



OVERCOMING THE TAXONOMIC IMPEDIMENT: AN ACTION PLAN FOR INDIA

J POORANI*

ICAR-National Research Centre for Banana, Thogamalai Road, Thayanur Post, Tiruchirappalli 620102,
Tamil Nadu, India

*Email: poorani.j@icar.gov.in (corresponding author)

ABSTRACT

Insect taxonomy in India has been on a terminal decline and the unknown and undocumented insects of India face the threat of extinction before they are formally described due to climate change, habitat destruction and other anthropogenic factors. Ways to overcome the so called 'Taxonomic impediment', loosely defined as the lack of experts and funds and other resources for taxonomic research, are briefly discussed in the Indian context. A combination of concise morphological descriptions, high resolution digital imaging and open access web publishing with at least minimum molecular characterization (COI sequences) appears to be an ideal way to promote fast track documentation of Indian insects. Needless to add, increased funding and opportunities for insect taxonomy is the foremost requirement to further the cause of insect taxonomy in India. For this, insect taxonomic services should be recognized as a major input in agricultural pest management technology by ICAR and state agricultural universities.

Key words: Insect taxonomy, taxonomic impediment, diversity, India

Insects are the most omnipresent, successful, and dominant forms in the whole of animal kingdom and remarkably adaptable to a variety of environments and habitats. They play a major role in agriculture as pests of crops and livestock, transmit diseases and cause great losses to mankind. On the other hand, beneficial insects provide a variety of ecosystem services as predators and parasitoids that can be used for biological pest control, pollinators, soil fauna involved in decomposition and nutrient cycling, etc. and some insects are valuable sources of chemicals and medicines. In agriculture, accurate identification of insect pests, both native and new invasive species, their bioagents, pollinators and other beneficial insects is of fundamental importance for effective, sustainable pest management and conservation of beneficial fauna.

India, with 2% of global space, is one of the megadiversity nations in the world in terms of insect diversity with a rich and diverse fauna. At present, 66741 species of insects (including Collembola, Protura, Diplura and other groups) and 6134 species of arachnids are known from India, accounting for about 6.5% of the world fauna (Banerjee et al., 2022;

see Table 1). India's insect diversity is unique with a high level, nearly one-third, of endemism. Precise estimates of actual numbers are lacking for India, but apparently only about one-third of our existing insect diversity has been documented / formally described.

Anthropogenic factors and climate change have emerged as key determinants of changes in the biodiversity of well-studied species-groups in many parts of the world, but detailed studies on these aspects are lacking in India. The unknown and undocumented insects of India are facing the threat of extinction before description due to the threats posed by climate change, habitat destruction and most importantly, lack of expertise and funds for insect taxonomic research (the so called "taxonomic impediment"). Insect taxonomy in India has been on a steady and alarming decline in recent years and the taxonomic impediment has been the most challenging problem to overcome.

The higher classification of insect orders has undergone a drastic change in recent times based on comprehensive phylogenetic analyses of morphological and molecular characters of

representative world collections. This has come due to large scale collaboration among insect taxonomists of the world based in major museums with access to representative world collections and NGS facilities. The major task for Indian insect taxonomists is to do primary revisions and re-examine the known taxa as per the latest revised phylogenetic classification for major orders / families / tribes of insects and it involves a lot of alpha taxonomy, looked down by the advanced world.

Table 1. Number of insect and arachnid species known from India (data up to December 2021, ZSI)

| Group | Number of species - World | Number of species - India | 2021 additions |
|------------|---------------------------|---------------------------|----------------|
| Collembola | 8162 | 340 | |
| Diplura | 975 | 18 | |
| Protura | 816 | 20 | |
| Insecta | 1053881 | 66363 | 303 |
| Arachnida | 60052 | 6134 | 52 |

‘Taxonomic impediment’ is generally interpreted as the dearth of qualified taxonomists to take up the laborious task of documenting biodiversity before extinction and the lack of funds and other resources. Recent attempts by some insect taxonomists of the world to ‘speed up’ the taxonomic process and describe taxa at a rapid pace have drawn a lot of attention. For example, replacing descriptions and hypotheses of species with a DNA barcode (wrongly dubbed a ‘diagnosis’; Sharkey et al., 2021), or replacing name-bearing specimens held in public curated collections with photographs of species live in the field (Pape, 2016), have resulted in a big furore and adverse reactions from the world taxonomic community (Ceríaco et al., 2016; Ahrens et al., 2021; Engel et al., 2021).

Unfortunately, Indian insect taxonomists are not a part of any of the major initiatives on the higher classification of insects and face a plethora of problems for establishing research collaborations, mainly due to lack of funding and practical problems in exchanging specimens and research material due to various restrictions. Analysis of publications on

the systematics of Indian insects in the last decade with particular focus on insect groups that are of importance as crop pests, predators, parasitoids, and pollinators shows worrying trends. The numbers of new taxa and new records in different orders from India in 2021 are summarised in Table 2. Analysis of the publications over the last decade shows that for several major groups of insects there is hardly any expertise in India.

Isolated descriptions of a single or few unrelated taxa still form a major chunk of the papers published from this region and revisions of genera and supra-generic taxa are few and far between. Even a cursory look of recent taxonomic publications on Indian insects confirms that for most Indian insect taxonomists, publishing descriptions of new taxa takes precedence over redefinition and recognition of already described ones. Many Indian taxonomists have poor knowledge of the International Code of Zoological Nomenclature and wilfully neglect publication ethics.

The state of insect collections in India is a major concern. At present, reference collections in many institutions have been badly neglected and need proper curation and restoration. The major institutional collections in India are at the Zoological Survey of India, Kolkata and its various regional stations (general faunistic collections); Indian Agricultural Research Institute, New Delhi (National Pusa Collection, mainly insects of agricultural importance), Forest Research Institute, Dehradun and KFRI, Peechi (forest pests); and NBAIR, Bangalore (mainly parasitoids and predators of crop pests). Besides these, some agricultural universities under NARS (e.g., UAS, Bangalore; TNAU, Coimbatore), Zoology departments of traditional universities (e.g. Aligarh Muslim University, Aligarh; Panjab University, Patiala; University of Calicut, Calicut) and private institutions and individuals working on specific groups (e.g. ATREE, Bangalore) are maintaining small collections.

Table 2. New species and records of insects from India in 2021
(Source: Banerjee et al., 2022)

| S. No. | Order | New genus | New species | New subspecies | New record |
|--------|---------------|-----------|-------------|----------------|------------|
| 1 | Diptera | | 8 | 1 | 6 |
| 2 | Lepidoptera | 1 | 14 | | 22 |
| 3 | Trichoptera | | 3 | | 10 |
| 4 | Neuroptera | | 3 | | |
| 5 | Coleoptera | | 23 | | 5 |
| 6 | Hymenoptera | 1 | 80 | | 13 |
| 7 | Hemiptera | 4 | 45 | | 6 |
| 8 | Thysanoptera | | 4 | | 9 |
| 9 | Psocoptera | | 1 | | 1 |
| 10 | Orthoptera | | 11 | | |
| 11 | Blattodea | | 3 | | |
| 12 | Odonata | | 3 | | 5 |
| 13 | Ephemeroptera | | 21 | | 7 |
| 14 | Arachnida | 3 | 48 | | 4 |
| | Total | 9 | 227 | 1 | 88 |

The state of many of these collections is by and large very poor. Unfortunately, recent initiatives like the ICAR funded Network Project on Insect Biosystematics (NPIB) and the Niche Area of Excellence for Capacity Building in Taxonomy of Insects and Mites have been abandoned midway despite excellent performance indicators. The fate of regional collections made under the NPIB is not known and in the absence of dedicated manpower, these small collections are not likely to survive for long, if they still exist.

At this juncture, the primary duty of insect taxonomists in India is to make the known fauna identifiable and also discover and document unknown taxa, primarily and inevitably using alpha taxonomy with at least minimum molecular support in the form of DNA barcode sequences wherever possible. There is a need to promote revisionary taxonomy and re-examine known taxa as per the latest revised higher classification for major orders / families / tribes of insects. For this, better funding, infrastructure and training for young taxonomists and networking of all Indian taxonomists should be ensured. The reality today is that examination of type specimens in various foreign museums is not possible for fund-starved Indian insect taxonomists and in many cases, particularly female types, only inferences could be drawn about the correct generic / species placement. Digitized types / type photos generously shared by

most international museums have only limited utility in many cases. Such issues could be solved much faster by using DNA barcodes and refinement of protocols for sequencing of museum specimens stored in poor conditions in India.

Good taxonomic theory and practice has always been based on the inclusion of morphology, biology / ecology / behaviour and any other characters of utility to distinguish taxa and contrary to popular opinion, taxonomy remains one of the most integrative of all biological disciplines. The latest advances in imaging and molecular tools should be used for documenting the Indian insect fauna. At present, taxonomists working on various groups of insects of importance in agriculture and forestry are scattered in different institutions including the NBAIR, Bangalore, UAS, Bangalore, other NARS institutions, traditional universities, Zoological Survey of India and its regional stations, and institutions under the Indian Council of Forestry Research and Education (ICFRE) such as Forest Research Institute, Institute of Wood Science and Technology, and others. Better linkages are needed for the taxonomists under a country-wide umbrella so that expertise and collections in the custody of these institutions can be tapped. Identification services for researchers and students of entomology need to be strengthened because only a handful of insect taxonomists extend a helping hand.

“Turbo-taxonomy” or fast track taxonomy, an approach combining *cox1* sequences, concise morphological descriptions by an expert taxonomist, and high-resolution digital imaging to streamline the formal description of large numbers of new species combined with open access web-publication and automated pushing of content from journal into a wiki, may create the most efficient and sustainable way to conduct taxonomy in the future (Riedel et al., 2013). As pointed out by Riedel et al. (2013), a combination of digital imaging and molecular techniques allows the reduction of formal species descriptions to brief but highly accurate diagnoses and a mandatory requirement for the publication of genetic data following the example of the Bacteriological Code will be highly useful for non-taxonomists. Unfortunately, facilities for DNA sequencing and high-resolution digital imaging are not within easy reach for many underfunded Indian insect taxonomists.

CONCLUSION

As pointed out by Engel et al. (2021), the taxonomic impediment is the lack of qualified taxonomists and not the technical approaches. Indian insect taxonomists have a moral duty to ensure their work remains relevant, responsible and accountable to the needs of stakeholders and provide a solid foundation for agricultural entomologists for detection of invasive pests, generation of technologies in integrated pest management and biological control, etc. Institutions like IARI and NBAIR, where imaging facilities, DNA sequencing and fast and open internet access are easily available, should do more to promote insect taxonomic research by networking and sharing their resources. This will ensure that at least economically important insect groups are treated on an integrated taxonomic framework in line with the latest world standards. Last but not the least, lack of funds and employment prospects for insect taxonomists remains the most difficult challenge to overcome. Poor recognition to insect taxonomists should also be rectified by recognizing insect systematics as a major input in agricultural pest management technology.

Recently, the European Commission has started an initiative called “The Red List of Insect Taxonomists” to assess the available taxonomic expertise on insects across Europe, particularly for selected taxa of importance such as pollinators. A similar exercise in India is needed for identifying the number, location and academic profile of available expertise in insect taxonomy. This will help in better networking, sharing resources, including pooling of collections on various insect groups.

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