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Ischaemum dioecum (Poaceae: Andropogoneae): the most strangest new species from Northern Western Ghats, Maharashtra, India

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Abstract

Ischaemum dioecum, a new strange species from Northern Western Ghats, Maharashtra, India is described and illustrated. The most spectacular and unusual feature of the species is its dioecious breeding system i.e. male and female plants are sexually separate entities, which is being documented first time in the tribe Andropogoneae. Other distinguishing features are such as: sessile spikelets 1-flowered (only upper floret developed), palea bi-dentate with an arista from the sinus and pedicelled spikelet reduced or absent; stamens four with unusually filiform and elongated filaments, ca. 15 mm long; peduncle of male plants glandular and with tubercle-based bristles; style and stigma extraordinarily long each may be up to 14 mm long and pedicel 1/2–4/5 of the sessile spikelet. A table of morphological comparison and detailed discussion with allied species from Africa, India and Australia is given along with the keys to close genera. A detailed discussion on the similar case of dioecism in grasses; habitat characteristics, distribution of the populations and inter-specific interaction, adaptation and morphological affinities of *I. dioecum* is discussed with African, Indian and Australian taxa. It is apparently a narrow endemic species. Based on IUCN Red List Categories and Criteria, the species is assessed here as Critically Endangered (CR).

Keywords: Critically Endangered, Dioecy, Endemic, Gramineae, India, Ischaeminae

Introduction

Ischaemum Linnaeus (1753b: 1049) is, taxonomically, one of the most complex genera in the tribe Andropogoneae (Landge & Shinde 2021) reaching its greatest complexities in South East Asia where some biosystematics work badly needs doing (Cope 1982, Mistry 1988). The genus has been placed, with six others, in its own sub-tribe Ischaeminae by (Soreng *et al.* 2015, 2017). Species in the genus are extremely diverse exhibiting complex forms, chiefly occupying wet tropical areas from Africa to Australia representing the highest diversity in India. Even in the tropics—in India (highest diversity in Western Ghats), the species dwell thwart vast ecological amplitudes mostly associated with wet places in and near pond, river (flanks) and on the edges of fresh water bodies, frequently on the forest margin, in glade, in the deep forest (rare), mostly in open grasslands, on seasonal rocky outcrops (basaltic, lateritic, high and low level ferricretes) as flush vegetation, on the escarpment, on the face of cascades and on the crest of the Ghats during monsoon and is very rare in microhabitats at the base of other grasses on rocky outcrops.

Ischaemum is characterized by the combination of certain distinguishing features such as: a secund, usually bi-nate spiciform-raceme (sometimes solitary or rarely digitate), spikelets coriaceous, crustaceous, membranous or in various combinations, mostly rugose or noduled across the back on the lower glume, pedicel and internode excavated and adnate at the base forming a peculiar "U or V or J" shaped structure with callus which is sometimes accompanied with a pore at the base. All the former revisionary and other major studies in a decade by the Indian authors (Sreekumar & Nair 1991, Sur 2001, Singh & Rao 2008, Srivastav & Nair 2010) seemed to favour either describing new species or changing taxonomic status of pre-existing species, with time, instead of scratching a bit on prevailing serious taxonomic and systematic problems in the genus. There exists no up-to-date comprehensive molecular analysis or monograph on the genus that could be used as a universal guide for the identification. The immensities of variable forms in the

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genus complicate the identification to a great extent so much so that the identification, sometimes, becomes almost impossible. Unless and until, the problem is visualized by a molecular resolution, it should not be solved. Currently, the genus is represented by 87 species in the world of which 63 are exclusively from India and 43 of which seems to be endemic—mostly from the state of Kerala. In Maharashtra, 26 species occur—including the one currently being described in this paper.

In August 2021, while exploring grasses—especially the members of the genus *Ischaemum*, in Temhini Ghats, Raigad district, Maharashtra and surrounding high-elevation area covered in dense tropical forest, seasonal grasslands and rocky outcrops, the first author accidentally discovered a remote population of a strangely small delicate grass, lurking in the unique microhabitats: in the stilt roots or at the base of other taller grass species. The specimens were few in discrete patches confined in the area about $6m^2$ and indeed were the elements secluded from the vision of ordinary field exploration. The unique ecological niche acquired by this species due to its small size and delicate habit had isolated it from the other grasses thriving in the macrohabitats. Some crucial observations were made in the field itself and few individuals were collected for a further study without damaging the population. When the specimens were studied under the stereo-microscope at The Blatter Herbarium (BLAT), their true pistillate nature was revealed. Strangely, the entire gathering constituted only female individuals! It validated the observations made in the field, where only stigmas were seen exserted from the apices of the concealed spikelets, which we initially took for protogyny.

The male plants were observed during subsequent field visits in the same locality but they were extremely few and highly exhausting to discern. These individuals were very delicate and could easily be damaged by even slightest of the trampling or shower. Thus, the first author studied them on the field itself using a dissecting microscope and objective lenses of the compound microscope for generating higher magnifications. In the same visit, another locality (Fig. 4) was discovered where this species was flourishing on a slippery basalt slope in a distinct spatially segregated colonies. After critical study of relevant literature (Roxburgh 1832, Hackel 1889, Hooker 1897, Cooke 1908, Blatter & McCann 1928, 1935, Bor 1940, Fischer 1957, Bor 1960, Cope 1982, Mistry 1988, Sreekumar & Nair 1991, Lakshminarasimhan 1996, Sur 2001, Clayton *et al.* 2005, Singh & Rao 2008, Srivastav & Nair 2010, Simon & Alfonso 2011, Potdar *et al.* 2012, Kabeer & Nair 2009, Fish *et al.* 2015, Lakshminarasimhan *et al.* 2019, Chorghe & Prasanna 2021) the species could not be ascertained with any known species in the genus, chiefly because of the characters such as: dioecy, four larger stamens, 1-flowered sessile spikelet and lodicules lacking in the upper floret of female plant. Thus, we described it as a new species after extensive literature survey and communication with numerous experts in the field across the globe.

"It would be very unusual to find a dioecious species in that genus [*Ischaemum*], although of course it is not impossible." (Dr. E.A. Kellogg in personal communication). "It is possible that dioecy might emerge in Andropogoneae." (Mr. Watchara Arthan in personal communication). In another communication "That's an interesting new species, occurring in a very peculiar microhabitat! The apparently dioecious breeding system caught my attention since this has not been reported in Andropogoneae so far." (Dr. Cassiano Welker).

Materials and method

The collected grass specimens were studied under the stereomicroscope at The Blatter Herbarium (BLAT) and processed for the herbarium preparation by following the standard method given by Forman & Bridson (1991). The International Code of Nomenclature for algae, fungi, and plants (The Shenzhen Code, Turland *et al.* 2018) has been used for the nomenclature of the new species. We communicated with various herbaria such as: BLAT, BSI, CAL, BAMU, WCAS, BSJO, DD, ASSAM, MH, JCB, SUK, K, E, G, US, L, LE, AVH, Z, W, B, M & BM (acronyms according to Thiers 2020 continuously updated) during the present study for consulting herbarium specimens of other and a few related species in the genus.

Living specimens under observation

Soil collected from the base of the taller grasses in the type locality on 8 August 2021 was maintained under observation in the grass experimental set-up at St. Xavier's College (Autonomous) Mumbai. The first grass seedlings to emerge were of *Heteropogon ritchiei* Blatter & McCann (1928: 623), an endemic species, and after the two months couples of other tiny grasses were detected emerging near the roots of the former. After 15 days, when only one of them had matured, and rest of the specimens died, it was identified as the female of *Ischaemum dioecum*. However, it did not conceive any seed in absence of the male plant! We observed the leaves in this plant became little thick under the

cultivation as compared to extremely thin leaves in its natural habitats. It is quite challenging to simulate unique habitats of this grass under cultivation experiments; perhaps, this was the reason why other individuals died before even maturation. We sustained this observation in order to confirm their true dioecious breeding system.

Key to allied genera of *Ischaemum*

1. Sessile spikelets suppressed, only pedicelled spikelets developed 2
1. Sessile and pedicelled spikelets both are well developed (latter sometimes reduced but pedicel not curved) 3
2. Rhachis of the raceme inarticulate; glumes keeled, ciliate or glabrous on the back ..... ***Dimeria***
2. Rhachis of the raceme articulated (jointed and fragile); glumes rounded not keeled, with a tuft of hairs on the back ..... ***Pogonachne*** (monotypic genus narrow endemic to Maharashtra, India)
3. Pedicelled spikelets represented by linear curved pedicel; lower glume of the sessile spikelet covered all over with transverse much raised ridges which are often broken up into teeth or wart-like papillose excrescences, not keeled ..... ***Thelepogon***
3. Pedicelled spikelets mostly well developed, if reduced then lower glume of the sessile spikelet not as above, keeled 4
4. Inflorescence racemiform-panicle; spikelets of each pair similar or hermaphrodite, glumes not winged; lower glume of the sessile spikelet keel-less and prominently ribbed-veins ..... ***Spodiopogon****
4. Inflorescence spiciform-raceme; spikelets of each pair dissimilar or heteromorphic (if homomorphic then glumes winged see *Ischaemum*) 5
5. Geniculate awn present 6
5. Geniculate awn absent ..... ***Glyphochloa*** (endemic to Western Ghats, India)
6. Lower glume of the sessile spikelet with a distinct median longitudinal groove 7
6. Lower glume of the sessile spikelet convex or flat or may be somewhat depressed but never with a distinct median longitudinal groove as mentioned above ..... ***Ischaemum***
7. Lower glume of the sessile spikelets with two vertical rows of hair; upper glume of the sessile spikelets with a tuft of hairs at or above the middle; upper glume of both the spikelets are wingless ..... ***Triplopogon*** (monotypic genus narrow endemic to Maharashtra, India)
7. Lower glume of the sessile spikelets without two vertical rows of hair; upper glume of the sessile spikelets without any tuft of hairs; upper glume of both the spikelets with wing-like crest ..... ***Andropterum*** (monotypic genus endemic to Africa)

*A couple of species from North East India and China may have leaves long petiolated and lamina with a peculiar sagittate base, quite similar to that of some robust species of *Ischaemum* from Western Ghats, India.

Taxonomic Treatment

Ischaemum dioecum Landge & R. D. Shinde, *sp. nov.* (Figs. 1, 2 & 3)

Type:—INDIA. Maharashtra state: Raigad district, near Patanus village, 8 August 2021, 18°26’51.7”N 73°22’17.1”E, *Shahid Nawaz* PR-01A (BLAT) **[**holotype**]**; isotype: *Shahid Nawaz* PR-01B (BLAT) [pistillate plant specimens].

Diagnosis:—Ephemeral habit, up to 20 cm high, with numerous stilt-roots from nodes; dioecious breeding system; leaves long, hispid, acute at the base and petioled; lower glume of the sessile and pedicelled spikelet (if present) 2–4-nerved; lower floret in the sessile spikelet absent or if present then barren, elodiculate and epaleate; upper floret of the staminate plant is lodiculate (lodicules giant, ca. 3.5 mm long) bearing four stamens with anthers 6.0–10 mm long on an extremely filiform and extraordinarily elongated filaments ca. 15 mm long; upper floret of the pistillate plant is elodiculate with unusually long style ca. 14 mm long with two plumose stigma, purplish, 6.0–10 (–14) m long; peduncle in staminate plant glandular beset with tubercle-based trichomes; palea apex bi-dentate most often with a central arista; pedicelled spikelet (if present) half as long as the sessile spikelet, barren, reduced to a single glume; pedicel 1/2–4/5 of the sessile spikelet, slender, linear glabrous or ciliate on the margin.

Description:—Male plant: Ephemeral, ca. 20 cm, geniculately ascending, non-caespitose, extremely delicate, weak and slender with numerous maroonish-red stilt-roots (roots very delicate and may easily break) from the nodes bearing micro papillae near the base. Leaf blade linear, acuminate, very thin membranous, hispid, 2.0–5.0 × 0.3–0.5 cm, acute at the base with a long pseudopetiole (ca. 1.5 cm long), puberulous. Ligule ca. 3.0–4.0 mm long, oblong-lanceolate, membranous, lacerated at the apex into few segments, hairy on the margin or not. Sheath very slender, terete, striated, glabrous, margin sub-hyaline-membranous strongly overlapping, 1.0–3.5 cm long, not keeled. Inflorescence a solitary spiciform-raceme fully exserted from the spathaceous sheath. Peduncle broad, somewhat swollen bearing tubercle-based bristles, elongated, with glandular depressions oozing a dense brownish viscous fluid. Spiciform-raceme ca. 28–42 mm long, solitary, comprising three well developed sessile spikelets with bare pedicels

(on maturity deciduous together with the adjacent rhachis internode and pedicel) pedicelled spikelets are sometimes present but by a single, reduced glume. **Sessile spikelet**: linear-oblong, awnless, 9.0–12 (–13) mm long (including a callus); callus, ca. 1.2–2.2 mm long, densely bearded with white hairs (i.e. 6.0–9.0 mm long), reaching up to the middle of the sessile spikelet; **lower glume**: linear-oblong, 8.0–10 (–13) × 2.0–3.0 (3.5) mm, slightly longer than the upper glume, convex base wards and flattened upwards, initially herbaceous-membranous and later becoming somewhat coriaceous, scabrous, puberulous or glabrous, apex acute, 2–4-nerved (only 2 clearly visible other two obscure), nerves not anastomosing, margin evenly inflexed throughout the length, sharply keeled upwards, glabrous, no trace of nodulations and rugosity; **upper glume**: linear-lanceolate, 7.0–9.0 (–12) × 2.2–3.3 (–3.8) mm, 1–3-nerved, glabrous, acute, naviculate, keeled, slightly winged near the apex, ciliate, margins inflexed. **Floret**: lower floret is absent only upper floret is present, staminate: **lemma** linear-lanceolate, almost equal to upper glume in length but narrower, 3-nerved, glabrous, hyaline-membranous, acute, un-awned; **palea** linear long obspatulate, sub-equal to its lemma, broadest at the base, hyaline-membranous, 3-nerved, apex bi-dentate (often with a distinct arista from the sinus (excurrent mid-nerve), arista ca. 3.0–4.5 mm long), glabrous. **Pedicelled spikelet**: Absent most of the times, if present then by a single 2-nerved reduced glume ca. 5.0 mm long. **Pedicel** linear, slender, 7.0–10 mm long, ciliate on both the angles or completely glabrous. **Rhachis internode** sub-equal to the pedicel and almost identical in shape, ciliate on both the angles or completely glabrous, fragile and articulate. **Stamens** four, filaments slender, drooping, considerably elongated during anthesis reaching ca. 15 mm long; anthers 6.0–10 mm long, orangish-yellow, exhibiting both lateral and apical dehiscence. Lodicules fleshy, sub-hyaline, clavate, sharply oblique at the apex, ca. 3.5 mm long. Pedicelled spikelets short almost reduced to a glume, barren or absent altogether. **Female plant**: An extremely slender, delicate, geniculately ascending, stilt-rooted, non-caespitose ephemeral grass, 10–14 cm high. Culm solitary, weak, un-branched, striated, up to 12-noded, hardly exceeding 0.6 mm diameter; the root system is extremely shallow; internodes as long as the sheath or slightly longer, terete; nodes swollen, glabrous, some lower and few upper ones with stilt roots up to about half the length of the plant. Sheaths 0.8–2.5 cm long, terete, glabrous or setaceous near the margin with bulbous-based trichomes (ca. 3.0 mm long), tightly en-clasping and disintegrating in the lower portion of the culm during anthesis, sheath near the inflorescence is quite broad, somewhat ribbed, slipping-off and slightly laterally compressed. Ligule membranous, ca. 1.0 mm long, slightly brownish, obtuse to somewhat truncate at the apex with appressed white hairs on the adaxial side. Blade: lower linear-lanceolate longer than the upper ones, 0.8–2.0 × 0.2–0.3 cm, the ones about the inflorescence are ovate-elliptic to slightly oblongish in outline, beset with bulbous-based trichomes (1.0–1.5 mm long) on both the surfaces, margins uniseriately-pectinate. **Inflorescence** a highly reduced, solitary (with a triad of one sessile spikelet and two bare pedicels, sometimes with a single glume) or binate (each spiciform-raceme is reduced to only single sessile spikelet accompanied by a barren pedicel) spiciform-raceme, 5.0–5.6 mm long, almost completely subtended by a spathaceous sheath; fragile on maturity and sessile spikelets deciduous together with the adjacent rhachis internode and pedicel. **Peduncle** very short, slender, clavate, glabrous, rarely more than 10 mm long, apex dilated and broad. Spikelets either sessile or in a combination of one sessile and other pedicelled (often reduced to a single, barren glume) in a raceme. **Sessile spikelet**: ovate-lanceolate, 5.0–5.6 mm long (including a callus), strictly pistillate; callus 0.8–1.0 mm long, slightly oblique, broad, bearded with white hairs almost reaching the middle of the sessile spikelet; **lower glume**: ovate-lanceolate, 5.0–5.6 × 1.5–1.8 mm (un-opened, broadest near the base), slightly shorter than the upper glume, initially herbaceous-membranous and later becoming somewhat coriaceous, convex towards the base with two bosses and flattened upwards (sometimes with two shallow bosses in the middle and below), glabrous or hairy on the back, apex acute to somewhat bi-dentate with a short hyaline portion, 2–4-nerved (only two clearly visible others obscure), nerves not anastomosing, margins glabrous, broadly and evenly inflexed throughout the length, keels acute, no trace of nodulations and rugosity; **upper glume**: ovate-lanceolate, 5.1–5.7 × 1.5–1.8 mm (broadest at the base), navicular, keel herbaceous, 3-nerved, glabrous, sub-hylaine, apex acute, devoid of a hump in the middle, margin hyaline, glabrous and inflexed; **lower floret**: entirely absent (if present then barren and is only represented by an epaleate lemma which is ovate-lanceolate, 3.2 mm long (broadest near the base), barren, without lodicules, glabrous, hyaline-membranous, 1–3-nerved, apex obtuse or slightly oblique); **upper floret**: strictly female/pistillate, elodiculate: **upper lemma** linear-lanceolate, 4.0–5.4 × 0.8–1.0 mm, sub-equal to lower glume, paleate, bi-fid (lobes acuminate, 1.8–2.5 mm long), glabrous, awn geniculate issuing from the sinus, 12.5 mm long (column brown 5.0 mm long and bristle pale, scabrid, 7.5 mm long), slightly humped in the middle on the dorsal side; **upper palea**: very linear, almost obspatulate with a broad base (enclosing an ovary) and linear upper portion, 3.0–4.0 × 0.3–0.4 mm (broadest at the base), very delicate, hyaline-membranous, margin inflexed, broader at the base, glabrous, apex bi-dentate (often shortly mucronate from the sinus (excurrent mid-nerve), mucro ca. 1.0–2.0 mm long), finely 3-nerved; **pistil**: ovary ovoid, 1.0 mm long, style ca. 14 mm long (when young, highly coiled inside the spikelet), two stigma plumose, purplish, 6.0–10 (–14) mm long; lodicules absent; caryopsis not seen. **Pedicelled spikelet**: represented only

by a bare pedicel, which is extremely narrow, not swollen, linear, 3.2–4.0 × 0.2–0.3 mm, unusually long, flattened, excavated throughout on the inner angle, confluent into the callus, hairy along the margins or completely glabrous, apex densely bearded or with a calloid outgrowth, mostly devoid of pedicelled spikelet sometimes with a single lower glume (un-identical to the lower glume of sessile spikelet, linear-elliptic 3.2 mm long, 2–4-nerved (only two are clearly visible), sub-hyaline, herbaceous, convex on the back and apex bi-dentate).

Distribution:—Hitherto, based on our surveys, the species has been observed only in a couple of localities i.e. near Patanus village and Rawalje village, Raigad District, Maharashtra (Western Ghats), India. *Ischaemum dioecum* is apparently an extremely rare and narrow endemic species in the genus.

Flowering and fruiting:—August to mid September (life cycle of individuals hardly exceeding 20 days).

Additional specimen examined:—INDIA. Maharashtra state: Raigad district, near Rawalje village, 24 August 2021, 18°26'36.9"N 73°21'29.0"E, *Shahid Nawaz* RR-05 (BLAT) [staminate plant specimen, spikelets were removed for the study].

Habitats and ecology:—In complex network of dense roots mingled with seasonally wet thin film of soil at the base of other taller grass species such as: *Ischaemum diplopogon* Hooker (1896: 129), *Heteropogon ritchiei* & *Dimeria blatteri* Bor (1949: 70), on the flank of the river associated with rocky outcrops and on the slope of basalt rocks. The microhabitats are protected from the direct sunlight, wind and precipitation; thus are special with their own specific environmental conditions that include moisture, temperature and light. These factors are regulated by the presence of benefactor species (three mentioned above) from directly influencing *I. dioecum* therefore contributing positively in survival of this species. In the late October, when monsoon subsides, the resultant heat generated by the basalt rocks, on prolonged exposure to sunlight is immense; eradicating all the annual and transient vegetation cover. In such challenging habitats, plants that are acclimatized rapidly complete their life cycle by bearing seeds. In which *I. dioecum* has the shortest life cycle, hardly exceeding 20 days!

Associated species:—*Arundinella pumila* Steudel (1854: 114), *Heteropogon ritchiei*, *Ischaemum diplopogon*, *Dimeria blatteri*, *Ischaemum barbatum* Retzius (1791: 35), *I. semisagittatum* Roxburgh (1832: 320), *Ischaemum sp.*, *Geissaspis sp.*

Etymology:—The epithet alludes to a dioecious breeding system of the species, where male and female plants are sexually separate individuals.

Population and threat:—In the first locality the habitats are encroached and disturbed by tourists visiting Devkund waterfall during monsoon when the individuals are in flowering. The first author has also observed that the shallow shores of the river attract many villagers especially women for washing clothes. However, the second locality is far from the reach, at least for villagers and their livestock. The basalt slopes make the domestic quadrupeds unable to climb and disturb the thin population of *Ischaemum dioecum*. These basalt habitats, during monsoon, are extremely slippery and difficult to climb upon. At least because of this, there the population of this extremely rare grass is, perhaps, on a small magnitude, protected. However, in this habitats *Celosia sp.* is very troublesome and exhibits a great possession. It may threat the existence of this species in future.

IUCN status:—Based on our field observations, it can be asserted that the population is severely fragmented and confined over the two localities (Figs. 3 & 4) few kilometers apart from each other. The type locality exhibits tourist encroachment and disturbance. The total number of individuals in both the subpopulations is less than 25 in which female plants are relatively higher in numbers as compared to the male counterparts. The observed data suggests 7 male individuals over 18 female individuals. Hitherto, based on the limited surveys, data is not available to discuss declination thus those categories and criteria cannot be assessed. We have not seen *Ischaemum dioecum* in any other locality except the two given though surveyed the region more or less for almost a month during monsoon. Based on this it is perhaps not too quick to assess the plant as Critically Endangered (CR) under B1 (Extent of occurrence <100 km^2), D (mature individuals <50) of IUCN Red List Categories and Criteria (2019).

Notes:—Since, the species is extremely delicate, slender, weak and non-tufted, it demands an additional support from the stilt-roots, that are present up to almost half of the plant height assisting it to stand upright without falling. In some specimens stilt-roots are present till the last node i.e. below the inflorescence, and may measure up to 12 cm high. The staminate and pistillate plants differed quite sufficiently in appearance of the inflorescence that one might easily mistake them for members of different species! The most striking contrast between the two is that the formers are essentially awnless, whilst those of the pistillate plants bear conspicuous awns (Figs. 1 & 2). The features that are common in both plants are such as: solitary habit with stilt-roots; leaves thin-membranous, hispid, long, petioled and acute at the base; ligule membranous; few spikelets up to three or less than three in the spiciform-raceme; 2–4-nerved lower glumes of the sessile spikelets; lower floret absent; upper palea bi-dentate at the apex with an arista from the sinus and pedicelled spikelets absent or reduced to a single glume i.e. half the length of the sessile spikelets.

Females in comparison to males are, at least somewhat, easier to search in the field and tend to exist in a relatively higher numbers. Whilst, the male plants are very few and extremely rare in occurrence and challenging to trace; so far, we, during our surveys, found only few male plants in which only two were collected for further study. As compared to the female plants, males are slightly taller, more delicate, bearing thinner leaves and higher number of stilt-roots.

TABLE 1. Morphological comparison of *Ischaemum dioecum* with a few allied congeners.

Morphological characters	***Ischaemum dioecum***	***Ischaemum albovillosulum****	***Ischaemum roseotomentosum****	***Ischaemum hubbardii****
Habit	Ephemeral, stilt-rooted, non-tufted, simple, extremely delicate, slender, 10–20 cm high.	Perennial, densely to loosely tufted, simple, not delicate, slender, ca. 40 cm high.	Perennial, tufted, with intravaginal innovations, not delicate or slender, culm bases pubescent, 70–130 cm high.	Perennial, tufted, not delicate or slender, up to 75 cm high.
Leaf blade	Very thin, membranous, linear-lanceolate 0.8–5.0 × 0.2–0.5 cm, petioled (petiole ca. 3.0 cm long), acute at the base, not pilose.	Not thin or membranous, linear-lanceolate, epetiolate.	4.0–15 × 0.5–0.8 cm, tuberculately pilose near the base,	Linear-lanceolate 5.0–14 × 1.0–1.5 cm, petioled (at least lower ones), acute at the base, not pilose.
Ligule	Eciliate-membranous, 1.0–4.0 mm long, lacerated (bi-partite) on maturity or not, hairy on the margin or not.	Imperceptibly hair-fringed or eciliate-membranous, up to 1.0 mm long.	Eciliate-membranous, up to 0.5 mm long.	Eciliate-membranous, lacerated.
Sheath	Terete, 1.0–4.0 cm long, glabrous, striated, membranous, margin hyaline, without keel.	-	Terete, long, pilose with tubercle-based hairs.	Basal sheath strongly compressed (keeled), with degenerating old sheaths.
Breeding system	Dioecious.	Andromonoecious.	Andromonoecious.	Andromonoecious.
Inflorescence	A solitary spiciform-raceme (if bi-nate then each spiciform-raceme reduced to a single sessile spikelet)	A solitary spiciform-raceme, 10–12 jointed, 6.0–8.0 cm long. Tomentum of the young inflorescence is white.	A solitary spiciform-raceme, 5.0–7.0 cm long. Tomentum of the young inflorescence mauvish-pink or sometimes golden.	Bi-conjugate spiciform-racemes.
Sessile spikelet	Male plants: Linear-elliptic, 9.0–12 mm long. Female plants: Ovate-lanceolate, 5.0–5.6 mm long	Elliptic [linear-elliptic], ca. 10 × 2.0 mm.	Oblong-lanceolate, ca. 8.0 mm long	6.0–7.0 mm long.
Lower glume	Male plants: Linear-oblong, 8.0–10 (–13) × 2.0–3.0 (3.5) mm, coriaceous, glabrous, not rugose or noduled; convex at the base flattened upwards; margin not winged; 2–4 nerves present. Female plants: Ovate-lanceolate, 5.0–5.6 × 1.5–1.8 mm; with two shallow bosses towards the base and in the middle; margin wingless; 2–4 nerves present.	Elliptic, coriaceous, glabrous, not rugose or noduled, hairy on the inner side towards the apex; margin wingless; 9-nerved.	Oblong-lanceolate, ca. 8.0 mm long, coriaceous, flat or convex between the keels, densely villous on the back in the inferior 2/3, pilose towards the margins above, wings lobed (1.0 mm wide) on the keels and apex emarginated.	Oblong, 6.0–7.0 mm long; flat or slightly convex on the back; margin narrowly winged.
Upper glume	Male plants: linear-lanceolate, 7.0–9.0 (–12) × 2.2–3.3 (–3.8) mm; wing ciliolate on the keel near apex; 1–3 nerved. Female plants: Ovate-lanceolate, 5.1–5.7 × 1.5–1.8 mm; wingless on the keel; 1–3 nerved.	9.0 mm long, acuminate, coriaceous, hairy inside and on the keel outside, 5-nerved.	Lanceolate, 7.0 mm long, apex emarginated and dorsally pilose.	Cymbiform , ca. 8.0 mm long with a very narrow scabrid wing above the middle.

.....continued on the next page

TABLE 1. (Continued)

Morphological characters	*Ischaemum dioecum*	*Ischaemum albovillosulum**	*Ischaemum roseotomentosum**	*Ischaemum hubbardii**
Lower floret	Male plants: absent. Female plants: mostly absent, if present then barren, epaleate and elodiculate.	Barren; lemma epaleate.	Barren; lemma linear-elliptic, ca. 4.0 mm long, membranous, 2-nerved, dorsally slightly pilose; palea ovate-lanceolate, hyaline, nerveless, 1.0 mm long.	Well developed, staminate, lemma 6.0 mm long, obscurely 3-nerved; palea oblong, acute, 4.5 m long, hyaline.
Upper floret	Male plants: staminate, lodiculate; lemma linear-lanceolate 7.0–9.0 (–12) mm long, 3-nerved, un-awned; palea linear long obspatulate, sub-equal to its lemma, apex bi-dentate most often with a central arista. Female plants: pistillate, elodiculate; linear-lanceolate, 4.0–5.4 × 0.8–1.0 mm, 3-nerved, awned (geniculate awn ca. 12.5 mm long); palea very linear, almost obspatulate 3.0–4.0 × 0.3–0.4 mm, apex bi-dentate most often with a central arista.	Hermaphrodite; upper lemma stipe-like, membranous, ca. 5.0 mm long, geniculate awn ca. 30 mm long; palea absent.	Hermaphrodite; lemma bi-partite, thinly membranous, slightly hairy with a geniculate awn from sinus, ca. 30 mm long; palea ovate-lanceolate, ca. 1.0 mm long, emarginated, slightly membranous and nerveless.	Hermaphrodite; lemma 5.0 mm long, cleft to the middle, geniculate awn ca. 20 mm long issuing from the sinus; palea lanceolate, 3.5 mm long, hyaline, apex obtuse.
Stamens	Male plants: Four. Female plants: absent.	Three	Three.	Three
Ovary/Caryopsis	Female plants: Ovary 0.5–1.0 mm long. Male plants: absent.	Caryopsis 2.5 mm long.	Ovary 3.0–4.0 mm long.	-
Stigma	Female plants: Plumose 6.0–10 (–14) mm long. Male plants: absent.	Stigma plumose.	Stigma plumose.	Stigma plumose.
Pedicelled spikelet	Male plants: absent, if present then barren and reduced to a lower glume, ca. 5.0 mm long. Female plants: reduced to only pedicel, no glume is present.	Developed, elliptic, ca. 10 mm long.	Reduced, barren, 3.0–4.0 mm long, represented only by its glumes.	Occasionally reduced to the glumes only.
Lower glume	If present, then, ca. 5.0 mm long, 2–4-nerved.	Coriaceous, hirsute with long tubercle-based hairs especially on keels and sub-apical arch, 15–17-nerved.	3.5 mm long, similar to the sessile counterparts but smaller, lower 2/3 pilose.	If present, oblong-acute, 5.0 mm long, oblique, many nerved, broadly winged on either side.
Upper glume	Absent.	2/3 of lower glume i.e. approx. 3.3 mm long, glabrous, acute, 11-nerved.	Lanceolate, ca. 2.5 mm long, thinly membranous, lower back pubescent, 1-nerved.	If present, cymbiform, membranous, shortly aristate, wingless.
Pedicel	Male plants: Linear, slender, 7.0–10 mm long (i.e. 4/5 of sessile spikelets), ciliate on both the angles. Female plants: extremely narrow, flattened, not swollen, linear, 3.2–4.0 × 0.2–0.3 mm.	-	Pedicel yellowish to purple, densely villous the hairs pinkish or sometimes golden.	Almost half as long as the sessile spikelets i.e. 3.5 mm long, densely ciliate on the back and toothed at the top.

*Information is based on the protologue (Bor 1938, Phipps 1963, Simon 1989) and other relevant literature such as (Cope 1999, Clayton *et al.* 2006, Simon & Alfonso 2011, POWO 2021). "-" dash indicates the information is not known from protologues of the concerned species.

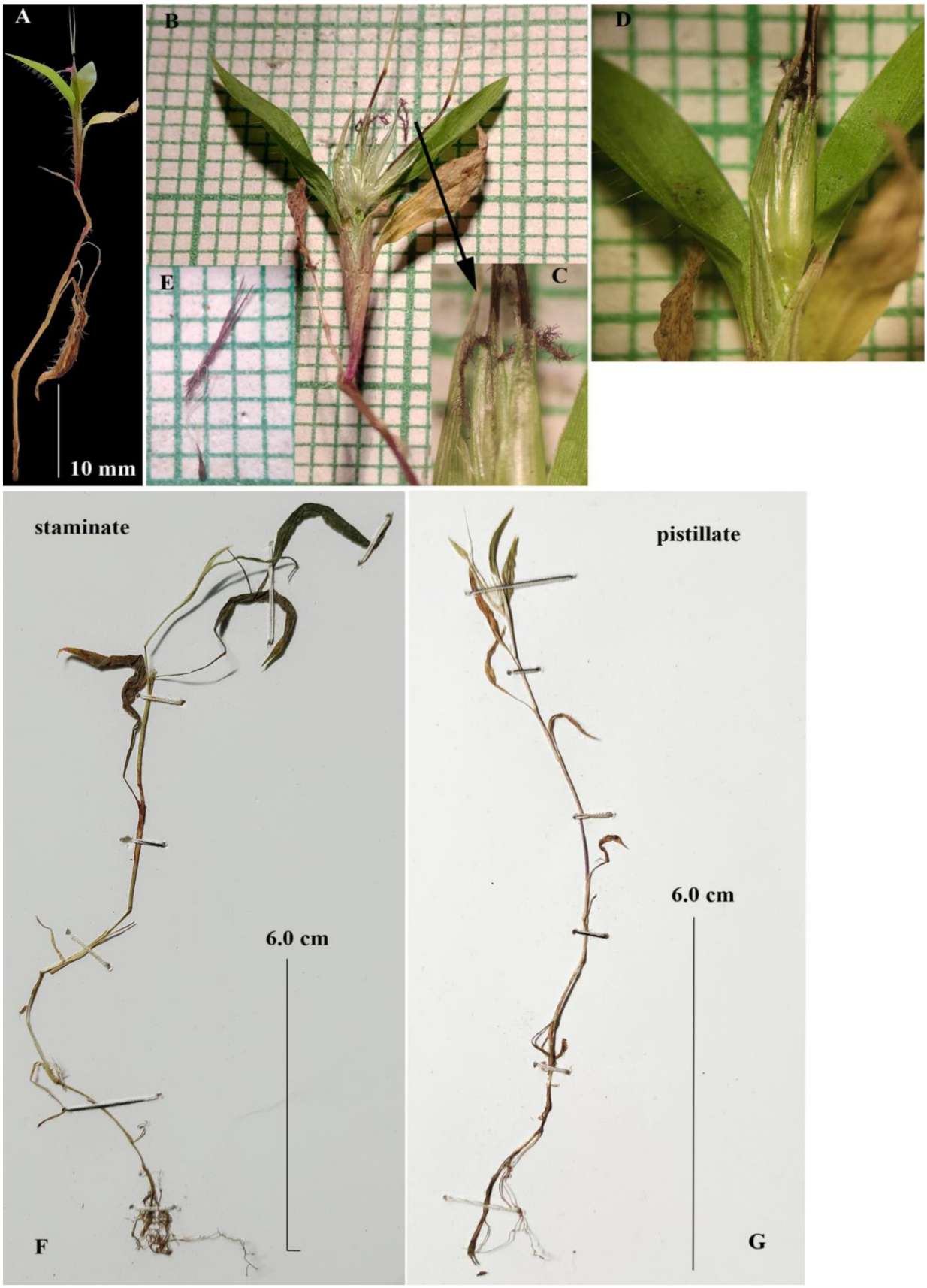

FIGURE 1. ***Ischaemum dioecum***. **A**. Habit. **B**. Magnified upper portion of the plant with raceme. **C**. Magnified raceme showing the apically exserted stigma (stigma highly broken). **D**. Spikelets with a subtending sheath. **E**. Pistil from the young spikelet. (Based on *Shahid Nawaz* PR-01B at BLAT: isotype). **F**. Male plant (un-awned) from second locality [*Shahid Nawaz* RR-05; paratype]. **G**. Female plant (awned) from the first locality [*Shahid Nawaz* PR-01A; holotype]. (Photography by: Shahid Nawaz)

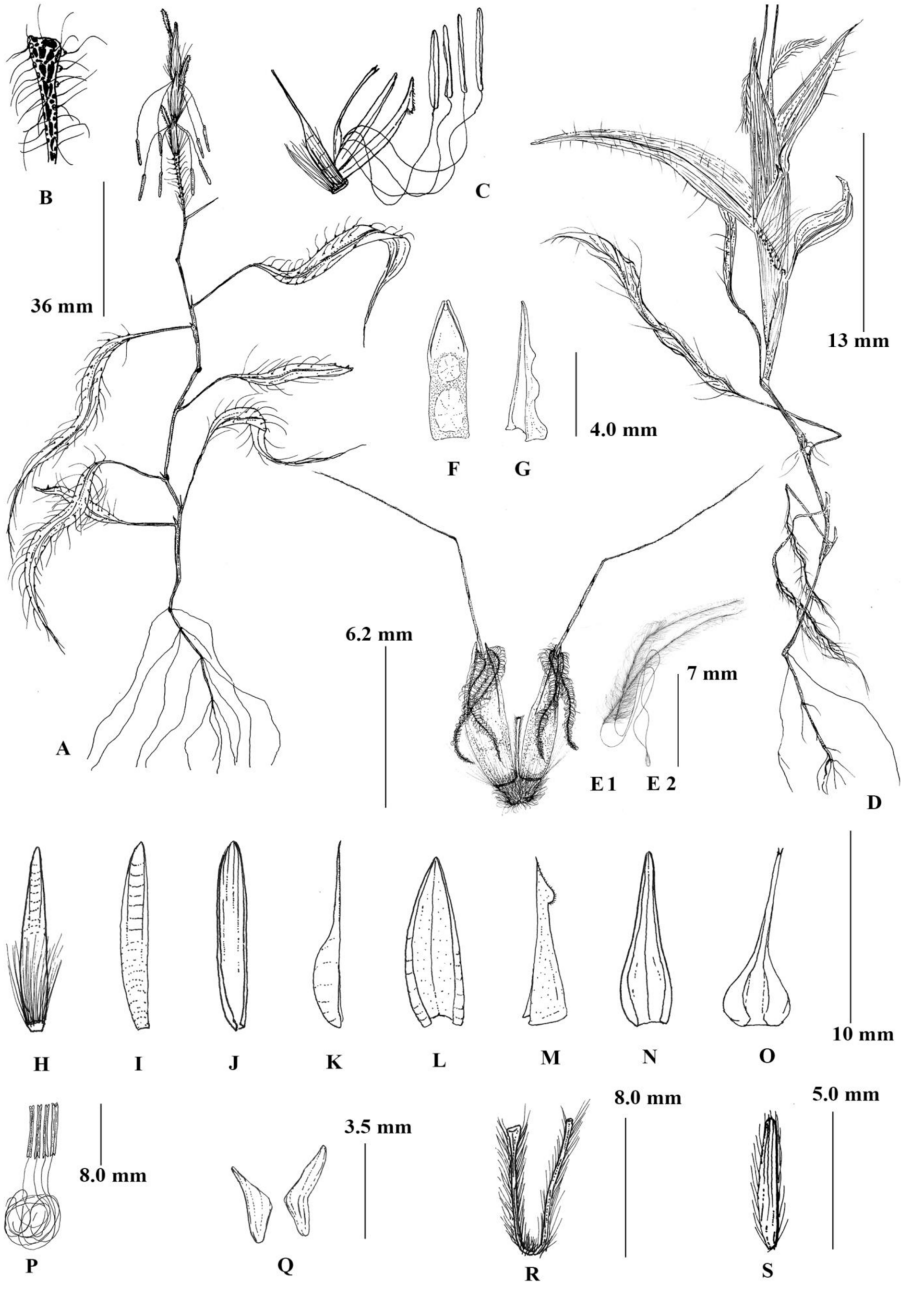

FIGURE 2. Illustration of *Ischaemum dioecum* (The male plant and its parts have been redrawn from the field note book of Shahid Nawaz). **A**–**C** & **H**–**S**: Male plant & its parts. **D**–**G**: Female plant and its parts. **A**. Male plant habit. **B**. Magnified peduncle. **C**. Sessile spikelet opened-up. **D**. Female plant habit. **E1**. Reduced bi-nate spiciform-raceme (sheath and callus hairs were removed to expose the raceme). **E2**. Pistil from the mature spikelet. **F**. Lower glume (outer view). **G**. Lower glume (lateral view). **H**. Sessile spikelet. **I**. Lower glume (outer view). **J**. Lower glume (inner view). **K**. Lower glume (lateral view). **L**. Upper glume (inner view). **M**. Upper glume (lateral view). **N**. Lemma. **O**. Palea. **P**. Stamens. **Q**. Lodicules. **R**. Rhachis internode and pedicel. **S**. Pedicelled spikelet. (Illustrated by: Shahid Nawaz)

Note: Male plants, as compared to their female counterparts, were quite fewer and extremely delicate. Thus, the first author dissected and studied a couple of fresh specimens on the field under a dissecting microscope and illustrated the floral parts in his field notebook. Later, after facing an irreversible loss of the intended type specimens of the male plant of *Ischaemum dioecum* with other important grass specimens in the field, his field note book was reconsidered to redraw and reproduce the same illustration for this paper. A re-visit to the type locality at the end of October 2021, when monsoon had subsided, revealed that the previously associated other grasses had now established a gregarious community possessing a taller stature, and the very effort to examine their roots and bases was futile. Sooner, the thin population of *I. dioecum* had completely disappeared. In view of the very restricted range of this species, it perhaps seems that, it has not been very successful in colonization and may be very recent in origin. It is also reflected through its acquisition of such a unique microclimatic condition to live that in absence of which the species might become extinct.

FIGURE 3. Transient microhabitats of *Ischaemum dioecum* in the type locality during monsoon (first locality: near Patanus village) (Alphabets M & F followed by arrows indicate male and female plants respectively). (Photography by: Shahid Nawaz)

FIGURE 4. Transient microhabitats of *Ischaemum dioecum* on the soil-filled cracks of basalt slope in post monsoon period (second locality: near Rawalje village). (Photography by: Shahid Nawaz)

Discussion

However, with the discovery that this species is dioecious, a re-evaluation of its generic position might be pertinent using molecular data. Currently, on the basis of the morphological features such as: U-shaped internode, annular callus, coriaceous, 2-keeled lower glume, upper glume laterally compressed and keeled, upper lemma bi-fid with a geniculate awn from the sinus, petiolated leaves and peculiar *Ischaemum*-like general appearance; this species would seem to be placed correctly in *Ischaemum* but with certain exceptions as discussed under diagnosis. Another opinion, yet perhaps not very strong, is that, a differential breeding system i.e. dioecy, may not create a sufficient basis for the erection of the novel genus. As, for instance, a few genera such as, *Eragrostis* Wolf (1776: 23), *Cyclostachya* Reeder & C. Reeder (1963: 95) [*sensu lato Bouteloua* Lagasca (1805: 134)] and *Poa* Linnaeus (1753: 167), contain a few species, that, against the majority of bisexual plants, are dioecious. An interesting case of diclinous plants was discussed by Reeder & Reeder (1963) when erecting a new genus *Cyclostachya* based on *Bouteloua stolonifera* Scribner (1891: 302). This species was based only on the pistillate plants specimen as a type. It was, for over 70 years, not known the species was dioecious, until Reeder & Reeder (1963). They also stated that male plants are usually overlooked or very rarely ever collected and never had been collected together in the field until 1958. Because as they occur in spatially segregated colonies; quite similar to that of the case with *Ischaemum dioecum* in which, at least on a lower scale, spatial segregation is apparent in the field. Most interestingly, they found that the staminate plants of *B. stolonifera* were identified as *B. scorpoides* Lagasca by Griffith (1912) at US herbarium and this disposition was followed by Hitchcock (1913). For more information on its proper identification, refer Arrieta & Peterson (2021). It reflects the possibilities of identifying sexually separate plants of the same species as individuals of different species.

Distribution of unisexual florets on the plant differs among the monoecious taxa in Andropogoneae (Le Raoux & Kellogg 1999). Maize is the example of a considerable degree of sexual separation i.e. monoecious, in the tribe which has been furthered by *Ischaemum dioecum* into a complete segregation of breeding system as two separate plants i.e. dioecious. Unisexuality in the tribe Andropogoneae has been studied by Kinney *et al.* (2008). According to them, unisexual spikelets initially bear primordia for both androecium and gynoecium later in developmental phase either is aborted by the action of a particular unexpressed gene thereby regulating the sexuality of the plant. In the female plants of *Ischaemum dioecum*, the androecium is completely absent. This is a unique species in the whole tribe which is strictly dioecious in nature. According to Connor (1979) breeding system variants in cereals and pasture grasses have been extensively studied which may be taken as a guide to study these variants in wild grasses; clearly in which only surface has been scratched. He also stated that strictly dioecious genera are relatively few, and most of them are oligotypic or monotypic, and dioecism occurs in only 18 genera among 7 tribes. *Ischaemum dioecum* is the most curious dioecious departure in the genus and the tribe Andropogoneae.

Habitat characteristics, inter-specific interactions and distribution of the population of *Ischaemum dioecum*

Ischaemum dioecum was discovered in the stilt roots of the taller grasses gregariously growing along the flanks of the river on lateritic outcrops during monsoon (Fig. 3). Such habitats are nutrient deficient in nature due to excess concentration of iron, which is one of the key reasons that why the plants are delicate and small in overall size. The alteration of very wet and dry condition creates an unusual ecological situations and varying microhabitats that support unique biota (Sreejith *et al.* 2016). Habitats such as this have microclimate of their own and are indeed unique from that of the open grasslands or deep forest settings. Lower macrescent (withered and persisting) leaves of other taller grasses form a sort of dense veil, thereby protecting this small grass from the direct exposure of intense sunlight, rain and strong breezes, maintaining the microclimate relatively cool, moist and safe. This species has only been observed during monsoon, for a short phase, owing to its transient nature. Searching for this small species, in such a fugitive ecological niche, is utterly daunting. This task turns almost impossible during the times of heavy downpour when the plant is flowering. The second locality (Fig. 4), in which basalt slope is seen, harbors a discrete and restricted population of *Ischaemum dioecum* in the very unique microhabitats of the basalt cracks wherein water flows through root assemblage at the base of dense benefactor species *I. diplopogon* which forms almost a gregarious monospecific community on the slop. In this locality microhabitats are diverse and relatively darker and cooler as compared to the surrounding macrohabitats during monsoon; thus, favoring existence of *I. dioecum*. Moreover, such microhabitats are protected from the direct sunlight and strong breezes. The plants growing under dense canopies (in the present case other taller grass species) could also have the cost of reduced light (Holmgren *et al.* 1997) and presence of compact and tall vegetation around acting as a windshield, thereby reducing evaporation (Schöb *et al.* 2013). Such habitats drive the force of speciation and adaptive radiations. Outside of its peculiar habitats, this species does not occur and is highly

susceptible to survive in the direct exposure to sunlight, precipitation and breezes. In view of the very restricted range of the only dioecious congener; it perhaps seems that, it has not been very successful in colonization. It is also reflected through the acquisition of such unique ecological amplitude to live that the absence of which may endanger the very existence of the species. The performance of dioecious species could increase or decrease depending on the interacting overstorey shrub species, and eventually this differential performance could result in a local spatial segregation of the sexes (Graff *et al.* 2018). With this statement, our observation perfectly aligns.

Since all the plant species in the habitats of (Figs. 3 & 4) are non-woody and mainly constitute herbaceous composition i.e. chiefly grasses, thus dealing with high levels of inter-specific competition for resources in the upper soil layer. This interaction is explained well in detail by (Davis *et al.* 1998 & Bucci *et al.* 2009). We studied distribution of naturally established male and female plants in these habitats. We observed the female-biased population of *Ischaemum dioecum* due to higher susceptibility of male plants to abiotic stress. This is apparently seen in the field, as male plants are extremely rare and challenging to trace. Our observation is quite in contrast to (Dawson & Ehleringer 1993, Delph 1999, Obeso 2002); according to these authors, dioecious plant populations in harsh-environments should be male-biased, in which male are higher in number opposed to females. The female population of *I. dioecum* is often seen secluded in the deep coverage of the other vegetation may be representing the survival strategy from stress-causing abiotic factors, such as: intense sunlight, wind, moisture and temperature, which could be proven harmful if directly affected. This hypothesis has been confirmed when our study of the habitats and interaction of this species with other vegetation and abiotic factors. We observed that, when the cover of other vegetation is thinned-out or shallowed, the female and male plants would proportionally disappear. This contrasts with the observations made by Bertiller *et al.* (2000) on a dioecious grass *Poa ligularis* Steudel (1854: 257), in which females were found to be distributed close to shrubby patches, whereas males were more common in open areas. We also observed that interaction with the other plants (here we refer them as benefactor species) may reduce the stress caused by abiotic factors and therefore is positively helpful in sustenance of the species. Somewhere on a measure, effects of climate change on population sex ratio may be expected on disproportionate loss of other vegetation from the habitats making microclimate exposed and vulnerable. It is also capable of severely affecting distribution dynamic, population and equally survival rate of the species. Graff *et al.* (2018) experimentally demonstrated that positive interaction of a dioecious plant with other plants in the vicinity may reduce or enhance the effect of abiotic stresses on the seemingly maladapted sex to arid environments. They also observed, as we did, that benefactor species abundances play the key role in maintaining the population of a dioecious plant, the model plant they selected to study was *Poa ligularis*.

However, it is unknown why male plants are exceeding the numbers of female plants in the habitat of (Fig. 4). Otherwise, they are relatively fewer and extremely challenging to trace in the habitat of (Fig. 3). We failed to re-locate them in our subsequent field visits in both the localities and surrounding high montane region in the end of October. It is observed that male plants have an extremely short life cycle, as compared to the female plants, lasting only for a few days (may be <15 days) and culminating quickly after the event of pollen dispersal. This hypothesis was supported further by the later observations made on the subsequent field visits in the mid September when we only found female plants (at least a couple of). We hypothesize that a few number of male plants is compensated by the four extremely long stamens, first time in the genus against the three in all other species, bearing abundant supply of pollen dust. That way, a single plant may be equipped with enough pollen grains to reach more than a dozen of female plants in the vicinity or may be to the plants spatially segregated by a considerable distance by anemophily or entomophily!

The habitats of this kind are often overlooked on the fields, and as Bor (1951) said, have never been systematically explored. According to him, many grass species that looked upon as rare, lurking at the base of other taller grasses and examination of such habitats in Bombay [erstwhile Bombay Presidency] would be very profitable. When Bor (1950) was working on considerably large collection of grasses from the Blatter Herbarium at K herbarium, said, "Bombay [erstwhile Bombay Presidency] contains disproportionate number of interesting genera which are endemic, most of them monotypic, beside a large number of endemic species. Nearly all of these are annuals and come into flower at the end of the rains when plant hunting is not, in the ordinary course of events, popular." In another incident, an endemic and very rare annual grass was discovered by C. E. Hubbard in the tufts of the specimens of *Danthonidium gammei* (Bhide 1912: 513) C. E. Hubbard, sent to K herbarium, collected by Charles McCann in 1919 (Bor 1948). This grass was later called *Bhidea borii* Deshpande, V. Prakash & N. P. Singh (1989: 1094). Certainly, back then, Dr. Bor had realized the uniqueness of such microhabitats in determining the novelties of taxa.

Lodicules' function and their presence in *Ischaemum dioecum*

Unlike the captivating graceful perianth whorls of typical petaloid dicotyledonous and monocotyledonous flowers, grasses have been observed with quite a remarkable reduction in this particular organ as much, to almost, as a scale-

like appendage called the lodicules (Arber 1929) or perigonate annulus (Judziewicz & Soderstrom 1989), confined at the base of an ovary making it epigynous. Lodicules, though, vary in the materials of their composition (chartaceous, hyaline-membranous, rigid or fleshy), serve a singular function of assisting in exsertion of the stamens and pistil by thrusting apart a lemma from palea during anthesis. This is attained by their hygroscopic nature; becoming turgid by absorbing moisture from the thin air. Their taxonomic implications have been, however, lately realised; they are utilized in segregating species and even genera in grasses. In the female plants of *Ischaemum dioecum*, the lodicules are absent in the only fertile upper floret of the sessile spikelet, in which a typical lateral exsertion of the style, as generally observed in *Ischaemum*, is circumvented. In this species, as the lemma and palea do not separate during anthesis, an unusual apically exserted stigma is seen (Figs. 1 & 2). This mode of apical exsertion has been observed in the pistillate flowers of dioecious or monoecious taxa (Connor 1979); in which lemma and palea do not separate in the absence of lodicules. Such genera—a few to quote, in which lodicules may be absent in the female florets are *Apocopis* Nees, *Lopholepis* Decaisne *sensu stricto*, *Lophopogon* Hackel (1887: 26), *Pogonatherum* Palisot de Beauvois (1812: 56), *Amphilophis* Nash (1901: 71). However, in the only fertile upper floret of the sessile spikelet of the male plants lodicules are giant i.e. ca. 3.5 mm long. However, the stamen exsertion is sub-apical because glumes are only slightly opened. The theory of their function in pollen dispersal is consistent with Kinney *et al.* (2008).

Curious adaptations of *Ischaemum dioecum*

The plants are very delicate and slender, and too weak to stand without the additional support by stilt roots. It is highly strange to have discovered tubercled ornamentation and depressed glands secreting viscous brown fluid on the peduncle of male plants. While studying their populations in the microhabitats, the fine residue of this substance was also detected on the spikelets and stigmas of the female plants. However, there is no trace of any glandular organ on the female plants. This observation strengthened the hypothesis that the exudate on male plants has a definite function, equivalent to nectar in other plant groups, in alluding tiny biotic agencies (including ants) to affect a pollen transfer onto the female plants in the vicinity. Whether the pollination is completely entomophilous is difficult to proclaim at the moment but it could be very likely based on the above case study.

The paleas in both the staminate and pistillate plants are most often mucronate to aristate (arista ca. 1.0–4.5 mm long) from the sinus of the bi-dentate apex. This feature is nowhere seen in the genus *Ischaemum*. *Ischaemum dioecum* has also a slight tendency towards the 3-nerved palea; one of the most unusual features in the genus!

After critically studying the habitats of *Ischaemum dioecum*, we observed that the basal leaves of other taller grasses significantly contribute in diverting breezes from entering into the microhabitat. It may hinder the process of anemophily. Thus, the male plants seem to have developed glands on the peduncle to attract pollinators as biotic agents to disperse their pollens. It stands as a marvelous evolutionary response in the pursuit of Darwinian postulates i.e. struggle for existence and survival of the fittest!

The female plants of *Ischaemum dioecum* have very long almost a filiform style (ca. 14 mm long). It is very unusual to observe this long style which is highly coiled and packed inside the tiny space of the upper floret in the sessile spikelets. A pair of stigmatic arms may measure up to 14 mm long, packed almost in the same manner as of style. During anthesis, stigma is exserted apically and droops over a spathaceous sheath in which the spikelets are subtended. In the young spikelet stigma is shorter in length, may measure 5.0 mm (Fig. 1, E) whereas during maturation grows extraordinarily long, ca. 14 mm (Fig. 2, E2).

Morphological affinities of *Ischaemum dioecum*

In *Ischaemum dioecum* hairs of the callus are unusually long and distinctly silky whitish especially in the male plants where they apparently exceed half of the length of the sessile spikelet and may measure up to 6.0 mm long. In the tribe Andropogoneae, such long silky hairs of the callus, partially concealing the spikelets, are characteristically associated with *Saccharum* Linnaeus (1753a: 54) and its allies having homogamous spikelet pairs and also frequently seen in species of genus *Eriochrysis* P. Beauvois (1812: 182) and the new world members of *Schizachyrium* Nees (1829: 331) with decompound inflorescence.

Ischaemum dioecum, with no closely allied species, is unique in having its dioecious breeding system, reduced raceme, four stamens, 1-flowered spikelets, bi-dentate 3-nerved palea with a central arista. However, a few features are commonly shared by some congeners as discussed below under two sections.

Similarities to African and Australian congeners

Ischaemum dioecum has a few similarities with a distant Australian narrow endemic species *I. albovillosum* B.K. Simon (1989: 86) and African species *I. roseotomentosum* Phipps (1963: 30), as some characters such as: leaf bases

acute (at the least in lower blades), solitary spiciform raceme, linear sessile spikelets, lower glume not rugose or noduled on the keels, lower floret of the sessile spikelet barren, elodiculate and epaleate and pedicel 1/2–4/5 of the sessile spikelet, are mutually shared.

The first species to be recognized on the basis of the neuter lower floret of sessile spikelet was *Ischaemum roseotomentosum*—a grass first collected by J.M. Rattray in 1948 in Rhodesia (now officially the Republic of Zimbabwe) in South Africa. Later in 1989, B.K. Simon described a new species *I. albovillosulum* from North West Australia, wisely discerning its affinities with Phipps' grass from Zimbabwe, as both the species tend to exhibit certain features such as: a solitary spiciform-raceme and the neuter lower floret of the sessile spikelet. The trend of reduction in the lower floret would have perhaps been triggered in *I. roseotomentosum* in which the lower lemma is well developed ca. 4.0 mm long, palea is reduced in size i.e. ca. 1.0 mm long and stamens are entirely absent. This trend is further seemed to be continued in *I. albovillosum* where the lemma only remained and the palea disappeared without a trace and it reached to its extreme in *I. dioecum* with a complete reduction of the lower floret!

There are couples of similarities among these three species especially in the leaf blade acute at the base, pedicel half or more than half as long as the sessile spikelet, lower glume of the sessile spikelet few nerved (<4) and the lower floret neuter. However, quite interesting to note, their distributional ranges never overlap for they are known to occur on three different lands i.e. Africa, India and Australia widely separated by oceans. These three species seem to be marginal in the genus *Ischaemum* mainly on the account of a solitary spiciform-raceme, reduction in the numbers of nerves on lower glume of the sessile spikelets and the trend of reduction in the lower floret of the sessile spikelet; the tendency of becoming 1-flowered spikelets. For a more detailed comparison refer (Table 1).

Andropterum Stapf (1917: 38), a monotypic genus endemic to Africa in the sub-tribe Ischaeminae, characterized by the solitary spiciform-raceme with laterally compressed wing-like muticous crest of the upper glume of both the spikelets; lower glume of pedicelled spikelet laterally much compressed with a broad wing throughout the keel on the back and lower glume of the sessile spikelet with a deep longitudinal groove. In this genus the lower floret of the sessile spikelet is epaleate and staminate, whilst the upper floret strictly pistillate; where a considerable degree of internal sexual separation is evidently observed. In the staminate plants of *Ischaemum dioecum* a broad wing in the upper portion of the upper glume of the sessile spikelet is apparently seen. There are a few similarities between the Indian endemic monotypic genus *Triplopogon* Bor (1954: 52) and *Andropterum* such as: lower glume of the sessile spikelets with a median longitudinal groove; lower floret of the sessile spikelet staminate, whilst the upper strictly pistillate. Their molecular affinities are clearly unknown.

Similarities to Indian congeners

Also, it is somewhat closer to an Indo-Thai grass *Ischaemum hubbardii* Bor (1938: 98) at least in the acute leaf bases, pedicel more than or half as long as the sessile spikelet, lower glume not rugose or noduled, winged upper glume of sessile spikelet and smaller reduced pedicelled spikelet (almost half as long as the sessile spikelet). Another species *I. tadulingamii* Nair & Sreekumar (1985: 385), endemic to Kerala, has its lower floret of the sessile spikelet barren and the pedicel is more than 1/3 of the sessile spikelet; sharing these features with *I. dioecum*. *Ischaemum dioecum* is somewhat allied to *I. pappinisseriensis* Ravi, Mohan & Rajesh (1998: 155), a species endemic to Kerala, in completely sterile pedicelled spikelet with a well developed pedicel more than 1/3 the length of the sessile spikelet, long callus hairs and densely ciliate joints of rhachis. However, in former the entire pedicelled spikelet, if present, is reduced to a single glume (vs. two glumes in the latter but the upper one is highly reduced).

Future prospects

Further research is needed to answer several questions in which few are: Origin of *Ischaemum dioecum*? Is this species proper fit in *Ischaemum* or demands an erection of a new monotypic genus? What are the factors responsible for the regulation of sexual dimorphism and its gene expression? Where the dioecy in this particular species is derived from, although it is, as such, absent in the tribe Andropogoneae? Why the species demands such an ecological specificity for the establishment? Why is the plant population female-biased? Why the distribution is so regionally confined? Why are there glands on the peduncle in the male plants? Have these glands been evolved independently in the tribe or have been ancestrally derived from *Bothriochloa* in which glands are present in the lower glumes? Why the life cycle culminates within such a short phase only during monsoon? The molecular studies to evaluate the taxonomic position and affinities of *I. dioecum* within the genus *Ischaemum* are highly recommended.

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