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Tripogon cope (Poaceae: Chloridoideae), a New Species Supported by Morphometric Analysis and a Synopsis of *Tripogon* in India

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Abstract—**Tripogon cope** Newmaster S. G., V. Balalasubramaniam, M. Murugesan, & S. Ragupathy a new species from South India, is described and illustrated. A key for the identification of all Indian *Tripogon* species is included. A detrended correspondence analysis identified 21 groups of taxa including the sp. novum from the 48 samples, analyzing 36 morphological characters. A discriminant function analysis was used to rigorously test the classification of specimens provided in the cluster analysis. This study provides preliminary evidence of morphometric variation within and among species of *Tripogon*, which allows further development of hypothesis concerning species boundaries. Discussions concerning ecological data and distribution are presented in the context of conservation initiatives of rare and endemic *Tripogon* taxa within India.

Keywords—Biodiversity, Endemism, India, Nilgiri Biosphere Reserve, Poaceae, Tripogon.

The genus *Tripogon* Roem. & Schult. is comprised of nearly 40 species in tropical and subtropical regions of Asia (33 spp.), Africa (9 spp.), Australia (1 sp.), Arabia (8 spp.), and in the Americas (3 spp.) from the southern U.S.A. to Argentina (Watson and Dallwitz 1992; Peterson et al. 1997; Clayton et al. 2006). Rúgolo de Agrasar and Vega (2004) reported that Asia constitutes the center of diversity for this genus, with 23 species. For example, 16 species are native to China (Clayton et al. 2006). This study reports morphological variation in 21 species of *Tripogon* revealing the diversity of this genus in India.

Most Indian species of *Tripogon* are helophytic to xerophytic, glycophytic and occur in open habitats. Of the 21 species in India, only eight occur in the study area, namely Velliangiri Hill. All Indian *Tripogon* have oblong spikelets, unkeeled fertile lemmas (keeled in *T. bromoides* Roth*)*, two lateral apical lemmatal teeth, and a terminal lemmatal awn. Apart from the newly described **Tripogon cope** and *T. capillatus* Jaub. & Spach, all Indian species of the genus are annual.

Recent floristic surveys have reported considerable diversity within protected religious areas in India, some of which harbour a significant portion of the *Tripogon* flora. Ten species of *Tripogon* are found in the Western Ghats, which is part of Nilgiri Biosphere Reserve (NBR) in Tamil Nadu (Bor 1960; Nair and Henry 1983). Of these ten species, two are endemic to this region, which comprises our study area. We participated in a floristic investigation on a part of Western Ghats, namely Velliangiri Holy Hill, which revealed a considerable diversity of flora with over 1,715 species of angiosperms that includes 439 endemics (Murugesan 2005; Ragupathy et al. 2008). It is astonishing that this relatively small (48 sq. km) holy reserve contains over half of the angiosperm diversity known from comprehensive surveys of the large (5,520 sq. km) Nilgiri Biosphere Reserve (Murugesan 2005).

The Velliangiri Hills hold a rich biodiversity that is largely unaltered by human activities because of its cultural and religious importance (Ragupathy et al. 2008). The Holy Hill of Southern India, known more popularly as "Thenkailaya malai" in Tamil, houses the Velliangiri Andavar Temple and the cave of "Panachilngas". Both of these locations are popular pilgrimages and hundreds of people visit the temple barefoot every new moon. It is a dangerous trek through grasslands and forests harbouring wild bison, elephants, and poisonous snakes, concluding with a 10 km hike up the steep hillside through a tropical moist deciduous forest with many thorny shrubs. Devotees believe that if they walk with their shoes on, animals will attack them. The pilgrims start walking up the hill in the early morning and climb down before dark. Field biologists must adhere to and respect these religious customs. The time restriction may explain why botanists have not completely explored the richness of this unique flora. In fact, only a few botanical collections have been made from the Velliangiri hills. Those of Raju and Rathinavelu (in 1932), Sebastine (in 1959), Vajravelu (in 1972), and Chandrabose and Karthikeyan (in 1978) are deposited at the Madras Herbarium (MH), Southern Circle of the Botanical Survey of India, Coimbatore.

Our recent floristic surveys (2003–2007) of the Velliangiri Hills which included working with local aboriginal cultures, have yielded several new species. This paper describes and illustrates *Tripogon cope*, a new species from, Nilgiri Biosphere Reserve, a biodiversity hotspot in India (Nair and Daniel 1996; Vivekananthan et al. 1997). Morphological traits, micromorphological features of the spikelet, and foliar characters were compared for all Indian tropical *Tripogon* species using morphometric analyses. A list of representative specimens examined and a key to the 21 species occurring in India are provided.

Materials and Methods

The study area (6°40′ to 7°10′E, 10°55′ to 11°10′N) is located within the Velliangiri Hills, which forms a major range in the Western Ghats and part of the Nilgiri Biosphere Reserve. The mountain range of the study area consists of seven hills with different aspects, microtopography and altitudes of 520–1,840 m. The Palghat District of Kerala forms the western boundary of the Velliangiri hills, with the plain of Coimbatore district to the east, the Nilgiri mountains to the north, and the Siuvani hills forming the southern boundary (Fig. 1). The annual temperature of the reserve ranges from 0°C during winter to 41°C during summer, with rainfall

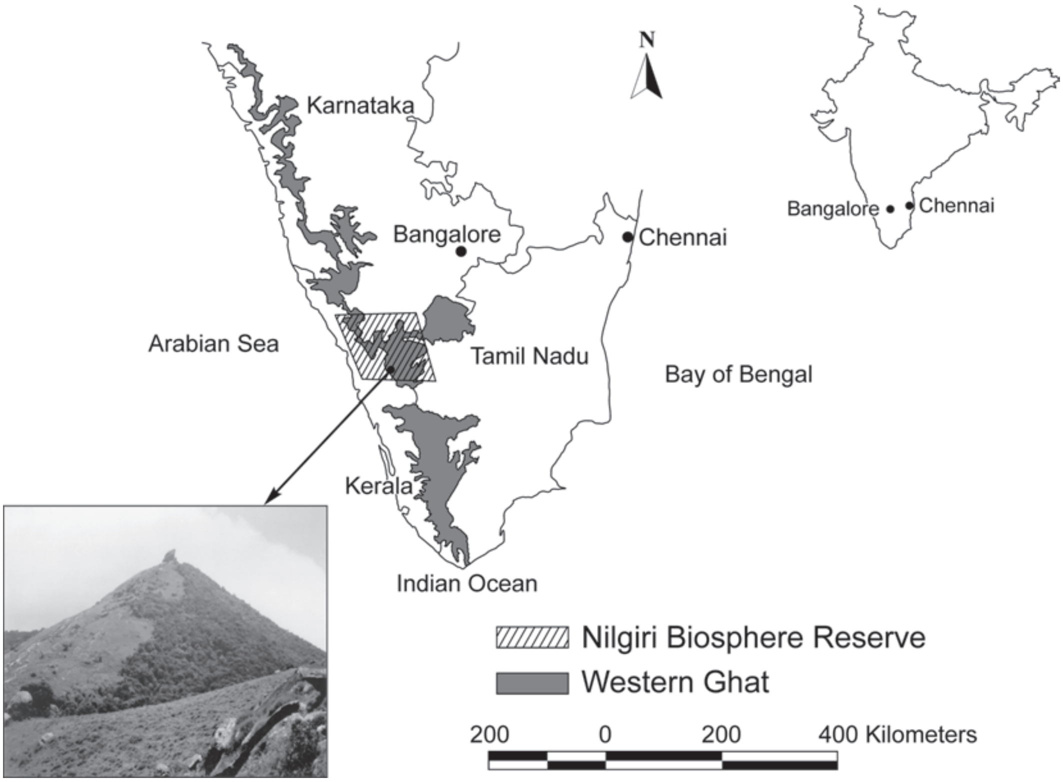

FIG. 1. Velliangri Hill (arrow, lower left) located on the Nilgiri Biosphere Reserve, Westen Ghats, India (map modified from Kodandapani et al. 2004).

ranging from 500–7,000 mm. Seasonal rivers such as the Neelivaikal, Mayar and Andisunai pass through the hill landscape.

Floristic explorations were made in the study area from April 2003 to January 2007 and included all seasons in order to collect any ephemerals. Six collections or "specimens" of *Tripogon* from each population were collected. Corresponding field data included details of the specimens (habit, phenology, and abundance) and environmental variables (habitat, latitude, longitude, altitude, soil type, and plant associations). Multiple populations were sampled along five transects separated by 2 km to ensure that we were not collecting vegetative colonies. This also accounted for local morphological variants within the different ecosites. Herbarium specimens were deposited in the herbarium of Kongunadu Arts and Science College, Coimbatore (KASCH). Isotypes of new taxa were deposited at Madras Herbarium (MH), Southern Circle, Botanical Survey of India, Coimbatore, and Ontario Agricultural College Herbarium (OAC) and Biodiversity Institute of Ontario, University of Guelph, Ontario. Identified specimens were compared with the type specimens deposited in MH. Line drawings for new species, *Tripogon cope* Newmaster et al. sp. nov (Fig. 2) and the morphologically similar *T. wightii* Hook.f. (Fig. 3), which is endemic to this region, are also presented for reference.

Tripogon cope has an annual life cycle, which was confirmed by repeated observations through the several seasons between 2003–2008. The plants are ephemeral, lasting for three months before setting seed and dying.

Morphometric Analyses—36 morphological variables (Appendix 1) were recorded from 25 specimens from our collections in the Velliangiri hills and 23 herbarium (MH, KASC, OAC) specimens of closely related species from previous collections within India. A matrix of 48 specimens and 36 morphological characters were used in a multivariate analysis. Canonical ordination was used to detect groups of specimens and to estimate the contribution of each variable to the ordination. A principal component analysis (PCA) (ter Braak and Smilauer 1998) was used to identify the length of the ordination axis and the need for either a linear or unimodal ordination technique. Unimodal, indirect ordination Detrended Correspondence Analysis (DCA) was used to explore variation in species scores in this study. A cluster analysis was used to classify the specimens, as it is better in representing distances among similar specimens, whereas DCA is better in representing distances among groups of specimens (Sneath and Sokal 1973). Cluster analysis was performed with NTSYS (Rohlf 2000). A distance matrix was generated using an arithmetic average (UPGMA) clustering algorithm and standardized data based on average taxonomic distance subjected to the unweighted pair-group method. A discriminant function analysis (DFA; SPSS 1999) was used to rigorously test the classification of specimens provided in the cluster analysis. The object of DFA is to predict multivariate responses that best discriminate subjects among different groups (Ramsey and Schafer 1997). A total of 36 morphological characters for each of the 48 specimens was used as input for a DFA. The 48 specimens used as input for a DFA were each coded as belonging to one group as designated a priori groups which 1) determined if the classification was accurate, 2) provided discriminant functions for the classification of the taxa and, 3) indicated if there are important morphological characters for each of the canonical discriminate functions.

TAXONOMIC TREATMENT

KEY TO THE SPECIES OF *TRIPOGON* IN INDIA

1. Palea of lower or empty florets lacking or highly reduced 2
    2. Ligule an eciliate membrane . . . . *T. wardii*
    2. Ligule a ciliolate membrane . . . . *T. siamensis*
1. Palea of lower or empty florets with well-developed palea 3
    3. Leaves equitant, blade apex pungent . . . . *T. pungens*
    3. Leaves not equitant, blade apex odourless 4
        4. Lemmas cleft at the apex into 2 lobes 5

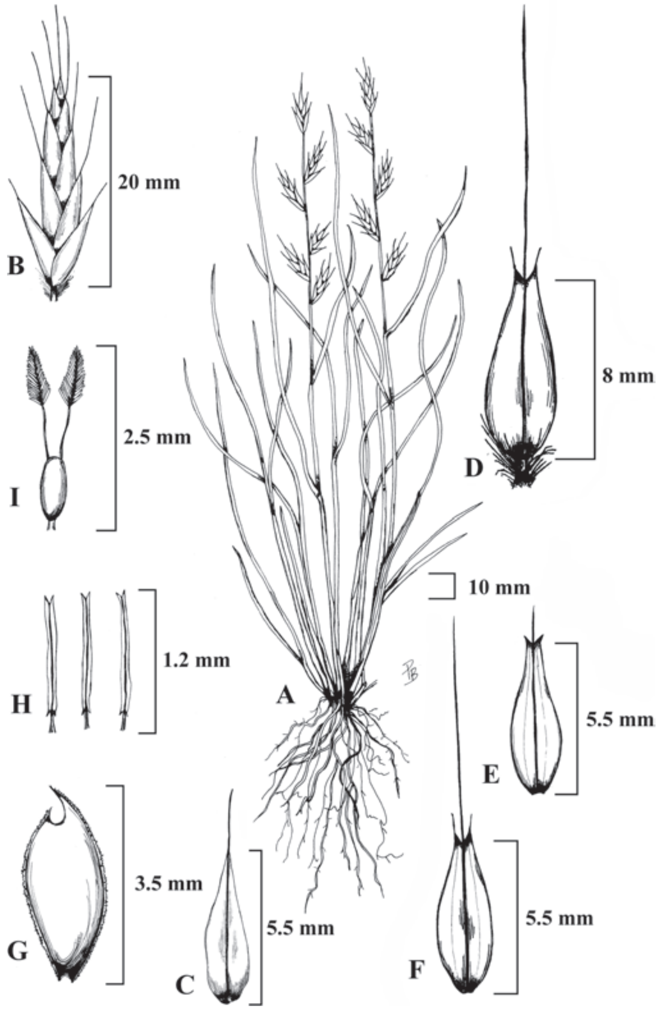

FIG. 2. *Tripogon cope* Newmaster et al. sp. nov. A-Habit; B-Spikelet; C-Lower glume; D-Upper glume; E-Floret; F-Lemma; G-Palea; H-Stamens; I-Pistil & lodicules.

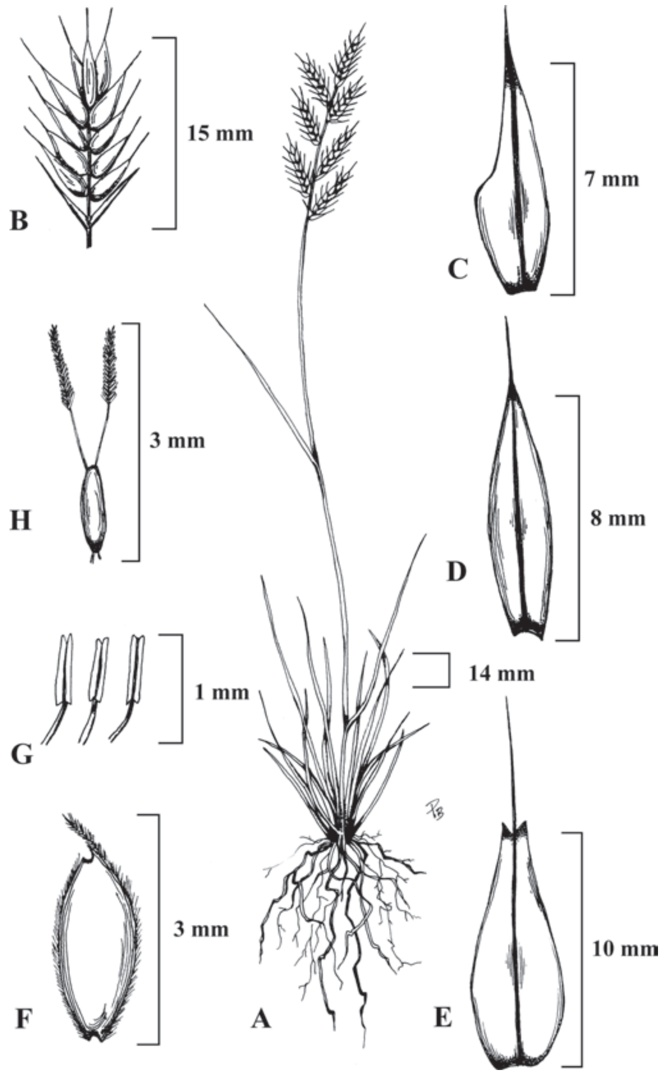

FIG. 3. *Tripogon wightii* Hook.f. A-Habit; B-Spikelet; C-Lower glume; D-Upper glume; E-Lemma; F-Palea; G-Stamens; H-Pistil.

5. Median awn equal to or longer than lemma 6
   6. Awn flexuous, 10–25 mm long . . . . *T. capillatus*
   6. Awn straight, <10 mm long 7
      7. Perennial; rachilla internodes 1 mm; lemma apex 1-awned . . . . *T. wightii*
      7. Annual; rachilla internodes 2 mm; lemma apex 3-awned . . . . *T. cope*
5. Median awn shorter than lemma, occasionally absent 8
   8. Glumes dissimilar in shape and texture . . . . *T. lisboae*
   8. Glumes similar in shape and texture 9
      9. Palea keels winged 10
         10. Lower glume linear, ... 11
            11. Ligule a fringe of hairs, leaf-blades flat or involute . . . . *T. thorelii*
            11. Ligule a ciliolate membranous, leaf-blades convolute . . . . *T. purpurascens*
         10. Lower glume lanceolate 12
            12. Lower glume apex emarginate . . . . *T. sivarajanii*
            12. Lower glume apex acute . . . . *T. multiflorus*
      9. Palea keels wingless 14
         14. Lemma apex with single awn 15
            15. Ligule eciliate membranous; leaf blades convolute . . . . *T. polyanthus*
            15. Ligule ciliate membranous;leaf blades involute 16
               16. Lower glume apex mucronate, upper glume oblong . . . . *T. jacquemontii*
               16. Lower glume apex dentate, upper glume lanceolate . . . . *T. larsenii*
         14. Lemma apex 3-awned 17
            17. Ligule ciliolate membranous; lower glume lanceolate 18
               18. Lower glume apex obtuse; lemma oblong . . . . *T. narayanae*
               18. Lower glume apex attenuate; lemma elliptic . . . . *T. trifidus*
            17. Ligule an eciliolate membranous; lower glume ovate . . . . *T. ravianus*
4. Lemmas cleft at the apex into 2 or more lobes 19
   19. Ligule absent; lemma apex entire . . . . *T. vellarianus*

19. Ligule a ciliolate membrane; lemma apex lobed 20
 20. Spikelets elliptic; lower glume ovate .... *T. anantaswamianus*
 20. Spikelets oblong; lower glume lanceolate 21
  21. Lower glume apex dentate; upper glume elliptic .... *T. bromoides*
  21. Lower glume apex obtuse; upper glume lanceolate .... *T. filiformis*

Tripogon cope Newmaster S.G., V. Balalasubramaniam, M. Murugesan, and S. Ragupathy, sp. nov.—TYPE: INDIA. Tamil Nadu, Velliangiri hills, 1,840 m, 18 Dec. 2006, *Ragu and Newmast 55277* (holotype: OAC; isotype KASCH).

Gramen annuus, usque 15–25 cm altum. *Culmi* caespitosus, erecti; ligulae ciliatus; laminae filiformes, involutus, 5–20cm longa, usque 1.5–2.5 mm latae. *Inflorescentia* simplex racemus, vel ramos 2–3 gerens, 4–15 cm longum; rhachis complanatus. *Spiculae* solitarius, compressi, sessiliflorus fertile ad circ. 6. *Glumae* persistens, linearis-lanceolatus, unicarinatus, uninervis, infimus 5–10 mm longum. *Lemma fertile* membranaceus, 15–16 mm longa, trinervis, ecarinatus, bifidus apice ad apicem, aristatus usque 9.5 mm longis. *Palea* 3.5 mm longa, binervis, alatocarinatus. Caryopsis usque 0.5 mm longa, adhaerens pericarpium.

Annual grass with caespitose culms up to 25 cm tall. Sheaths persistent with compacted or fibrous dead sheaths enveloping base of culm. Ligule ovate, membranous, 0.5–0.8 mm long, with a fringe of pilose hairs, pilose hairs up to 2.5 mm long. Leaf-blades linear-lanceolate, the tips often extending beyond than inflorescence, involute, 5–20 cm long, 1.5–2.5 mm wide, stiff, scaberulous above and below, margin glabrous to hirsute; veins 18–20 below, 5–8 above; apex acuminate. Inflorescence of 2–3 unilateral racemes up to 12 cm long. Rachis flattened, scaberulous, ca. 5 mm wide. Spikelets solitary, linear-lanceolate, distant, regularly packed, in two distinct rows, 1.5–2 cm long; spikelet internodes 15–20 mm. Fertile spikelets sessile, linear-lanceolate laterally compressed, 1.2–1.8 cm long, fertile florets 6–7, one or more sterile florets above. Rachilla internodes 2 mm long, visible between lemmas. Callus hairs 1–1.8 mm long. Glumes persistent, similar, shorter than spikelet. Lower glume linear-lanceolate, 5–6.5 mm long, hyaline to membranous with hyaline margins, 1–veined, lateral veins absent, apex narrowly acuminate, awns 2–3 mm long. Upper glume linear-lanceolate, 5–10 mm long, 1.5 times length of adjacent fertile lemma, hyaline membranous, 1-keeled, 3-veined, lateral veins thin, teeth up to 1.2 mm long, apex narrowly acuminate, awns 2–3 mm long. Lemmas linear-lanceolate, up to 16 mm long (including awn), 3-awned, central awn up to 9.5 mm long, lateral awns up to 1.8 mm long, awns attached below the teeth, hyaline membranous, central nerve thick, obtusely or slightly keeled, lateral veins extending to near base of dentate bifid apex, with 2 lobes 2–2.5 mm long. Apical sterile florets resembling reduced, up to 6. Palea ovate, ca. 3.5 × 1.5 mm, membranous, margin ciliolate, keels broadly winged, cleft at apex. Lodicules 2, obovate, membranous. Stamens 3, 1–1.2 mm. Stigma up to 2 mm long. Ovary 0.4–0.6 mm, elliptic-ovate. Caryopsis elliptic-ovate, ca. 0.5 mm long (Fig. 2).

Paratype—Additional specimens examined from type locality - Velliangiri hills, 18 Dec. 2006, *Newmast. & Ragu. 55279* (KASCH).

Etymology—Dedicated to Dr. Thomas A. Cope of Royal Botanic Gardens, Kew, botanist and specialist in Poaceae, who confirmed the distinctness of the new species.

Distribution—This species has been found at the top of Velliangiri hills, ca. 1500 m.; Fl. and Fr.: August – October. *Newmast. & Ragu. 55278* (KASCH), *Newmast. & Ragu. 55279* (KASCH), *Newmast. & Ragu. 55280* (KASCH), *Newmast. & Ragu.* 55281 (KASCH) and *Newmast. & Ragu.* 55282 (KASCH).

Observations—This new species grows in moist shola border and occasionally on rocks and is frequently associated with *Crotalaria clarkei* Gamble and *Garnotia arundinacea* Hook.f. **Tripogon cope** appears to be closely allied to *Tripogon wightii* Hook.f. based on the presence of simple caespitose culms, involute leaf blades. The shape and texture of the glumes are similar, as is the texture, lobed apex, and position of the awns on the lemmas. However, **Tripogon cope** is differentiated by its annual life cycle and: ciliate membranous ligule, ovate leaves that are longer than the inflorescence, fewer fertile florets, spikelet shapes, pilose callus, entire lower glume, and 3-awned lemma (Table 1).

Tripogon wightii Hook.f. Fl. Brit. India, 7:286, 1886; Fl. Madras Presidency, 3:1269, 1957; The Grasses of Burma, Ceylon, India & Pakistan, 524, 1960; Fl. Tamil Nadu 3: 145, 1989.—TYPE: *Wight 1793* (KEW), seen by Dr. Cope.

Perennial grass with culms erect up to 35 cm high. Leaf-blades linear-lanceolate, 5–10 cm long, 0.2–0.5 cm wide. Racemes 5–15 cm long. Spikelets 11–13-flowered, oblong, ca. 1.5–2cm long. Lower glume linear-lanceolate, 5–6 mm long, 1–1.5 mm wide, lobed on one side. Upper glume linear-lanceolate, 7–8 mm long, 1–1.5 mm wide, awn ca. 1–1.5 mm long. Lemma ovate or lanceolate, 10–11 mm long, 2–2.5 mm wide (including awn), 2 (3)-lobed with 3-nerved awn between lobes. Palea elliptic or obovate, 3–4 mm long, 1–1.5 mm wide, broadly winged, ciliate along the margin. Stamens ca. 1 mm long. Pistil 2–3 mm long (Fig. 3).

Table 1. Diagnostic characters to separate *Tripogon cope* and *T. wightii* Hook.f.

	T. cope	*T. wightii*
Duration	annual	perennial
Length of culm sheath (cm)	10–25	15–40
Ligule structure	ciliate membrane	fringe of hairs
Leaf blade shape	ovate	filiform
Leaf blade length (cm)	3–20	5–12
Leaf blade width (mm)	1.5–2.5	1
Raceme length (cm)	6–12	4–15
Number of fertile florets	5–6	10–15
Spikelet shape	linear-lanceolate	oblong
Spikelet length (mm)	15–25	15–20
Rachilla internode length (mm)	2	1
Callus	pilose	pubescent
Lower glume shape	linear lanceolate	linear
Lower glume length (mm)	5–6.5	6–8
Upper glume shape	linear-lanceolate	lanceolate
Upper glume length (mm)	5–10	7–9
Upper glume lateral vein prominence	obscure	absent
Fertile lemma shape	linear lanceolate	oblong
Fertile lemma length (mm)	5–6.5	7–9
Fertile lemma keel prominence	slightly keeled	rounded
Lemma lobe length (mm)	2.5	1.5
Lemma lobe apex	acuminate	acute
Number of lemmatal awns	3	1
Lemmatal awn length (mm)	up to 9.5	up to 6

Distribution—This rare species is found on rocks at a height of about ca. 1,500 m in Velliangiri Hill and is endemic to Southern Peninsular India (Ahmedullah and Nayar 1987; Henry et al. 1989). Fl. and Fr.: August – November. *Newmast. & Ragu. 55283* (KASCH), *Newmast. & Ragu. 55284* (KASCH), *Newmast. & Ragu. 55285* (KASCH) and *Newmast. & Ragu. 55286* (KASCH).

Results and Discussion

A discriminant function analysis (DFA) used 36 quantitative characters to classify heterogeneity in 48 specimens into what is currently considered 20 known taxa of *Tripogon* (*T. anantaswamianus* Sreekumar et al. *T. bromoides* Roth, *T. capillatus* Jaub. & Spach, T. *filiformis* Nees ex Steud., *T. jacquemontii* Stapf., *T. larsenii* Bor, *T. lisboae* Stapf., *T. multiflorus* Miré & J.M. Gillett, *T. narayanae* Sreekumar, Nair & Nair, *T. polyanthus* Naik & Patunkar, *T. pungens* C. E. C. Fischer, *T. purpurascens* Duthie, T. *ravianus* Sunil & Pradeep, *T. siamensis* Bor, *T. sivarajanii* Sunil, *T. thorelii* A. Camus, *T. trifidus* Munro ex Stapf, *T. vellarianus* Pradeep, *T. wightii* Hook.f., *T. wardii* Bor, and **Tripogon cope.** The canonical correlation from the discriminant functions is the ratio of the between groups sums of squares to the total sums of squares. Thus, the first discriminant function is responsible for 60% of the between group differences (variability in the discriminant scores). The second function is responsible for an additional 14% of the between group variance and the third function is responsible for an additional 11% of the variance. Wilk's Lambda was used to test the hypothesis that there are no difference in variance ($p < 0.001$) between the groups of taxa which represent different species (SPSS 1999). There were significant differences ($p < 0.001$) for first two canonical functions. 100% percent of the groups (representing 21 species) were correctly classified using the DFA into 21 distinct groups of taxa including the new species of *Tripogon.*

The ordination analyses utilized DCA in the separation of 21 species from the 48 specimens that were analyzed and provided a measure of the important morphological variables in the classification. Principal components analysis (PCA) provided a character gradient that was unimodal (3.6 Standard Deviations SD) violating the assumption of a linear model (ter Braak and Smilauer 1998). Consequently, a DCA was used to classify the 48 specimens into distinct groups representing 21 species. High eigenvalues for the X-axis (0.892) and the Y-axis (0.607) indicated that the gradient axes were of considerable length and justified the use of DCA. The X-axis (axis 1) is strongly correlated with 21 characters; these include the length of the raceme, spikelets, glumes and fertile lemmas (Table 2; Fig. 4). The Y-axis (axis 2) is strongly correlated with 13 characters; some of these include duration of

Table 2. DCA analysis of 36 quantitative variables (taxonomic characters) for 48 specimens (classification of 21 *Tripogon* species). Pearson correlations indicate the characters significant to the classification (** = p value < 0.01, * = p value < 0.05).

	DCA axis X		DCA axis Y	
Characters	P Corr.	Sig. (2-tailed)	P Corr.	Sig. (2-tailed)
Duration	0.294(*)	0.042	0.434(**)	0.002
Length of culm sheath -carriage	0.129	0.383	−0.031	0.837
Length of culm sheath (cm)	−0.313(*)	0.03	0.172	0.243
Ligule structure	−0.156	0.291	0.001	0.997
Leaf blade shape	−0.344(*)	0.017	0.284	0.051
Leaf blade vernation	0.161	0.274	0.427(**)	0.002
Leaf blade length (cm)	−0.541(**)	0.001	0.577(**)	0.001
Leaf blade width (mm)	−0.520(**)	0.001	0.119	0.422
Racemes length (cm)	−0.680(**)	0.001	0.347(*)	0.016
Number of fertile florets	0.763(**)	0.001	−0.01	0.944
Spikelet shape	−0.234	0.11	−0.607(**)	0.001
Spikelets length (mm)	−0.892(**)	0.001	0.036	0.81
Floret callus indumentum	0.16	0.277	0.035	0.813
Glumes similarity	0.293(*)	0.043	0.182	0.216
Lower glume shape	−0.403(**)	0.004	−0.430(**)	0.002
Lower glume length (mm)	−0.753(**)	0.001	−0.13	0.38
Lower glume apex	0.295(*)	0.042	0.268	0.066
Upper glume shape	−0.151	0.304	−0.134	0.363
Upper glume length (mm)	−0.798(**)	0.001	−0.125	0.397
Lower glume consistency	0.234	0.109	0.317(*)	0.028
Upper glume lateral veins prominence	−0.081	0.585	0.385(**)	0.007
Upper glume apex	−0.392(**)	0.006	0.081	0.585
Fertile lemma shape	0.360(*)	0.012	0.011	0.943
Fertile lemma length (mm)	−0.367(*)	0.01	−0.445(**)	0.002
Fertile lemma consistency	−0.626(**)	0.001	−0.061	0.683
Fertile lemma keel prominence	0.182	0.216	−0.113	0.446
Fertile lemma key couplet for chloroid veins	−0.620(**)	0.001	−0.452(**)	0.001
Lemma apex incision	0.338(*)	0.019	−0.374(**)	0.009
Number of lemmatal primary teeth or lobe	−0.203	0.167	0.239	0.101
Lemma apex presence of awn	−0.006	0.966	−0.229	0.117
Number of lemmatal awns	−0.101	0.494	0.125	0.397
Principle lemma awn position	0.009	0.95	−0.327(*)	0.023
Principle lemma awn length (mm)	−0.557(**)	0.001	−0.156	0.29
Palea keels presence of wings	−0.239	0.102	0.12	0.418
Palea keels how much winged	−0.490(**)	0.001	−0.072	0.627
Palea keels indumntum	0.197	0.179	0.593(**)	0.001

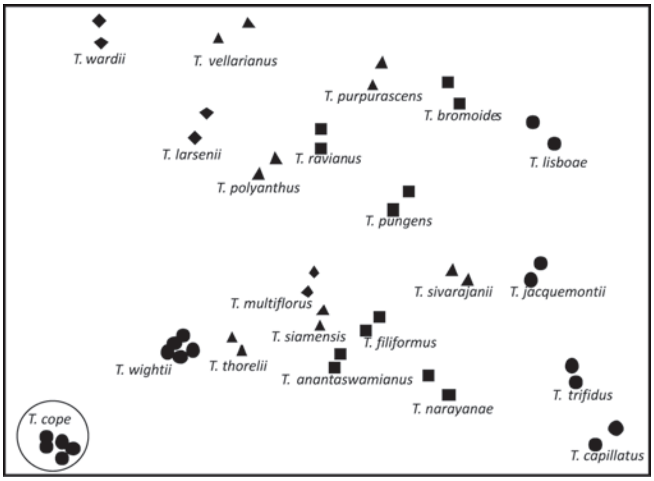

FIG. 4. Scatter plot of the first two axes from a detrended correspondence analysis (DCA) for 36 quantitative variables (taxonomic characters) of 48 specimens (classification of 21 *Tripogon* species). The new species *Tripogon cope* is circled, including its respective intraspecific variation.

life cycle, position and number of awns on the lemma, shape of lemma, leaf blade length and venation (Table 2; Fig. 4).

The DCA ordination of the first two canonical functions identifies a distinct cluster of five specimens that represent the new species, **Tripogon cope** in the proximity of the respective allied species, *Tripogon wightii* (Fig. 4). Intraspecific variation among the samples of the new species is within the natural range of variation for the 21 *Tripogon* species in the ordination (Fig. 4). This study provides preliminary evidence of morphometric variation within and among species of *Tripogon*, which allows further development of hypotheses concerning phenetic species concepts.

The NB Reserve appears to be a centre of diversity for several taxa. *Biophytum longipedunculatum* Govind (Oxalidaceae) and *Tripogon wightii* Hook.f. are endemic to this region. Both species are allied to the recently discovered and described respective species *B. coimbatorense* Murugesan et al. (unpubl.) and **Tripogon cope.** *Tripogon* is represented in Australia by one endemic species, namely *T. loliiformis* (F. Muell.) C. E. Hubbard. (Rúgolo de Agrasar and Vega 2004). Although this species shares an annual life cycle with **Tripogon cope** it differs in that it has shorter spikelets (6–13 mm long) and differing glume characters.

A modern summary of the distribution and systematics of *Tripogon* from a global perspective is lacking. Most of what has been published comes from the Indian flora. Previous additions to the Indian flora have included two new species of *Tripogon* (Naik and Patunkar 1973; Sreekumar et al. 1983; Pradeep and Sunil 1999; Sunil and Pradeep 2001). Significant taxonomic contributions to our understanding of *Tripogon* include a catalogue of world grasses by Peterson et al. (2001), a revision of African species of *Tripogon* (Phillips and Launert 1971; Phillips 1974), new species of *Tripogon* from Africa (Cope 1992), a summary of grass genera worldwide (Watson and Dallwitz 1992), an online world grass flora by Clayton et al. (2006), and nomenclature changes by Veldkamp (1996). Unfortunately there have been no phylogenetic studies of the genus *Tripogon*.

Additional floristic studies of *Tripogon* are needed to determine the distribution of rare species and their ecological requirements so that conservation strategies can be implemented. Little is known about the genus *Tripogon* and its evolution within the Poaceae. We are currently conducting phenetic and phylogenetic research on the genus *Tripogon* to resolve species concepts within the world distribution and provide a phylogeny for the genus. Combined with further biological and ecological data, this information will contribute to conservation initiatives at a global scale.

Limited protection for rare species of *Tripogon* exists because little is known about its biology and global distribution. Fortunately, 8 of the 21 species of *Tripogon*, including **T. cope** and the related species *T. wightii*, are endemic to a protected region. Velliangiri Hill is protected within the Nilgiri Biosphere Reserve (NBR) as one of nine Biosphere Reserves in India. The rich floristic diversity in the Velliangiri Hills (1,715 species) is partly due to contributions from neighbouring floras, via migration. Approximately 4,000 species of flowering plants are present in the Western Ghats, of which 3,238 are estimated to be present in the NBR (Balakrishnan and Ansari 1990). According to Nair (1991) about 51 genera are endemic to the Western Ghats, of which 15 occur in the Nilgiri Biosphere Reserve, and 4 of which are endemic to the Velliangiri Hills (Nair and Daniel 1996; Vivekananthan et al. 1997). Further floristic study will likely will reveal additional new species from this region and noteworthy range extensions.

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