

## READING ABOUT SPECIES CONCEPT IN BIOLOGY

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**Abstract.** Species concept interested many scientists most of them considering species as a real biological entity characterized by a common ancestor and represented by a lineage that maintains its integrity with respect to other lineages through both time and space. Terms of reproductive isolation are most important in the most popular biological definition of species. Because of its historical dimension when talking about species, phylogeny, systematics and palaeontology must be implied. In this article there are mentioned more than 10 outlooks, starting with the popular one and antiquity to phylogenetic outlook and even “nihilism” about species term.

**Keywords:** fixism, variation, evolution, phylogeny, populations, reproductive isolation, morphology, genetics.

**Rezumat. Citind despre conceptul de specie în biologie.** De la numirile populare ale speciilor și trecând prin filosofia antică de metempsihoză, în articol sunt trecute în revistă concepțiile corespunzătoare istoriei omenirii, mai întâi cu sens empiric și mai ales în Evul Mediu, cu evidențierea continuității reproductive în sânul speciilor și implicit – izolarea lor de altele. Cea mai populară definiție a speciei ține seama de izolarea reproductivă. Sunt apoi menționate concepțiile: lineană, morfologică (sau tipologică), de specie biologică, stadiul de considerare ca entitate izolată reproductiv, conceptele evolutive și filogenetice.

**Cuvinte cheie:** fixism, variație, evoluție, filogenie, populații, izolare reproductivă, morfologie, genetică.

### INTRODUCTION

Species is considered the fundamental taxonomic unit; under this character, the term of species represents one of the most important concepts which actions in the biological science.

Taking into consideration this idea, the definition of this term is very important, because the way in which the term of species is perceived influences and determines the specialist’s entire reporting manner to the biological science and its current theories.

EMIL RACOVIȚĂ (1912) considered species as the fundamental biological unit. A serious research in the natural history cannot exist without the specific identification of the studied creatures. Species is an isolated colony of consanguinity. Isolation criterion has a decisive importance.

Species have a history; only this history gives us a clear idea on the species and by what kind of relationships they are phylogenetically bound with the neighbouring or close species.

Species are historical phenomena, and the term of species is a **morphologic** (of form and structure), **geographic** (of space) and **historic** (of time) entity.

### DISCUSSIONS

Considering the above ideas we can say the biologists know the scientific name of a species (often of Latin or Greek origin) was introduced by Carolus Linnaeus (Linné) in 1735 (first edition of *Systema Naturae*). Since those times all scientists have been using the binominal nomenclature – name of species including two parts: - genus name or generic name; - specific name, which in botany is called the specific epithet.

After Darwin’s theory on the evolution of species through natural selection, species are not just similar, they may actually be related. On the one side, all species should be descended from a common ancestor and on the other side, species are not homogeneous, fixed, permanent things. According to the last opinion, individuals of a species are all different, and over time species change. This suggests that species do not have any clear boundaries but are rather momentary statistical effects of constantly changing gene-frequencies. Accepting the rise of a new species from a parental line is usually named speciation, but there is never a clear line demarcating the ancestral species from the descendant species.

#### Popular outlook

The term of “species” originates in the empirical popular knowledge; among all world nations we can observe the dividing of the living world into different categories and “kinds” which coincide more or less with the biological species, scientifically defined and identified. BĂNĂRESCU (1973) remarked that the different human populations define precisely some “kinds”, reaching even the quasi-identity with the biological species, according to the traditional interest in subsistence which some biological groups present. Thus, some Papuan tribes cited by MAYR (1963) recognize very well the bird species, almost every biological species being also named by them; this is due to that those tribes traditionally hunt birds, both for feeding, i.e. subsistence, and for the decoration feathers (cultural and even ritual role). But, BĂNĂRESCU (op. cit.) remarked, the same tribes confound invertebrate species, being of lower interest for them. Similarly, the nations to which fishing is an important part of their traditional economy (as it happens for the Romanian people, too) most of the fish species distinguish very well, especially those with a special alimentary importance. Romanian fishermen named almost all fish species with separated names, often they have names even for the different

developing stages of some fish species intensively caught (catfish, carp, pike perch, pike); even names for the recently introduced species spontaneously appeared: Topmouthgudgeon (*Pseudorasbora parva*), Pumpkinseed sunfish (*Lepomis gibbosus*), Grass carp (*Ctenopharyngodon idella*); the only important exceptions are the gobies, group in which several species are confounded, as well as the different species of the pipefish, which are not differentiated by fishermen. In exchange, Romanian people did not give specific names to amphibians and reptiles, the lack of the economic and cooking interest being obvious. The salamander defines all urodeles; from anurans only the Great bittern, toads and treefrogs distinguish from the generic name of “frogs”; tortoises are not differentiated; among lizards only the European green lizard occur, and the term of “snake” leads to huge confusions, excepting *Anguis*, different other species being included in this name, from *Eryx* to vipers.

### **In Antiquity**

The first systematization was made in the ancient Greece. If Plato introduced the term “eidos” (εἶδος) or “id” for the abstract type of a species (and generally for a classification category, not only biological), Aristotle already used the term of genus, respectively species in natural sciences, including for the living world. As a reply to the primitive transformism, of mystic or magic kind (including metempsychosis), expressed by Anaximander or Empedocles, Aristotle asserted the immutability of species, the “id” being the essence and, at the same time, the typology of the animal and vegetal species; the same argumentation applies to natural elements, chemical substances, etc.

### **In the Middle Age**

In Byzantium, the Orthodox Christian writers and philosophers (often familiarized with the “laic” culture of time and also being what we may call “science men” – that time, the epistemological discontinuation between science and religion not being present, appearing much later in West) also rise the species problem in the living world, within creation theology. St. Basil the Great, and later St. Maximus the Confessor, minutely told about what St. Maximus had named divine reasons of creation – every species (not only the biological one) has its own reason which gives it its own identity (including its specific features but not only them) and the unchanged perpetuation along time. Divine reasons of the created species are immutable but, considering that God support everything which means life, the way in which the reason of the species expresses is updated for each individual, in its own way, under the God’s protection. Thus, not only the perpetuation and species identity is explained, but also the intraspecific variation and the way the last one is compatible with the species unchanged perpetuation – potentially, up to infinity. More than that, we can read even the empiric term, but correct and “very” modern, of the reproductive continuity within a species, and implicitly, of the isolation from other species.

### **In Linné outlook**

This concept, filtered through the western theology, can be found in Linné, who described the species constancy along time by the identity of some features which are inherited by generations and which give the objective character of each species, defining them distinctly from one another.

### **Typological or morphological outlook**

The scientists of the 18<sup>th</sup> – 19<sup>th</sup> centuries adopted and developed mainly the idea of the morphological typology of a species, from Linné, the single criterion for its recognition, thus being closer, in concept, to Aristotle and his “id” than to the Fathers of Byzantium (for whom there is enough room for intraspecific variability, and typology is not the only determinant of the specific identity); with this outlook they include themselves in the current of enlightenment, as it was expressed that time in philosophy and science.

This typological or morphological outlook on species minimizes intraspecific variability and tries to define precisely the morphologic type from which the species should deviate just a little. But, this “little” is the problem, because it cannot be established how much. BĂNĂRESCU (1973) remarked that under this outlook on species, some “twin” species, slightly morphologically different, are not recognized, but the species description basing on morphological and chromatic variations, as well as an infinite number of variations and „aberrations” multiplies. In the middle of the period dominated by this outlook the evolutionist theory appeared, being favoured by the confusion of the difference between species and intraspecific theory; although he entitled his work “On the Origin of Species”, Darwin had not a clear definition for a species and admitted: “*I was struck how entirely vague and arbitrary is the distinction between species and varieties*” (DARWIN, 1859). Although later he intuited the reproductive isolation, Darwin did not develop this idea, the data on the material (genetic) basis of the intraspecific variability and interspecific isolation being absent, returning to the typological/morphological criteria. In exchange, in the environment dominated by the typological outlook on species, where the species definition was already insufficient, the evolutionist thesis led to an explosion of “species” and “varieties”. After Al. Iftime (in verbis), the huge development of “varieties” and “species” thus described is well illustrated by the synonym list of some species as *Lacerta viridis*: *L. (Seps) varius* LAUR., *L. punctata* DAUDIN, *L. chloronota* RAFINESQUE, *L. cyanolaema* GLUCKSEL (representing individuals with a blue throat in “nuptial cloths”), *L. viridissima* FITZ, *L. bilineata* DAUDIN, *L. sericea* DAUDIN, *L. bistrinata* SCHINZ, *L. smaragdina* MEISSN., *L. elegans* ANDRZ, and the incredible number of varieties: *versicolor*, *punctata*, *mentocoerulea*, *variolata*, *cinereo-nigrescens*, *maculate*, *istriensis*, *nigra*, *holomelas*, *fusca*, *concolor*, *radiata*, *quadriradiata* (see the enumeration

in SCHREIBER, 1912). Towards the beginning of the 20<sup>th</sup> century, the reaction to these exaggerations already appeared, in the sense of classifying those numerous types described as subspecies, forms or variations of the same species, as Schreiber already did for *L. viridis*, and many others for other groups (especially mammals), without a rigorous support ones again, but appealing the “common sense”. If SCHREIBER (1912) was right regarding *L. viridis*, and correctly intuited the separation of the species *L. media* (syn. *L. trilineata*), Bedriaga or Boulenger, one before and one after Schreiber, considered that *trilineata* was a subspecies of *viridis* – illustrating the endless dilemma of “splitting” (the separation tendency of the species) versus “lumping” (the tendency of merging them) and the limits of the typological outlook: taxa are often described but their real ratio remains disputed.

### Species relativization

Also, from the application of the evolutionist outlook, but exaggerating in another sense, currents which relativize the species develop. A good example is RACOVIȚĂ (1929), who wanted to remove the term “species” (primarily considered creationist) with that of “origin”, a kind of evolutionary line in which, unfortunately, the limit between forms is not so clear, considering that after the theory accepted by Racoviță, „origins” come one from another and it is not recommended to distinguish the species... Exaggerating, Racoviță asserted that “so called *Asellus aquaticus*”, known for more than 150 years, is not a “species” but “idle chatter”. Regarding this kind of exaggerations, BĂNĂRESCU (1973), resuming MAYR (1957, 1963) commented: “Linné the fixist, underlining the specific characters and the precise delimitation of the species, came closer to the present biological opinion on the species than those transformists who denied both their relative constant and their categorical delimitation in their wish of proving the species evolution”.

### Biological outlook

The necessity of defining the species developed more and more obvious after the appearance of genetics as a discipline and of the attempts “to reconcile” the genetic data with the evolutionist theory. DOBZHANSKY (1937) directed attention to the reproductive isolation, and MAYR (1942) created the definition, basing on this ideas: a species is “a complex of natural populations in which breeding takes place in a real or potential moment and which are reproductively isolated by other similar complexes of populations”. This was named Biological Species Concept (BSC) and responds to Linné’s intuition on the objectivity on species, as well as the necessity of verifying experimentally the conspecificity of some populations or taxa.

### Reproductive isolation

Taking into consideration the importance of the reproductive isolation in the biological concept on species, we have to understand what the reproductive isolation means. Classical example is the horse and the donkey, from which result sterile hybrids (mule, respectively hinny). This is only a single case among many other reproductive isolation types. Reproductive isolation can be:

Prezygotic: mechanisms prevent the zygote appearance. Here, the selectivity of the adult is included, which always prefers the reproduction with conspecific individuals, on ethologic or biochemical criteria, avoiding that one with heterospecific individuals as much as possible, but also the morphologic mechanisms (of morpho-physiological compatibility) hindering the mating between two species, as it is the case of the distinct genitalia in numerous insects; and, also, the biochemical mechanisms, which hinders the fecundation possibility of the ovule by a spermatozoid originating in another species, thus hindering the development of the hybrid zygote. [Isolation of “habitat” or the “seasonal” one, cited by BĂNĂRESCU (1973), are relative – a good example is *Rana ridibunda* and *R. esculenta*; BĂNĂRESCU (1973) considered them isolated by the different period of reproduction, and *R. esculenta* is just the hybrid between *R. ridibunda* and *R. lessonae*!]

Postzygotic: mechanisms which action after the zygote has formed. The total inviability of the zygote is very spread, which manifest either immediately or in a certain moment in its development, up to the adult state; or the hybrids can develop but their viability is reduced (only a part of the hybrid zygotes develop, much less than in an intraspecific fertilization), and if they develop they have a reduce *fitness* (manifested by vigour, competitiveness, etc.), inferior to the parental species. Another possibility is the development of the hybrid, but to be sterile, either totally (hybrids of both sexes are sterile) or partial (only the hybrids of one sex, generally the males are sterile). Sterility can appear in F1 or in F2 (in the last case F1 hybrids are fertile, but in the next generation sterility is present – so-called “hybrid breakdown” or „hybrid loss/destruction”). It can happen that the hybrid is fertile only with one of the parental species, but also with both of them.

### Introgression phenomenon

As it can be seen, there are situations when fertile hybrids exist for parental species. In this case, yet, the reproductive isolation appears, manifested by the reduce *fitness* of the hybrids, which led to their reduced success in avoiding the predators, surviving in nature and having descendants. There is the tendency for the hybrids to be absorbed by one or another parental species by subsequent breeding with the parental species, slowly losing the largest part of the genetic material from the other species (introgression process) because the hybrid genotype is less competitive, less viable, and it is removed by combination and selection. Under these circumstances, between two species a hybridization

area appears, named tension area; the tension appear because the hybrid area is supported by two elements with a contradictory action: dispersion of the parental species specimens in the areas where they can meet and hybridize; and the reduce *fitness* of the hybrids. Hybrid area was also named “*hybrid sink*” (hybrid leakage or loss) because in the hybrid area specimens of the parental species always immigrate, but which, genetically speaking, they “lose themselves”, their genetic material “being wasted” by hybridization in unviable hybrid combinations or with a reduced viability. Yet, in a lesser degree, everything is not lost in the hybridization area, a very small quantity of genetic material permitting the so-called horizontal gene transfer, by introgression, by the specific “barrier”. But, the species preserve their homogeneity and the barrier of the reproductive isolation functions even under these circumstances. Therefore, hybrid areas can appear between species as *Bombina bombina* and *B. variegata* or *Triturus montandoni* and *T. vulgaris*; but, the species preserve their homogeneity by the mechanisms of the above-mentioned types; in time, the populations in which hybridization appear “go” towards one of the parental populations and, by the introgression phenomenon, they practically can lose all “alien” genetic material.

Also, there is another very interesting isolation type, i.e. in which the hybrid copies and produces into the gametes only the genetic material of one of the parental species (and there is no recombination between them). Interestingly, under these circumstances, the zygotes formed during the mating of the two hybrids are mostly unviable – in exchange, the hybrid can reproduce with the parental species, thus producing either the parental species whose genetic material is expressed by the hybrid in gametes, or hybrids again, when mating with the other parental species. Thus, it results a dynamic equilibrium between parental species and hybrids, the last ones being always present, but limited in number, and the parental species keeping inevitably their homogeneity – the so-called hybrid genetic hybridization. Such kind of system appears between the species of Marsh frogs – *Rana (Pelophylax) ridibunda* and *R. (P.) lessonae* which have as a hybrid of this particular type the form named *R. (P.) esculenta* – kl meaning hybrid “klepton” (“thief”) because it „parasitizes” one of the parental species, but being totally dependent on it (if the parental species, whose genome is not expressed by the hybrid, disappeared the hybrids also would disappear immediately, because the hybrid phenotype cannot appear in its absence).

These situations underline the complexity of the reproductive isolation mechanisms but support the biological outlook on species because the isolation mechanisms are finally present and efficient.

#### **Apomictic species: limits for the biological outlook?**

Biological outlook on species was criticized for its limits on the apomictic or partenogenetic species, which reproduces as clone lines and obviously are reproductively isolated from other species or populations, but inside them the breeding does not take place. It is true that the species exclusively apomictic are a few: even in the plants hold as an example, like Common dandelion (*Taraxacum officinale*) there are mictic (sexed) populations and apomictic populations, and the fecundation of the apomictic specimens by the mictic ones appear occasionally. Among reptiles, there is also the situation in which a species, normally sexed, can reproduce partenogenetically in need; examples are numerous, among the known ones being *Crotalus horridus*, *Python molurus* and *Varanus komodoensis* (Al. Iftime, in verbis). In this case, the clone lines identify themselves as belonging to a species by their genetic classification within the variability limits of the bisexual „parental” species. Anyway, forcing as little bit MAYR’S definition (1963), we can assert that the partenogenetic clone lines are potentially able to breed with conspecific sexed individuals. Even in the case of the totally apomictic species, we can notice a reproductive link (as much as it can exist in this system) among their members, because generations come one from another and manifest a total genetic identity practically.

Regarding bacteria and viruses, it is considered that the stem cells which can make easier the genetic recombination or the genetic material transfer by different processes of so-called parasexuality (non-sexual forms, i.e. non-meiotic, of transfer of the genetic material) are closer (or even conspecific).

It can be asserted that the great problem for the biological outlook on species is not created by the clone lines but it is not easy to establish practically if two populations are conspecific or not. Theoretically, one can assert that if in the breeding of some individuals of two populations the *fitness* of the hybrids is lower than in parental populations (i.e. including total non-viability) populations are not conspecific, while if the *fitness* of the hybrids is higher (hybrid vigour) or equal with that of the parental populations, they are conspecific. But practically it is very difficult to test, this implying hybridization experiments and *fitness* evaluation. From this point of view, the biological outlook on species does not exclude the common aspects with the typological one – as the species is identified basing on the criteria of the reproductive isolation, for the identification, constant morphologic features are used as being specific for the described biological species.

#### **Presumed „ring-species”**

We remind that BĂNĂRESCU (1973) tried to complete the species definition given by MAYR (1963) with the idea that “the breeding within species takes place really or potentially at least between the neighbouring populations, the extreme ones may be reproductively isolated” – referring to the presumed “species in open ring”, as those of *Larus*, which might intergrade in circle around the Arctic Ocean, being reproductively separated only in the North Atlantic. But this completion is not necessary; MAYR (op. cit), proponent of the idea of “ring-species”, already recognized: “*The study of geographic variation of sterility factors indicates the feasibility of speciation by distance in completely continuous series of populations, but I believe that not a single case has been proved unequivocally*” (our

underlining) – i.e. actually the hypothesis of the “ring-species” is not proved. Mayr already admitted the error in some cases; others were invalidated later.

### **Evolutionary species concept**

Another approach appeared due to someone’s wish of including also the fossil forms in species definition (because in fossils is extremely difficult, if not impossible, to evaluate correctly the reproductive isolation) and to give to the species definition a diachronic character. Therefore, the evolutionary species concept (ESC) appeared basing on the definition proposed by SIMPSON (1951): “*a species is a population unitary line linked by ancestor-descendent relationships, which keeps its identity in front of other such lines and has its own evolutionary history*”. Unfortunately, it can be observed immediately that the definition is less specific than that of MAYR’S (1963), reaching the subjectivism of the typological outlook, because there is not an objective criterion, empirically verifiable, according to which the “preserving of identity” and “its own evolutionary history” to be evaluated. An insular subspecies, for instance, “preserves its identity” naturally, potentially to the infinite although it is not reproductively isolated if it comes experimentally in contact with another subspecies. Geographical isolation becomes as much important as the reproductive one. For example, a sad example according to these criteria, Brown bear from Hokkaido and Kurile (*Ursus arctos yesoensis*) could be classified as a distinct species from the Brown bear from Siberia because it keeps its identity (by geographic isolation), and has its own evolutionary history ... as any other population, if the theory of the biological evolution is accepted! Much worse, the feral sheep from the Soay Island also could be considered a valid species, exactly after the same criteria, in addition, a rustic breed readapted to the free life, hence a clear identity and preserved for hundred or thousand generations. And, indeed, such situations already appear, recently being proposed the separation of the Sumatran tiger as a distinct species (*Panthera sumatrae*) from *P. tigris*! Fortunately, this proposal was not taken into consideration, but it is alarming that this “evolutional outlook” is spreading, especially in conjunction with the distribution of the cladistic outlooks which introduced the idea of “apomorphic” (derived) and “plesiomorphic” (ancestral) features, in a failed effort of objectification of taxonomy. Which are ancestral and which are derived, and why it is not so clear in practice as in theory, leaving space to subjectivism, as well as to artefacts induced by the efforts of mathematical modelling. The result of this application is, once again, the flourishing of a high number of described taxa, subspecies raised at the species rank, etc., returning to the situation from the typological outlook period – and, in addition, the cladism leads to the chronic instability of taxonomy, and to the proliferation of a large number of flagrantly contradictory classifications.

### **Phylogenetic outlook**

Following the idea of distinguishing the species after some definite features, within the evolutionary outlook (i.e. to see what “the keeping of identity” means), an objectification attempt led to the so-called phylogenetic outlook, initiated by CRACAFT (1989): “*a phylogenetic species is an irreducible (basal) group of organisms, which can be diagnosed differently from other similar groups, inside of it appearing a parental succession of ancestor-descendent relationships*”. Unfortunately, the result was nothing else but a higher extremism, if the only criterion for the “identity” identification is the possibility of diagnosing. Any subspecies or clinal form which can be diagnosed, even any domestic breed, stem, cultivation, etc. can be considered a species, and some authors wondered where we go if the definition would extend till the diagnosing by genetic differences of the order of the substitution of a basal pair – which is theoretically possible (HARRISON, 1998; MALLETT, 2001)! Fortunately, at least for the time being, practical common sense prevented the application of the phylogenetic outlook in the effective description of new species.

### **“Nihilism” about species**

After the obvious failure of the evolutionary and phylogenetic outlooks, now some voices raised again which support the abandonment of the species term (MALLETT, 2001), asserting that the population, not the species, represents the objective classification level, objective unit in biology. But the metapopulational dynamics, migration, mosaic distribution etc. make the recognition and the delimitation of the populations actually impossible at the level of imposing it as an objective unit. To abolish the term of species, by the virtue of the inconsistent critics directed to the biological outlook means to transform the living world into an amorphous mass in which any utilizable classification, empirically and experimentally, cannot be recognized, hence scientifically; practically, it means to cancel the scientific testability criterion of all theories in biology (including the evolutionary theory, defined by ... the species origin) and thus biology is not a science anymore.

### **Returning to the biological outlook**

If there are some critics to the biological outlook, this was made in order to try the perception improving on the species as an objective reality, not to abolish it; but the failure of these attempts does not mean the abolition of the species term but the returning to the biological outlook on species, finally the only one which can assure the objectivity of the scientific approach in biology.

## CONCLUSIONS

1. Aristotle and other pre-Darwinian scientists used the words *genus* and *species* to mean generic and specific categories; they took the species to be distinct and unchanging, with an “*essence*”, like the chemical elements.
2. Linnaeus and his successors classified organisms according to differences in the form of reproductive apparatus but without claim about the relationship between similar species.
3. Lamarck suggested that an organism could pass on an acquired trait to its offspring. By those times, most scientists understood that species could change form over time, and that the history of the planet provided enough time for major changes.
4. With the acceptance of Darwin’s natural selection idea, it was also accepted and argued that it was populations that evolved, not individuals.
5. For sexually reproducing organisms, the term of “species” means a group of individuals that could potentially interbreed and produce fertile offspring of both sexes.
6. The modern evolutionary synthesis (1937-1947) appeared to unify ideas from different biological specialties: genetics, cytology, systematics, botany, morphology, ecology and palaeontology. This neo-Darwinian synthesis reconciliated Mendelian genetics with gradual evolution by means of natural selection and explained changes in local populations as a broad scale changes or macroevolution.
7. Up to actual knowledge, the term “species” is not useful when studying bacterial evolution. Microbiologists see genes as moving freely between even distantly related bacteria, with the entire bacterial domain being a single gene pool.
8. Most of the above outlooks on species concept coincide. Differences between them are more a matter of emphasis than of outright contradiction. Therefore we can say no species concept yet proposed is entirely objective, or can be applied in all cases without resorting to judgment. Given the complexity of life, some have argued that such an objective definition is in all likelihood impossible, and scientists should settle for the most practical definition.

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