concepts, but the key question is whether there is an ontological status for the species. In our opinion, species exist in Nature in the form of populations and lineages whose individuality is generally maintained by reproductive isolation. Although there are no species concepts that can be applied in general, given the variety of types of natural groups, it is not certain that there should only exist a single-species concept. The acceptance of different species concepts does not necessarily mean that they should be used arbitrarily or that these concepts would be valid under any circumstances. Some recent studies suggest that genomes are more permeable than previously thought, but biological evolution has fashioned nature with a discontinuous appearance, probably because the permeability of genomes does not and has not been the norm (i.e. different evolutionary lineages are maintained separately over time). This explains why the apparent discontinuities (e.g. ecological, morphological, behavioral) are in most cases confirmed by molecular discontinuities; therefore, for systematics, a multidisciplinary approach is the most coherent. Thus, we often use different, concordant lines of evidence to identify subtle entities that are evolutionarily different.

Speciation takes place over time and this causes difficulties in taxonomy. However, this does not mean that nature constitutes a continuum because new biological entities could be generated during a gradual process, thereby creating a discontinuous scenery. de Meeûs *et al.* [1] recognize the distinction between the taxonomic species and the object to which this species refers. Therefore, should their words be interpreted to mean that species are no more than subjective constructions that only exist in our minds? It is possible that de Meeûs *et al.* accept the existence of natural groups that are more or less independent from an evolutionary point of view and, in this case, are these real species not susceptible to being defined? In this context, we agree with Hey *et al.* [3] who consider the species taxa as a hypothesis, pending revision with regards to the possible existence of evolutionary entities that exist independently of human concepts. However, we think that the biological context imposes the use of a particular species concept, and further knowledge of the species entity will lead to perfection of this concept. The species taxa therefore constitute an improvable concept of the evolutionary entity, an improvement that is made possible by integration of different sources of information [4]. This indicates that the species concepts are basic in the knowledge of the natural diversity because they can be used in the formulation of general predictions, in accordance with a hypothetic-deductive procedure.

Before discounting the possibility of one or more valid species concepts, or even invalidating the biological species concept, we should not forget that the affirmation of an unacceptable fit between the species understood as an arbitrary concept and the species understood as a real objective entity because the dynamics of the evolutionary process, requires support by empirical data and should not be generalized. Even allowing for an imperfect match between concept and referent, one or more species concepts of non-arbitrary application (referring to different types of natural groups), including classical concepts such as the biological species concept, could serve as models that help us to understand how biodiversity is structured.

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Letter Response

Response to Vilas and Paniagua: Analyzing the structure of biodiversity

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We did not expect complete agreement with our views on the biological species concept, but we were surprised by Vilas and Paniagua's comments (above), in particular, their aspiration to rescue the biological species concept. Vilas and Paniagua did not address the main points that were discussed in our article. For example, we covered not only plants and animals, but also different forms of life, including microorganisms, which provided the strongest arguments against the biological species concept. In addition, we dealt with asexually and sexually reproducing organisms, including non-classical forms of sexual reproduction.

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We disagree with Vilas and Paniagua's view that 'we are just beginning to understand the genetics of speciation'. We believe that the current abuse of the species concepts confuses the evolutionary biology debate and we want to clarify this confusion. There are three elements of concern regarding the species concept: (i) taxonomy; (ii) evolution; and (iii) biological diversity assessment. The species as a taxonomic unit is not a real problem as long as keys for species recognition are available to the public. Describing evolution and its mechanisms, or assessing biological diversity are rendered difficult by the use of any species concept. Applying a species concept within the context of evolutionary biology forces one to deal with the evolution of a fixed entity. The evaluation of biological diversity cannot be performed properly if any type of species concept is used. This was demonstrated with our bacteria and birds example in Ref. [1]. Alternative tools for evaluating biological diversity that could be generalized are being developed [2]. The *Escherichia coli* lineage provides one example that illustrates these problems. The name *E. coli* is used to describe commensal bacteria of humans that protect the digestive tract from other microbes, whereas the name *Shigella* spp. describes another group of bacteria that are deadly pathogens of humans. Physicians consider *E. coli* and *Shigella* spp. as two different genera because of the differences in their effects on human health. However, *Shigella* are actually forms of *E. coli* that recurrently appear by lateral transfers of genes between different *E. coli* strains [3]. Thus, the distinction between *E. coli* and *Shigella* is clinically useful, but it is not helpful in terms of evolutionary biology or biodiversity assessment.

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Letter

Immunodiagnostic approaches for detecting *Taenia solium*

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In a recent *Research Focus* [1], Ito and Craig stated that: 'the most reliable serology to detect cysticercosis in humans and animals is to analyze the antibody response against specific *T. solium* antigens'. The detection of circulating *Taenia solium* antigen, however, was given little attention in this article because of the problems associated with crossreactivity to other *Taenia* spp.

Antibody detection tests [e.g. enzyme-linked immunosorbent assay (ELISA) and enzyme-linked immunoelectrotransfer blot technique (EITB)] are the most appropriate tools for measuring exposure to *T. solium* in sero-epidemiological surveys and for confirmation of *T. solium* as the etiological agent of epilepsy. Conversely, antigen detection tests are more useful for other purposes such as the detection of active cysticercosis or the follow-up of NCC patients after treatment [2–5]. Although the available monoclonal antibody-based sandwich ELISAs for detecting circulating cysticercus antigen (Ag-ELISA) are not species-specific and can crossreact with *Taenia hydatigena* cysticerci in pigs, this should not jeopardize the diagnosis of human cysticercosis because *T. hydatigena* does not occur in humans.

At least two Ag-ELISAs [6,7] have been validated under experimental and field conditions, and there are several advantages in using these Ag-ELISAs to diagnose human cysticercosis from serum samples. Ag-ELISAs only detect cases of active cysticercosis (i.e. the presence of living cysticerci) [3–5,8], which is important for deciding on the appropriate antiparasitic treatment (according to the guidelines proposed by Garcia *et al.* [9]). Patients with only calcified cysts, who do not need anthelmintic treatment, are consistently negative when tested by the Ag-ELISA [8]; this has also been confirmed in a pig model infected with only calcified cysts [10]. When identifying *T. solium* as the etiological agent of epilepsy, antibody detection is more appropriate than Ag-ELISA because dead cysts are more-often responsible for epileptic seizures than those caused by living cysts [11].

The sensitivity of the Ag-ELISA is very high, even in light infections, for example, the Ag-ELISA can detect a single-cyst infection in a pig model [10]. The Ag-ELISA is very specific, and no cross-reactions were observed in sera from patients infected with other parasites, such as *Schistosoma*, hydatid cysts, *Ascaris*, *Trichuris*, filaria, *Entamoeba*, *Plasmodium* or *Trypanosoma* [3]. The Ag-ELISA is also an efficient tool for the follow-up of

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