Domestication process and linguistic differentiation of millets in the Indian subcontinent

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The vernacular names of millets were gathered through field surveys in the Indian subcontinent since 1983. Farmers have an appropriate awareness of the status of millets and their relative weeds in the domestication process. This symbiotic process between millets and farmers was reconstructed by integrating field observations, botanical experiments, archaeological data, and linguistic sources. There were various vernacular names in the Eastern Ghats and Southern Deccan Plateau, where Indian millets were widely cultivated with their relative species today. It is obvious that the several names in the old Indo-Aryan and Dravidian languages are related to the vernacular names of millets. *Brachiaria ramosa* and *Setaria pumila* have been domesticated from the weeds that grew around upland rice fields via a mimic companion weed type that was mainly related to *Panicum sumatrense* and other grain crops. *Brachiaria ramosa* has become an independent crop in pure stands, while *Setaria pumila* grows as a mixed crop with *Panicum sumatrense* and other millets. Consequently, *Brachiaria ramosa* and *Setaria pumila* are so-called "tertiary crops," meaning, they are a double secondary crop for the other millets and upland rice. The order of first occurrence of millets from historical sites generally supports this evolutionary process. This domestication center of millets covered the Eastern Ghats and Southern Deccan Plateau.

Key words: dispersal, domestication, linguistic differentiation, millets, mimic companion weeds

Introduction

The indigenous millets of the Indian subcontinent have been domesticated across their ranges of present-day cultivation for some 3500 years (de Wet et al. 1983a; Fuller 2002; Pokharia 2008). These millets include *Paspalum scrobiculatum* L. (*kodo* millet), *Echinochloa frumentacea* Link (Indian barnyard millet), *Panicum sumatrense* Roth. (little millet), *Brachiaria ramosa* (L.) Stapf. (*korne*), *Setaria pumila* (Poir.) Roem. & Schult. (*korati*; syn. *Setaria glauca* (L.) P. Beauv.), *Digitaria cruciata* (Nees) A. Camus (*raishan*), and *Digitaria sanguinalis* (L.) Scop. (Chandra and Koppar 1990; de Wet et al. 1983a, b, c). The former three species seem to be secondary in origin, through the mimic and/or companion weeds of the rain-fed paddy and then upland rice in Eastern India. The next two species, *Brachiaria ramosa* and *Setaria pumila*, were domesticated as secondary crops that were associated with the other millets via their mimic companion weed types in South India (Kimata et al. 2000; Kimata 2015a, 2015b, Kobayashi 1987, 1989). *Digitaria cruciata* was domesticated in the late nineteenth century by Kashi natives in Meghalaya and is cultivated only in the Kashi Hills (Singh and Arara 1972). Unfortunately, *Digitaria sanguinalis* has disappeared, and its origin is not clear.

In contrast to other millets, which were probably domesticated in humid Eastern India, *Brachiaria ramosa* and *Setaria pumila* have adapted to the dry climate of the semi-arid tropics. *Brachiaria ramosa* was cultivated in the hot, arid red soil region of Southern India, whereas *Setaria pumila* was cultivated in the hot sub-humid ecoregion in red and lateritic soils of Orissa, as well as in the hot semi-arid ecoregion on red loamy soils of Southern India (Sehgal et al. 1992). *Brachiaria ramosa* tolerates drought better than *Setaria pumila*, it

Fig. 1. Field surveys in the Indian subcontinent.

has undergone a specializing adaptation to arid regions, and it has nearly attained the tertiary domesticated phase (Kimata et al. 2000). On the other hand, the local varieties of *Setaria pumila* have adapted to drier fields in Southern India than in Orissa. *Setaria pumila* was normally grown with *Panicum sumatrense*, but it seemed to grow singly when the latter failed to grow in severe droughts, which was observed in our 1987 survey. This possibly suggests that *Setaria pumila* could become an independent crop. *Brachiaria ramosa* is an underutilized millet that is restricted in cultivation today to dry areas in the two border districts of Tumkur and Anantapur in the states of Karnataka and Andhra Pradesh, respectively. *Brachiaria ramosa* is cultivated in pure stands as a sole tertiary crop, while *Setaria pumila* is still cultivated by mixed cropping with *Panicum sumatrense* and other grain crops as a minor domesticated plant. A tertiary crop is a type of double secondary crop of *Panicum sumatrense* and others and a secondary crop of upland rice.

The methodological concept of the "basic agricultural complex," the so-called "from seeds to stomach" idea, was proposed by Nakao (1967) while studying the origin of agriculture. A domesticated plant always is accompanied by a cultural complex, which includes cultivation practices, processing, cookery, religious use, vernacular names, and other aspects (Kimata and Sakamoto 1992). Bellwood and Renfrew (2002) recently proposed and examined their "farming/language dispersal hypothesis" cooperative across the disciplines of archaeology, linguistics, and genetics from a broad comparative perspective. These millets and their relative weeds also have many vernacular names in each locality and language. This report is concerned with the reconstruction of their domestication process, particularly *Brachiaria ramosa* and *Setaria pumila*, from the point of view of their vernacular names with reference to linguistic archaeology, because good linguistic data have not yet been sufficient for the indigenous millets (Fuller 2002; Southworth 2005).

Field surveys and methods

Extensive field surveys were conducted in Karnataka, Andhra Pradesh, and Tamil Nadu in 1985, 1996, 1997, and 2001; Maharashtra in 1987; Orissa in 1987 and 2001; Madhya Pradesh and Bihar in 1989; and Himachal Pradesh and Uttar Pradesh in 1996. Furthermore, the surveys were added in Nepal in 1983 and Pakistan in 1985 and 1989 (edited by Sakamoto 1987, 1989, 1991). The observations that concentrated on *Brachiaria ramosa* and *Setaria pumila* were made in the local fields, particularly in 1996 to 1997 and 2001 (Fig. 1). The vernacular names of cereals and their wild/weed relatives were gathered from local farmers in each locality and language, used to construct a database, and were also extracted from the literature about Indian agriculture. The vernacular names from farmers were given an expression that was written in English by local farmers and regional researchers from agriculture extension stations. Moreover, the vernacular names of food items were collected from the English menu of local restaurants and cookbooks from each state.

Table 1. Vernacular names of *Brachiaria ramosa,* summer annual in India

State	Language	Status	Vernacular names
Orissa	Oriya	Weed with *Pas. scrobiculatum*	gusara pata, chusara mata
		Weed/Domesticated?	ghusara pata, lota, ghada langi
Maharashtra	Marathi	Domesticated	chama pothaval [3]
Andhra Pradesh	Telugu	Weed	akki hullu, votlu kosavu
		Domesticated	andakora, anda korra, *pedda sama* [1], disakalu, edurigaddi
Karnataka	Kannada	Domesticated	kornne, korale, korne, korneki, kornike, bennakki hullu [3]
Tamil Nadu	Tamil	Mimic companion weed with *P. sumatrense*	koothi same, sakkalati same, *same melatti* [5], pil sama, pani varagu
		Domesticated	kam pampul, palapul [3]
Kelara	Malayalam	Domesticated	chama pothaval [3]

Italics cited from 1) Fuller 2002, 2) Kobayashi 1991, 3) Ambasta 1986.

Results

Brachiaria ramosa was cultivated mainly in a few states of South India. This semi-arid area is subject to a savanna climate in Deccan Plateau. *Brachiaria ramosa* and its relatives are summer annuals and have many vernacular names in each locality and language as shown in Table 1. The following tables contain some vernacular names that are cited for the convenience of discussion, but the results of surveys are from the author's own data. This domesticated type has been known by various vernacular names in Maharashtra and South India (cf. Chandra and Koppar 1990; Kawase 1987; Kimata et al. 2000; Kobayashi 1987, 1989). The domesticated type was called similar names: *hama pothaval* in Maharashtra, *chama pothaval* in Kelara, and *kama pampul* and *palapul* in Tamil Nadu. On the other hand, it was called different names in the border area between Andhra Pradesh and Karnataka, mainly *korne, korneki*, and *andakora*, and sometimes *pedda sama* and *disakalu*. The mimic companion weed type was known as *koothi same, sakalati same,* and *pil same* in Tamil Nadu. The weed type was known as *gusara pata* and *chusara mata* in Orissa, and *akki hullu* and *votlu kosavu* in Andhra Pradesh.

Setaria pumila was cultivated at a few hill sites that were mainly in Orissa and South India. This semi-arid area is also subject to a savanna climate in Deccan Plateau. *Setaria pumila* and its relatives are summer annuals and have many vernacular names in each locality and language as shown in Table 2. The domesticated type was known by a great variety of vernacular names in Orissa and in the border area between Andhra Pradesh and Karnataka (cf. Chandra and Koppar 1990; Kawase 1987; Kimata et al. 2000; Kobayashi 1987, 1989). These names were usually shortened to a single word, such as *nehari* in Orissa, *lingudi* in Maharashtra, *korati* in Andhra Pradesh, *korlu* in Tamil Nadu, and *korin* in Karnataka, and the names were sometimes composed of two words, including kuku lange and *kukur lange* in Orissa, *kora samuru* in Andhra Pradesh, and *samuru korra* in Karnataka. The mimic companion weed type was known by many vernacular names, too. Further, these names were usually a single word, such as *nauri* in Bihar, *lingri* in Orissa, *nauri* in Madhya Pradesh, *korale* in Andhra Pradesh, and *erikorra* in Karnataka. They sometimes have adjectives that indicate the associated plants, for example, in Andhra Pradesh, *varagu korali* and *varagu sakkalathi* indicate a companion weed of *kodo* millet, while *samalu korali* and *arasama* indicate a companion weed of little millet. The weed type was often called *navari* in Madhya Pradesh, *ghas* in Orissa, and unique names such as g*hoda langi,* meaning horse tail, in Orissa and *sana korulu*, meaning little foxtail millet.

The vernacular names of other indigenous millets and rice in the Indian subcontinent are shown in Table 3. The domesticated type of *Panicum sumatrense*, a summer annual, was usually called *samai, same, sama,*

Table 2. Vernacular names of *Setaria pumila,* summer annual in India

State	Language	Status	Vernacular names
Bihar	Hindi	Mimic companion weed with *Pas. scrobiculatum*	nauri, navri, nebri, neuri, nevri, nibri, harri, tutuam
Orissa	Oriya	Weed	ghoda langi, kukulange, birailange and gaso (Kondha), ghas; *bilai lange* and *lota* [2]
		Mimic companion weed with *E. coracana, Pas. scrobiculatum, P. sumatrense* and *Oryza sativa*	lingri, ghas lingudi, kukuru lange; *ghas lingri* [2]
		Domesticated type with *Pas. scrobiculatum* and *P. sumatrense*	nehari, kuku lange, kukur lange (Konda Dora), kukuru range; *kukuru lange* [5], kuku lange, lingudi, lengudi, kukukangdi
Madhya Pradesh		Weed	navari, navri, naviri (Variga)
		Mimic companion weed with Pas. scrobiculatum	*harri, nauri, navri, neuri, nibri, tutuam, nebri* and *nevri* [2]
Maharashtra	Marathi	Weed	ghas lingudi
		Domesticated type	lingudi, lengudi
Andhra Pradesh	Telugu	Weed	sana korulu
		Mimic companion weed with *Pas. scrobiculatum* and *P. sumatrense*	korale, kurale, kurule kaddi, korinlu, samuru korali, arasama, varagu korali, varagu sakkalathi
		Domesticated type	korati, korindlu, korinlu, koral, kora samuru, same korulu, samelu, sama, arasama, chinna sama, tela samuru, nerige, nerigalu, *samuru korra* [2]
Tamil Nadu	Tamil	Domesticated type	korlu, korati
Karnataka	Kannada	Mimic companion weed with *E. coracana, Pas. scrobiculatum, P. sumatrense* and *Oryza sativa*	erkorra, korindulu, arasama, nerigalu, neriya
		Domesticated type with *P. sumatrense*	korin, korra, korrulu, samuru korra
Others	Hindi	Domesticated type	*bandhra* [1]

Italics cited from 1) Fuller 2002, 2) Kobayashi 1991.
Austin 2006: *korai* [*kora, korali*] (Bengali, Deccan, Hindi, India and Bangladesh), *bandra* (Hindi, India), *varagu korali* (*varagu*, firewood, *korali*, ear or corn, Tamil)

and similar names in South India, while it was called *vari* and *wari* in Maharashtra, *gurji* and *koeri* in Orissa, and *gondula* in West Bengal. Further, indigenous people called it various names, including *kutki* (Vaiga) and *mejheri* (Gobdi) in Madhya Pradesh; *gundli* (Munda) in Bihar; *ghantia* (Kunda Tading), *gurgi* (Kunda Dora), and *suau* (Paraja) in Orissa; and *batta* (Kotha) in Tamil Nadu. The mimic companion weed type was identified and called *akki marri hullu*, meaning weed-like rice, *kadu same,* meaning weed little millet, and *kosu samalu* only in Karnataka, while the weed type was sometimes called *kadu* and *fodo* in Karnataka, *gabat* in Maharashtra, and *erigola* and *arasama* in Andhra Pradesh.

The domesticated type of *Paspalum scrobiculatum*, a perennial, was mainly called *kodo, kodora*, and similar names, but it had different names such as *harik* in Maharashtra; *arik* in Andhra Pradesh; *arka, alka*, and *varagu* in Karnataka; and *varagu* in Tamil Nadu. The mimic companion weed grew in upland rice fields. It was called *kodo* and *kodaira* in Madhya Pradesh, *kodo war* in Bihar, and *kodoghas* (Paraja) in Orissa. The wild/weed type was called *kotocha* in Maharashtra, *khar sami* and *kodo wani* in Bihar, and *kodo ghas* in Orissa.

The domesticated type of *Echinochloa frumentacea*, a summer annual, was known as *jangora* in Uttar Pradesh; *sawan* and similar names in Madhya Pradesh and Bihar; *sankari wari* in Maharashtra; *jhari, dhatela*, and *gruji suau* (Paraja) in Orissa; *ooda* in Andhra Pradesh; *kudurai vali* in Tamil Nadu; and *wadalu* in Karnataka. The ancestral weed species, *Echinochloa colona* was called *chichivi* in Maharashtra, *dhela* in Orissa, and probably *sain* in Bihar. *Digitaria cruciata* was a summer annual called *raishan* only in Kashi Hills. The domesticated type of *Coix lacryma-jobi* was a perennial called *re-si* in Nagaland (Church 1886), while the other weed species

Table 3. Vernacular names of other indigenous millets and rice in Indian Subcontinent

Country / State / Growth habit	Language	Status	Vernacular names (Indigenous people) *Panicum sumatrense* summer annual	*Paspalum scrobiculatum* perennial	*Echinochloa frumentacea* summer annual	*Digitaria curuciata* summer annual	*Coix lacryma-jobi* perennial	*Oryza sativa* perennial
Pakistan								
NWFP								chawl
Gilgit								
Baltistan								
Punjab					*sarou* [4], *swank* and *sawank* [6]			
Baluchistan					*sawara* [6]			
India								
Jammu & Kashmir		domest			*karin* [4]			
Himachal Pradesh		domest		katai				
Uttar Pradesh	Hindi	domest		koda				dhan
(Uttaranchal)		domest			jhangora, jangora, madira			dhan
Punjab		domest	*kutki* [4]	*kodora* [4]				
Haryana								
Rajasthan								
Gujarat		domest		*menva* [4]				
Madhya Pradesh		weed			chichvi = *E. colona*		gulru = *C. aicantia*	pasahi=*O. rufipogon*
		comp. weed		kodo, *kodaira, kodaila and marendo* [2]	chichvi, *nauri* [2]			
		domest	kutki (Vaiga), mejheri (Gondi, Kaland Vaiga)	kodo	sawan, savan, sawai			dhan, chawal, lehi= upland rice
Maharashtra	Marathi	wild		kotcha				deobath =*O. rufipogon*
		weed	gabat		sankariwari			
		domest	vari, wari, nagri, sama, varag, kodra, warai [2]	kodo, kodora, harik	wari			tandul
Bihar (Jharkhand)	Hindi	wild		khar sami = *Pas. indicum*, *kodo wani; matwani* and *kharasami (Pas. sp.)* [2]	sain		gurya	
		comp. weed		kodo war, *marendo* [2]				
		domest	gundli (Munda)	kodo (Munda)	sawan, swan, sama			chawal, dhan, gora-dhan = upland rice
Orissa (Chattisgarh)	Oriya	weed		kodo-ghas, goddo	dhela = *E. colona*		korankhar = *C. aicantia*, gorigodio	balunga
		comp. weed		*kodoghas* (Paraja), *mandia* and *kodo* [2]				
		domest	gurji, koeri, suan	kodo, koddo, koda	jhari, dhatela			dhan, gadeba dhan = upland rice
	Others	domest	ghantia (Kunda Tading), gurgi (Kunda Dora), suau (Paraja), nalisuan, kusuda, kosula (Others)		gruji suau (Paraja)			
Andhra Pradesh	Telugu	weed	ara sama, erigola					
		domest	same, sama, samuru, *nella shama* [4]	arka, *allu* [4]	ooda, oodalli, *bouth-shama* [4]			paddy, biyyam
Tamil Nadu	Tamil	domest	sawa, sama, samuru, samai, *cha'mai* and *shama* [6], batta (Kotha)	varagu, *waragu* [2], *kodra* and *harik* [2]	kudurai-vali, korali		kassabija [4]	paddy
Karnataka	Kannada	weed	kadu, fodo					
		comp. weed	akkimarrihullu, *akki hullu, kavadadara hullu, kaddu same, kosu samalu* and *verri arasamulu* [2]					
		domest	same, sawan, sami, hejjanve, *pani varagu* and *samulu* [2]	varagu, arka, alka, kodo	wadalu			gouri
Kerala								
West Bengal	Bengali	weed/ domest			*shama* = *E. colona* [4]		garemara = *C. gigantia*	
		domest	*oondula* [4]	*koda* [4]	*sama* and *kheri* [4]		*aururu* and *kunch* [4]	
Megaraya	Khasi	domest				raishan		
Nagaland		domest					*re-si'* [4]	chahau
Others	Hindi	domest	*shavan* [1], *kutki* and *gundli* [4]	*kodu* and *kodhra* [1], *kodaka* [4]	*sa'nwa, sa'muka* and *sawa* [4], *shama, sanwa* and *sawank* [1]		*gurlu, giral* and *garahedua* [1], *kauch-gurgur, saukru'* and *lechusa* [4]	*vrihi* [1]
	Sanskrit	domest		*kora'susha* and *kodrava* [4]				
	NW Province	domest		*kodon* and *marsi* [4]	*sarwak* and *shamak* = *E. colonum* [4]			
	Deccan	domest			*kathli* [4]			
	unknown	domest						
Nepal	Nepalese	weed			sama and ketu (Newar) = *E. orvzicola*			
		domest		kodra				dhan, paddy
Bhutan	Bhutanese							
Bangradesh		domest						
Sri Lanka	Sinhalese	domest	*mene'ri* [4]	*wal-amu* [4]	*wel-manukku* [4]		*ki'kir-rindi'* [4]	

Italics cited from 1) Fuller 2002, 2) Kobayashi 1991, 4) Church 1886, 6) Kawase 1991, ..

that often invaded rice paddy fields was called *gulru* in Madhya Pradesh, *gurya*, meaning small, in Bihar, *korankhar* in Orissa, and *garemara* in West Bengal.

Oryza sativa L., a perennial, was usually called *chawa*l or *dhan*, but the upland rice was called *lehi* in Madhya Pradesh, *gora dhan* in Bihar, *gadeba dhan* in

Table 4. Vernacular names of Asian and African millets in Indian Subcontinent

Country / State / Growth habit	Language	Status	Vernacular names (Indigenous people) *Panicum miliaceum* summer annual	*Setaria italica* summer annual	*Eleusine coracana* summer annual	*Sorghum bicolor* summer aannual	*Pennisetum glaucum* summer annual
Pakistan							
NWFP			*olean* [6]	*ghgh, ghok, gokhton, gokhtan, grashik, grach, oras* and *orass* [6]			bajera, baijera
Gilgit			*olean, chiena, cheena, bau* and *onu* [6]	*gras, cha, cheng* and *cheena* [6]			
Baltistan			*tzetze* [6]	*cha* [6]			
Punjab				*kangani, kangni* and *kongoni* [6]	*mandoh* [6]	*jowar, jowari* [6]	bajra,
Baluchistan							
India							
Jammu & Kashmir	Kashmiri						
Himachal Pradesh			charai	kauni			
Uttar Pradesh	Hindi	weed			*khadua* = hybrid by *E. indica* [2]		
		comp. weed			*jhhadua* = hybrid by Indaf [2]		
		domest	china, sawan	kangani, kangooni	mandua, ragi	jowar, jwar, juara	bajra
(Uttaranchal)		domest	cheena, chin	kauni, kouni, korin, konin	mandua, manduwa, marwa, koda		
Panjab	Panjabi						
Haryana							
Rajasthan							
Gujarat	Gujarati						
Madhya Pradesh		wild/weed					
		domest		kang, kakun	ragi, madia	jowar	bajira
Maharashtra	Marathi	wild/weed			nachuni = *E. indica*		
		domest	wari, tane	rala, rai	nachani, nachuni, nachana, ragi	jowar, jowari, jowary	bajeri, bajri
Bihar (Jharkhand)	Hindi, Bihari	weed			*marwani, malwa* =*E. indica* [2]		
		domest	cheena	kauni	marua, maruwa, *malwa jangali-suau* (Paraja) = *E. indica*	jowar	bajera
Orissa (Chattisgarh)	Orya	wild/weed					
			pani-varagu, cheena	kangu, gangu	ragi, manje-suau (Paraja), mandia (Kondho), pahado-mandia (Kond Dora)	jonna, jhna, jowary, jowar	kayna
		domest					
	Others	domest		kangul (Paraja)			
Andhra Pradesh	Telgu	domest	variga	korra, kora, koralu, navane	ragi, tamada	jonna, jower	bajera, sajja, *gantilu'* [4]
Tamil Nadu	Tamil	domest	pani varagu, *varagu* and *katacuny* [4]	thenai, korra, *thennai* [1], *tinai* [4]	ragi, kapai	jowar, jara, jora, cholam	bajera, cumba, cumbu, *cumbu'* [4], *kambu* [6]
Karnataka	Kannada	weed			*kadu ragi, ragi kaddi,* = *E. indica* [2]; *hullu* = hybrid by Indaf [2]		
		domest	baragu	navane, nawane	ragi, nachina	jowar	bajra
Kerala							
West Bengal	Bengali	domest	*cheena* [5]	*ka'kun* [4]	kodo	jowar, junero	
Others	Hindi	domest	*chin, morha* and *anu* [1], *chena* and *chi'na* [4], *cheena* [5]	*kangni, kangu* and *kakun* [1], *ka'ngni, ta'ngan, kavuni* and *rawla* [4]	*ragi* [4]		*ba'jra, ba'jri* and *lahra* [4]
	Sanskrit	domest	*vrihibheda* [4], *u^nu^* and *vreelib-heda* [5]	*ka'ngu* and *priyangu* [4], *kunau^* and *privunau^* [5]			
	unknown	domest	*sa'wan-jethwa, kuri, phikar, ra'li* and *bausi* [4], *worga* (Telinga) [5]			*joa'r* [4]	
Nepal	Nepalese	domest	china	kauni, kaoni-tangure	kodo	junero-makai	bajra
Bhutan	Bhutanese			kaaun			
Bangradesh							
Sri Lanka	Sinhalese			*tana-ha'l* [4]			

Italics cited from 1) Fuller 2002, 2) Kobayashi 1991, 4) Church 1886, 5) de Candole 1989, 6) Kawase 1991.

Orissa, and probably *gouri* in Karnataka. The wild relative *O. rufipogon* Griff. was used specially for a festival food and called *pasahi* in Madhya Pradesh, *deobath* in Maharashtra and probably *balunga* in Orissa.

The vernacular names of Asian and African millets in the Indian subcontinent are shown for comparison with those of Indian millets in Table 4. These species are all summer annuals. *Panicum miliaceum* L. was widely called *cheena* and similar names, while it was known as *wari* and *tane* in Maharashtra and *varagu* and similar names in Orissa, Andhra Pradesh, Tamil Nadu, and Karnataka. *Setaria italica* (L.) P. Beauv. was

Table 5. Vernacular names of other cereals in the Indian subcontinent

Country / State	Language	Status	Vernacular names (Indigenous people)			
Growth habit			*Triticum aestivum* winter annual	*Hordeum vulgare* winter annual	*Avena sp.* winter annual	*Zea mays* summer annual
Pakistan			ghandam, suji			makai
India						
Jammu & Kashmir						
Himachal Pradesh						makka
Uttar Pradesh	Hindi	domest				makai, makka, maki
(Uttaranchal)		domest	gehun			makka
Punjab						
Haryana						
Rajasthan						
Gujarat						
Madhya Pradesh		wild/weed				
		domest	gahun	jao		makai
Maharashtra	Marathi	wild/weed				
		domest				makka
Bihar (Jharkhand)	Hindi	domest				makai, jenera = teosint
Orissa (Chattisgarh)	Orya	wild/weed				
		domest	ghaun, gahomo			makka
Andhra Pradesh	Telgu	domest				
Tamil Nadu	Tamil	domest	godi, gangil = *T. diccocum*; *godome, kothimai and kothi* [4]	gangi		
Karnataka	Kannada	domest	aja = *T. diccocum*			makai
Kerala						
West Bengal	Bengali	domest				
Megaraya						
Nagaland						
Others	Hindi	domest				
	unknown	domest				
Nepal	Nepalese	domest	gaun, tro	jau, ne, uwa (Sherpa)		makai
Bhutan	Bhutanese					
Bangradesh						
Sri Lanka	Sinhalese					

also widely called *kangani, kauni*, and similar names in Sanskrit, while it was called *rala* and *rai* in Maharashtra, *korra* and *navane* in Andhra Pradesh, *korra* and *thenai* in Tamil Nadu, and *navane* in Karnataka. *Eleusine coracana* Gaertn. was usually called *ragi* in Madhya Pradesh, Orissa, and South India, while it was called *mandua, marwa*, and similar names in Uttar Pradesh and Bihar, *natuni* and similar names in Maharashtra and Karnataka, *tamada* in Andhra Pradesh, *kapai* in Tamil Nadu, and *kodo* and similar names in Uttar Pradesh, West Bengal, and Nepal. Further, indigenous people called it various names, such as *manje suau* (Paraja), *mandia* (Kondho), and *pahado mandia* (Kond Dora) in Orissa. *Sorghum bicolor* Moench was generally called *jowar* and similar names, but it was called *cholam* in Tamil Nadu, *junero* in West Bengal, and *junero makai* in Nepal. *Pennisetum glaucum* (L.) R. Br. was also generally called *bajra* and similar names, but it was sometimes called *kayna* in Orissa, *sajja* in Andhra Pradesh, and *cumba* and similar names in Tamil Nadu.

The vernacular names of the other cereals are shown in Table 5. *Triticum aestivum* L. was called *gehun, godi*, and similar names. *Triticum dicoccum* Schübler, Char. et Descr. was *gangil* in Tamil Nadu and *aja* in Karnataka. *Hordeum vulgare* L. was called jao and similar names. Those two species are winter annuals. *Avena sativa* L. was not cultivated in South India. *Zea mays* L., a summer annual, was widely called *makai* and similar names, while the relative teosinte was introduced for fodder and was called *jenera* in Bihar.

The vernacular names of Indian cookery-used cereals are shown in Table 6. The various millets were cultivated and used for a lot of cookery, particularly in South India. Each cookery had slight differences in the vernacular name. However, there were a few exceptions of cookery-used millets and rice. For example, the boiled grain was widely called *chawal* or *bhat*, but it was also known as *annam* in Andhra Pradesh, *sadam* and *soru* in Tamil Nadu, and *anna* in Karnataka. Further, the thick porridge was called *onda* in Orisa, *samkati* in Andhra Pradesh, *kali* in Tamil Nadu, *mude* and similar names in Karnataka, and *dhido* and *senne* (Sherpa) in Nepal. The thin porridge was called *bari* in Uttar Pradesh, *peja* in Madhya Pradesh, *ambil* in Maharashtra, *jau* in Orissa, *ganji* in Andhra Pradesh and Karnataka, and *kulu* in Tamil Nadu. *Mave* was a raw flour food that was offered to gods and made only from foxtail millet and rice in Tamil Nadu.

Table 6. Vernacular names of Indian foods made from cereals

Country	Grain			Meal grain	Flour/baked breads			/fermented		/fried				/fermented	/roasted	/steamed	/fermented	/boiled			Raw flour	Alcoholic drink
State	/boiled																					
	chawal	pulao	biriyani	upma	chapati	roti	paratha	nan	puri	samosa	vada	murukku	dosa	tsuamma	idli	idli	mude	samkati	bari	sweet	mavu	
Pakistan																						
NWFP	*dhara* [6]					*shanik* [6]																
Gilgit	*chawal*, *gharaji* and *zibek* [6]					*tathuji* and *roti* [6]																
Baltistan						*chakhor* [6]																
Punjab	chawli, *bar* [6]				chapati	roti		nan	puri	samosa							+			*kheer* [6]		
Baluchistan																						
India																						
Jammu & Kashmir	chawl				chapati	roti																
Himachal Pradesh	chawal bhat				chapati	roti																
Uttar Pradesh								nan						bukkuna,								
(Uttaranchal)	bhat				chapati	roti			puri					bukani					bari	kheer, kheel, tasmai		
Punjab																						
Haryana	chawal bhat																					
Rajasthan																						
Gujarat																						
Madhya Pradesh	bhat					roti										idli			pej, pej	kheer		
Maharashtra	bhat, tandul	pilav, pao	briyani		chapati	bhakar, roti		nan			wada								ambil, ambli			handia,
Bihar (Jharkhand)	bhat			dara		roti			puri											kheer		
Orissa (Chattisgarh)	bhat	pulao	briyani	upma	chapati	chakuli, roti			poori		vada	murukki	dosa			idly	onda		pej, jau			
Andhra Pradesh	annamu			uppuma, uppittu	chapathi	roti			poori		vada	murukku	dosai			idly, idry	samkati, ambali		ganji	kheer		
Tamilnadu	sadam, soru		briyani	uppuma	chapathy	roti	parota		poori		vadai	murukku	dasai			idli, idly	kali		kulu		mavu	
Karnataka	anna	pulau	briyani	uppittu	chapati	roti	paratha	nan	puri, burugu	samosa	vada		dosa, dosai			idri	mude, mudde, muddi		ganji	kheer		
Kerala																	mudii					
Nepal	bhaat, bhat					roti								tsuampa			dhido, senne (Sherpa)				chan, chann, tompha, roxi	
Bhutan																						
Bangradesh																						
SriLanka	batt																					

Italics cited from 6) Kawase (1991).

Discussion

The wild types, which were ancestral species of Indian millets, grew in wet places or habitats such as around pond peripheries and river sides. They also invaded rice paddy fields. In Pakistan, Nepal and India, many grass species, Poaceae, grow in paddy fields and on levees. Eventually, these weeds grew together in rice paddy and/or upland fields as a sympatric habitat and then became companion weeds. Some companion weeds mimicked the morphological and ecological traits of rice and became mimic companion weeds. The relationship between these plants and farmers gradually changed from subconscious and antagonistic to friendly. Farmers began to use them for fodder and insurance crops under a semi-domesticated status through the symbiotic situation. Finally, these plants were independently cultivated for food grains under a domesticated status. Therefore, this evolutionary process established a symbiotic relationship among plants and farmers (Kimata 2015a, 2015b). There are two types of mimicry in this process. One type is inter-specific to different species under the status of companion weed type, while the other is intra-specific

Table 7. Summary on linguistic archaeological names of millets and other cereals

Species name	English name	Old Indo-Aryan	Dravidian	Others
Brachiaria ramosa	brown top millet	?	see Table 1	
Setaria verticillata	bristly foxtail	?	?	
Setaria pumila	yellow foxtail	?	see Table 2	
Panicum sumatrense	little millet	?	see Table 3	
Paspalum scrobiculatum	kodo millet	*kodrava*	**ar-V-k-*, **var-ak-*	**var-ak-* (Tamil, Malayalam, Kannada), **ar-Vk-* (Kannada, Telugu)
Echinochloa frumentacea	Sawa millet	*syamaka*	see Table 3	
Digitaria cruciata	Khasi millet	nil	nil	see Table 3
Coix lacryma-jobi	Job's tear	nil	?	
Oryza sativa	rice	*vrihi*	**var-inc*	see Table 3
Oryza rufipogon	wild rice	*nivara*	*navarai/nivari*	see Table 3
Panicum miliaceum	common millet	*cina(ka)*	**var-ak-*	**ə-ria* (Proto-Munda), **var-ak-* (Telugu)
Setaria italica	foxtail millet	*kanku(ni), *kangu(ni), tanauni. (rahala)*	**kot-*, **tinai, *tin-ay, *nuv-an-av*	**kam-pu* (Tamil, Malayalam), **ar-Vk-* (Kannada, Gondi/Gorum, Kuwi),
Eleusine coracana	finger millet	*madaka*	**arak/*arak-*	*derav* (Kherwarian Munda),
Sorghum bicolor	sorghum	*yavanala, yavakara*	**conn-al*	**caŋa(-)ɔav* (Proto-Munda)
Pennisetum glaucum	pearl millet	**bajjara*	**kampu*	**kam-pu* (Kannada, Telugu)
Triticum aestivum	wheat	*godhuma*	**kul-i*	*godi* (Kannada),
Hordeum vulgare	barley	*yava*	**koc-/*kac-*	*kaj* (Kota/Konkani), *koj* (Toda), *gajja* (Prakrit)
Avena sativa	oat	?	?	see Table 5
Zea mays	maize	nil	nil	see Table 5

Modified and based on F.C. Southworth (2005)
Reconstructed forms are conventionally preceded by astarisks to denote non-attestation (Southworth 2005)

to the same species as a result of hybridization between the domesticated type and the closely related weed type.

The domestication process is supported by the linguistic recognition of various types by farmers, such as the weed, companion weed, mimic companion weed, semi-domesticated, and domesticated types of *Brachiaria ramosa* and *Setaria pumila*, in their vernacular names (Tables 1 and 2). The linguistic differentiation shows a close relationship to the domestication process, for instance, in Jalaripalli Village, Andhra Pradesh, where *Setaria pumila* that is mixed with little millet is called *kora samuru*, meaning foxtail millet-like little millet, and *tela samuru*, meaning the grains mixed with little millet, which is sold at a local market. This linguistic recognition suggests clearly the agro-ecological status of *Setaria pumila* as a secondary origin (Kimata et al. 2000).

The vernacular names of *Panicum sumatrense* and *Paspalum scrobiculatum* distinguish three types in their domestication process. The names of the mimic companion weed type are called, for example, *akki hullu* (little millet), meaning a rice-like weed, and *kodoghas*, meaning a kodo millet-like weed in upland rice fields (Kobayashi 1991). The linguistic differentiation indicates that both species were also a secondary crop via a mimic companion weed in upland rice fields. This thoroughly conforms to the observations that were made in the fields. The vernacular name of *Echinochloa frumentacea* is clearly distinguished from that of *Echinochloa colona*, which is one of the ancestral species (Yabuno 1962). For instance, the former is called *jhari* and the latter is *dhela* in Orissa (Table 3). Sometimes, the same names were used by farmers to name *Panicum sumatrense* and *Echinochloa frumentacea*, *same* and *sawan*, but the names were not used in the same place and time. In the same way, the vernacular name of *Eleusine coracana* is distinguished from a relative weed, *Eleusine indica,* and the hybrids. However, the weeds associated with other millets and cereals have no names (Tables 4 and 5). Interestingly, *Panicum miliaceum* and *Setaria italica* have various names in North-West Frontier Province and Gilgit, Pakistan (Kawase 1991). The vernacular names of Indian cookery-used millets are unique, particularly in South India, because rice (eastward) and wheat (westward) are staple foods today in the other states (Table 6) (Kimata 1991).

The linguistic archaeological names of millets and other cereals are summarized in Table 7. The old Indo-Aryan names for *Brachiaria ramosa*, *Setaria verticillata, Setaria pumila*, and *Panicum sumatrense* are not found

Table 8. Summary on the first occurrence of grain crops in South Asian

Species / Period	Early 4500 B.C.-	Mature -2600 B.C.	Late -2000 B.C.	(South India) 2300-1800 B.C.	(South India) 1800-1200 B.C.	-0 A.D.	1500 A.D.	1900 A.D.
Paspalum scrobiculatum					trace			
Panicum sumatrense				trace	a few			
Echinochloa cf. colona					many			
Brachiaria ramosa			wild?	many	many			
Setaria verticillata			wild?	many	many			
Setaria pumila			wild?	trace	trace			
Setaria sp.			a great many					
Digitaria cruciata								domesticated
Digitaria sanguinalis							(unknown, disapeared)	
Panicum miliaceum		a few						
Panicum sp.			a few					
Setaria italica			possible					
Eleusine coracana			?	possible				
Sorghum bicolor			many					
Pennisetum glaucum			trace	trace	trace			
Coix lacryma-jobi						possible		
Oriza sativa		many		trace	trace			
Hordeum vulgare	a great many			many	many			
Triticum dicoccum				trace	trace			
Triticum durum/aestivum				many	trace			
Triticum sp.	a great many			many	many			
Avena sativa	a few							
Zea mays								introduced

Modified and Based on Fuller et al 2001, Fuller and Madella 2001, and Fuller (personal communication).

in the ancient literature (cf. Southworth 2005). This might indicate that these millets were domesticated in India relatively recently. In contrast, because *Paspalum scrobiculatum* is named *kodorava*, this word is considered to be the origin of *kodo* and *kodora*. The word *syamaka* for *Echinochloa frumentacea* is considered a derivation of *shama* and *sama*. The word *cina(ka)* of *Panicum miliaceum* is also considered to be the origin of *cheena*, and the words *kanku(ni)* and *rahala* for *Setaria italica* are the origin of *kangani,* which was widely used, and *rala*, which was used in Maharashtra. The word *madaka* for *Eleusine coracana* is considered to be the origin of *mandua* in Uttar Pradesh and the word **bajjara* is the origin of *bajra* (*, reconstructed forms by Southworth 2005). The Dravidian name **var-ak-* for *Paspalum scrobiculatum* and *Panicum miliaceum* is considered to be the origin of *varagu*, and the names **tinai* and **nuv-an-ay* for *Setaria italica* are the origin of *thenai* in Tamil Nadu and *navane* in Andhra Pradesh and Karnataka. Because these species have old Indo-Aryan or Dravidian names, they might have been introduced from the Western areas or domesticated within India a relatively long time ago, according to the archaeological evidence (Weber 1992).

The first occurrence of grain crops in South Asia is summarized in Table 8, which is based on Fuller et al. (2001) but modified with additional information (Fuller and Madella 2001; Fuller, personal communication). *H. vulgare, Triticum* species (great many), and *Avena sativa* (a few) were identified in the Early Phase (around 4500 B.C.) of Harappan sites. *O. sativa* (many) and *Panicum miliaceum* (a few) were identified in the Mature Phase (around 2600 B.C.). Then, *Setaria* species (great many), *Sorghum bicolor* (many), and *Pennisetum glaucum* (syn. *americanum*, trace) were found in the Late Phase (around 2000 B.C.). The following species were found in early South Indian sites (2300 to 1800 B.C.): *Panicum sumatrense* (trace), *Brachiaria ramosa* (many), *Setaria verticillata* (many), and *Setaria pumila* (trace). Then, traces of *Paspalum scrobiculatum* and many *Echinochloa* cf *colona* (possibly *Echinochloa frumentacea*) were identified in the late sites (1800 to 1200 B.C.). Asian millets occurred historically in the following order: *Panicum miliaceum; Setaria* species; then *Brachiaria ramosa*, *Setaria verticillata, Panicum sumatrense*, and *Setaria pumila*; and *Echinochloa* cf *colona* and *Paspalum scrobiculatum*. However, *Brachiaria ramosa*, *Setaria verticillata, Setaria pumila,* and *Echinochloa* cf *colona* might have been gathered as a wild grain.

The naming scheme of millets and their relative weeds is summarized in Table 9. Farmers have four

Table 9. Naming scheme of millets and weeds by farmers in India

Stage	Awareness	Typical cases (species name) [meaning]
I	Unknown	no name: ghas, hullu [weed]
II	Non distinctive	the same name of crop as weed: ragi, malwa (*Eleusine coracana*)/ragi, malwa (a weed, *E. indica*) kodo (*Paspalum scrobiculatum*) /kodo (the weed) kukuru lange (*Setaria pumila*)/kukury lange (the mimic weed)[dog's tail]
III	Identified	
1.	a specific word	(most crop has several specific names called by each language group) madua (*E. coracana*)/khadua (*E. indica*) grujisuau (*Echinochloa frumentacea*)/dhera (a weed, *E. colona*) merendo, kodowar (a mimic weed, *P. scrobiculatum*)/matwali, kharasami (a weed, *Paspalum sp.*)
2.	added a few adjective words	
2.1	meaning "weed"	lingudi (*Setaria pumila*)/ghas lingudi (the weed) kodo/kodo ghas,
2.2	like "another crop"	same melatti (a mimic weed, *B. ramosa*) [like little millet] akkihullu (a mimic weed, *P. sumatrense*) [weed like rice]
2.3	indicating a morphological trait	ragikaddi (a weed, *E. indica*) [finger millet with spike like a stick] bilai lange (a weed, *S. pumila*) [cat's tail]
2.4	indicating an ecological trait	samulu (*Panicum sumatrense*)/yerri arasamulu (the weed with grain shattering) same (*P. sumatrense*)/samuru korra (*S. pumila*) [foxtail millet growing in little millet field] varagu sakkalathi (*S. pumila*) [a mimic weed, second wife of kodo millet] sakkalathi same (a mimic weed, *B. ramosa*) [second wife of little millet]
2.5	indicating a utility	same (*P. sumatrense*)/ pilsame (*Brachiaria ramosa*) [for fodder],
IV	Classified into some landraces	marua (*E. coracana*): three varieties; agat- [early], madhyam- [medium] and pichhat- [late] /maruani (*E. indica*). sama (*P. sumatrense*): four varieties; manchi- [summer], pala- [short], ara- [tall] and varagu- [sowing in January].

stages of awareness of the symbiotic process between them and plants. They are unknown (stage I), non-distinctive (II), identified (III), and classified into some local varieties (IV). In stage I, the farmers have no name for wild/weed plants and call them ghas and *hullu*. In stage II, the farmers use the same name for the crop (*ragi*) and weed (*ragi*). In stage III, the farmers identified and called millets a specific name, for instance, *madua* for *Eleusine coracana* (domesticated) and *khadua* for *Eleusine indica* (weed). Furthermore, farmers added a few adjective words to the root of the millet name, for example, to mean "weed" (*ghas lingudi*, meaning weed of *Setaria pumila*) and "like another crop" (*same melatti*, meaning mimic weed like little millet), and to indicate a morphological (*bilai lange*, meaning cat's tail) or ecological trait (*yerri arasamulu*, meaning weed with grain shattering) and a utility (*pil sama*, meaning *Brachiaria ramosa* for fodder). In stage IV, farmers classified the millets into some local varieties, for example, *Eleusine coracana* was known as *marua* and was classified into the varieties *agat-* (early), *madhyam-* (medium), and *pichhat-* (late); and a weed, *Eleusine indica*, was known as *maruani*. As a consequence of this survey, farmers appear to have an appropriate awareness of the status of millets and their relatives, even though they sometimes use the same names for millets in different places.

In conclusion, the domestication process of millets based on field observations (Kimata et al. 2000), experimental results (Kimata 2015a, 2015b), and these linguistic sources is illustrated in Fig. 2. This domestication center of millets covered the Eastern Ghats and Southern Deccan Plateau. Although this process is quite complicated among millets and their relatives, it is very effective for understanding the domestication by a secondary origin via weed and mimic companion weed types. Oats and rye were the secondary crops of wheat that developed cold tolerance (Vavilov 1926), while Indian millets were secondary crops of upland rice that developed drought tolerance. *Bachiaria ramosa* tolerates drought better than *Setaria pumila*, and it became an independent crop. *Setaria pumila* is almost always grown with little millet, but it seems to grow singly when little millet fails to grow

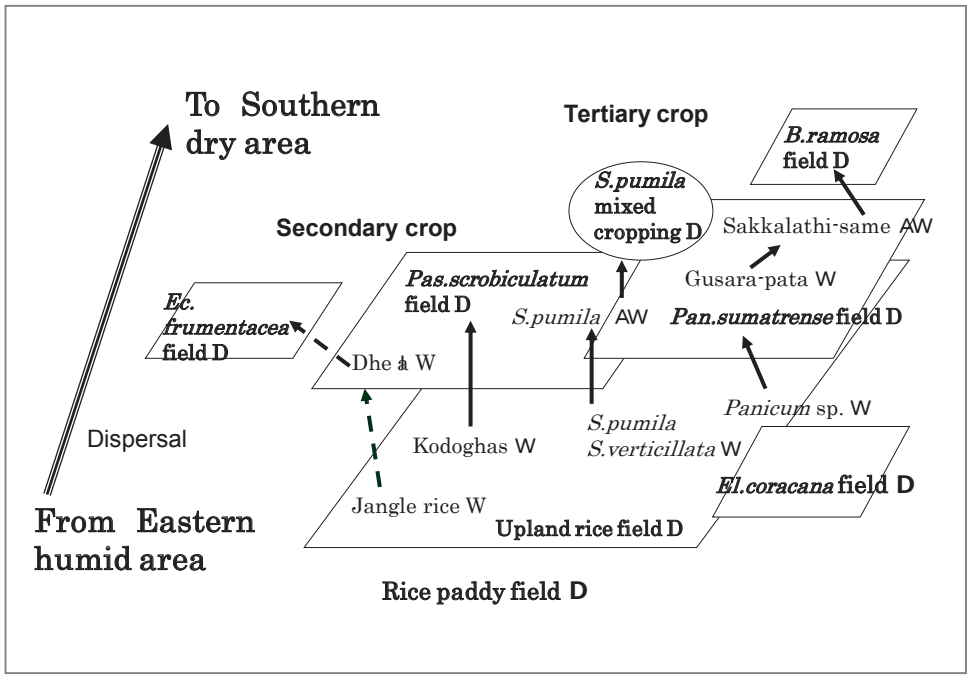

Fig. 2. Domestication process of millets in the Indian subcontinent

in severe droughts. Both species are so-called tertiary crops, meaning, they are a double secondary crop for the other millets and upland rice. The millet domestication process indicates the importance of weed–crop complexes and basic agricultural complexes as a plant–man symbiosis.

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