THE ONTOLOGY OF EVOLUTIONARY THEORY
Are species individuals rather than classes?*

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Introduction

Mary B. Williams' papers (or at least some of them) may be included in a tradition that pursues an axiomatization program of empirical theories. In this respect, I think her main work is the axiomatization of Darwin's Evolutionary Theory. She presents Darwin's Theory as a deductive system where axioms are the fundamental principles from which one can infer as theorems all the other claims of the theory. The paper I am going to discuss is "What is Evolutionary Theory Really About?"[1] This paper attempts to prove the following theorem:

(T) 'Species' is an independent primitive term of the axiomatization

She makes use of this theorem in order to prove that a species cannot be defined as a class of organisms. (It could be of help though IT IS NOT NECESSARY to read Williams' paper first.) Let's begin now with the discussion.

In the first part of the above mentioned paper, "The Ontological Status of Species", Williams provides arguments to support the claim that *species are individuals rather than classes:*

* Dr. Carlos Ulises Moulines has given me the most helpful suggestions and criticism. Though I must add that only I am responsible for any mistakes that still occur in the text.

[1] All references are to this paper that will be published in *Memorias del Tercer Simposio Internacional de Filosofía.* Instituto de Investigaciones Filosóficas, UNAM, México.

The basic claim of this section is that to conceptualize species as classes is to make a mistake about the ontological status of species; species are individuals; the relationship of an organism to its species is that of part to whole, not that of set membership (p. 2).

I intend to show that this claim has no support at all (at least in this paper).

1. The first argument that Williams uses to support the claim that species are individuals originated in Hull's and Ghiselin's works and runs as follows:

> SPECIES' NAMES ARE ATTACHED TO THE TYPE SPECIMEN RATHER THAN TO THE SPECIES.

And then she adds:

> When zoologists name a species they (a) select a particular specimen and name it, (b) give a lengthy description of the characteristics of the species, and (c) give a brief list of diagnostic traits which help to differentiate the species from its nearest neighbours. If the species were a class [and this is the point], then the type specimen would be expected to be typical of the class, but 'there is no requirement that a type be typical, and it frequently happens that it is quite aberrant.' (Simpson)
> . . .it is clear that names are attached to species not by intensional definitions but by ostensive definitions. As Ghiselin puts it, the name of a species is attached not by definition but by christening (pp. 3-4).

The previous argument has several difficulties that make it impossible to use it as a support of her thesis.

In the first place Williams seems to confound the impossibility of formulating a species' definition either in an intensional manner, that is

$$A=\{x/Px\}, \text{ where } Px \leftrightarrow (C_1(x) \& \ldots \& C_n(x))$$

or in an extensional manner, that is

$$A=\{O_1, \ldots, O_n\}$$

with the fact that the class doesn't exist. The hindrance in defining the class seems to originate in the fact that the type specimen is not typical of the class. But it is one thing to argue that a given class is very difficult to define adequately, and a quite different thing to say that this class does not exist.

Incidentally, this reminds us of the problems that were generated by Wittgenstein's discussion of the concept of 'games' (cf. Sections 66 f. of the *Philosophical Investigations*), i.e.,

> that were used by Wittgenstein to undermine the belief that where one concept is given, one property too, must exist which is common to all and only those things falling under this concept. Between the activities called 'games', there are only occasional, overlapping, crisscross resemblances bereft of continuity as is the case between members of a family. Hence the designation 'family resemblance'.[2]

Wittgenstein purported to show that it is a mistake to try to define the class of games by well-known extensional or intensional means; but it would be awkward to say that he thereby showed that the class of games does not exist.

IN SHORT, we cannot say that a class doesn't exist (e.g. a species) just because it is difficult or even at present impossible to provide an extensional characterization of it (by means of a list of members) or an intensional definition (by means of a list of properties its members have to fulfil). The question of the existence of a class is different from the question of having a way to characterize it. On the other hand, as Wittgenstein himself shows, there are other ways, beside extensional and intensional definitions, to determine a class.

2 *Cf.* Stegmüller, W. *The Structure and Dynamic of Theories.* Springer-Verlag, Germany, 1979.

In the present case, Williams' difficulties in using the class notion seem to originate in the fact that the members of a species, as compared with the type specimen (the one from which the name of the species is obtained), are quite different. But actually this doesn't seem to be a great hindrance. Although the elements of a set may strongly differ among themselves we can look for a way of determining their common membership to a class. For example, the sun and a billiard ball. In a mechanical theory both objects may be regarded as belonging to the class of particles to which the theory is applied, but no one would deny the important differences that exist between them.

2. The second argument that, according to Williams, supports the thesis that species are individuals rather than classes comes from the works of Hull. This is:

> SPECIES ARE LOCALIZED SPATIO-TEMPORAL WHOLES RELATED THROUGH ANCESTRY.
>
> If a species were a class (of the type that functions in scientific laws), it would be spatiotemporally unrestricted (p. 4).
>
> But evolutionary theory is concerned with species as Lineages of organisms which persist while changing *indefinitely* through time: lineages are formed by reproduction, and reproduction is necessarily a spatiotemporally localized process. Thus a species, like an individual but unlike a class, is spatiotemporally localized.

If we consider a class in the sense that Williams seems to have in mind, that is, an abstract entity of the form

$$[a]=\left\{y / y \in S, y \; R \; a\right\} \text{ given the set S and the relation R on S}$$

it is apparent that we cannot have a spatio-temporal entity. But notwithstanding that, there would be no problem in locating the elements of this class.

In the same way that all of us are spatio-temporal located entities and at the same time belong to the human kind –an abstract entity. In addition to that, Williams' argument would not apply *only* to the species' problem because it could also be applied in the same way to *every* class of empirical objects. Let's consider another example: the class of electrons. We already know that a class is an abstract entity but if we are working in a physics laboratory we try to locate electrons and to study their empirical interactions without being disturbed by the fact that electrons belong to a class.

3. The third argument of Williams is taken from Hull and Ghiselin:

SPECIES EVOLVE (Hull 1981; Ghiselin 1981)
Individuals change through time but classes do not.

This argument does not prevent us from using the notion of class. We can construe evolution as a process (that can also be mathematically stated) of emergence of different successive classes. We can use the notion of a sequence of classes which is well-known from mathematics.

If Williams objects (as she will probably do) that we cannot define precisely the moment in which one class ends and another emerges, we can answer with the help of the notion of 'fuzzy set'. According to this notion (that Zadeh has expressed in mathematical terms), anything belong to some class with non -zero probability, that is

$$0 < p(x \in I) \neq 1$$

for some class I and a possible element x of the class. This notion says that some elements may belong to a certain class with a certain probability. For example, some animals may belong to a certain species with a certain probability.

THE CENTRAL ARGUMENT of M. Williams is based upon a theorem that she attempts to demostrate. The theorem is the following

(T) 'Species' is an independent primitive term of the axiomatization.

We will now describe this axiomatization of Evolutionary Theory and prove a theorem that shows that two of its axioms are dependent. (The description is not a complete one.) Starting on page 6, Williams makes a description of her axiomatization of Darwin's theory of Evolution including two axioms (B1 and B2) that delineate "the properties of the set of reproducing organisms on which natural selection works" "Any set with these properties will be called a *biocosm.* The primitive terms of biocosm are *biological entity* and *is a parent of*". The symbols used by Williams are:

B = set of all biological entities
bi = variable for biological entities
/ = denotation of the relation *is a parent of*
– = logical symbol of negation

The following axioms and definition are a formalization of those presented by Williams in her axiomatization (cf. Williams, Mary B. 'Deducing the consequences of evolution: A mathematical model' in *J. Theor. Biol.* 29, 1970, pp. 346-347):

AXIOM B1

For any b_i in B, $-(b_i / b_i)$

(That means: no biological entity is a parent of itself) Williams (on p. 347) states the definition of the relation *is ancestor of* denoted by //.

DEFINITION B1

$b_i // b_j$ iff b_i / b_j or there exists a finite non-empty set of biological entities $\{c_1, \ldots, c_n\}$ with $n \geq 1$ such that b_i / c_1 and c_1 / c_2 and ... and c_n / b_j

And then the

AXION B2

For any pair of biological entities b_i, b_j, if $b_i // b_j$ then $-(b_j // b_i)$

(That means: if b_i is an ancestor of b_j then b_j is not an ancestor of b_i).

It is possible to prove the following theorem that shows that the two axioms are dependent.

THEOREM: AXIOM B2 entails AXIOM B1

1) Our premise is axiom B2
   $\forall$ i,j if b_i // b_j then – (b_j // b_i)
2) Axiom B2 includes the particular case in which j = i:
   if b_i // b_i then – (b_i // b_i)
3) But if we make use of the tautology 'p then -p entails -p', *2)* entails
   – (b_i // b_i)
4) Using now DEFINITION B1 and the De Morgan's Theorem we obtain
   –(b_i / b_i) and – $\exists$ $\{c_1, \ldots, c_n\}$ with $n \geqslant 1$ such that b_i / c_1 and c_1 / c_2 and. . .and c_n / b_i
5) And using the simplification of the conjunction:
   – (b_i / b_i), that is, axiom B1.

Let's discuss now the proof of Theorem (*T*) (mentioned on p. 67). Mary Williams wants to prove to theorem in order to show that a species cannot be defined as a class of organism. I will show that she didn't succeed in doing this.

In order to prove the theorem, Williams uses a modified version of Padoa's principle that was published by McKinsey in 1945.[3] This presentation of McKinsey's version is not found in Williams' work. It was added here for a better understanding of Williams' proof.

According to McKinsey, if we have an abstract mathematical system S with undefined ideas ($K_1, K_2, \ldots ; R_1, R_2, \ldots ; o_1, o_2, \ldots$)

where Ki represents an undefined class,
Ri an undefined relation
and oi an undefined operation,

[3] McKinsey, J. "On the Independence of Undefined Ideas". *Bulletin of the American Mathematical Society*, 291-297, 1935.

then K1 is independent of ($K_2, \ldots; R_1, R_2, \ldots; o_1, o_2, \ldots$) if we can find two concrete representations of S: S' and S" such that:

For S': the abstract system is interpreted as (Ki'; Ri'; oi')
For S": as (K_1", K_2'; . . .; R_i; o_i)

and such that

Kl' and Kl" are different in extension, so that there is an element a which to Kl' but not to Kl".

Let's make a reconstruction of Williams' proof in terms of McKinsey's version:

(i) From the beginning we are confronted with a great difficulty. We don't know which is the abstract mathematical system that Williams uses.

In the first place, she asserts that E is her "abstract mathematical system with primitives (b, D, $\not\triangleright$, φ)" where

b is an organism
D is a species
$\not\triangleright$ is a relation that should be read 'is a parent of'
φ is a real valued function.

The following representations are the concrete interpretations of E in McKinsey's terms

For E1 ($b_1, D_1, \not\triangleright_1, \varphi_1$)
For E2 ($b_1, D_2, \not\triangleright_1, \varphi_1$)

in order to prove that "D is independent of (b, $\not\triangleright$, φ). But if we now compare this with Williams' explanations then, it seems that we were wrong in thinking that (b, D, $\not\triangleright$, φ) was the abastract mathematical system that she considers in the proof. She says:

Lct B denote the set of all organism b, and let C denote the set of all species D. Then D is independent of (b, $\nsucc$, φ) if there exist two concrete models $\bar{E}$, $\bar{\bar{E}}$ of E such that $\bar{B} = \bar{\bar{B}}, \bar{\nsucc} = \bar{\bar{\nsucc}}, \bar{\varphi} = \bar{\bar{\varphi}}$ and $\bar{C} \neq \bar{\bar{C}}$ (p. 13).

According to this assertion the concrete interpretations in McKinsey's terms are:

For E1' $(B_1, C_1, \nsucc_1, \varphi_1)$
For E2' $(B_1, C_2, \nsucc_1, \varphi_1)$

Now we tend to think that the abstract mathematical system is E with primitives (B, C, $\nsucc$, φ).

(ii) In addition to that, we can see that the first abstract mathematical system doesn't fulfil the axioms.

In her paper the axioms are presented in an informal way. In order to avoid ambiguities we can look for the formal presentations of the axioms in Mary Williams' work "Deducing the Consequences of Evolution".

Let us consider for example, axiom D 3. It says:

'For any biological entity b in B, φ (b) is a positive real number.'

Clearly, the axiom is fulfilled by (B, C, $\nsucc$, φ) because it makes a quantification over the set of organisms. But it is not fulfilled by (b, D, $\nsucc$, φ) because, in this case, we can make no quantifications (b has no elements).

(iii) Without taking into account the previous inconveniences, let's continue with the proof.

Let's suppose that Williams uses the second set of primitives (the one that fulfils the axioms).

According to McKinsey, if we want to show that C is independent of (b, $\nsucc$, φ) we must find two concrete interpretations in which B, $\nsucc$, φ do not change while C differs in extension in both interpretations. That is, there must exist an element D that belongs to the first interpretation of C (that is C1) but not to the second (C2).

The way in which Williams deals with this requirement consists only in giving a dubious example in which she mixes the two sets of primitives. The example is the following:

> Consider all speciation events in which the origin of the new species is a few immigrations of small numbers of organisms to a locality which then became isolated from the locality of the ancestor species and in which the population in the isolated locality gradually develops physiological barriers to reproduction with the ancestor population.
>
> For model $\overline{E}$, let the interpretation of $\overline{D}$ (going back to the first set of primitives) be the population from the time it develops complete physiological barriers.
>
> For model $\overline{\overline{E}}$, let the interpretation of $\overline{\overline{D}}$ be the population from one generation before it develops complete physiological barriers.

And she also asserts that D1 as well as D2

> would make the axioms into true statements about the world (p. 13).

But, if she is using the second set of primitives, what she must prove (and there is no formal proof of this here) is that C fulfils the axioms and not D.

(iv) Even granting that Williams gives an informal version of McKinsey's version of Padoa's Principle, we must also have to admit that this informal version is wrong. What she must show is not only that there are two different concrete interpretations in which C differs in extension, but *also* that the other primitives can be kept fixed while C varies in extension. To show this with the two systems proposed (and mixed) by Williams doesn't seem to be possible.

If we choose the first system (ignoring, for the time being, that it doesn't fulfil the axioms) that refers to an individual organism and to an individual species (the (b, D, $\ntriangleright$, φ)) we may obtain the following concrete interpretations.

For model E1 (Rin-tin-tin, THE DOG, $\ntriangleright$, φ)
For model E2 (Mickey Mouse, THE MOUSE, $\ntriangleright$, φ)

Here it is clear that we cannot change D (the species) without changing b (the organism).

If now we choose the second set of primitives (B, C, $\ntriangleright$, φ) that refers to a set of species and a set of organisms we may obtain the following concrete interpretations:

For model E1 {{ Rin-tin-tin, Mickey Mouse, Porky } , {THE DOG, THE MOUSE, THE PIG};$\ntriangleright$; φ}

For model E2 {{ Rin-tin-tin, Porky } ; { THE DOG, THE PIG } ; $\ntriangleright$, φ}

Here it is also impossible to see how we can change C (the set of species) without changing B (the set of organisms).

As a final comment, I want to say that my purpose was not to determine whether the thesis that claims that species are individuals rather than classes is right or not, but to show that the arguments that Williams uses to support this thesis are not adequate.