



Nomenclatural changes for some freshwater red algae from India

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In preparing a bibliographic check-list on freshwater red algae of India, we noted that nomenclatural changes are necessary for nine taxa currently placed in *Acrochaetium*-*Audouinella*-*Chantransia* complex and *Batrachospermum sensu lato*. These are *Audouinella desikacharyi* nom. nov., *A. keralayensis* (Jose & Patel) comb. nov., *Kumanoa balakrishnanii* (Chaugule) comb. nov., *K. dasyphylla* (Skuja ex Balakrishnan & Chaugule) comb. nov., *K. iyengarii* (Skuja ex Balakrishnan & Chaugule) comb. nov., *K. kylinii* (Balakrishnan & Chaugule) comb. nov., *K. mahabaleshwarensis* (Balakrishnan & Chaugule) comb. nov., *K. umamaheswararaoi* (Baluswami & Babu) comb. nov., and *K. zeylanica* (Skuja ex Balakrishnan & Chaugule) comb. nov. All the above-mentioned species, excepting *Kumanoa zeylanica*, appear to be endemic to India, since no other records are known outside India.

Key Words: *Audouinella*; *Batrachospermum*; freshwater red algae; India; *Kumanoa*; taxonomy

INTRODUCTION

We have been compiling over the last several years, bibliographic references and geographical distributional records of members of the division Rhodophyta occurring in non-marine environments published during the past 150 years (1846-2012) (Ganesan and West 2008). The combined data includes information on approximately 70 taxonomic entities (species, varieties, unidentified, and doubtful records) occurring in the vast Indian sub-continent. These taxa are distributed among 19-20 genera: *Audouinella*, *Balliopsis*, *Batrachospermum sensu lato*, *Bostrychia*, *Caloglossa*, *Catenella*, *Chroodactylon* (including *Asterocytis*), *Chroothece*, *Compsopogon*, *Compsopogonopsis*, *Hildenbrandia*, *Kumanoa*, *Kyliniella*, *Lemanea* / *Paralemanea*, *Nothocladus*, *Polysiphonia*, *Porphyridium*, *Sirodotia*, *Thorea*, and *Tuomeya*. We noted that several nomenclatural changes are necessary and these are made here. Complete distributional records of all the taxa recorded from India, supported by biblio-

graphic references and comments will be included in our final publication of Bibliographic Checklist of Non-Marine Rhodophyta (Red Algae) of India.

MATERIALS AND METHODS

This research is a literature survey and we relied entirely on publications available through our personal libraries, library services at the University of Melbourne and resources from academic friends around the world.

OBSERVATIONS AND DISCUSSION

Phylum Rhodophyta
Class Florideophyceae
Order Acrochaetales

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Family Acrochaetiaceae**Genus** *Audouinella* Bory de Saint-Vincent emend.

Harper & Saunders 2002

Audouinella desikacharyi E. K. Ganesan & J. A. West nom. nov.**Basionym.** *Chantransia pulvinata* Schmidle 1900, p. 79.**Homotypic synonym.** *Audouinella pulvinata* (Schmidle) Desikachary, Balakrishnan & Krishnamurthy 1990, p. 75; Silva 2012; *non Audouinella pulvinata* (Levring) Garbary 1987, p. 145.

Comments. Pending critical morphometric and molecular studies on *Audouinella* species known from India, we treat tentatively all freshwater species with an “acrochaetoid” morphology in a broad sense (i.e., bluish and / or reddish in color, with a single or multiple plastids, with or without pyrenoids and with or without asexual / sexual reproduction) under a single generic name (see also Harper and Saunders 2002). The Indian species was described for the first time by Schmidle (1900) as *Chantransia pulvinata* Schmidle from freshwater (Matheran; Ponsoy Spring falls, Lake Danger Point, growing on stones) in Maharashtra state of Western Ghats, India. According to Stafleu and Cowan’s Tax. Lit. II, Schmidle’s herbarium is in Zurich herbarium (ZT), Switzerland (Michael J. Wynne personal communication), which “probably” houses the original collection made from India. Desikachary et al. (1990) transferred *C. pulvinata* to *Audouinella* as *A. pulvinata* (Schmidle) Desikachary, Balakrishnan & Krishnamurthy and possibly based on the description given by De Toni (1905), provided an English description translated from the German protologue. The characteristic feature of the species, apart from the small pulvinate and heterotrichous habit, is the torulose nature of the cells of the discoid base. Much earlier, Levring (1953, p. 477, Fig. 12A-F) described and illustrated as new, a marine species, from Australia as *Acrochaetium pulvinatum*, which Garbary (1987) transferred to the genus *Audouinella* as *A. pulvinata* (Levring) Garbary (1987, p. 145). Hence, as a later homonym, but referring to an entirely different taxon occurring in freshwaters of India, the combination made by Desikachary et al. (1990) is illegitimate (Silva 2012). Consequently, we here propose a new name, *Audouinella desikacharyi* for the Indian freshwater species honouring the late Professor T. V. Desikachary. No collection other than the original one is known.

Chantransia (also *Pseudochantransia*) as generic names, are not generally in current usage, but simply treated as *form-genera*, *form-taxa* or *genera incertae sedis* (Vis et al. 2006, Chiasson et al. 2007, Schneider and Wyn-

ne 2007). More importantly, *Chantransia* spp. are considered as phases in the life-cycle of genera belonging to different orders like Acrochaetiales, Batrachospermales, and Thoreaales (Pueschel et al. 2000, Necchi and Jiménez 2002, Zucchi and Necchi 2003, Chiasson et al. 2005, 2007, Necchi and Oliveira 2011). Chiasson et al. (2007) demonstrated, by molecular data and culture studies, that the form taxon *Chantransia pygmaea* is “unequivocally associated with five different taxa among three genera”: 1) ‘*Batrachospermum ambiguum*, (currently referable to *Kumanoa ambigua* [Montagne] Entwisle, Vis, Chiasson, Necchi & Sherwood), *B. arcuatum* Kylin, and *B. atrum* (Hudson) Harvey, 2) *Nemalionopsis tortuosa* Yoneda & Yagi, and 3) *Thorea violacea* Bory de Saint-Vincent. On the other hand, they have pointed out earlier (Chiasson et al. 2005) and confirmed recently (see Pueschel et al. 2000, Necchi and Oliveira 2011) that *Chantransia macrospora* constituted the alternate phase for a single species (*B. macrosporum* Montagne), although other species of *Batrachospermum* were also present in the same stream. Necchi and Oliveira (2011) recently showed that “*Chantransia pygmaea*” is associated with 7 species of the Batrachospermales and 2 species of Thoreaales. Hence, caution should be exercised in relating one *Chantransia* species with one or several *Batrachospermum* species occurring in the same water body. It is pointed out that *A. desikacharyi* (= *C. pulvinata* Schmidle) was collected from Matheran in Maharashtra state where *Kumanoa kylinii* (Balakrishnan & Chaugule) E. K. Ganesan & J. A. West (= *Batrachospermum kylinii* Balakrishnan & Chaugule see below) was also collected. Hence, *A. desikacharyi* may or may not be associated with the *Chantransia* phase of *K. kylinii*, which can be clarified by culture studies with molecular analysis.

Audouinella keralayensis* (Jose & Patel) E. K. Ganesan & J. A. West comb. nov.*Basionym.** *Acrochaetium keralayensis* Jose & Patel 1990, p. 179.

Comments. This species was collected from Periyar river, near Alwaye, Kerala, India and is a notable omission in Kumano (2002). It is currently treated as *Acrochaetium* in AlgaeBase (Guiry and Guiry 2012), while it does not appear in Index Nominum Algarum (INA) database (Silva 2012) either under *Acrochaetium* or *Audouinella*. Ott (2009) treated it under *Pseudochantransia* as *P. keralayensis* (Jose & Patel) Ott. Jose and Patel (1990) provided a Latin diagnosis and also designated the Holotype (C, No. K 20) at the Department of Biosciences, Sardar Patel University, VallabhVidyanagar, Gujarat, India.

Order Batrachospermales**Family** Batrachospermaceae**Genus** *Kumanoa* Entwisle, Vis, Chiasson, Necchi & Sherwood 2009

Entwisle et al. (2009) segregated *Batrachospermum* species from the sections *Contorta* and *Hybrida* to a new genus *Kumanoa*. Vis et al. (2012) initially recognized 31 species of *Kumanoa*, but in a recent monograph, Necchi and Vis (2012) recognized 35 species worldwide. In the most recent update AlgaeBase (Guiry and Guiry 2012), 43 binomials are cited under *Kumanoa*, of which 6 names are considered synonyms, thus making a total of 37 species names at present. Necchi and Vis (2012) in their monograph listed 12 species as “doubtful” members of *Kumanoa*, because of “the unavailability of type specimen or descriptions missing key diagnostic characters presently used to delineate species reliably.” Of these 12 doubtful species listed by Necchi and Vis (2012), 5 species were described based on specimens collected from India. Based on published information available to us, we here reconfirm the status of these 5 “uncertain” species, and also add 2 more species described from India as belonging to *Kumanoa*. *Kumanoa* was characterized by certain features like 1) twisted or coiled nature of the carpogonial branches and axial position of compact carposporophytes and 2) molecular data forming a well-supported clade distinct from other sections of the genus based on *rbcl* and small subunit of ribosomal gene sequences (Entwisle et al. 2009). Other recent studies (Necchi et al. 2010, Vis et al. 2012) revealed that molecular data do not support any further infrageneric categories under *Batrachospermum sensu lato*. From a distributional point of view, species of *Kumanoa* are more commonly reported from tropical and subtropical latitudes and strictly from freshwater environments like *Batrachospermum*. It is becoming increasingly clear that the twisted or contorted nature of the carpogonial branches and the central position of the carposporophyte are easily recognizable features to distinguish *Kumanoa* from *Batrachospermum* species *sensu lato* from different regions of the world (Liao 2010, Eloranta et al. 2011, Goodman 2011). It is also relevant to point out that other genera like *Nothocladus*, *Sirodotia* and *Tuomeya*, which are closely related to both *Batrachospermum* and *Kumanoa*, share some female reproductive structures like: 1) symmetrical or asymmetrical nature of (long or short) the carpogonial branch and 2) diffuse or non-compact carposporophytes creeping among cortical filaments. While studying the literature on the 17 *Batra-*

chospermum sensu lato species records from India, we found that 7 species have been clearly described and illustrated to have twisted or curled carpogonial branches and axial or nodal position of the carposporophytes and hence we transfer them to *Kumanoa*. Critical molecular studies on Indian freshwater reds will be needed conclusively to confirm (or reject) our transfers to *Kumanoa*, but to facilitate communication and documentation of the known algal flora of India, we considered it reasonable to make a number of proposals here. Of the 7 species of *Kumanoa* reported here, except *K. zeylanica* recorded both in Sri Lanka and India, 6 species are known from the original or a few other collections in India, but mostly from the same place of occurrence. Without substantial further investigations on their distribution patterns in different parts of India and other regions, it is difficult to assess as to whether some of the Indian *Kumanoa* species are “robust” or “frail” endemics (Tyler 1996). Molecular data are very useful not only for precise identification, but also for evaluating inter and intra specific affinities between populations and ultimately for phylogenetic and phylogeographic evaluation. As far as we could verify, there are no molecular sequence data studies on any of the Indian freshwater red algal taxa.

***Kumanoa balakrishnanii* (Chaugule) E. K. Ganesan & J. A. West comb. nov.**

Basionym. *Batrachospermum balakrishnanii* Chaugule 1980, p. 7.

Comments. Chaugule (1980, Figs 13, 14 & 17) showed clearly the characteristic twisted nature of the carpogonial branches, 9-14 cells long, with “2-3 compact helices” and the axial nature of the carposporophyte. Hence, this species should be referred to the genus *Kumanoa*. In describing the new species collected from a stream at Kas, Satara district, Maharashtra, India, Chaugule (1980) provided a Latin diagnosis and “probably” deposited the Holotype specimen in the Herbarium of the University of Pune, Pune, Maharashtra, India. We were unsuccessful to obtain the Holotype specimen for our study. This species was not mentioned by Kumano (2002), Ott (2009), INA (Silva 2012), and AlgaeBase (Guiry and Guiry 2012), probably because the description was published in a regional journal of limited circulation within India and abroad. Necchi and Vis (2012) did not include this species either under valid or doubtful taxa in their monographic study of *Kumanoa*.

***Kumanoa dasyphylla* (Skuja ex Balakrishnan & Chaugule) E. K. Ganesan & J. A. West comb. nov.**

Basionym. *Batrachospermum dasyphyllum* Skuja ex Balakrishnan & Chaugule 1980a, p. 230.

Comments. Considering that it was a manuscript name given by Skuja, Balakrishnan and Chaugule (1980b) examined the Holotype material borrowed from the Herbarium, Uppsala, Sweden and validated the species with a detailed description with figures and Latin diagnosis. Balakrishnan and Chaugule (1980b, Figs 4 & 7) described and illustrated the characteristic features attributed to *Kumanoa*, like the spirally twisted carpogonial branches and axial position of the carposporophyte, characteristic features attributed to *Kumanoa*. This species is known so far from India by the single original collection made by Iyengar in 1930. Necchi and Vis (2012) included *B. dasyphyllum* under the list of “doubtful species” of *Kumanoa* because the type specimen was not available for their study. The specific epithet is corrected here to *dasyphylla* from *dasyphyllum* according to Latin grammar.

***Kumanoa iyengarii* (Skuja ex Balakrishnan & Chaugule) E. K. Ganesan & J. A. West comb. nov.**

Basionym. *Batrachospermum iyengarii* Skuja ex Balakrishnan & Chaugule 1980a, p. 232.

Comments. Balakrishnan and Chaugule (1980a) described the two diagnostic features of *Kumanoa* 1) “carpogonial branches are comparatively long, with 13-17 barrel-shaped cells and spirally twisted” (Balakrishnan and Chaugule 1980a, Fig. 12) and 2) carposporophyte (Balakrishnan and Chaugule 1980a, Fig. 13) is axial in position. Hence, this species should be transferred to *Kumanoa*. The authors provided a Latin diagnosis and also designated a Lectotype (Iyengar no. IB 80, coll. Iyengar, 1930) (Balakrishnan and Chaugule 1980a, see also Kumano 2002). Both INA (Silva 2012) and AlgaeBase (Guiry and Guiry 2012) treated this taxon as valid and currently accepted in their respective databases, but under *Batrachospermum* (as *B. iyengarii*). Necchi and Vis (2012) were unable to obtain the Holotype specimen and justifiably included it under “doubtful” species.

***Kumanoa kylinii* (Balakrishnan & Chaugule) E. K. Ganesan & J. A. West comb. nov.**

Basionym. *Batrachospermum kylinii* Balakrishnan & Chaugule 1980b, p. 298.

Comments. The description and figures by Balakrishnan and Chaugule (1980b, Figs 3 & 9) clearly suggest that this entity should be transferred to *Kumanoa*. It is a valid and taxonomically accepted species (Kumano 2002, Guiry and Guiry 2012, Silva 2012) but included under the genus *Batrachospermum*, as *B. kylinii*. Necchi and Vis (2012), because of the non-availability of the type specimen for their monographic studies, included it as a doubtful member of *Kumanoa*.

***Kumanoa mahabaleshwarsense* (Balakrishnan & Chaugule) E. K. Ganesan & J. A. West comb. nov.**

Basionym. *Batrachospermum mahabaleshwarsense* Balakrishnan & Chaugule 1980a, p. 231.

Comments. Balakrishnan and Chaugule (1980a) described and illustrated the carpogonial branches as 3-38 cells long, spirally twisted and occasionally curved with carposporophytes axial in position. Hence, this species clearly belongs to *Kumanoa* and the transfer is made here. The Holotype (BBC 102, coll. Balakrishnan in 1962) was deposited at the Herbarium, University of Pune, Maharashtra, India (Balakrishnan and Chaugule 1980a, p. 232; Kumano 2002, p. 219). INA (Silva 2012) and AlgaeBase (Guiry and Guiry 2012) included it as a valid and taxonomically accepted species, but under the genus *Batrachospermum* as *B. mahabaleshwarsense*. Necchi and Vis (2012), because of the non-availability of the Holotype specimen, included it as a doubtful species of *Kumanoa*. The specific epithet ‘*mahabaleshwarsensis*’ had been already corrected to *mahabaleshwarsense* in INA (Silva 2012).

***Kumanoa umamaheswararaoi* (Baluswami & Babu) E. K. Ganesan & J. A. West comb. nov.**

Basionym. *Batrachospermum umamaheswararaoi* Baluswami & Babu 1999, p. 247.

Comments. Baluswami and Babu (1999, Figs 10, 11 & 20) described and illustrated carpogonial branches in *B. umamaheswararaoi* as up to 6 cells long and spirally coiled with carposporophytes axial in position and hence it should be transferred to *Kumanoa*, as the genus is currently circumscribed. The Holotype specimen (No. 2A) was stated to have been deposited in the Laboratory of Phycology, Department of Botany, Madras Christian College, Chennai, India. Baluswami and Babu (1990) apparently based their observations on a single collection made by Azhakanandam in 1990 and this species has not

been reported again. Although it is a validly published species, it is not included either in Kumano (2002), INA (Silva 2012), or AlgaeBase (Guiry and Guiry 2012). The description of this species was apparently over-looked because it appeared in a publication that was not readily available outside of India. Necchi and Vis (2012) did not include this species either under valid or doubtful taxa in their monographic study of *Kumanoa*. Members of *Batrachospermum sensu lato* are reported commonly in the tropical regions, from low to high altitude hill streams with running and clear waters, especially during the cooler months of the year. This Indian species occurs in a habitat, uncommon for most species of the genus, e.g., a small, enclosed and stagnant road-side freshwater pond with abundant macrophyte vegetation. Some species like *Batrachospermum dornense* Tarnavski & Radulescu do occur in specialized habitats like peat bogs in the northern hemisphere (Caraus 2002).

***Kumanoa zeylanica* (Skuja ex Balakrishnan & Chaugule) E. K. Ganesan & J. A. West comb. nov.**

Basionym. *Batrachospermum zeylanicum* Skuja ex Balakrishnan & Chaugule 1980a, p. 235.

Comments. Balakrishnan and Chaugule (1980a) described and illustrated the characteristic features 1) the carpogonial branches spirally twisted or contorted to 13 cells, (Balakrishnan and Chaugule 1980a, Fig. 14) and 2) axial carposporophyte (Balakrishnan and Chaugule 1980a, Fig. 16). Hence it clearly belongs to the genus *Kumanoa*. It is a valid and taxonomically accepted species (as *B. zeylanicum*) both in INA (Silva 2012) and AlgaeBase (Guiry and Guiry 2012). The type locality of this species is not clear. According to Kumano (2002), it is Jog Falls, Karnataka state, India. However, INA (Silva 2012) mentioned it to be “Kalulara” (correct spelling is Kalutara and not “Kalulara”) in Sri Lanka (formerly Ceylon). The specimen was collected by W. Ferguson and the Lectotype is specimen no. 1, NS 238 in Uppsala University Herbarium (UPS). Balakrishnan and Chaugule (1980a) made their observations on this species using specimens collected by Iyengar in 1926 from Jog Falls, Karnataka state. Given the uncertainties of correct identifications of specimens from different locales, it is difficult to know if these two collections are of same entity. Necchi and Vis (2012, p. 73) included this species as a doubtful member of *Kumanoa*, since type specimen was not available for their studies. The specific epithet is corrected here from *zeylanicum* to *zeylanica* according to Latin grammar.

CONCLUSION

Nomenclatural changes were made for nine taxa occurring in India and currently placed in *Acrochaetium-Audouinella-Chantransia* complex and *Batrachospermum sensu lato*: *Audouinella desikacharyi* nom. nov., *A. keralayensis* (Jose & Patel) comb. nov., *Kumanoa balakrishnanii* (Chaugule) comb. nov., *K. dasyphylla* (Skuja ex Balakrishnan & Chaugule) comb. nov., *K. iyengarii* (Skuja ex Balakrishnan & Chaugule) comb. nov., *K. kylinii* (Balakrishnan & Chaugule) comb. nov., *K. mahabaleshwarensis* (Balakrishnan & Chaugule) comb. nov., *K. umamaheswararaoi* (Baluswami & Babu) comb. nov., and *K. zeylanica* (Skuja ex Balakrishnan & Chaugule) comb. nov. All the above-mentioned species, excepting *Kumanoa zeylanica*, appear to be endemic to India. Further investigations on these and other freshwater red algae in India are in progress.

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