

GENETIC RESOURCE OF INDIAN PHASEOLI: DISTRIBUTION, VALIDITY OF SPECIES AND ENDEMISM

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(Received: August 15, 1993; accepted December 26, 1994)

ABSTRACT

The herbarium collections in India record the occurrence of 12 species of *Phaseolus*, mainly found in the southern regions of the Western and Eastern Ghats and Eastern Himalayas. A review of all published records shows that actually 16 species occur mainly in the Western Ghats, Deccan plateau, and Eastern and Western Himalayas. On the basis of comparative morphology, it is established that *P. aureus*, *P. mungo*, *P. radiatus*, *P. sublobatus*, *P. aconitifolius*, *P. calcaratus* and *P. trilobus* are the only valid species. The endemic nature of these species to India is confirmed by ancient history and nomenclature.

Key words: *Phaseolus*, *Vigna*, mungbean, uradbean, mothbean, ricebean, species validity, endemism.

The importance of estimation and conservation of genetic resources of the Indian grain legumes cannot be overemphasized. At least four widely cultivated pulses, viz. mungbean, uradbean, mothbean and ricebean, belong to the genus *Phaseolus* and they belong to the Hindustan centre of origin. Necessarily, at present there is a great thrust on genetic improvement of these pulse crops through hybridization and other gene transfer methods. The present study deals with the distribution of Indian Phaseoli, validity of species and their antiquity as revealed by nomenclature, ancient history and literature.

The genus *Phaseolus* consists of 230 species of which 20 are cultivated for their edible pods or seeds [1]. After removing the synonymy, the number of species may be reduced to 150–200 [2]. The genus can be divided into two main groups, the Asiatic and the American. The Asiatic species have small cylindrical pods without a beak, small seeds and broad spur-like stipules, and most of the plant surface is pubescent, e.g., *mungo*, *aureus*, *radiatus*, *sublobatus*, *calcaratus*, *trilobus*, *aconitifolius* and *angularis*. The American species have large flat pods with a beak, large seeds and small cuneate stipules, which include *vulgaris*, *coccineus*, *lunatus*, *acutifolius*, *caracalla* and a few other minor species.

On the basis of some morphological and biochemical evidences, Verdcourt [3] and Westphal [4] proposed the transfer of the Asiatic *Phaseolus* species to *Vigna*. However, there is not much cytological evidences to support the transfer of the former *Phaseolus* species to *Vigna* [5] and no successful hybridization between any of the *Phaseolus* and *Vigna* species has yet been reported. Therefore, in the present investigation the Asiatic species are mentioned under the old nomenclature of the genus *Phaseolus*.

DISTRIBUTION

There is no authentic information for determining the distribution pattern and density of various *Phaseolus* species. In the absence of deliberate collection and identification of *Phaseolus*, it is necessary to rely on the herbaria and published literature for this purpose. Therefore, the world famous collection of herbarium sheets available in the Botanical Survey of India, Calcutta, and the Indian Museum, Calcutta, was considered to be a reliable indicator of gross distribution of the various *Phaseolus* species. In view of the fact that both these herbaria represent the collections made by different workers over a long period of time, the identification and validity of the species may be questionable in some cases. Discounting for the obviously introduced species, e.g. *semirectus*, the distribution of all the species has been taken at their face value. The species covered are *P. aureus*, *P. calcaratus*, *P. dalzelli*, *P. mungo*, *P. aconitifolius*, *P. pauciflorus*, *P. radiatus*, *P. torosus*, *P. sublobatus*, *P. trilobus*, *P. trinervius* and *P. velutinus*. Figure 1 represents the distribution of twelve *Phaseolus* species as available in the two herbaria. The gross distribution pattern emerging from this is that there are certain areas in the subcontinent which exhibit a great wealth of *Phaseolus* species. The southern part of both the Eastern and Western Ghats is rich in a number of species. So are the Eastern Himalayas. The wealth of West Bengal in *Phaseolus* is possibly more apparent than real because most of the collectors were once located in Calcutta. The Chhotanagpur hills and the hills of Himachal Pradesh and upper Uttar Pradesh, upper part of the Eastern as well as Western Ghats also contain large diversity of the genus.

Another possible way to get an idea about the gross distribution of the genus *Phaseolus* is to collect and collimate all published records including flora of various regions. Thus, 27 different published flora and literature by different authors [6–32] were taken into consideration and a distribution pattern was worked out. Barring the acknowledged synonyms, total 16 species are stated to occur in India (Fig. 2). These are *P. aureus*, *P. calcaratus*, *P. dalzelli*, *P. grandis*, *P. khandalensis*, *P. mungo*, *P. minimus*, *P. angularis*, *P. aconitifolius*, *P. pauciflorus*, *P. radiatus*, *P. sublobatus*, *P. trilobus*, *P. trinervius*, *P. velutinus* and *P. weightii*.

Each point on the map of India (Fig. 2) represents one mention of that species in a given flora. Of course, due weightage was given where the author indicated its occurrence as extensive, widespread, occasional, etc. and the author's identification has been accepted at its face value. It can be seen that the Western Ghats are very rich in various species. In

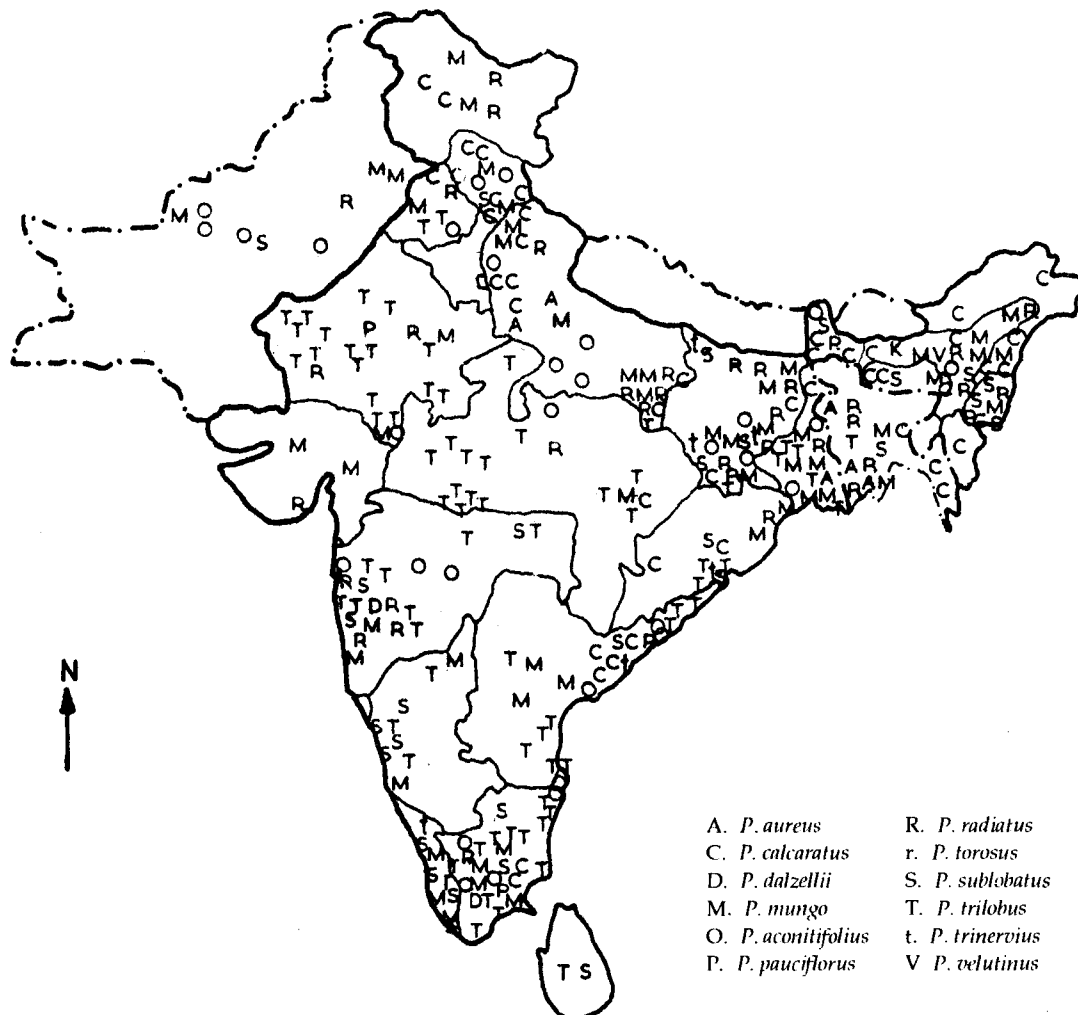


Fig. 1. Distribution of 12 *Phaseolus* species based on the collection of herbarium sheets of the Botanical Survey of India and the Indian Museum, Calcutta. The alphabets on the map represent the corresponding species.

addition, a number of species are also found in the central portion of the Deccan Plateau, and the Eastern as well as Western Himalayas, especially in Himachal Pradesh, Uttar Pradesh and Punjab. The Gangatic plains and their Chhotanagpur Hills also show a small degree of diversity of the genus.

The overall assessment leads to the conclusion that in India a great diversity of endemic species of phaseoli exists. Moreover, this wealth seems to be especially located in the Western Ghats and also in certain regions of the Eastern and Western Himalayas.

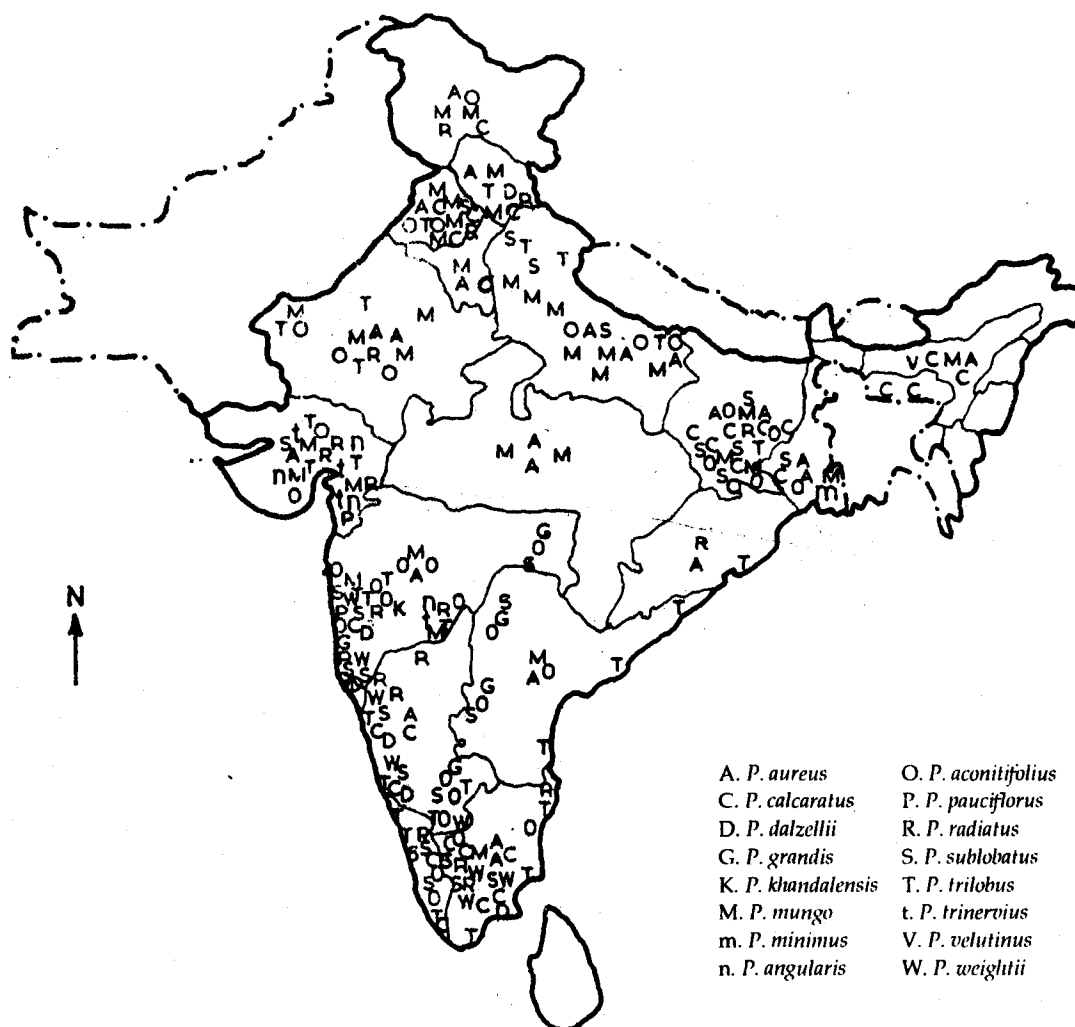


Fig. 2. Distribution of 16 *Phaseolus* species as recorded in 27 different flora published by various authors. The alphabets on the map represent the corresponding species.

VALIDITY OF SPECIES

In the analysis to follow, the validity of only those species which have been widely used for hybridization and genetic improvement, is discussed.

I. *Phaseolus aureus*, *Phaseolus mungo* and *Phaseolus radiatus*. There is a lot of confusion about the validity of *aureus*, *mungo* and *radiatus* as distinct species. What is considered as a valid species by one taxonomist may be considered as a variety or a subspecies by another.

Hooker [7] considered *aureus* and *mungo* to be the same species. Prain [33] classified *aureus* as a variety of *mungo*. Bailey [2] identified *aureus* and *mungo* as two distinct species. He distinguished *aureus* by its seeds nearly globular, green, brown, yellow, rarely blackish, hilum not concave, and pod short hairy, from *mungo* which possesses oblong, blackish seeds with concave hilum or scar.

Again, according to some other botanists, these two species are different from each other. According to Kachroo [21] *mungo* can be distinguished from *aureus* by the much shorter, stout, very hairy pods and larger oblong seeds which vary in colour from blackish to olive green. Srivastava [26] also distinguished *aureus* by its near-globular seeds and short hairy pods from *mungo* which produces oblong seeds and long hairy pods. After detailed analysis of various taxonomic possibilities, the present authors concluded that *aureus* and *mungo* are two distinct species which differ chiefly in stem hair, pod size, seed colour and hilum.

So far as the validity of *radiatus* is concerned, similar difference of opinion exists. According to Hooker [7], *radiatus* is a variety of *mungo*. Duthie [9] distinguished *radiatus* by its dark green leaves and spreading pods from *mungo* which develops yellowish green leaves, ascending or suberect pods and larger seeds. Aiyer [3] however differentiated *radiatus* from *mungo* by less hairy and slightly taller plants and smaller pods than *mungo*, and the seeds of *radiatus* are green as against black, very dark brown or greenish seeds of *mungo*.

According to the present authors' observations, *radiatus*, *aureus* and *mungo* are three distinct species. *Radiatus* differs from *aureus* chiefly by stem hair, pod size and seed colour, whereas *radiatus* differs from *mungo* by stem hair, pod size, seed colour and hilum.

II. *Phaseolus sublobatus*. The confusion about *sublobatus* is relatively less. It is considered to be synonymous with *trilobus*. Prain [33] reported that in the Index Kewensis *sublobatus* and *trilobus* are considered to be the same species, but this is an impossible identification since these two species are entirely different from each other. Duthie [9] considered *sublobatus* as separate from *trilobus*. He distinguished *sublobatus* by having twining nature and hairy pods from *trilobus* with trailing nature and glabrous pods. According to Cooke [16], *sublobatus* is different from *trilobus*. He distinguished *sublobatus* having twining or suberect stems, leaflets occasionally somewhat 3-lobed, hairy, pod hair dense and reddish brown, whereas *trilobus* possesses prostrate stem, leaflets commonly 3-lobed, glabrous or very slightly hairy, pod glabrous or sparingly hairy.

The present authors conclude that there is a possibility of *sublobatus* and *trinervius* being the same species but *sublobatus* is entirely different from *trilobus*, which differ from each

other mainly in plant habit, leaflet shape, stipule shape, pod colour and hair, and seed colour. We believe that *sublobatus* is also different from *aureus* and *mungo*. *P. aureus* and *P. sublobatus* differ mainly in plant habit, leaf hair, stipule shape, pod shape, colour, hair and size, seed colour and hilum. *P. mungo* and *P. sublobatus* differ mainly by their growth habit, stem hair, leaf hair, stipule shape, pod shape, colour, hair and size, and seed colour.

III. *Phaseolus calcaratus*. According to Hooker [7], *calcaratus* and *sublobatus* are two different species. The characters of *calcaratus* and *ricciardianus*, as identified by Hooker [7] and Prain [33], respectively, are more or less the same, which indicates that these two species are synonyms of each other. According to the authors, the main common characters of these two species are flexuous stem, clothed with fine deciduous hairs, stipules lanceolate, leaflets entire or faintly lobed, bracteoles linear, and pods glabrous. Hooker [7] also considered *calcaratus* as a different species from *mungo*. He distinguished *calcaratus* having short stem hair, stipules much smaller and narrower, racemes not capitate, pods glabrous, whereas *mungo* has more or less dense, loose deflexed hairs, ovate stipules, and long spreading deciduous silky pod hairs. Prain [33] treated *ricciardianus* as a different species from *calcaratus*. He included *hirtus* under *P. calcaratus* vars. *major* and *typica*, and *pubescence* under *P. calcaratus* var. *typica*. But he distinguished *calcaratus* and *mungo* as two different species. He distinguished *calcaratus* by having pods subcylindrical and glabrous from *mungo* producing slightly compressed and pubescent pods. Bailey [2] considered *calcaratus* to be different from *mungo* by glabrous or thinly hairy pods and glossy seeds compared to the presence of hairy or even shaggy pods and dull seeds in *mungo*.

According to Fyson [27], *calcaratus* is different from *sublobatus* by having leaflets bigger, broadly ovate, acuminate, flowers yellow, and pods glabrous, as against the smaller and ovate leaflets, yellow or reddish flowers and hairy pods in *sublobatus*.

We conclude that *calcaratus*, *ricciardianus*, *hirtus* and *pubescence* are not different species, but *sublobatus* and *mungo* are entirely different from *calcaratus*, which differs mainly by leaf apex and size, flower size, pod shape, size and hair, and seed shape, colour, hair and size. *P. calcaratus* is differentiated from *mungo* by growth habit, stem hair, leaf apex, stipule shape, flower size, pod shape, colour and hair, seed shape, colour, hair and size. We also differentiate *calcaratus* from *aureus* by the main characters, viz. plant habit, leaf apex, stipule shape, flower size, pod shape, colour and hair, seed shape, colour, hair, size and hilum.

IV. *Phaseolus aconitifolius* and *Phaseolus trilobus*. There is some confusion in the distinction of these two species also. According to Hooker [7], they are two different species. *P. aconitifolius* can be distinguished by its lanceolate stipules, leaflets deeply 3-lobed with the central lobe ligulate, bracteoles linear, pods stouter and seeds larger as against *trilobus* which develops oblong stipules, leaflets more or less deeply 3-lobed with the central lobe

spathulate, bracteoles ovate. Prain [33] stated that in Hortus Bengalensis and Flora Indica, Roxburgh indicated by the name *P. aconitifolius* the plant which is known in India as moth. and moth is undoubtedly *aconitifolius*. According to Duthie [9], however, these two are different from each other. *P. aconitifolius* can be distinguished by its small, linear and lanceolate stipules, as the stipules are large and oval in *trilobus*. The other distinguishing characters are more or less the same as described by Hooker [7]. Srivastava [26] distinguished *aconitifolius* by its lanceolate stipules and deeply lobed leaflets as against oblong stipules and shortly lobed leaflets in *trilobus*. Our observations indicate that these are indeed different species which mainly differ by plant habit, leaf shape and apex, stipule shape, pod colour, seed shape, colour, hair and size, and hilum.

Again, we believe that *aconitifolius* and *trilobus* are entirely different from *aureus* and *mungo* whose main distinguishing characters are as follows. The species *aureus* and *aconitifolius* can be distinguished mainly by plant habit, leaf apex and margin, stipule shape, flower size, pod colour and size, and seed shape, colour and hair. The species *mungo* and *aconitifolius* can be distinguished mainly by plant habit, stem hair, leaf apex and margin, stipule shape, flower size, pod colour and size, seed shape, colour and hair, and hilum. The main distinguishing characters between *aureus* and *trilobus* are growth habit, leaf shape, hair, apex and margin, stipule shape, flower size, pod colour and size, seed colour and size and hilum. *P. mungo* can also be distinguished from *P. trilobus* mainly by plant habit, stem hair, leaf shape, hair, apex and margin, stipule shape, flower size, pod colour and size and seed colour and size.

From the above discussion, it can be concluded that *aureus*, *mungo*, *radiatus*, *sublobatus*, *aconitifolius*, *calcaratus* and *trilobus* are valid species but closely related by various morphological characteristics. Thus, *aureus*, *mungo* and *radiatus* differ in few main characters. *P. aureus* differs mainly from *sublobatus*, *aconitifolius*, *calcaratus* and *trilobus* by a large number of qualitative and quantitative characters. Similarly, *mungo* differs mainly from *sublobatus*, *aconitifolius*, *calcaratus* and *trilobus* by a variety of easily recognizable characters.

NOMENCLATURE AND ANCIENT HISTORY

1. *Phaseolus mungo* L.

English name: blackgram, uradbean.

Local names: Sanskrit — *mash*; Bengali — *mash kalai*; Hindi — *urad*, *urd* or *urid*; Marathi — *urid*; Gujarati — *adad*; Tamil — *ulutham paruppu*; Telugu — *manipa pappu*; Kannada — *udu*, *udni bele*; Malayalam — *uzhunnu*; Arabic — *mash*; Persian — *mash*; Northern Sudanese — *lubia tamassi*.

According to Piper and Morse [35], it is cultivated only in India. De Candolle [36] stated that it is cultivated in India for more than 2000 years, as indicated by Theophrastus, and has also been found among lacustrine remains. The existence of considerable varieties and names in the modern Indian languages and the ancient Sanskrit and Hebrew names also indicate its antiquity. The Navdatoli–Maheshwar archeological material comprising the remains of cereals, legumes, oilseeds and fruits provides the first comprehensive record of ancient plant economy in India [37]. According to Mittre [38], carbonized seeds of *mungo* have been obtained from this Chalcolithic site dated 1440–1660 B.C. as well as from Paiyampalli, Madras dated about 645 B. C. in Krishnayajurveda Samhita, possibly written, before 1000 B.C., the seed of this plant is mentioned as edible [39]. Its name is also mentioned in Vishnupuran [40] as an annual plant, which was used in Hindu religious rites, and it is presumed that the Vishnupuran is as old as 1045 B.C. In Charak Samhita [41], its name appears at several pages for various medicinal purposes. The original Charak Samhita was a book written by Agnibesh and subsequently edited by Charak. Vedabyas mentioned Charak's name in Skandapuran and it was found that Byasdeb was born more than 5000 years ago. Thus, it can be concluded that Charak Samhita by Charak is more than 5000 years old and the original book by Agnibesh was written still earlier.

2. *Phaseolus aureus* Roxb.

English name: Green or golden gram, mungbean.

Local names : Sanskrit — *mudga*, *supashreshtha*; Bengali — *mug*; Hindi — *mung*, *harimung*; Punjabi — *muji*; Oriya — *dhalamug*; *kalamug*; Marathi — *mug*; Gujarati — *mag*; Tamil — *pachaipayru*; Telegu — *pachapesalu*; Malayalam — *cerupayaru*; Burmese — *painak*; Arabic — *muj*; Persian — *mung*.

According to De Candolle [36], it is commonly cultivated in India. Bailey [2] and Zuckovskij [1] stated that it is not a wild plant and has been cultivated in India since prehistoric times. The occurrence of a large number of varieties and so many names in the modern Indian languages as well as Sanskrit indicate that it is under cultivation for 1–2 thousand years. Mittre [38] reported that it is as old as 1440–1660 B.C. Burkill [42] stated that it has a vedic name. In Krishnayajurvedi Samhita, it is mentioned for edible purpose. In Vishnupuran, it is described as an annual plant used in Hindu religious rites. In Charak Samhita, its name appears frequently as having medicinal value.

3. *Phaseolus radiatus* L.

Local name: Bengali — hallimug.

According to Piper and Morse [35], it grows wild in India. From the archeological remains of *radiatus*, it is assumed that the crop was cultivated or used in ancient India [37].

4. *Phaseolus sublobatus* Roxb.

Local names: Bengali — *goramug*; Telugu — *teejapesara*.

5. *Phaseolus aconitifolius* Jacq.

English name: dew gram, mothbean, aconite-leaved kidney bean.

Local names: Hindi — *moth, mat*; Hindustani — *mouti*; Marathi — *matki*; Telugu — *kumkumapesalu, minimulu*; Tamil — *tulkapyrai*.

The absence of a Sanskrit name, and lack of difference in its names in the different modern Indian languages points to its relatively recent introduction in cultivation [36]. According to De Candolle [36], it is being cultivated for less than 2000 years (mentioned by Discorides and not by Theophrastus). The frescoes at Pompeii (79 A.D.) indicate its possible antiquity.

6. *Phaseolus calcaratus* Roxb.

English name: rice bean, Japanese rice bean, climbing mountain bean.

Local names: Bengali — *gaimoog*; Hindi — *sutari, meth*; Nepali — *shiltong*.

Piper and Morse [35] stated it as a wild species Hooker [7] and Vavilov [12] are of the opinion that it is found both in wild and under cultivation.

7. *Phaseolus trilobus* Ait.

English name: wild gram, three-lobed kidney bean.

Local names: Sanskrit — *mudgaparnee*; Bengali — *mugani*; Hindi — *rakhal, kuluv*; Marathi — *ranmug*; Tamil — *panipavar, naripavir*; Telugu — *pillapesarethta*.

The presence of a Sanskrit name and several names in the modern Indian languages indicates that it has been cultivated in India for long and is known at least for 3000 years [36]. Its mention in Charak Samhita for its medicinal values indicates that it is known for more than 5000 years.

Thus, a survey of ancient literature indicates that *mungo, aureus, radiatus* and *trilobus* were indeed known and possibly cultivated in ancient India. In contrast, *calcaratus* and *aconitifolius* are possibly of recent introduction in cultivation. The paucity of information on the antiquity of *sublobatus* is perhaps due to improper identifications of the carbonized remains found in various archaeological excavations.

CONCLUSION

It is necessary to be extremely cautious about claiming success or failure in varietal and interspecific crosses as well as karyotype analyses and cytogenetic studies, and the derived interrelationships. It is hoped that the present study will encourage one to identify the experimental species with care and lead him to proper literature for confirmation. It is also hoped that the consolidated information provided here on the geographic distribution of the endemic species will greatly encourage germplasm collection and conservation of the *Phaseolus* group.

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