

# The role of citizen science in studying Lepidoptera biology and conservation in India

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**Abstract:** Citizen science is transforming the landscape of big data on biodiversity, ecology and conservation. In India, new data on the distribution and biology of butterflies and moths are being generated through the Butterflies of India and Moths of India websites with contributions from a large network of amateur naturalists. These efforts have led to new species descriptions, species rediscoveries, and range extensions into India. These citizen science platforms are filling gaps in our knowledge of butterfly and moth distributions, flight periods, early stages, larval host plants and other natural history information, including that of many endemic, rare and endangered species.

Key words: biodiversity informatics, butterflies, moths, Lepidoptera

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Recent reports of decline in insect populations have raised alarm worldwide (Hallmann et al., 2017; Leather, 2018; Sánchez-Bayo and Wyckhuys, 2019). The situation with Lepidoptera is not any different, with many studies reporting population declines of butterflies and moths (Fox, 2013; van Langevelde et al., 2018; Thogmartin et al., 2017). In Europe and North America, citizen science programmes have been used successfully to generate large data sets for monitoring populations (Carpaneto et al., 2017; Chandler et al., 2017; Dennis et al., 2017; Pocock et al., 2015, 2017). The United Kingdom Butterfly Monitoring Scheme (UKBMS) has been collecting butterfly data since 1976 (<https://www.ukbms.org>). The Big Butterfly

Count has been conducting annual butterfly counts in the United Kingdom since 2010 (<https://www.bigbutterflycount.org>).

National Moth Week, which started in 2013, conducts annual moth monitoring in July across the world (Moskowitz and Haramaty, 2013). In the United States, caterpillar-monitoring programs are being used to monitor arthropod early stages (Hurlbert et al., 2018).

In India, there has been no long-term monitoring of insect populations or large-scale rigorous documentation of insect biodiversity. In fact, the problem remains of insufficient data on even flagship groups such as butterflies with respect to their diversity and distributions, flight periods, early stages and other basic ecological information. In order to fill this gap, in 2010, the Indian Foundation for Butterflies

launched a species-based bioinformatics platform, Butterflies of India (<https://www.ifoundbutterflies.org/>).

Using the same bioinformatics backbone, numerous other citizen science initiatives were launched subsequently covering [odonates](#) (April 2014), [moths](#) (November 2014), [cicadas](#) (February 2015), [reptiles](#) (August 2017), [amphibians](#) (August 2017), [birds](#) (October 2017) and [mammals](#) (September 2018). Collectively, they form Biodiversity Atlas – India (<https://www.bioatlasindia.org/>), which is a species-based bioinformatics platform that is voluntarily supported by numerous organisations such as the National Centre for Biological Sciences, Indian Foundation for Butterflies, Diversity India, and Titli Trust, and by thousands of naturalists and citizen scientists worldwide who contribute data. The platform is designed for aggregating,

displaying and analysing biodiversity data from tropical developing countries and other biodiversity hotspots such as India. It is a distributed platform of stand-alone, taxon-specific, natural history websites that give ownership and recognition to contributing naturalists. These websites are being used extensively for research as well as educational and outreach activities by professional and citizen scientists. This article tracks the progress of the Lepidoptera sections of this bioinformatics platform and offers an insight into some of their user-friendly features.

Since the launch of the bioinformatics platform in 2010, the number of species pages for butterflies and moths has increased significantly. At last count on 12 January 2020, the Butterflies of India website (Kunte et al., 2019) had 1,029 species while the Moths of India website (Sondhi et al., 2019) had 1,200 species. Fig.

Table 1. Growth in numbers for the Butterflies of India and Moths of India websites

Websites in numbers	Butterflies of India	Moths of India
Launch year	2010	2015
No. of species pages	1,029	1,200
No. of lifecycles	360	77
No. of curated images	70,000	7,000
No. of contributors	Over 1,000	Over 160
No. of expert reviewers	21	18
No. of website visits	1,065,226	37,139
No. of unique visitors	312,096	17,357

Fig. 1. A. Growth of species pages on the Butterflies of India (blue line) and Moths of India (red line) websites. B. Growth of peer-reviewed images on the Butterflies of India website.

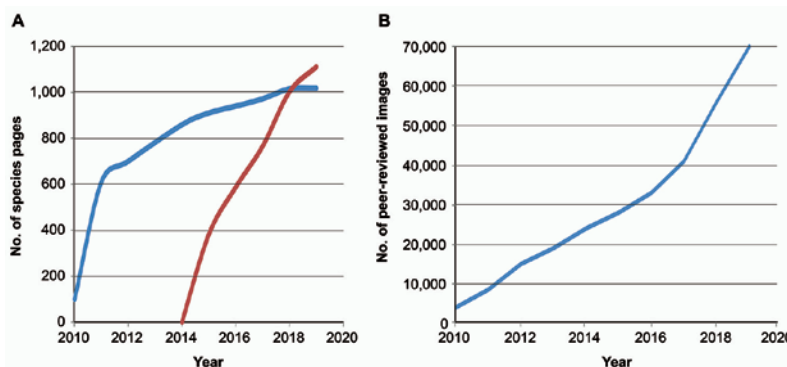


Fig. 2. *Callerebia dibangensis* and *Hypolycaena narada*, two recently described butterfly species, on the Butterflies of India website. Images: Krushnamegh Kunte from Butterflies of India, used with permission from the photographer, Natural History Museum, London, and NCBS.



1A shows the species page growth curve of the websites. The contributions from citizen scientists for both the websites have grown rapidly with over a 1,000 contributors for the butterfly website and 200 contributors for the moth website (Table 1). More than

70,000 butterfly images and 7,000 moth images, along with the associated information on precise locations, dates, species and subspecies, seasonal forms, sex, etc., form large datasets on the websites (Table 1, Fig. 1B).

Fig. 3. Representative species rediscoveries and first Indian records on the Butterflies of India website. Images: *Symbrenthia silana*: Krushnamegh Kunte, *Callinaga aborica*: Sanjay Sondhi, *Hestina nicevillei*: David Raju, *Bhutanitis ludlowi*: Sujatha Padmanabhan, *Byasa crassipes*: Arjan Basu Roy and Yoji Matsuda, *Erynnis pelias*: Balaji P. Balachandran; from Butterflies of India, used with permission from the photographers and NCBS.

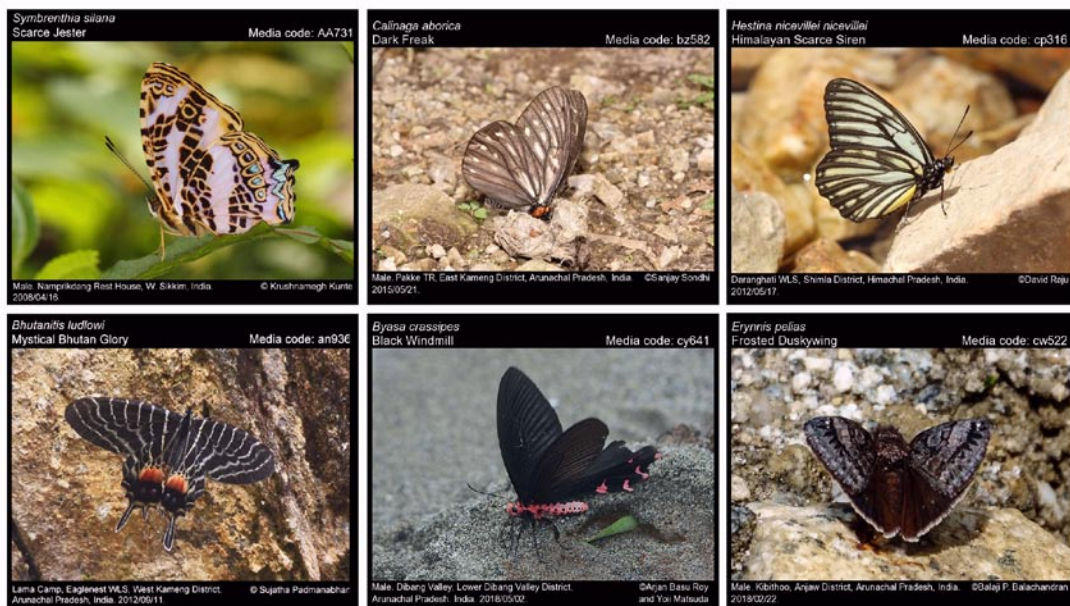


Fig. 4. Representative species discoveries and first Indian records on the Moths of India website. All images: Sanjay and Yash Sondhi, from Moths of India, used with permission from the photographer and NCBS.



Peer review and curation of the images and other information contributed are two critical aspects of these websites, making them arguably the largest and most reliable sources of information on Indian butterflies and moths. Photo-documentation

Fig. 5. In addition to displaying images of adult butterflies and moths and all the variation that they represent, the websites also display images of early stages (eggs, caterpillars and pupae).



of early stages of 355 butterfly species and 77 moth species, along with information on larval host plants, is also presented. A dedicated team of 21 reviewers for the butterfly website and 18 reviewers for the moth website has worked on a voluntary basis to curate these resources. The number of website visits and the number of unique visitors continues to grow rapidly as the websites have become the go-to resources for casual nature lovers, serious naturalists, citizen scientists and professional researchers alike (Table 1). The websites have received dozens of citations in scientific research papers, along with mentions in popular articles and natural history books.

Two new butterfly species described from India in recent times, *Callerebia dibangensis* Roy, 2013 and *Hypolycaena*

*narada* Kunte, 2015 are also displayed on the website (Fig. 2). Many species rediscoveries and new records for India such as *Symbrenthia silana*, *Erynnis pelias*, *Byasa crassipes*, *Bhutanitis ludlowi*, *Calinaga buddha*, *Calinaga aborica*, *Athyma punctata* and *Hestina nicevillei* are also featured on the butterfly website (Fig. 3). Similarly, a new moth species described from India, *Theretra shendurneensis* Sondhi, Kitching, Basu & Kunte, 2017 as well as several new records for India such as *Marumba irata*, *Macrobrochis albifascia*, *Krananda lucidaria*, *Sinna floralis* and *Sphinx oberthueri* are reported on the moth website (Fig. 4).

Such an impact is possible because of highly committed contributors and the Indian naturalist community on the whole. This community continues to grow because

Fig. 6. Contributors may also submit observations on larval host plants and nectar plants, which generate a useful understanding of plant-butterfly/moth relationships that are important for species conservation. Images: Paresh Churi, Medha Rao, Darraprasad Sawant and Abhinav D. Nair; from Butterflies of India, used with permission from the photographers and NCBS.

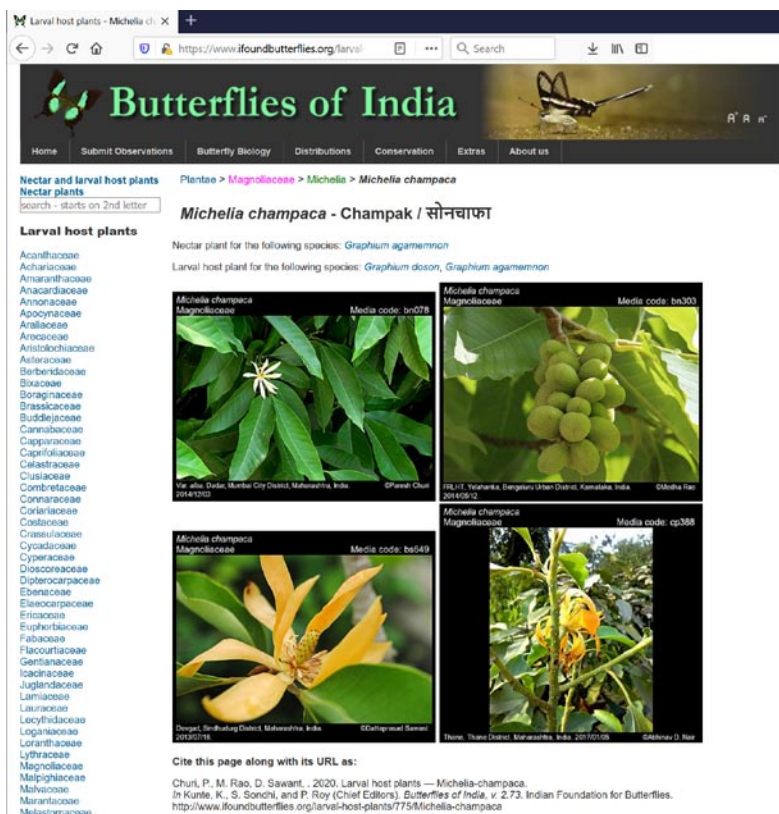


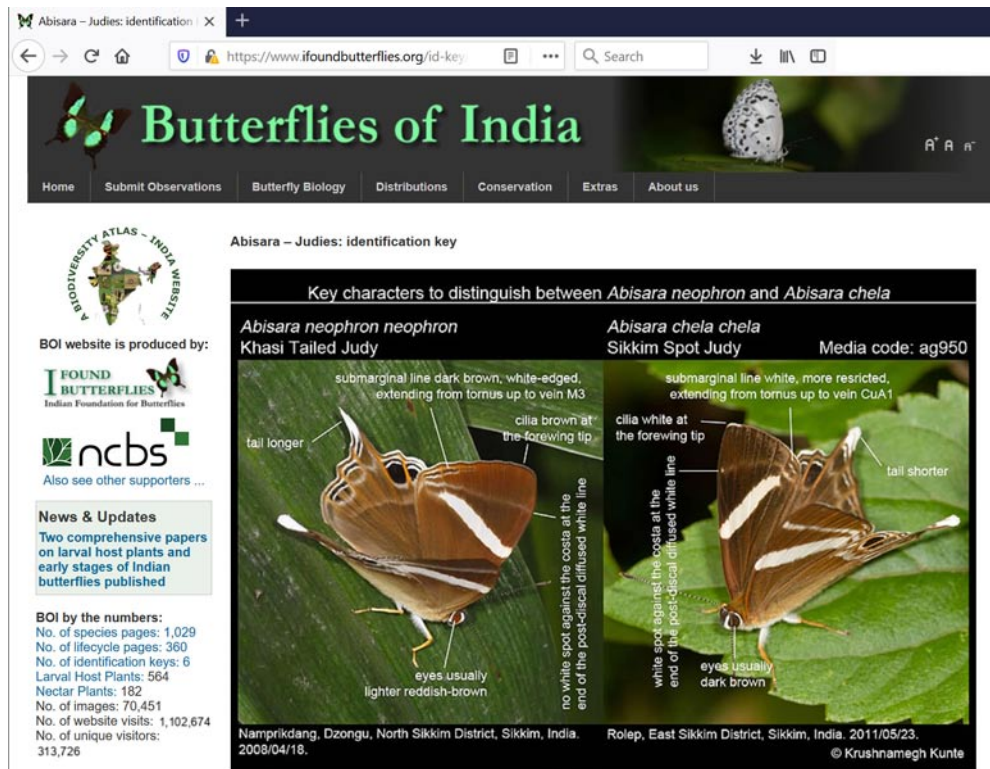
Fig. 7. All observations are centrally databased at a subspecies level. From these spot records, distributional ranges of species and subspecies are displayed on individual species pages. Such information, along with information on flight periods, is useful in the long term to study effects of climate change. The map is used with permission from NCBS.



of outreach and training achieved through Biodiversity Marathons and yearly meets. Biodiversity Marathons are data marathons that are held every few months in different parts of the country, typically hosted by local non-governmental organisations (NGOs) and other groups, and coordinated by NCBS. These events typically start with a nature trail, followed by an indoor session that explains various key features of these citizen science platforms, and encourage the participants to contribute their images and other data to these unique natural history data repositories. Annual Butterfly and Moth Meets are organised to help participants become better naturalists and citizen

scientists through training in field methods and species identification. These meets are organised in partnership with NGOs such as Titli Trust, Diversity India and Nature Mates. The meets not only generate valuable biodiversity data, they also benefit local communities, who assist to organise these biodiversity meets. In the past decade, more than 20 such meets have been organised in diverse locations such as Arunachal Pradesh, Nagaland, Meghalaya, West Bengal, Uttarakhand, Karnataka and Kerala. Participation in global events such as National Moth Week helps generate additional data and awareness.

Fig. 8. An example of an illustrated identification key. Images: Krushnamegh Kunte; from Butterflies of India, used with permission from the photographer and NCBS.



The websites have numerous user-friendly features and functions that provide additional information to users. They also provide intuitive navigation and tools to identify species and explore the diversity of butterflies and moths. Some of these features include:

- Taxonomically updated binomial and trinomial scientific names, along with higher classification (tribes, subfamilies, families and superfamilies) for all the species covered.
- Reliable information and well-curated, peer-reviewed image libraries of butterflies and moths along with their early stages (eggs, caterpillars and pupae), larval host plants and nectar plants (Fig. 5-6).
- Complete information on the species name, exact location and date, along

with the name of the photographer on each image displayed (Fig. 2-4).

- Distribution maps for species (Fig.7).
- Identification keys (Fig. 8).
- Information on flight periods by state.
- Information on similar species, references for identification, and bibliography (for moths).
- Advanced search that permits users to: (a) locate species by common name, scientific name, family, subfamily and genera, (b) browse species by life stages (adult, egg, caterpillar, pupa), and (c) search by photographer, month, state, district, etc. This can assist users to plan their field trips, prepare for species that they might encounter in a particular area in a specific season, and also prepare a

Fig. 9. Interface to submit observations by citizen scientists. Contributions from ordinary citizen scientists is driving the rapid growth of these websites and all the information that is generated on the butterflies and moths of India. Used with permission from NCBS.

Submit Observations

Taxon (if known): Bhutanitis lidderdalii lidderdalii - Himalayan Bhutan Glory (subspecies)

Taxon search: Searches after 3rd letter entry, if not found use 'plus button'

Date: 30 Aug 2019

Life stage: Adult

Location: Pange to Talle forest road, Talle WLS, Lower Subansiri District, Arunachal Pradesh, India

Location search: Searches after 2nd letter, if no location is found use the 'plus button' to add a new location.

Altitude (optional): Altitude in meters, whole number

Gender (optional): Male

Species form (optional): if not found enter own value


Seasonal, abberant etc (optional): if not found enter own value

Habitat (optional): Mid-elevation evergreen forest

Notes (optional):

Name for copyright (do not include copyright symbol): Krushnamegh Kunte

Email (of contributor): krushnamegh@ifoundbutterflies.org

 BhutanitisLidderdaliiLidderdalii07\_TalleToPangeForestRd-TalleWLS\_2019-08-30\_KrushnameghKunte.jpg 531.24 KB

JPG format. Before uploading, images should ideally be cropped close to the butterfly as the resolution allows and be 680 x 470 pixels (width x height), or if larger, in that ratio. Avoid images larger than 1200pixels to conserve our storage space. No logos/copyright and borders please.

personal field identification guide for their field trip.

- A user-friendly interface to submit images with relevant information, to be used by citizen scientists to submit their observations (Fig. 9).

Going forward, on the 10<sup>th</sup> anniversary of the Butterflies of India website in 2020, the Biodiversity Atlas – India platform will see a major upgrade to its content management system, launch of new features including mobile applications, and a long-term population monitoring programme for Indian butterflies. These are certainly exciting times to do natural history, citizen science and big-data science in India. We hope that these developments will build a

substantial knowledge base on Indian biodiversity, and contribute towards its scientific exploration and conservation.

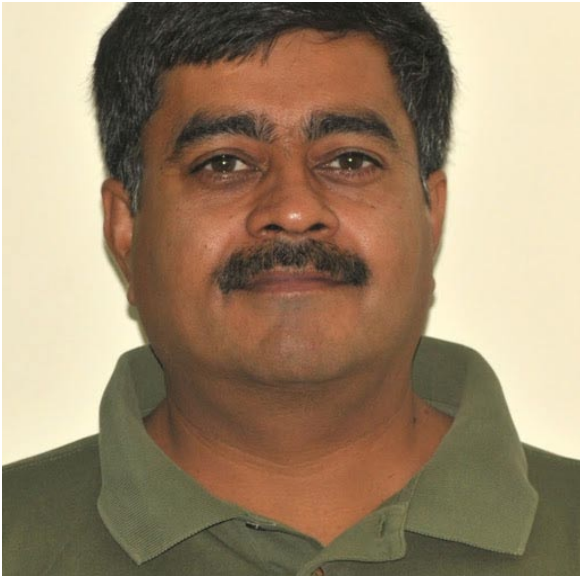
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