23 Integrative taxonomy – Methods and Applications

Sandhya Sukumaran and A. Gopalakrishnan

Central Marine Fisheries Research Institute, Kochi-682 018

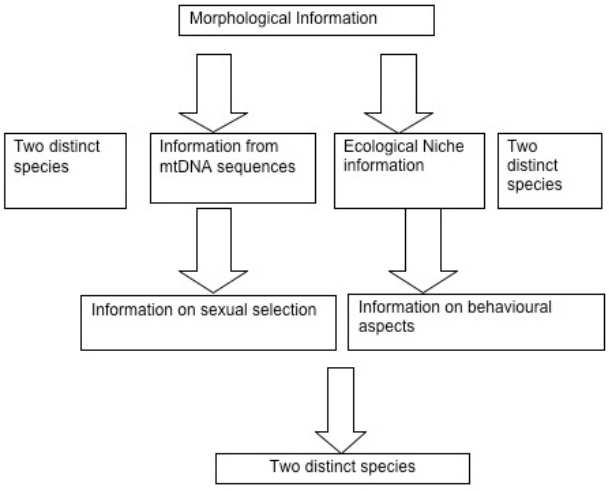
Taxonomy is the discipline in biology aimed at characterizing and naming taxa and taxonomy plays a major role in conserving biodiversity. The central unit of taxonomy is species and generating biological information requires naming of species. Thousands of species are being named every year since the advent of Linnaean nomenclature in 1758. Alpha taxonomy relates to species level characterizations whereas beta taxonomy is related to higher level studies. The advent of new tools for species level identification of groups of organisms has contributed immensely to the rapid development of this branch of science. DNA sequencing technologies, access to museum collections, information about phyogenetics and phylogeography, advances in evolutionary studies and computer tomography have revolutionized conventional taxonomy in such a way that conventional taxonomy could be supplemented and complemented with information generated from all the above approaches. Species delimitation and a scientific consensus on naming could be achieved now by using a combination of different methods along with traditional taxonomy tools and this is the objective of integrative taxonomy. The term "integrative taxonomy" was coined by Dayrat, 2005 to describe a comprehensive approach to naming species.

Integrative taxonomy

Evolutionary biological studies focus upon the divergence of lineages and the aim of a taxonomist is to identify the point along the continuum where species classifications are to be applied and reaching a consensus regarding this generates lot of conflicts among taxonomists. Population biological studies, sexual mating behavior, molecular phylogenetic and phylogeographical information and other evolutionary disciplines are recently being introduced for species delimitation and consequently integrative taxonomy has emerged. The most important and evolving fields are molecular phylogenetics and systematics and the previous decade has seen revolutionary changes in molecular systematic studies. Integrative methods are being increasingly used in species delimitation and all the methods need not be applied simultaneously. Information regarding evolutionary aspects of the species under consideration should be taken into account while selecting the methods. Integration can be attempted when morphological information is not sufficient for species delimitation or even when morphology is sufficient other methods can supplement the information. In addition to this, application of several methods provide insights into the processes that make them separate species like divergent selection on some traits, behavior and consequent adaptation. Thus integrative taxonomy improves rigour contributing to efficient biodiversity inventorization.

Methods for integration

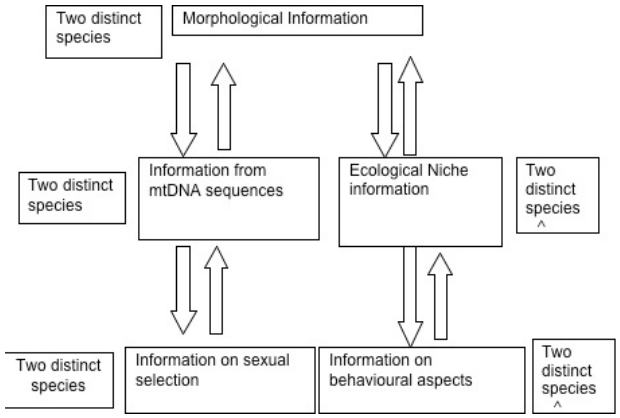
Integration of different approaches can be done in two ways (Padial *et al*. 2010); integration by congruence and integration by cumulation. In the method of integration by congruence, concordance between different sets of information is desired. Thus this method assumes that when different sets of characteristics show concordance, the evolutionary lineages are fully separated and can be classified as separate species.



The sets of characters to be considered depend on the knowledge of the investigator regarding the evolutionary trajectory of the species. Congruence approaches provide more confidence in taxonomic information and consequent taxonomic stability.

The limitation with congruence approach is that it is more stringent and so the risk of underestimation of species numbers is more as in many cases divergence in all the characters is not necessary for species delineation. In the case of cichlid fishes, adaptive radiation is associated with strong divergent selection on morphological traits whereas these differences in morphological traits were not associated with strong reproductive isolation.

Integration by cumulation is based on the principle that divergence in any one of the traits can be taken as evidence for existence of taxonomically distinct species groups. So in this method, evidence is accumulated from all the sources and the evolutionary characteristics and significance of different traits are studied and even if one single character is enough to explain the species level status it is considered. This has been the approach of conventional taxonomy.



The main disadvantage with integration by cumulation is that there is a risk of overestimation of species as divergence in a single character may not lead to reproductive isolation.

Integrative taxonomy considers many traits for species delimitation and this process enhances the knowledge about the evolutionary processes driving their speciation. When a particular character has more importance in selection and consequent speciation, that character should be given more importance while taking decisions about their species status. Integrative taxonomy has a pluralistic approach to taxonomy and so it promotes deeper understanding of the species and populations in question.

The following points should be considered while making taxonomic decisions;

1) When multiple disciplines are incorporated into taxonomic investigations, rigor associated with taxonomic investigations could be substantially improved.
2) Morphology should be the basic criteria in any taxonomic investigation and molecular genetic information should also be invariably used along with this.
3) When there is a mismatch with different sets of information, evolutionary traits of the species should be considered and importance should be given to the trait that is most significant from an evolutionary point of view.
4) Conventional taxonomists should be trained in using additional methods so as to improve accuracy and speed in decision making

Suggested Reading

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