Species as units of generalization in biological science: a philosophical analysis

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A Appendix: Species are individuals – or are they?

Abstract

Recently Coleman & Wiley presented a new defense of the species-are-individuals thesis, based on an analysis of the use of binomial species names by biologists. Here I point out some problems in their defense and I argue that although in some domains of biological science species are best understood as individuals, Coleman & Wiley fail to establish that this is true for the whole of biology.

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A.1. Introduction

Recently Coleman & Wiley (2001) presented a new defense of the species-are-individuals thesis (hereafter SAI-thesis). In the debate over the SAI-thesis the issue is usually construed as a straightforward dilemma: either species have the ontological status of individuals, or of classes, without a third option (e.g., Ruse, 1987). Although both sides in the debate are still represented in the literature, most biologists and philosophers nowadays hold the view that species are individuals with organisms as their parts, rather than classes having organisms as members. Those authors who find convincing arguments on both sides of the dilemma usually subscribe to an ontology of species as individuals and attempt to construct an epistemological account of how such individuals can function as kinds (e.g., Griffiths, 1999; Millikan, 1999). Coleman & Wiley defend the SAI-thesis by attempting to disprove the view that species are classes.

Construing the issue as a yes-or-no dilemma is too simple in two respects. Firstly, there is the assumption (which is by no means self-evident) that the issue has but two horns. Traditionally, species have been understood as all belonging to the same category of things and the species problem has been interpreted as the quest for the one true definition of the associated concept. In the last decades several authors have abandoned this monistic stance in favor of so-called 'species pluralism'. As with most '-isms', 'species pluralism' denotes a heterogeneous collection of positions, which however share the view that there are different sorts of species taxa. This view allows a third option: the SAI-thesis is both true and false, depending on the situation considered. Given that there are species taxa of different sorts, not all of them need to be individuals (or classes for that matter). From this perspective the term 'species' is seen to be a homonym, denoting different kinds of things associated with different concepts in different domains of biological research. If this perspective is correct, it follows that the SAI-thesis should be evaluated independently for each distinct concept; findings for one concept need not automatically apply to the other concepts at stake.

Secondly, choosing one of the horns of the original dilemma does not resolve the problem of the ontological status of species. For if species are indeed always individuals, then what kind of individuals are they and are they always of the same kind? There are several feasible options, e.g. interactors (dynamic processes entities) and lineages (branches on phylogenetic trees). And if species are not individuals, then what are they? Again there are several options, e.g. collections of organisms (Ruse, 1987; Mahner & Bunge, 1997) or groups of populations (as in Mayr's *Biological Species*

Concept; cf. Boyd, 1989). On this level as well the issue has more than two horns and more than one may simultaneously be right.

The homonymic nature of the term ‘species’ manifests itself in at least two ways. Firstly, ‘species’ is used by biologists to denote both the dynamic units of evolution and the static units of biodiversity (Lidén and Oxelman, 1989; Ereshefsky, 1991; 1992; Mahner & Bunge, 1997). The architects of the Modern Synthesis emphasized the dynamic nature of species: “(…) the taxonomic categories in general, and species in particular, are not static but dynamic units.” (Dobzhansky, 1935); and:

> “The species is (…) an ecological unit which, regardless of the individuals composing it interacts as a unit with other species (…). Species are the real units of evolution, they are the entities which specialize, which become adapted, or which shift their adaptation.” (Mayr, 1969).

From this dynamic perspective species are composite entities that actively participate in evolutionary processes and interact as cohesive wholes with their environment and the entities therein, similarly to soccer teams participating in matches and tournaments (‘interactors’: Hull, 1980). Recently Gould (2002: 703ff.) extensively discussed and defended this perspective on species.

By contrast, units of biodiversity are static entities resulting from rather than participating in evolutionary processes: “Taxa (including species) are (…) atemporal components of a historical pattern. They are the products of evolution, not its determinants.” (Lidén and Oxelman, 1989); and: “(…) species are generally considered to be products of evolution (lineages), but not the units participating in processes.” (Kluge, 1990). Understood in this manner species constitute the building blocks of the ‘tree of life’ that phylogenetic systematics investigates. ‘Unit of evolution’ and ‘unit of biodiversity’ in the sense above are both individual-concepts, i.e. concepts associated with entities rather than classes. The fundamental difference between these two types of entities becomes clear when considering the allocation of organisms from the past: whereas dead organisms no longer constitute parts of any coherent entity partaking in evolutionary processes, they still belong to some branch on the tree of life.

Secondly, biological science consists of several distinct (sometimes partly overlapping) research contexts like ecology, ethology and phylogenetic systematics, all employing the concept of species in investigating their own particular kinds of questions. Since the demands posed on this concept generally are incompatible between different research contexts, no single concept will suit all contexts of biological research (Kitcher, 1984; Kornet, 1993; Shaw, 1998). The term ‘species’ is thus best understood as the common denominator for a number of distinct scientific concepts, each tailored to the idiosyncratic demands of a particular research context. In some cases these concepts will be individual-concepts, in others class-concepts. Many discussions of the ontology of species consider only one context, resulting in divergent conclusions: Ruse (1987) analyzed evolutionary biology and concluded that species are kinds, while Lidén and Oxelman (1989) considered phylogenetic systematics and decided that species are individuals. Both conclusions may well be valid within the considered research contexts, but their validity does not automatically extend beyond the boundaries of these contexts. Kitcher (1984), Falk (1988) and Dupré (1993) have made similar points.

A.2. Criticisms of Coleman & Wiley’s defense

Coleman & Wiley defend the SAI-thesis by analyzing biologists’ use of Latin species-denoting binomials. They start from the straightforward dichotomy discussed above: in biological discourse binomials can be understood to function as singular terms, i.e. terms denoting entities rather than classes, or as categorical terms to be analyzed as predicate expressions (2001: 500). Whereas the former entails an ontology of species as individuals (an ‘objectual account’ of species in Coleman & Wiley’s terminology), the latter entails an ontology of species as classes whose names are interchangeable with predicate expressions that reflect the necessary and sufficient conditions for species membership (a ‘predicative account’ of species). My focus is now on the two main steps in Coleman & Wiley’s defense. First (Section 2) they present some examples from biological practice in which binomials are used as singular terms. These examples serve to show that an objectual account of species fits some cases, but cannot rule out the possibility that other cases require a predicative account of species. In their Section 3 they attempt to rule out this possibility by refuting the so-called eliminability thesis, which says that binomials in biological discourse are “(…) substitutes for complex predicate expressions that do function as categorical terms” (2001: 506). Lacking a third option, a refutation of the eliminability thesis would directly entail that only an objectual account of species is adequate to biological practice.

Although I consider their first example, "*Fundulus nottii* is a species" (2001: 503), somewhat unfortunately chosen[36], I do not deny that cases in which binomials denote objects rather than classes are abundant in biology. Clear examples can be drawn from e.g. ecology or phylogenetic systematics. What I do dispute is that biology consists exclusively of such cases. Biology also comprises many cases in which binomials are used as class terms supporting generalized knowledge statements:

> "(…) If I have identified a fruit fly as an individual of *Drosophila melanogaster* on the basis of bristle pattern and the proportions of face and eye, I can 'predict' numerous structural and behavioral characteristics which I will find if I study other aspects of this individual." (Mayr, 1961).

Inferences from the observed properties of organisms to their unobserved properties (Mayr, 1961; 1969) or to properties of other organisms belonging to the same species (Millikan, 1999) must be ontologically founded, i.e. there must be an ontological guarantee that the organisms of one species are the same in relevant respects (Griffiths, 1999; Millikan, 1999). Whereas ontologies of species as classes automatically provide such a guarantee (due to the intensionality of class definitions – see below), ontologies of species as individuals with organisms as their parts do not, since an entity's parts need not be the same in any respect. Species-as-individuals ontologies must therefore explicitly state how such inferences are supported. No such accounts have been provided so far; moreover, ontologies of species as lineages are in principle unable to provide them[37].

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[36] It is not a regular statement within the biological body of knowledge. Rather, it is a metastatement connecting a scientific name to a level of organization at which nature is being studied. To say that *Fundulus nottii* is a species is on a par with saying that Helium is an element, i.e. that what bears that name has a role in scientific theory on a particular ontological level. Regular biological statements in which binomials function as names of individuals convey properties of and relations between actual species (e.g. genealogical history or geographical distribution). Coleman & Wiley's example does not convey any such knowledge.

[37] Griffiths' (1999) and Millikan's (1999) recent attempts to this extent illustrate why. Because of the slow evolutionary change that occurs within lineages inferences across the boundaries of subsequent lineages are supported in their accounts of species, while inferences from organisms at the beginning of a lineage to organisms at later stages of

By refuting the eliminability thesis Coleman & Wiley purport to establish that predicative accounts of species are unsuitable to scientific practice. The eliminability thesis however allows for a strong and a weak reading. In its strong reading the thesis entails that Latin binomials can be substituted by predicate expressions in all scientific statements in which they occur. In its weak reading it only implies that this can be done at least in some statements. Since they hold that species are always individuals, Coleman & Wiley must refute the eliminability thesis in its weak reading.

Coleman & Wiley attack two ways of conceptualizing binomials as disguised categorical terms: by understanding them as placeholders for predicate descriptions of organism morphology, or as placeholders for specific instances of general properties thought to define the species category (e.g., potential interbreeding or common descent). I do not discuss the latter point. Against the former conceptualization Coleman & Wiley hold that sets of organism characteristics necessary and sufficient for species membership are virtually impossible to obtain. This is however only the case if some other criterion for allocating organisms to species is already at work, i.e., if we attempt to reconcile organism morphology with a classification based on another preconception regarding species membership. Coleman & Wiley's remarks (2001: 507) on the suitability of characters for diagnosing but not for defining species taxa suggest that they argue from just such a biased perspective[38]. Organism morphology as criterion for species membership is bound to conflict with this phylogenetic perspective. Once this perspective is abandoned, however, the conflict disappears for lack of a second party to conflict with. Although morphology-based classes of organisms generally will be non-real, nominalistic classes and will show little overlap with the species used in phylogenetic systematics, this does not prevent them from being practically useful and theoretically significant classes that can support generalized knowledge statements in other contexts of biological research. Consider for example fields that address 'how'-questions rather than 'why'-questions (Mayr, 1961) by studying organisms with respect to structural similarities and classifying them according to analogies rather than homologies (e.g., functional morphology and ecology; see the discussion in Griffiths, 1999). Since not all of biological investigation rests on assuming a phylogenetic

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the same lineage are generally unsupported. But I must leave a more extensive discussion of why I think their accounts are unsuccessful for elsewhere: Chapter 5.

[38] Elsewhere Wiley (e.g., 1989) exhibits a similar phylogenetically biased viewpoint in his assertion (following Hennig) that not morphology but genealogy is "the solid base on which we construct our hypotheses" (1989).

perspective, arguments against the eliminability thesis based on phylogenetic considerations cannot serve to refute the thesis for the whole of biological science.

Another problem in this part of Coleman & Wiley's analysis is that it rests on the traditional essentialistic conception of natural kinds as classes of entities that all share a set of (usually microstructural) properties necessary and sufficient for class membership (2001: 502), an account that for many reasons fails with respect to species. This renders their analysis incapable of addressing alternative accounts of species as natural kinds, such as Boyd's (1989; 1999) account in which natural kinds are defined by the natural mechanisms underlying the repetitive co-occurrence of particular properties, rather than by these properties themselves. Hence, even if the eliminability thesis were refuted in its weak reading, this does not imply the rejection of such alternative ontologies of species as natural kinds.

A.3. Species as sets

In their Section 4 Coleman & Wiley criticize the conceptualization of species as sets. Although many of their arguments seem to indicate real problems for this understanding of species, Coleman & Wiley are misguided in thinking that their attack supports the SAI-thesis. The problem lies in the formal difference between sets, which are defined extensionally, and classes, which are defined intensionally (Mahner & Bunge, 1997; Muller, 2001). The debate on the SAI-thesis hinges on the issue whether species are classes, not whether they are sets (but see Kitcher, 1987). Both species as individuals and species as classes can be reconstructed as sets, implying that arguments for or against the view of species as sets cannot help to establish the ontological status of species as individuals or classes. Such reconstructions take place by way of *associating* an abstract set of organisms with a particular species taxon, which is different from *identifying* the taxon with the set. The reconstruction of a species as a set thus does not imply the ontological statement that this taxon *is* a set. Kornet (1993) performed this reconstruction on the prototypical example of species as individuals: Hennig's phylogenetic species defined as chunks of the genealogical network. Coleman & Wiley's argument, saying that on the interpretation of species as (extensionally defined) sets of organisms a species ceases to exist when its extension changes (2001: 511), does not hold for (intensionally defined) classes: whereas a different set becomes associated with a species when its composition changes, the species itself remains in existence. Since the reconstruction of species as sets is compatible with the interpretation of species as individuals, judgments regarding the validity of the construction of species as sets do not reflect on the validity of the SAI-thesis.

A.4. Conclusion

Coleman & Wiley conclude that "(…) biological discourse contains an ineliminable reference to individual things called "species"" (2001: 516). Taken literally this statement, denying the eliminability thesis in its strong reading, is correct: in many cases Latin binomials indeed refer to individuals. However, this does not amount to saying that in biological science species are *always* to be conceptualized as individuals, i.e., it does not amount to the validity of the SAI-thesis for the whole of biology.

I believe the SAI-thesis is valid for some but certainly not all contexts of biological research. In their defense of the SAI-thesis Coleman & Wiley fail to take into consideration the heterogeneity of the species category. The fact that the term 'species' denotes different concepts in different contexts of biological research implies that in some contexts species might best be understood as individuals, whereas in others their proper ontology is that of classes or even natural kinds.

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