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Article in *Journal of Phycology* · June 2016

DOI: 10.1111/jpy.12448

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HIGH DIVERSITY OF *PSEUDO-NITZSCHIA* ALONG THE NORTHERN COAST OF SARAWAK (MALAYSIAN BORNEO), WITH DESCRIPTIONS OF *P. BIPERTITA* SP. NOV. AND *P. LIMII* SP. NOV. (BACILLARIOPHYCEAE)¹

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Forty-eight isolates of *Pseudo-nitzschia* species were established from the Miri coast of Sarawak (Malaysian Borneo) and underwent TEM observation and molecular characterization. Ten species were found: *P. abrensis*, *P. batesiana*, *P. fukuyoi*, *P. kodamae*, *P. lundholmiae*, *P. multistriata*, *P. pungens*, *P. subfraudulenta*, as well as two additional new morphotypes, herein designated as *P. bipertita* sp. nov. and *P. limii* sp. nov. This is the first report of *P. abrensis*, *P. batesiana*, *P. kodamae*, *P. fukuyoi*, and *P. lundholmiae* in coastal waters of Malaysian Borneo. *Pseudo-nitzschia bipertita* differs from its congeners by the number of sectors that divide the poroids, densities of band striae, and its cingular band structure. *Pseudo-nitzschia limii*, a pseudo-cryptic species in the *P. pseudodelicatissima* complex sensu lato, is distinct by having wider proximal and distal mantles, a higher number of striae, and greater poroid height in the striae of the valvocopula. The species were further supported by the phylogenetic reconstructions of the nuclear-encoded large subunit ribosomal gene and the second internal transcribed spacer. Phylogenetically, *P. bipertita* clustered with its sister taxa (*P. subpacificae* + *P. heimii*); *P. limii* appears as a sister taxon to *P. kodamae* and *P. hasleana* in the ITS2 tree. Pairwise comparison of ITS2 transcripts with its closest relatives revealed the presence of both hemi- and compensatory base changes. Toxicity

analysis showed detectable levels of domoic acid in *P. abrensis*, *P. batesiana*, *P. lundholmiae*, and *P. subfraudulenta*, but both new species tested below the detection limit.

Key index words: domoic acid; frustule; ITS2 transcript; Malaysia, pseudo-cryptic; *Pseudo-nitzschia*; rDNA

Abbreviations: AIC, Akaike information criterion; BI, Bayesian analysis; CBCs, compensatory base changes; DA, domoic acid; fg, femtogram; HCBCs, hemi-compensatory base changes; ITS2, second internal transcribed spacer; ML, maximum likelihood; MP, maximum parsimony; NJ, neighbor joining; PP, posterior probabilities; rDNAs, ribosomal RNA genes; SNPs, single nucleotide polymorphisms

Peragallo (1900) described *Pseudo-nitzschia* with *P. seriata* (Cleve) Peragallo, the type species (Peragallo & Peragallo, 1897–1908). *Pseudo-nitzschia* species are distributed worldwide in coastal and oceanic waters (reviewed in Lelong et al. 2012); some are known to be cosmopolites (Hasle 2002, Casteleyn et al. 2008, Lim et al. 2012a, 2014). To date, 26 species of *Pseudo-nitzschia* have been reported from tropical Malaysian waters (Lim et al. 2012a,b, Teng et al. 2013, 2014a, 2015) representing ~60% of the current taxonomically accepted species.

Shellfish contamination by the neurotoxin domoic acid (DA; Dao et al. 2006, 2009) and discoveries of toxigenic *Pseudo-nitzschia* species (Dao et al. 2014,

¹Received 5 June 2015. Accepted 6 June 2016.

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Editorial Responsibility: P. Gabrielson (Associate Editor)