0.6°C, indicating that the hills are more vulnerable to climate change and are warming up at a faster rate than the plains (Lakhotia 2006). A careful investigation of the global range of such species that are shifting to a higher elevation, or invading different habitats, will help us understand the pressure of human interference, deforestation, and climate change. Indian Peafowl data should be used as a bioindicator and could also be used for predictive modelling across the country to help us understand their pattern of invasion.

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References

Ali, S., & Ripley, S.D., 1989. *The compact handbook of the birds of India and Pakistan.* Bombay: Oxford University Press.

Baker, E.C., 1930. *The fauna of British India*. vol. 5. London: Taylor & Francis.

Baral, H.S., & Inskipp, S., 2013. Status of Indian Peafowl *Pavo cristatus* in Nepal. *Indian BIRDS* 8 (6): 145–147.

Barrett, B., 2018. Website URL: https://ebird.org/view/checklist/S50960456. [Accessed on 20 October 2019.]

Bhoumik, S., 2019. Website URL: https://ebird.org/view/checklist/S55208826. [Accessed on 20 October 2019.]

Bhusal, K., 2016. Website URL: https://ebird.org/view/checklist/S35191095. [Accessed on 20 October 2019.]

Burton, M., & Burton, R., 2002. *International Wildlife Encyclopedia*. New York: Marshall Cavendish.

Das, A., 2013. Website URL: https://ebird.org/view/checklist/S52038926. [Accessed on 20 October 2019.]

Dodsworth, P. T.L., 1912. Occurrence of the Common Peafowl *Pavo cristatus* in the neighbourhood of Shimla, N–W Himalayas. *Journal of Bombay Natural History Society* 21: 1082–1082.

Dookia, S., 2017. Website URL: https://ebird.org/view/checklist/S39905592. [Accessed on 20 October 2019.]

Fletcher, M., 1987. Website URL: https://ebird.org/view/checklist/S19194334. [Accessed on 20 October 2019.]

Guhathakurta, P., & Rajeevan, M., 2008. Trends in the rainfall pattern over India. Int. J. Climatol 28: 1453–1469.

Gurung, K., 2013. Website URL: https://ebird.org/view/checklist/S15227046. [Accessed on 20 October 2019.]

Guthrie, D., 2004. Website URL: https://ebird.org/view/checklist/S36696844. [Accessed on 20 October 2019.]

He, J., Yan, C., Holyoak, M., Wan, X., Ren, G., Hou, Y., Xie, Y. & Zhang, Z., 2018. Quantifying the effects of climate and anthropogenic change on regional species loss in China. *PloS one 13* (7): e0199735.

IMD, 2015. Annual Climate Summary-2014. Indian Meteorological Department, Government of India. Pp 24.

IPCC, 2018. Summary for policymakers. In: Masson-Delmotte, V., Zhai, P., Portner, H.O.,Roberts, D., Skea, J., Shukla, P.R., Pirani, A., Moufouma-Okia, W., Pean, C., Pidcock, R., Connors, S., Matthews, J.B.R., Chen, Y., Zhou, X., Gomis, M.I., Lonnoy, E., Maycock, T., Tignor, M., & Waterfield, T. (Eds.), Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C Above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty. World Meteorological Organization, Geneva, Switzerland.

Jagadeesan, C., 2016. Website URL: https://ebird.org/view/checklist/S30253278. [Accessed on 20 October 2019.]

Johnsgard, P. A., 1986. *The Pheasants of the World*. New York: Oxford University Press. Pp 1–295.

Jose V. S., & Nameer, P.O., 2020. The expanding distribution of the Indian Peafowl (*Pavo cristatus*) as an indicator of changing climate in Kerala, southern India: A modelling study using MaxEnt. *Ecological Indicators 110*: 105930.

Kumar, A., 2013. Website URL: https://ebird.org/view/checklist/S42984291. [Accessed on 20 October 2019.]

Kumar, D., 2016. Website URL: https://ebird.org/view/checklist/S30933536. [Accessed on 20 October 2019.]

Kumar, K. S., 2015. Website URL: https://ebird.org/view/checklist/S23622000. [Accessed on 20 October 2019.]

Lakhotia, A.S., 2006. Darjeeling warming up faster than world. The Telegraph (06-11-2006).

Modi, B., 2018. Website URL: https://ebird.org/view/checklist/ S51083570. [Accessed on 20 October 2019.]

Moteria, S., 2017. Website URL: https://ebird.org/view/checklist/S36037049. [Accessed on 20 October 2019.]

Padmanabhan, P., 2007. Ethno zoological studies on the tribals of Palakkad and Malappuram districts of Kerala, South India. *Kerala Forest Research Institute Research Report* no. 292.

Pakaravoor, C., 2014. Website URL: https://ebird.org/view/checklist/S20294000. [Accessed on 20 October 2019.]

Pimm, S.L., Jenkins, C.N., Abell, R., Brooks, T.M., Gittleman, J.L., Joppa, L.N., Raven, P.H., Roberts, C.M. & Sexton, J.O., 2014. The biodiversity of species and their rates of extinction, distribution, and protection. *Science* 344 (6187):1246752.

Plans, P., 2015. Website URL: https://ebird.org/view/checklist/S55009232. [Accessed on 20 October 2019.]

Rajarajan, V., 2016. Website URL: https://ebird.org/view/checklist/S28514674. [Accessed on 20 October 2019.]

Ramesh, K. & Mcgowan, P., 2009. On the current status of Indian Peafowl Pavo cristatus (Aves: Galliformes: Phasianidae): keeping the common species common. *Journal of Threatened Taxa* 1(2): 106–108.

Ross, R.S., Krishnamurti, T.N., Pattnaik, S. and Pai, D.S., 2018. Decadal surface temperature trends in India based on a new high-resolution data set. *Scientific reports* 8(1): 7452.

Thapa, A., 2019. Website URL: https://ebird.org/view/checklist/S61220781. [Accessed on 20 October 2019.]