

LETTER TO THE EDITOR

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# On the validity of “*Candidatus* *Dirofilaria hongkongensis*” and on the use of the provisional status *Candidatus* in zoological nomenclature

Filipe Dantas-Torres<sup>1\*</sup>  and Domenico Otranto<sup>2,3</sup>

## Abstract

The fast development of molecular taxonomy is impacting our knowledge of the world parasite diversity at an unprecedented level. A number of operational taxonomic units have been uncovered and new species described. However, it is not always that new parasite species are being described in compliance with the International Code of Zoological Nomenclature. This is the case of “*Candidatus* *Dirofilaria hongkongensis*”, a nematode found in dogs, jackals and humans in Hong Kong and parts of India. This name has been proposed without a formal description and without the designation of a holotype, and therefore is an unavailable name. Finally, we argue that using the provisional status *Candidatus* in zoological nomenclature is inappropriate, considering this term is not considered in the International Code of Zoological Nomenclature.

**Keywords:** *Dirofilaria*, Phylogeny, Taxonomy, New species, Nomenclature, Rules

## Letter to the editor

*Dirofilaria immitis* and *Dirofilaria repens* are widespread nematodes of major medical and veterinary importance. *Dirofilaria immitis* is ubiquitous in distribution and *D. repens* is present in the Old World [1, 2]. They are transmitted to animals and humans *via* the bite of infected female mosquitoes belonging to numerous species around the world [1].

In 2012, To et al. [3] reported three human cases of dirofilariosis in Hong Kong. One patient presented with cervical lymphadenopathy, one with an abdominal subcutaneous mass, and the other with a subconjunctival nodule. Cytochrome *c* oxidase subunit 1 (*cox1*) gene sequences obtained from the three human patients were identical. Further analysis showed homologies of 96.2%

and 89.3% to the *cox1* gene of *D. repens* and *D. immitis*, respectively. In a similar manner, a sequence of the 18S-ITS1-5.8S gene cluster was obtained from an intact worm, showing homologies of 94.0% and 94.9% to those of *D. repens* and *D. immitis*, respectively. To et al. [3] investigated the presence of this *Dirofilaria* sp. in dogs and cats, detecting 3% (6/200) of positive dogs and no positive cat. Finally, the *cox1* gene and 18S-ITS1-5.8S gene cluster obtained from dogs were found to be identical to those detected in the human patients. With solid evidence, To et al. [3] elegantly demonstrated that a new zoonotic species of the genus *Dirofilaria*, related to *D. repens*, was circulating among dogs and humans in Hong Kong, proposing the name “*Candidatus* *Dirofilaria hongkongensis*”.

Subsequently, this parasite has been referred to as *Dirofilaria hongkongensis*, *Candidatus* *Dirofilaria hongkongensis*, *Dirofilaria* sp. *hongkongensis*, *Dirofilaria* sp. “*hongkongensis*”, and *Candidatus* *Dirofilaria* (*Nochtiella*) *Honkongensis*, by different authors [3–15].

\*Correspondence: filipe.dantas@cpqam.fiocruz.br

<sup>1</sup> Department of Immunology, Aggeu Magalhães Institute, Oswaldo Cruz Foundation (Fiocruz), Recife, Brazil

Full list of author information is available at the end of the article



Unfortunately, To et al. [3] in the original reference to “*Candidatus* *Dirofilaria hongkongensis*” failed to identify either a holotype or give an appropriate morphological description, which are part of the rules of the International Code of Zoological Nomenclature (ICZN) [16]. Therefore, *Dirofilaria hongkongensis* must be considered *nomen nudum* and an unavailable name. This species name is not currently registered in ZooBank (as of 3 June 2020).

The parasite reported by To et al. [3] as “*Candidatus* *Dirofilaria hongkongensis*” has been detected in an Austrian traveller returning from the Indian subcontinent [9], in dogs, jackals and humans in south India [12, 13], and again in a human in Hong Kong [5, 15]. Other authors identified additional genotypes related to *D. repens*, referred to as *Candidatus* *Dirofilaria* sp. ‘Thailand II’ (also referred to as *Dirofilaria* sp. ‘Thailand II’) and *Dirofilaria* sp. “Thailand III” – in cats in Thailand [10, 11]. These genotypes were related but different from each other and different from “*Candidatus* *Dirofilaria hongkongensis*”.

Different genotypes related to *D. repens* or to *D. immitis* have been reported in the Americas [1]. For instance, a nematode extracted from the eye of a human patient in Pará State (northern Brazil), morphologically similar to, but genetically distinct from *D. immitis* (percentage of nucleotide difference 5% and 6% for 12S rDNA and *cox1*, respectively) [17]. Such a high nucleotide variation suggested the existence of a cryptic species of *D. immitis* in Brazil or of a closely related species. Nonetheless, in the absence of more data (e.g. additional male and female specimens, but also microfilariae from a proper host), no new species name was proposed.

Incidentally, other authors have also been using the provisional status *Candidatus* in zoological nomenclature (e.g. *Candidatus* *Babesia vesperuginis* and *Candidatus* “*Theileria senegalensis*”) in recent years (e.g. [18, 19]). This category has been proposed by Murray & Schleifer [20] for recording the properties of putative taxa of prokaryotes and has been implemented by the International Committee on Systematics of Prokaryotes [21]. According to the International Code of Nomenclature of Prokaryotes (ICNP) [22], the provisional status *Candidatus* may be used to record the properties of putative taxa of prokaryotes and should be used for describing prokaryotic entities for which more than a mere nucleic acid sequence is available but for which characteristics required for description according to the ICNP are lacking. Furthermore, the ICNP provides a list of information that should be included in the description of a *Candidatus*: “(a) Genomic information, i.e. nucleic acid sequences apt to determine the phylogenetic position of the organism. (b) All information so far available on (c) structure

and morphology (appropriate illustration) (d) physiology and metabolism (e) reproductive features (f) the natural environment, in which the organism can be identified by in situ hybridization or similar techniques for cell identification. (g) Any other available and suitable information” [22].

On the other hand, the provisional status *Candidatus* is not considered in the ICZN, which makes no reference regarding the use of this or similar term [16]. Therefore, the current use of this term in zoological nomenclature should be avoided, so as to avoid that several newly proposed names become unavailable. As emphasized elsewhere, the use of informal clade names is necessary until formal valid descriptions are available [23].

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FDT performed the literature review and wrote the manuscript. DO reviewed the manuscript. Both authors read and approved the final manuscript.

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Not applicable.

#### Consent for publication

Not applicable.

#### Competing interests

The authors declare that they have no competing interests.

#### Author details

<sup>1</sup> Department of Immunology, Aggeu Magalhães Institute, Oswaldo Cruz Foundation (Fiocruz), Recife, Brazil. <sup>2</sup> Department of Veterinary Medicine, Università degli Studi di Bari, Valenzano, Bari, Italy. <sup>3</sup> Faculty of Veterinary Sciences, Bu-Ali Sina University, Hamedan, Iran.

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