

On the taxonomic status, occurrence and distribution of *Cucumis hystrix* Chakrav. and *Cucumis muriculatus* Chakrav. (Cucurbitaceae) in India

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Abstract Field observations and herbarium studies distinguish *C. muriculatus* from *C. hystrix* for many distinct morphological characters. The present record of *C. muriculatus* in India is based on the collections from Mizoram, previously described as *Cucumis hystrix* var. *mizoramensis* Sutar et S.R. Yadav, and is synonymized under it here. Full description, taxonomic key and comparative morphology of *C. muriculatus* and *C. hystrix* are given along with notes on their ecology, adaptability under cultivation and economic potential. Collections of these two rare crop wild relatives of cucumber from Indian Gene Centre assume great significance for cucumber improvement.

Keywords *Cucumis hystrix* · *Cucumis muriculatus* · Crop wild relatives of cucumber · Cucumber breeding · Genetic resources · Indian Gene Centre · New distribution record

Introduction

Cucumber (*Cucumis sativus* L.) and melon (*C. melo* L.) are the two widely cultivated cucurbitaceous crops in the world (Pitrat et al. 1999). The Indian subcontinent is considered to be the centre of origin and a centre of diversity for these two cultivated species, respectively (Zeven and de Wet 1982). Of late, cucumber crop faces many biotic stresses including viral diseases. The search for resistance genes requires an assessment of the closely related taxa and their genetic relationship. *C. hystrix* Chakrav. is morphologically allied to *C. sativus*, even though its basic chromosome number ($x = 12$) is different, but same as that of melon. Chen et al. (2002) were successful in developing a synthetic amphidiploid of cucumber with *C. hystrix* (designated as *C. × hytivus* J.F. Chen et J.H. Kirkbr.), and further, Zhou et al. (2008) reported incorporation of downy mildew resistance from *C. hystrix* to cucumber. Under the national exploration plan of ICAR- National Bureau of Plant Genetic Resources, explorations were undertaken in Mizoram, Manipur, Nagaland and Arunachal Pradesh in north-east India for augmentation of *C. hystrix* germplasm.

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This resulted in the assemblage of samples of two morphologically distinct populations having broad similarity in fruit shape and surface pattern, but difference in many other vegetative, floral and fruit characters. They formed two discrete entities exhibiting many discontinuous variations, consistent across populations and generations demanding a critical taxonomic study.

Cucumis hystrix Charkrav. and *C. muriculatus* Charkrav. were originally described by Chakravarty (1952) based on the herbarium collections of N.E. Parry (from Tura Mountain, Garo Hills, Meghalaya) and L.H. Lace (from Ruby Mines district of Myanmar, erstwhile Burma), respectively. He described the affinities and characteristic features of *C. muriculatus* with respect to *C. sativus* and *C. prophetarum* L. and distinguished it in having small echinate-muriculate fruits, densely pubescent leaves, yellowish-brown stem, slender petiole and ovate seeds. According to him, *C. hystrix* is allied to *C. prophetarum* in having prickly fruits, but differs in having comparatively larger, not deeply lobed leaves and elongate fruits. The latter is with usually deeply lobed leaves and globose fruits. However, he has neither described the flowers of *C. hystrix* nor compared the distinguishing characters of these two species. Interestingly, the Monograph on Indian Cucurbitaceae (Chakravarty 1959) distinguished the two taxa with fruit surface pattern (fruit echinate in *C. hystrix* while muriculate in *C. muriculatus*) as the key identification character. However, his subsequent treatment (Chakravarty 1982) did not mention about *C. muriculatus* owing to the delimitation of the treatment of the family to the present political boundaries of India which excludes its type locality as is the case with many other species, according to his testimony.

Jeffrey (1980a, b) synonymized *C. muriculatus* with *C. hystrix* and also treated nomenclaturally invalid *C. yunnanensis* C.Y. Wu as its synonym without attributing any reason. Kirkbride (1993) followed Jeffrey in treating *C. muriculatus* as the synonym of *C. hystrix*. Kirkbride's description of *C. hystrix* is ambiguous; rather, it is a mix up of both the species. Also, he has not provided any illustration or photograph for the same. Later, de Wilde and Duyfjes (2007) followed Kirkbride while treating wild species of *Cucumis* of South-East Asia. Even though Kirkbride (1993) and de Wilde and Duyfjes (2007) provided detailed descriptions of *C. hystrix*, they

failed to recognise *C. muriculatus* as a valid species distinct from *C. hystrix*. Their studies were mainly based on collections from Thailand. The descriptions, illustrations and photographs presented by them for *C. hystrix* depicted partly of *C. hystrix* (Figs. 2a–i, k, 3a, c) and partly of *C. muriculatus* (Figs. 2j, 3b, d). They opined that variations mainly concern, “the length and colour of the hairs on the stems, the density of the hairs on the leaf blades, the character and orientation of the hairs on the petioles, the length of the pedicels of female flowers and fruiting pedicels, and the density of the spiny tubercles or hairs on the fruits”. These variations described by them, in fact, fall into two distinct groups; one corresponds with *C. muriculatus* and the other with *C. hystrix*, as originally described by Chakravarty (1952).

While describing *C. muriculatus*, Chakravarty (1952, 1959) gave stress to the nature of hairs on the lamina, length of peduncle (of male flower) and stalk of fruits. According to him, *C. muriculatus* differs distinctly from its allies in having muriculate - *Momordica* like fruit, densely pubescent leaves and shortly pedunculate flowers and fruits. He also differentiated it from *C. prophetarum* by the colour of stem, nature of petiole, and size and shape of seeds. In the protologue of *C. muriculatus*, Chakravarty (1952) depicted it with petiolar hairs curved upwards (not downwards as in *C. hystrix*). Moreover, he mentions the anthers as “*conduplicatae, fere 2 mm. longae, una unilocularis, ceterae biloculares; appendix connectivi hyalina, glabra, 0.5-0.7 mm. longa*”

Subsequently, de Wilde and Duyfjes (2007) noted these characters as discrepancies and commented to recheck the type specimens of *C. muriculatus* deposited at Royal Botanic Garden, Edinburgh (E). Lu and Jeffrey (2011) and Renner and Pandey (2013) also considered *C. muriculatus* as synonym of *C. hystrix* without assigning any reason. Uddin et al. (2012) reported the occurrence of *C. hystrix* from Bangladesh. Considering the descriptions and the illustrations, the material referred to by them agrees to Chakravarty's protologue for the same (not to *C. muriculatus*, though they treated the latter as the synonym of the former). Recently, Sutar et al. (2014) described a new variety of *Cucumis hystrix* viz., *C. hystrix* var. *mizoramensis* Sutar et S.R. Yadav based on the collections from Mizoram, India. According to them, the new variety differs from the typical variety in having retrosely (downwardly directed) spread

1–2 mm long hairs on stem and petiole (versus antrorse, upwardly directed), appressed, c. 0.5 mm long, non-protuberant hairs on hypanthium (versus globular protuberant hairs), reflexed calyx lobes (versus straight), oblong, lax hairs on the ovary (versus globose, dense hairs) and pointed aculei (versus blunt). They followed de Wilde and Duyfjes (2007) to delimit *C. hystrix* var. *hystrix* and overlooked the concept of *C. muriculatus*. A thorough morphological analysis of the images of the type specimens of *C. hystrix* (Kew Herb. N.E. Parry 859 [K000742801!], Fig. 1), and *C. muriculatus* (Edin. Herb. J.H. Lace 6325 [E00301190!], Fig. 2) along with live collections reveal that the two entities are quite distinct. Therefore *C. muriculatus* is resurrected here, based on the descriptions following hereafter, and characters depicted in Table 1.

Materials and methods

Explorations to various parts of Arunachal Pradesh, Manipur, Mizoram and Nagaland in North-Eastern Hill region of India bordering Myanmar (type locality of *C. muriculatus*) was conducted during 2010–2015. A total of 13 collections comprising of *C. hystrix*/*C. muriculatus* were assembled. Ex situ regeneration of collected seeds was carried out during rainy season in 2012, 2013, 2014 and 2015 at ICAR-NBPGR Regional Station, Thrissur, Kerala. Live specimens were studied in detail, including micro-morphological characters, and compared with standard descriptions of both the taxa. All the *Cucumis* sheets lodged at CAL and ASSAM were studied for distribution and phenology, apart from herbarium sheets (images) at E, IBSC, K, L, P, PE and WUK, including the types available online. Descriptions of *C. hystrix* in the Flora of China (Lu and Jeffrey 2011) and the images of specimens from Naban River Watershed National Natural Reserve, Yunnan, China (http://www.virboga.de/Cucumis_hystrix.htm accessed 09.03.2015) were also studied before arriving at a conclusion.

Results and discussion

From seedling stage onwards, the seed samples collected from 13 populations upon germination and flowering fall into two distinct morphological entities

(see Figs. 3, 4). The two entities were more dissimilar than similar for general morphological appearance, and matched satisfactorily with the earlier descriptions as well as type specimens of *C. hystrix* and *C. muriculatus*.

In *C. muriculatus*, the short aculei on the fused portion of the female hypanthium (also on the whole fruit surface) continue to grow as the fruit develops, so the mature fruits are covered by prominent aculei. Also, characters like robust growth, quadrangular stem, profuse long hairs on whole plant parts, dark-green leaf colour, petiolar hairs directing downwards, bright yellow corolla, reflexed long calyx lobes and fruit surface having pointed aculei with hyaline ends make it stand apart from *C. hystrix*. However Chakravarty's statement of *C. muriculatus* having yellowish-brown stem, slender petiole and prickly fruits in comparison to *C. prophetarum* is not agreed upon. Fruit ornamentation is not exactly prickly as the protuberances are not sharp. Further stem is not yellowish-brown. It is rather dark-green and almost like *C. sativus* and petiole is stouter than *C. prophetarum* but almost similar to *C. sativus* var. *hardwickii* (Royle) Alef. In fact, it varies from *C. prophetarum* in many characters like the non-procumbent habit, fruits without longitudinal white striations and non-aculeate nature.

A detailed botanical description of *C. muriculatus* and *C. hystrix* along with a morphological comparison given in Table 1 reveals that both the species are distinct for many reproductive characters, besides a few vegetative features. It appears that Sutar et al. (2014) did not make a detailed study of these variations among many populations, and also did not attempt to match their specimens with the type specimen as well as protologue of *C. muriculatus*, which led to coining a new variety (under *C. hystrix*) rather than fitting the variant population under *C. muriculatus*. While erecting *C. muriculatus*, Chakravarty inadvertently had made observations like petiolar hairs curved upwards, which might not be true as the orientation of hairs may change during herbarium preparation. On detailed analysis, we found that *C. muriculatus* has retrorse hairs on the petiole. Visually, both the species are strikingly different and a broad general resemblance in fruit shape is the only general character. Even then the shape and nature of tubercles on the fruit surface are different. In fact, the terminology 'echinate' is more applicable to the fruit



Fig. 1 Holotype of *C. hystrix* (Kew Herb. N.E. Parry 859 [K000742801]) ©The Director, Board of Trustees, RBG, Kew

surface of *Cucumis muriculatus* in the sense that it ends up in a pointed structure. It seems that Chakravarty attributed the term ‘muriculate’ to the surface pattern of just-fertilized fruit (deposited as type at E), as he may not had the opportunity to see the

mature fruit, which in turn becomes echinate as the fruit matures.

Further, seedling morphology of both the species are quite distinct; *C. hystrix* being delicate and thin with nearly terete stems, enlarged at nodes and with small light green leaves while *C. muriculatus* being



Fig. 2 Holotype of *C. muriculatus* (Edin. Herb. J.H. Lace 6325 [E00301190] © Edinburgh Herbarium, UK

fairly robust with quadrangular stems, not bulged at nodes and crystal green leaves. A perusal of Fig. 3 shows clear morphological distinction between the two. Even though the whole plant of *C. muriculatus* is

highly pubescent with long hairs, the seeds are less pubescent compared to that of *C. hystrix*.

Dwivedi et al. (2010) reported the occurrence of *C. hystrix* from Rajasthan based on field explorations in

Table 1 Morphological distinction between *Cucumis hystrix* and *Cucumis muriculatus*

Characters	<i>Cucumis hystrix</i>	<i>Cucumis muriculatus</i>
Stem	Thin, nearly round, light green	Turgid, fleshy, succulent, nearly quadrangular, dark green
Leaf colour	Light green	Dark green
Hairs on stem and petiole	Short, appressed-scabrid, 0.5 mm long; petiolar hairs antrorse	Hispid, 2–3 mm long; petiolar hairs retrorse
Hairs on lamina	Short, appressed, without a bulbous base	Long, bent and with bulbous base
Pedicele of male flowers	5–7 mm long, hairs short, appressed	2–3 mm long, hairs long, erect
Hairs on the pedicel of female flowers	Swollen based aculei present	Only simple hairs present
Calyx lobe— Male	Horizontal, 1–1.5 mm long	Reflexed, 6–7 × 1 mm
Female	Horizontal, 1–1.5 mm long	Reflexed, 8 × 1 mm
Shape of corolla lobe (male and female)	Elliptic	Ovate
Ovary	Elliptic-ovate, 1–1.1 cm long, with short upwardly directed aculei, arising from a globose swollen base	Ellipsoid, 1.4–2 cm long, with long straight aculei, arising from a pyramidal swollen base
Fruit	Aculeate, ovate, 4–4.5 × 1.8–1.9 cm, stalk end rounded or obtuse, tubercles thick, blunt, teat like with remnant basal portion of the aculei	Aculeate, ellipsoid, 5.8–6.5 × 1.6–1.9 cm, stalk end infundibular, tubercles fine, acute, with whip like aculei ends
Fruit taste	Non-bitter	Bitter and faintly sour
Seeds	Villous, placental end obtuse	Sparsely hairy, placental end acute

Aravalli Ranges of North West India. The characters described by them for their *C. hystrix* collections do not match with that of typical *C. hystrix*, for example, caducous spines, fruit weight ranging between 25 to 168 g, fruit length extending up to 12.5 cm and stripes on the fruits. Moreover, its occurrence in Aravalli Ranges (which is an adjoining part of Thar Desert) is clearly outside the home range of *C. hystrix*, which is a native of humid subtropics. In all probability, it is a misidentification of *C. sativus* L. var. *hardwickii* which has caducous tubercles, fruit size in the said range and a wider distribution across India without any niche specificity. The reported occurrence of *C. hystrix* in Eastern Ghats of Godavari district of Andhra Pradesh (Pullaiah and Karuppusamy 2008), which is again completely outside its home range, also needs to be investigated further.

Key to the species

- | | | |
|-----|---|-----------------------|
| 1a. | Stem and petiole hispid; leaves dark green; petiolar hairs curved downwards; calyx lobes 6–7 mm long, reflexed; male flower hypanthium base obtuse; aculei long, straight, with hyaline end; fruit stalk end infundibular, tubercles fine, acute, with whip like aculei ending | <i>C. muriculatus</i> |
| 1b. | Stem and petiole scabrous; leaves light green; petiolar hairs curved upwards; calyx lobes 1–1.5 mm long, straight; male flower hypanthium base acute; aculei short, directed upwards, without hyaline end; fruit stalk end not infundibular, tubercles thick, blunt, teat like, with semi persistent remnant aculei | <i>C. hystrix</i> |



Fig. 3 *Cucumis hystrix* Chakrav. **a** Stem; **b** upper surface of leaf; **c** lower surface of leaf; **d** male flower; **e** top view of male flower; **f** L.S. of male flower; **g** female flower; **h** L.S. of female flower; **i** surface of ovary; **j** fruit; **k** surface of fruit; **l** seed; **m** Juvenile stage

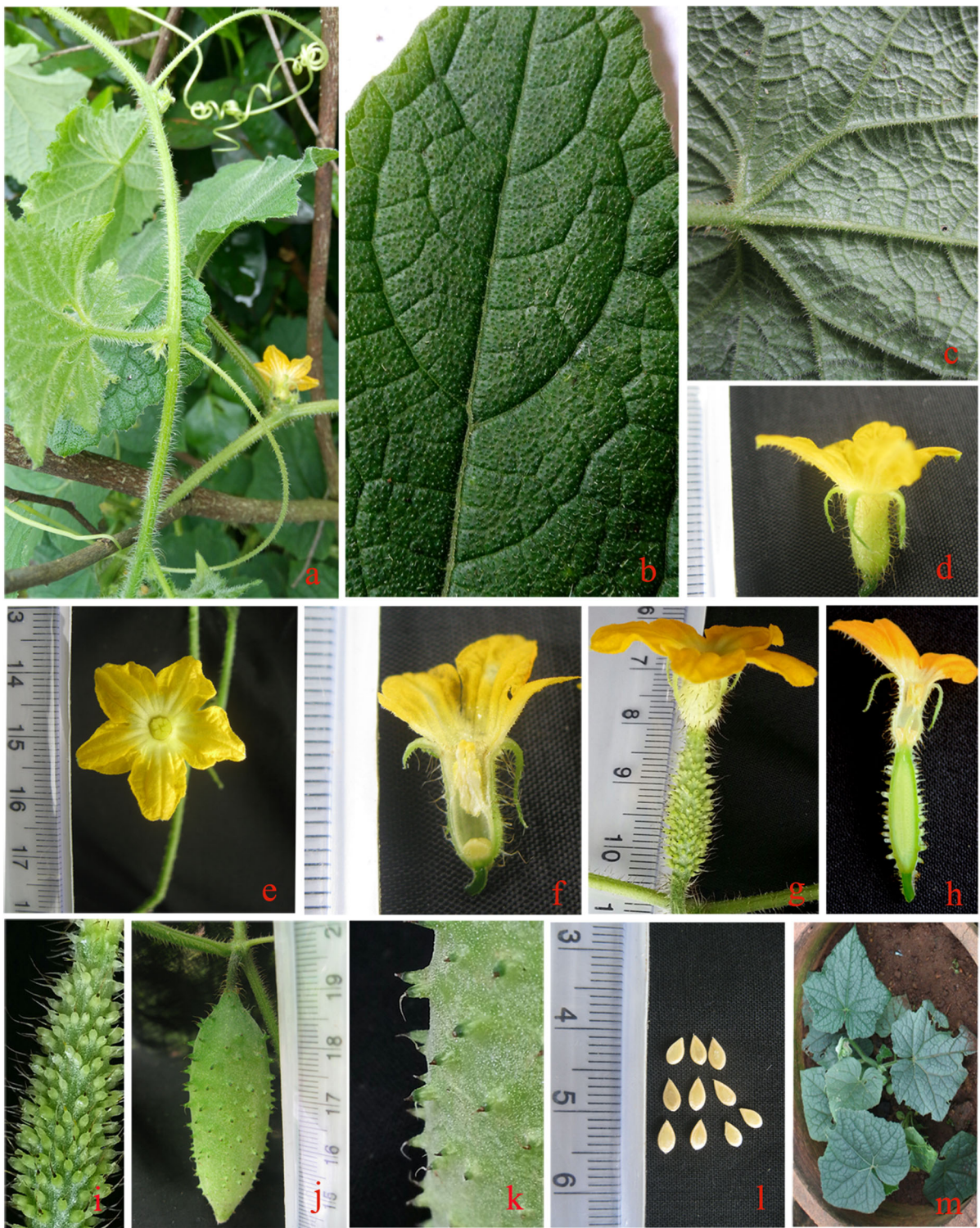


Fig. 4 *Cucumis muriculatus* Chakrav. **a** Stem; **b** upper surface of leaf; **c** lower surface of leaf; **d** male flower; **e** top view of male flower; **f** L.S. of male flower; **g** female flower; **h** L.S. of female flower; **i** surface of ovary; **j** fruit; **k** surface of fruit; **l** seed; **m** Juvenile stage

Cucumis hystrix Chakrav., Bom. Nat. Hist. Soc. 50(4): 896.1952; Rec. Bot. Surv. Ind. 17(1): 110. 1959; Chakrav. Fasc. Fl. Ind. 11: 32. 1982; Lu and Zhang, Fl. Sinicae 73(1): 207. 1986; Kirkbride, Bio. Syst. Monogr. genus *Cucumis* (Cucurbitaceae) 86. 1993 (p.p.); Chen, Fl. Yunnanica 6: 340. 1995; de Wilde and Duyfjes, Adansonia 29(2): 239-248. 2007 (p.p.); Lu and Jeffrey, Fl. China 19: 49. 2011 (p.p.)

Type: India, Meghalaya, Garo Hills, Tura Mountain, 4.11.1929, N.E. Parry 859 (holo K [K000742801!]).

Cucumis yunnanensis C.Y. Wu in C. Jeffrey, Cucurbitaceae of Eastern Asia 22.1980 (*nom. invalid* vide Jeffrey 1980b).

Herbaceous climber, annual, monoecious. Roots succulent. Stem sulcate, old stem split along the sulci but jointed at nodes, hairs short, antrorse and appressed, scabrid, stem hairs 0.5 mm long; internode 6–11 cm long. Leaves light green; petiole 4–8.5 × 0.3 cm, sulcate, appressed-scaberulous, hairs curved upwards; lamina ovate, 5-angular, appressed-scaberulous on both surface, serrate at margin, cordate at base, acuminate at apex, 7–8 × 8–8.5 cm; central lobe triangular, acuminate at apex, 3–6 × 2–5 cm; lateral lobes broadly triangular, acuminate at apex, 1.5–3.5 × 0.8–1.5 cm. Tendrils solitary, scabrous, 13–18 cm long. Male flowers axillary, shortly racemose, 5–7 flowered; pedicel 4–5 mm long, antrorse-appressed short hairy; hypanthium campanulate, base triangular or acute, 5–7 × 3.5 mm. Calyx lobes minute, 1–1.5 mm long, horizontal. Corolla infundibular, 1.5–1.7 cm in diameter; lobes appressed short hairy on veins outside, glabrous inside, elliptic, obtuse or shortly retuse and mucronate at apex, 6–8 × 4–6 mm. Stamens inserted about half way in the hypanthium tube; filaments 1 mm long, glabrous; anthers 3 mm long; connective prolonged beyond the anther lobes, 3 × 1.5 mm, yellow; pistillode globose, yellow, c. 1 × 1.5 mm. Female flowers axillary, solitary, pendant; pedicel 6–8 mm long, hairy; hairs antrorse, appressed, intermixed with swollen based aculei. Calyx and corolla same as in male flowers. Ovary elliptic, or elliptic-ovate, 1–1.1 × 0.4 cm, tuberculate, aculeate; aculei very short, directed upwards, arising from globose or cylindrical tubercles; style 2 mm long, subtended by a glabrous circular disc; stigma greenish yellow, 3-lobed, 3 mm long; each lobe bifid; hypanthium urceolate. Fruit ovate, a

short basal portion of the aculei remains green, turning greenish yellow when mature, surface greyish-white powdery, stalk end round or obtuse, blossom end nearly round with a faint rostration, 4–4.5 × 1.8–1.9 cm, non bitter; weighs c. 5–8 g; beak short, narrow, 3–4 mm; tubercles thick, blunt, teat like. Seeds many, 3–4.5 × 2–2.5 mm, creamish, ovate, placental end obtuse, compressed, villous; hairs caducous.

Phenology

C. hystrix germinated with pre-monsoon showers and completed its life cycle by the end of November or early December. Peak fruiting season in Mizoram and Manipur is October–November. Under ex situ conditions at Thrissur, early June sown plants came to flowering by the second week of July and fruits took 28–30 days to ripen. Flowering and fruiting continued till the end of November coinciding with senescence.

Distribution

Cucumis hystrix is of South-East Asian distribution ranging from south China to Myanmar, Thailand, Bangladesh and north-east India. In India, the Eastern Himalayan and North-eastern biogeographic regions, and adjoining parts of north Bengal are worth exploring for germplasm collections. Authors have collected germplasm of *C. hystrix* from six locations (including Dampa Wildlife Sanctuary and Zowkathar in Champai district bordering Myanmar) in Mizoram, one location in Arunachal Pradesh and two in Manipur states of India. In Mizoram, it is called *arphagma* (*phagma*—cucumber) meaning wild cucumber. We found the distribution range of *C. hystrix* from 800 to 1500 m; however de Wilde and Duyfjes (*l.c.*) mentioned it as 200–1800 m.

Specimens collected

1. INDIA. Arunachal Pradesh: Changlang district, Beyond 9 mile Changlang, 3.11.2012, Joseph John K. (JJK/2012-1).
2. INDIA. Manipur: Churachandpur district, Churachandpur market, 3.10.2012, K. Pradheep (originally from high altitude area of Singnat,

Churachandpur district; living coll. KP-1264 (IC597007) at ICAR-NBPGR).

3. INDIA. Manipur: Ukul district, Jessami on Phek-Meluri Road, 01.11.2015, Joseph John K. (JJK/Mis-15-1).
4. INDIA. Mizoram: Champhai district, 16 km before Khaswani, 21.10.2011, Joseph John K., and L.K. Bharathi (JB/11-150).
5. INDIA. Mizoram: Champhai district, 14 km before Khaswani, 21.10.2011, Joseph John K., and L.K. Bharathi (JB/11-143).
6. INDIA. Mizoram: Aizwal district, Vaivakawn, 21.10.2011, Joseph John K., and L.K. Bharathi (JB/11-156).
7. INDIA. Mizoram: Kolasib district, Near Bairavi, 14.10.2011, Joseph John K., and L.K. Bharathi (JB/11-48).
8. INDIA. Mizoram: Kolasib district, Silchar Road before Zero point, 17.10.2011, Joseph John K., and L.K. Bharathi (JB/11-90).
9. INDIA. Mizoram: Mamit district, Dampa WLS, 20.12.2010, K.V. Bhat, and S.R. Yadav (KVB/10-1A).

Herbarium sheets (deposited at Central National Herbarium, Kolkata)

1. INDIA. Arunachal Pradesh: Lohit district, Deopani River bank north of Roving, *s.d.*, A.S. Rao 48186 (CAL).
2. INDIA. Nagaland: Without precise locality, *s.d.*, C.B. Clarke, 182193 (CAL).

Herbarium sheets from Thailand (deposited at Leiden herbarium).

3. THAILAND. Without precise locality, *s.d.*, L3774204.
4. THAILAND. Northern Chiang Mai, 1080 m., *s.d.*, Phonsena, Duyfjes and de Wilde L0584868.
5. THAILAND. Doi Phu Ka NP., 1430 m., 18.10.2003, Phonsena, Duyfjes and de Wilde L0588037.

Cucumis muriculatus Chakrav., Bom. Nat. Hist. Soc. 50(4): 896.1952; Rec. Bot. Surv. Ind. 17(1): 110. 1959.

Type: Myanmar (erstwhile Burma) Ruby Mines dist., Oct. 1912, J.H. Lace 6325 (holo E [E00301190!]; iso E [E00276285!]).

C. hystrix var. *mizoramensis* Sutar et S.R. Yadav, Rheedeia 24(1): 46. 2014. *syn. nov.*

Type: India, Mizoram, Champhai dist., near Khawnuam village, 23° 23.549' N and 93° 21.287' E, 1187 m, 21.10.2011, Joseph John K. and L.K. Bharathi JB/11-132 (holo CAL; Iso K n.v., SUK n.v.)

Herbaceous annual climber, monoecious. Roots succulent. Stems fleshy sulcate, hispid, stem hairs 2–3 mm long; internodes 6–11.5 cm long. Leaves dark green; petioles 5–8.5 × 0.3 cm, sulcate, hairs curved downwards; lamina ovate, 5-angular, strigose-hispid on both surface, serrate at margin, cordate at the base with a sinus, 7–10 × 11–11.5 cm; central lobe triangular, acute at apex, 3–8 × 5.5–9 cm; lateral lobes broadly triangular, acute at apex, 1.3–3 × 2.5–5 cm; hairs on upper surface bent and bulbous based. Tendrils solitary, axillary, simple, hairy, 12–23 cm long. Male inflorescence shortly racemose; peduncle very short, 5–7 flowered; flowers bright yellow; pedicel hispid, 2–3 mm long, hypanthium campanulate, creamish inside and outside, base rounded or obtuse, 8–9 × 3.5 mm, hispid, hairs brown; calyx lobes narrowly acute at apex, reflexed, 6–7 × 1 mm; corolla infundibular, 2.2–2.4 cm diameter; lobes pubescent on veins outside, glabrous inside, ovate, shortly retuse, mucronate at the apex, 1–1.2 × 0.8–0.9 cm; stamens inserted above the receptacle tube (hypanthium); filaments 1 mm long, glabrous; anthers 3–3.5 mm long; connective prolonged beyond the anther lobes, 1 mm long, yellow; pistillode globose, 1 × 1.5 mm. Female flowers solitary, pedicel c. 4–7 mm long, with long downwardly pointed white hairs; hypanthium bulged at middle up to 0.8 mm, profusely villous hairy; calyx lobes 5, reflexed, 8 × 1 mm; corolla same as in male flowers, c. 2.5 cm in diam.; lobes 1–1.3 × 0.7–0.8 cm; staminodes attached about halfway in the hypanthium tube, 1 mm long, glabrous; ovary ellipsoid 1.4–2 cm long, 3–3.5 mm diam., aculeate; aculei brown, elongate, straight, soft, arising from a pyramidal swollen base, 1.5 mm long; style 4 mm long, subtended by a glabrous circular disc; stigma yellow, tripartite, 3 × 2 mm long. Fruit aculeate, ellipsoid, ash green, turning greenish yellow when mature, surface greyish-green, stalk end infundibular, blossom end beaked with a rostration, bitter when young, bitter and faintly sour when mature, 5.8–6.5 × 1.6–1.9 cm; weighs c. 10–13 g; beak short, broad, 3–4 mm; tubercles hairy, acute, fine whip like. Seeds 60–72, ovate, creamish,

placental end acute, 3–4 × 3 mm, compressed, sparsely hairy or not; hairs caducous.

Phenology

C. muriculatus germinated with pre-monsoon showers and completed its life cycle by the end of November. Peak fruiting season is August–October in Mizoram. Under ex situ regeneration at Thrissur, flowering started from 45 to 48 days and continued up to 90 days. Fruits took 28–30 days to ripen.

Distribution

It is a rare species probably restricted to Myanmar, Thailand and North-eastern hill region of India distributed from 700 to 1200 m altitude. In India it is rare, located only at three places, two in Mizoram and one in Nagaland. Field experiences indicate its overlapping distribution with *C. hystrix* in Mizoram. Our present collection of *C. muriculatus* from Mizoram (earlier described as *C. hystrix* var. *mizoramensis*) and Nagaland are new records for India.

Specimens collected

1. INDIA. Nagaland: Tuensang district, 5 km before Tuensang from Hatchang, 17.08.2014, K. Pradheep *et* Soyimchiten 1663 (NHCP).
2. INDIA. Mizoram: Champhai district, Near Zokhawthiar, Assam rifles check post, N 23° 23' 45.3 E 093° 23' 03.5, 21.10.2011, Joseph John K. (JB/11-132).
3. INDIA. Mizoram: Mamit district, Dampa WLS, 20.12.2010, K.V. Bhat *et* S.R. Yadav, (KVB/10-1B).

Herbarium sheets from Thailand (deposited at Leiden herbarium)

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2. THAILAND. Huangbauhn, Kanchanaburi province, 12.11.1971, van Beusekom, Phengkhlai, Wongwan and Geesink, L0588059.

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Threat status, ecology, viability under cultivation and economic importance

Though no critical assessment of population status of these species in North-eastern India was undertaken, according to a conservative estimate, both are threatened. *C. hystrix* is occasional in forest clearings on roadsides, but *C. muriculatus* is very rare. The alien invasive weed, *Mikania micrantha* Kunth is a severe threat to its survival in their native habitat. Present germplasm collections in both the *Cucumis* species after a lapse of more than 80 years of their type collections assume significance.

Non-bitter nature of *C. hystrix* fruits can form an important factor in the direct utilization of this species for edible purpose as a cultivated vegetable, apart from its use in cucumber breeding. In Churachandpur district of Manipur, Wokha district of Nagaland and Changlang district of Arunachal Pradesh, the wild gathered fruits of *C. hystrix* are sold in markets as vegetable. Apart from vegetable use, boiled fruits are used for treating liver-related ailments. It is reported to have host plant resistance for downy mildew (Zhou *et al.* 2008). At the same time, we have found the studied samples of both the species susceptible to other pests such as root-knot nematode (*Meloidogyne incognita*), spider mite (*Tetranychus urticae*), pumpkin caterpillar (*Diaphania indica*) and aphids (*Aphis gossypii*) under ex situ field conditions at Thrissur, Kerala. *Cucumis muriculatus* (rather than *C. hystrix*) has the closest morphological resemblance to cucumber and is yet to be utilised by breeders anywhere.

Both the species come up well during rainy season under ex situ conditions at Thrissur from June to November, although *C. muriculatus* was better adapted to the tropical humid regions. When grown in summer (Jan–March), we observed stunted growth in both the species; however *C. muriculatus* flowered and fruited at 30–34 °C day temperature, while *C. hystrix* failed to set fruits at higher temperature. Freshly harvested seeds have a short dormancy of 2–3 months. Though honey bees frequent the flowers, there is no pollinator specificity observed in both the species. Ripe fruits fall to the ground and get

disintegrated quickly leaving a soil seed bank on the ground.

Conclusion

C. hystrix and *C. muriculatus* are two distinct crop wild relatives of cucumber having sympatric distribution in North eastern Hill region of India. *C. muriculatus*, presently treated as a synonym of *C. hystrix*, is resurrected here as a valid species based on morphological evidence.

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Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest involved.

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