

Adenoides sinensis, a new sand-dwelling dinoflagellate species from China and reexamination of *Adenoides eludens* from an Atlantic strain

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ABSTRACT: The sand-dwelling dinoflagellate genera *Adenoides* and *Pseudadenoides* are morphologically very close but distinct in their molecular phylogeny. We established three cultures by isolating single cells from sand samples collected in intertidal zones of Qingdao (Yellow Sea), Dongshan (South China Sea) and Brittany (English Channel, North Atlantic, France). Strain morphology was examined with light and scanning electron microscopy, and both large subunit ribosomal DNA (LSU rDNA) and small subunit ribosomal DNA (SSU rDNA) sequences were amplified. Molecular phylogeny, corroborated by morphological examination showing the existence of a ventral pore, confirmed the identification of the French strain (RCC1982) as *Adenoides eludens*. The Chinese strains differed from *Adenoides eludens* in two additional posterior intercalary plates and differed from *Pseudadenoides* in one additional apical plate having the plate formula of Po, Cp, X, 5', 6'', 4S, 5''', 5p, 1'''' or alternatively Po, Cp, X, 5', 6'', 5S, 5''', 3p, 2'''''. Maximum likelihood and Bayesian inference, carried out with concatenated LSU and SSU sequences, demonstrated that the Chinese strains were closely related but different from *A. eludens* and, in corroboration with morphological evidence, supported their classification as a distinct species, *Adenoides sinensis* sp. nov. Morphological and molecular results confirmed the close relationship between the two genera *Adenoides* and *Pseudadenoides*.

KEY WORDS: *Amphidinium eludens*, *Amphidinium kofoidii*, Benthic dinoflagellates, Molecular phylogeny, *Pseudadenoides*

INTRODUCTION

The taxonomic history of *Adenoides* dates back to the pioneering work on benthic dinoflagellates by Herdman (1922). She described two sand-dwelling species, *Amphidinium eludens* Herdman and *Amphidinium kofoidii* Herdman, collected at Port Erin beach, UK (illustrated in Herdman 1922, figs 1 and 2). Both had a minute epitheca, the latter species having a slightly larger one (Herdman 1922). Herdman (1922) also described *Amphidinium kofoidii* var. *petasatum* Herdman (illustrated in Herdman 1922, fig. 3), which had a more pronounced epitheca. Thecal plates were not examined at that time, and these taxa were only separated on the basis of their general morphology. Later, Balech (1956) investigated some material collected at Roscoff, France, which he considered morphologically similar to *Amphidinium kofoidii*, having the distinctive epitheca and a pyrenoid with a starch ring. After examining the plate pattern (1', 4', 5c, 4s, 5''', 5p, 1''''') he erected the genus *Adenoides* Balech, designating *Adenoides eludens* Balech as type species. Dodge (1982) transferred *Amphidinium kofoidii* into *Adenoides* as *Adenoides kofoidii* Dodge without making

additional observations. Subsequently, Dodge & Lewis (1986) examined *Adenoides kofoidii*-like cells from Roscoff using scanning electron microscopy (SEM) but called it *Adenoides eludens*, on the basis that these two species might be conspecific, as previously considered by Balech (1956). Dodge & Lewis (1986) interpreted the plate pattern of *A. eludens* (= *A. kofoidii*) as Po, 3', 5c, 6s, 4''', 5p, 1'''''. Hoppenrath *et al.* (2003) investigated *A. eludens sensu* Dodge & Lewis (1986) from the North German Wadden Sea using SEM pictures and provided two interpretations of the plate patterns: Po, 4', 6c, 4s, 5''', 5p, 1'''' or Po, 4', 6c, 5s, 5''', 3p, 2'''''. Many studies were carried out on strains identified as *A. eludens*-like, until the taxonomy of this species was clarified by Gómez *et al.* (2015) using new samples from Wimereux (English Channel, France). Gómez *et al.* (2015) showed that *A. eludens sensu* Balech did not have a girdle similar to *A. kofoidii* and argued that *A. eludens sensu* Dodge & Lewis (1986) and Hoppenrath *et al.* (2003) were erroneously classified. Based on new morphological and genetic evidence, Gómez *et al.* (2015) established the genus *Pseudadenoides* F.Gómez, R.Onuma, Artigas & Horiguchi to include *Pseudadenoides kofoidii* comb. nov. F.Gómez, R.Onuma, Artigas & Horiguchi formerly classified as *A. kofoidii*. Apart from the absence of a girdle in *A. eludens*, the two genera also differ in the number of apical plates, that is five in *Adenoides* and four in *Pseudadenoides* (Gómez *et al.* 2015). Recently, a new *Pseudadenoides* species, *Pseudadenoides polypyrenoides* Hoppenrath, Yubuki, R.Stern & B.S.Leander, was described. This species is genetically

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