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ADVERTISING THE SIGNIFICANCE OF DIVERSE PLANT TAXA TO *APIS MELLIFERA* FORAGERS DURING THE DEARTH PERIOD IN NORTH HARYANA

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ABSTRACT

Intensive surveys conducted in 0-3 km radius of the experimental apiary during the dearth periods (June-October) in 2017 and 2018 unraveled 71 plant species belonging to 31 families as crucial flora for *Apis mellifera* L. foragers at Kaul, Kaithal, Haryana. Bee flora comprised of 23 weeds (32.4%), 16 ornamentals (22.5%), 12 plantation crops/trees (16.9%), 7 vegetable crops (9.9%), 5 fruit crops (7.1%), 3 forage crops (4.2%), 2 each oilseed and cereal crops (2.8% each) and 1 leguminous pulse crop (1.4%). Among the families, Fabaceae consisted of maximum floral resources (10, 14.1%) followed by Asteraceae (7, 9.9%) and Cucurbitaceae (5, 7.0%). Bee floral calendar was also prepared along with the description of reward potential to *A. mellifera* foragers in terms of pollen and nectar.

Key words: *Apis mellifera*, dearth period, apiary, plant taxa, bee flora, weeds, foragers, nectar, pollen, Haryana

World over, almost every place has a specific period when there is dearth or scarcity of bee flora for *A. mellifera*, characterized by lower availability of floral resources i.e., pollen and nectar (Prakash et al., 2007). Many studies have confirmed a long summer nectar-pollen dearth period (May to November) in North India (Sihag, 1990; Chaudhary, 2003a, 2003b, 2004; Bodla et al., 2009; Sihag, 2017). Shorter dearth periods from May-August have been reported from Punjab (Dalio, 2015), Maharashtra (Waykar and Baviskar, 2015) and Karnataka (Hosamani et al., 2018). Bees are therefore confronted with disparities in time and space of floral resource abundance, type and diversity, which might provide inadequate nutrition ultimately endangering survival of the colonies. Diversity of bee flora and bee floral calendars have been reported for North-eastern Haryana (Chaudhary, 2001a, 2001b, 2003b; Kaur et al., 2016); Chandigarh (Kumar et al., 2015, 2016), but present study is the first of its kind from Haryana to unravel dearth specific bee flora. Therefore, intensive surveys were conducted regularly in the vicinity of the experimental apiary to explore the diversity, temporal and spatial availability of nectariferous and polleniferous bee flora ensuring survival of bees during lean periods and developing the bee floral calendar to be utilized by beekeepers.

MATERIALS AND METHODS

The present study was carried out at the apiary located at College of Agriculture, Kaul, Kaithal, a sub-campus of Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India [237 m above mean sea level (amsl) at 29°51'46'' N and 76°39'39'' E] during dearth periods i.e., June to October 2017 and 2018. Thirty *A. mellifera* colonies (10 frame strength) were placed regularly under shady area during the course of experimentation and the apiary was provisioned with fresh water source. The hives were also fed with freshly prepared 50:50 carbohydrate solutions in half-frame feeders @ 500 and 750 g/ hive and pollen supplement @ 80 and 100g/ hive at weekly intervals during the course of investigation in 2017 and 2018, respectively. Floral nectar and pollen resources during the dearth period were recorded for temporal and spatial variations. For this, weekly surveys were carried out by roaming in 0-3 km radius of the apiary to unravel the diversity, abundance and utility of bee floral plants being visited by *A. mellifera* foragers during June-October 2017 and 2018. The foragers were observed keenly on flowers to ascertain the nectar or/and pollen gathering activities. The foragers visiting the flowers were held sideways by the anterior region of abdomen between the thumb and forefinger and the anterior abdominal part was slightly pressed. Alternatively, upon testing, if the liquid drop felt sweet, then the forager was considered as collecting nectar from the plant otherwise not. *A. mellifera* foragers inserting their proboscis into the floral nectaries during foraging were designated as nectar gatherers. The foragers hovering over and maneuvering the floral parts of blooming flora

were observed keenly for pollen collection as pollen plants/pellets in their corbiculae and adjudged as pollen gatherers (Yadav and Kaushik, 2012). The diversity and abundance of the bee flora was mapped and recorded focusing on the preparation of the bee floral calendar for the dearth period.

RESULTS AND DISCUSSION

The diverse bee floral plants as observed during dearth periods (2017 and 2018) are tabulated based on their family distribution, diversity/plant type, utility (nectar or/and pollen rewards) to the bees, intensity of visitation and bee floral calendar (Table 1 to 5). The inventory of reward giving bee floral resources prepared by conducting intensive surveys in 0-3 km radius of the experimental apiary at weekly intervals from June-October 2017 and 2018 unraveled a total of 71 different species of plants belonging to 31 families as potential bee flora. Among the families, Fabaceae consisted of maximum floral resources (10, 14.1%) followed by Asteraceae (7, 9.9%) and Cucurbitaceae (5, 7.0%) (Table 1). Likewise, Al-Ghamdi (2020) recorded 204 plant species belonging to 58 families as honey bee plants from Saudi Arabia, of which 13.0% belonged to family Asteraceae.

Based on diversity/plant type, *A. mellifera* bees foraged upon 23 weeds (32.4%), 16 ornamentals (22.5%), 12 plantation crops/trees (16.9%), 7 vegetable crops (9.9%), 5 fruit crops (7.1%), 3 forage crops (4.2%), 2 each oilseed and cereals (2.8% each) and 1 leguminous pulse crop (1.4%) (Table 1 and 4). From North-eastern Haryana, 123 plant species were recorded as suitable bee pasturage which included 30 ornamentals, 24 weeds, 19 vegetables, 19 trees, 11 fruit trees, 9 pulses, 6 oilseeds, 3 cereals, and 2 forage plants (Chaudhary, 2001a, 2001b, 2003a, 2003b). Moreover, bee floral plants were classified as sources of N, P, and both NP, as observed on respective bee floral plants during surveys conducted in dearth periods (Table 2 and 4). Of the 71 plant species recorded, 16 plants (22.5%) provided only nectar, 11 plants (15.5%) provided only pollen, and 44 plants (62.0%) rewarded the honey bees both with nectar and pollen. Severity of dearth was so high that only two, one, and five plant types served as high N, high P and high NP sources, respectively. The *A. mellifera* foragers were observed foraging most frequently *i.e*., during each visit on 17 plant species in their respective blooming periods. While, on 14 plant types visitation by the foragers was quite frequent compared to less frequent visits on rest of the 40 plants. Of the 17 species that were most frequently visited by bees, 13 served as important pollen sources during dearth (Table 3). In line with the findings, Al-Ghamdi (2020) summarized that out of 204 species of bee flora, 89 rewarded the bees with both nectar and pollen, 60 served as source of nectar while 55 provided only pollen to the bees.

The reward giving bee floral plants were regularly (June to October) observed and their flowering time and peak foraging activity by *A. mellifera* were recorded and the same are identified (Table 4) presented in the form of bee floral calendar depicting their bloom period and peak activity of foragers (Table 5). Among the ornamentals, *Lagerstroemia speciosa* (L.) (N1P1), *Cascabela thevetia* (L.) Lippold (N1), *Jatropha integerrima* Jacquin (N1P1) and *Jatropha gossypiifolia* L. (N2P2) were the important flora on which peak activity of bees was recorded during July-September, June-August, June-August and September, respectively. *Trifolium alexandrinum* L. (N1P1) and *Zea mays* L.(P3) were the major forage crops both frequently visited during June.

Out of huge diversity of weed flora, *Abutilon indicum* (Link) Sweet (N1P1), *Trianthema portulacastrum* L. (N1P1), *Commelina benghalensis* L. (N3P2), *Cleome viscosa* L. (N3P2) *Tridax procumbens* L. (N2P2), *Parthenium hysterophorus* L. (N2P2), *Tribulus terristris* L. (N2P1), *Cannabis sativa* L. (N2P2), *Chenopodium* sp. (P2), *Dicliptera paniculata* (Forssk.) I. Darbysh. (P2) and *Taraxacum officinale* (L.) Webber (N2P2) were the key bee floral resources on which bees were busy foraging during September-October, July, August, August, August-September, August, July, August, July, June, October and June, respectively. Minor sources, especially weeds, are known to ensure the survival of honeybees during severe dearth periods, no doubt, provide fewer flowers than crops, but more densely, constantly, spatially and temporally (Tscharntke et al., 2005; Geiger et al., 2010). During periods of high floral scarcity (May-June) *A. mellifera* has been reported to forage on *C. sativa*, *Cyprus rotundus* L. and *P. hysterophorus* (Dalio, 2012, 2013; Kumari and Kumar, 2017; O'Brien and Arathi, 2019). Availability of vegetables in campus and village area around the apiary proved a boon to the foragers during June-July with number of vegetables namely *Lagenaria siceraria* (Molina) Standl. (N2P2), *Luffa aegyptiaca* Mill. (N2P2), *Cucrbita pepo* L. (N2P2) and *Cucumis sativus* L. (N3P3). Among the plantation crops and trees, *Albizia lebbeck* (L.) Benth. and *Delonix regia* (Roj.)

Table 1. Family distribution of different bee floral plants available during dearth period (2017 and 2018)

Family distribution of different bee floral plants available during dearth period									
Family	Plant type								
	Ornamentals	Weeds	Oilseeds	Vegetables and legumes	Fruit crops	Plantation crops/ trees	Forage crops	Cereals and millets	Total
Acanthaceae	1	1							2
Aizoaceae		1							1
Amarathaceae		2							2
Amaryllidaceae		1							1
Apocynaceae	2					2			4
Asteraceae	2	5							7
Bignoniaceae	1								1
Cannabaceae		1							1
Caricaceae					1				1
Cleomaceae		1							1
Combretaceae						1			1
Commelinaceae	1	1							2
Convovulaceae		1							1
Cucurbitaceae		1		4					5
Cyperaceae		1							1
Euphorbiaceae	2		2						4
Fabaceae		2		1		6	1		10
Lamiaceae	2								2
Lythraceae	1				1				2
Malvaceae	1	2		1					4
Mimosoideae						1			1
Myrtaceae					2	1			3
Nyctaginaceae	1								1
Paparveraceae		1							1
Poaceae							2	2	4
Portulacaceae	1								1
Rhamnaceae					1				1
Rosaceae	1								1
Solanaceae				2					2
Verbenceae		1				1			2
Zygophyllaceae		1							1
Total	16	23	2	8	5	12	3	2	71

Table 2. Categorization of bee flora on utility basis to *A. mellifera* foragers (2017 and 2018)

Reward type	Category	Symbol	No. of plants (x)	Total flora (%) [(x/71) *100]
Nectar (N)	High	N1	2	2.8
	Medium	N2	1	1.4
	Low	N3	13	18.3
		Total	16	22.5
Pollen (P)	High	P1	1	1.4
	Medium	P2	5	7.0
	Low	P3	5	7.0
		Total	11	15.5
Both nectar and pollen (NP)	High	N1P1	5	7.0
	Medium	N2P2	15	21.1
	Low	N3P3	16	22.5
	Variable	N2P1	1	1.4
		N2P3	2	2.8
		N1P3	1	1.4
		N3P2	4	5.6
		Total	44	62.0
		Grand Total	71	100.0

Table 3. Bee floral categorization based on intensity of visitation by the *A. mellifera* foragers (2017 and 2018)

Plant types	Number of species of various plant types based on intensity of visit during flowering period		
	Forager bees observed most frequently i.e., during each visit in blooming period **(+++)**	Forager bees observed frequently in blooming period **(++)**	Forager bees observed less frequently in blooming period **(+)**
Ornamentals (16)	3	1	12
Forage crops (3)	1	1	1
Weeds (23)	8	5	10
Oilseeds (2)	0	2	0
Vegetables (7)	1	1	5
Legumes (1)	0	1	0
Fruit crops (5)	1	1	3
Plantation crops/Trees (12)	2	1	9
Cereals and millets (2)	1	1	0
Total (71)	17	14	40

Table 4. Bee floral diversity in the vicinity of apiary situated at College of Agriculture, Kaul, Kaithal, Haryana (2017 and 2018)

Plant type	English name	Scientific name	Utility to honey bees
Ornamentals	Purple heart	*Tradescantia pallida* (Rose) D.R. Hunt	N3P3
	Desert petunia	*Ruellia simplex* C. Wright	N3
	Pride of India/Crepe-myrtle	*Lagerstroemia speciosa* (L.)	N1P1
	Chrysanthemum	*Chrysanthemum indicum* L.	N3P3
	Rose	*Rosa indica* L.	N3P3
	Marigold	*Tegetes erecta* L.	N3P3
	Coleus	*Plectranthus scutellarioides* (L.) R.Br.	N3P3
	Rose moss	*Portulaca grandiflora* Hooker	N3
	Horseshoe vitex	*Vitex negundo* L.	N3P3
	China rose	*Hibiscus rosa-sinensis* L.	N3P3
	Yellow oleander	*Cascabela thevatia* (L.) Lippold	N1
	Pink oleander	*Nerium oleander* L.	N3
	Bougainvillea	*Bougainvellia glabra* Choisy	N3
	Spicy jatropha	*Jatropha integerrima* Jacquin	N1P1
	Red trumpet wine	*Campsis radicans* Seemann	N3P3
	Bellyache bush	*Jatropha gossypiifolia L.*	N2P2
Forage crops	Egyptian clover	*Trifolium alexandrinum* L.	N1P1
	Maize	*Zea mays* L.	P2
	Sorghum	*Sorghum bicolor* (L.)	P3
Weeds	Dandelion	*Taraxacum officinale* (L.) Webber	N2P2
	Lucerne	*Medicago sativa* L.	N2P2
	Indian mallow	*Abutilon indicum* (Link) Sweet	N1P1
	Billy goat weed	*Ageratum conyzoides* L.	N2P2
	Congress grass	*Parthenium hysterophorus* L.	P2
	Wild radish	*Blumea obliqua* (L.) Druce	N2P2
	Sessile joy weed	*Alternanthra sessilis* (L.) R. Br.	N2P2
	Tick weed	*Cleome viscosa* L.	N3P2
	Yellow rain lily	*Zephyranthes citrina* Baker	N2P2
	Wild sage	*Lantana camara* L.	N3P3
	Asiatic day flower	*Commelina benghalensis* L.	N3P2
	Desert horse purslane	*Trianthema portulacastrum* L.	N1P1
	Wireweed	*Sida acuta* Burm.f.	N3P2
	Tridax daisy	*Tridax procumbens* L.	N2P2
	Puncture wine	*Tribulus terristris* L.	N2P1
	Marijuana	*Cannabis sativa* L.	N2P2
	Field bindweed	*Convolvulus arvensis* L.	N3P3
	Lambs' quarters	*Chenopodium* sp.	P2
	Indian fumitory	*Fumaria parviflora* Lam.	P3
	Panicledfoldwing	*Dicliptera paniculata* (Forssk.) I. Darbysh.	P2
	Coffee sena	*Senna occidentalis* (L.) Silk	N3P3
	Ivy gourd	*Coccinia grandis* (L.) Voigt	N2
	Purple nutsedge	*Cyprus rotundus* L.	P3
Oilseeds	Jatropha	*Jatropha curcas* L.	N3P2
	Castor	*Ricinus communis* L.	N2P3

(contd.)

Vegetables and legumes	Lady's finger	*Abelmoschus esculentus* (L.) Moench	N3
	Chilli	*Capsicum annum* L.	N3
	Brinjal	*Solanum melongena* L.	N3
	Bottle gourd	*Lagenaria siceraria* (Molina) Standl.	N2P2
	Sponge gourd	*Luffa aegyptiaca* Mill.	N2P2
	Pumpkin	*Cucurbita pepo* L.	N2P2
	Cucumber	*Cucumis sativus* L.	N3P3
	Green gram	*Vigna radiata* (L.) Wilczek	N3P3
Fruit crops	Guava	*Psidium guajava* L.	N2P2
	Papaya	*Carica papaya* L.	N3P3
	Pomegranate	*Punica granatum* L.	N3P3
	Jujube	*Ziziphus mauritiana* Lam.	N2P3
	Black plum	*Syzygium cumini* (L.) Skeels	N3
Plantation crops/Trees	Lebbeck tree	*Albizia lebbeck* (L.) Benth.	N2P2
	Devil's tree	*Alstonia scholaris* (L.) R.Br.	N1
	Australian acacia	*Acacia auriculiformis* A. Cunn. ExBenth.	P3
	Arjun tree	*Terminalia arjuna* (Roxb.) Wight and Arn.	N3P3
Plantation crops/Trees	Golden shower tree	*Cassia fistula* L.	N3
	Teak	*Tectona grandis* L. f.	N3
	Egyptian thorn	*Acacia nilotica* L.	P3
	Pongam tree	*Millettia pinnata* (L.) Panigrahi	N3
	Camel's foot tree	*Bauhinia variegata* (L.) Benth.	N3
	Temple tree	*Plumeria alba* L.	N3
	Crimson bottle brush	*Callistemon lanceolatus* (Sm.) Sweet	N1P3
	Flame of the forest	*Delonix regia* (Roj.) Rafinesque	N2P2
Cereals and millets	Rice	*Oryza sativa* L.	P2
	Pearl millet	*Pennisetum typhoides* L.	P1

*+ (Forager bees observed very rarely), ++ (Forager bees observed less frequently), +++ (Forager bees observed during each visit); Where, N1 = High nectar, N2= Medium nectar, N3= Low nectar, P1 = High pollen, P2 = Medium pollen, P3= Low pollen

Rafinesque served as minor sources of nectar and pollen during June, while late in September-October, *Alstonia scholaris* (L.) R. Br. and *Callistemon lanceolatus* (Sm.) Sweet served as major nectar sources. *A. mellifera* foragers were seen foraging frequently for pollen on *Oryza sativa* L. and *Pennisetum typhoides* L. during August and September-October, respectively (Table 5). Kumar and Sharma (2016) reported 5 *Acacia* spp. as potential pollen source in Chandigarh, while *Acacia ataxacantha* DC. proved pivotal for bees in Nigeria during the respective dearth periods (Dukku, 2003). Plenty of nectar availability later from *A. scholaris* and *C. lanceolatus* (N1P3) during October-November reflected the end of the dearth period or vice versa the onset of minor honey flow season.

Based on two years of investigation, it is concluded that the plenty of bee flora (71 plant species) was available during dearth periods for the bees to forage upon; and only after proper identification and realizing their utility to bees, these may further be conserved and planted again to be utilized later by the *A. mellifera* foragers during lean periods. Identification of the diverse flowering plant community urban, peri-urban and rural areas and tailoring the same in the vicinity of bee hives to suit the ecology of the bees will definitely improve dearth survival under stationary conditions. Bee floral calendars, if already prepared, could also be used to estimate onset of dearth period.

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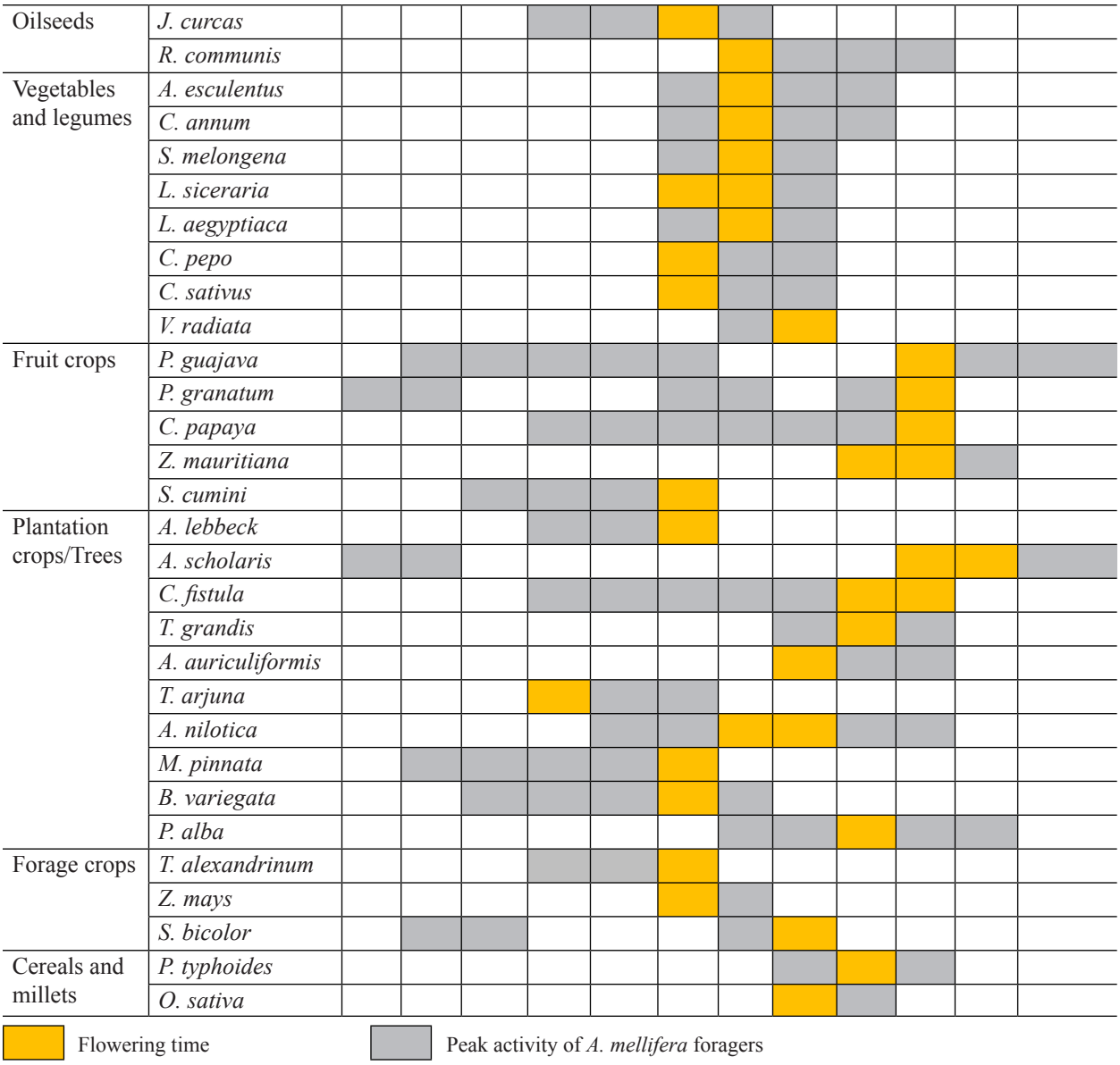
Table 5. Bee floral calendar and peak activity period of *A. mellifera* foragers (2017 and 2018)

Plant type	Scientific name	Flowering time and peak activity of *A. mellifera* foragers											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ornamentals	*T. pallida*												
	R. simplex												
	L. speciosa												
	C. indicum												
	R. indica												
	T. erecta												
	P. scutellarioides												
	P. grandiflora												
	V. negundo												
	C. lanceolatus												
	D. regia												
	H. rosa-sinensis												
	C. thevatia												
	N. oleander												
	B. glabra												
	J. integerrima												
	J. gossypiifolia												
	C. radicans												
Weeds	*T. officinale*												
	M. sativa												
	A. indicum												
	A. conyzoides												
	P. hysterophorus												
	B. obliqua												
	A. sessilis												
	C. viscosa												
	Z. citrina												
	L. camara												
	C. benghalensis												
	T. portulacastrum												
	S. acuta												
	T. procumbens												
	T. terristris												
	C. sativa												
	C. arvensis												
	Chenopodium sp.												
	F. parviflora												
	D. paniculata												
	S. occidentalis												
	C. grandis												
	C. rotundus												

(contd.)



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