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SOME NECTAR CHARACTERISTICS OF CERTAIN IMPORTANT WORLD HONEY SOURCES

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INTRODUCTION

Dr L. Bornus, Dr Z. Demianowicz and other Polish scientists have been among the foremost of those studying nectar production of plants that are honey sources. For this commemorative volume we have therefore carried out programmed searches, of the data base relating to nectar compiled for the **Directory of important world honey sources** (Crane, Walker & Day, 1984). The **Directory** gives data on 452 nectar-producing plants that have been rated as a major honey source (NI), usually in two or more countries.

Table 1 sets out the data recorded for each honey source, as far as it was available, and indicates which parts of the data were used as search fields. (In addition to the 452 nectar plants, the **Directory** contains entries for 15 important sources of honey derived from honeydew, but these do not concern us here.)

Table 1

Summary of information in entries of the
DIRECTORY OF IMPORTANT WORLD HONEY SOURCES

For each plant, information (as available) is printed in the order below. Data on similar characteristics are grouped together in paragraphs or 'blocks', as shown. The search fields are indicated by *

entry number **Botanical name of plant, authority; family**
any synonyms

common names
vegetative form of plant * (tree/shrub/herb); floral description
Distribution (tropical *, subtropical *, temperate *); and where native.
Habitat
Soil (salt tolerant *). Temperature (damaged by frost *). Rainfall (drought tolerant *)

Economic * and other uses
Food *. Fodder *. Fuel *. Timber *. Land use (hedges *, windbreaks *, shade *, afforestation *, amenity *). Soil benefit * (erosion control *, enrichment *). Other uses

Warning about the plant * e.g. toxicity of plant, including nectar, to man or animals (see also under pollen, honey), invasiveness. **Alert to beekeepers ***: difficulties in bee management, honey handling, etc.

Nectar rating + honeybee species
Nectar rating of a plant in a country is:

N1 = major honey source
N2 = medium honey source
N3 = minor honey source
N = honey source, importance unrated

Apis species: ac = *A. cerana*, ad = *A. dorsata*, af = *A. florea*, am = *A. mellifera*, tm = tropical *A. mellifera*

Blooms (dates). Nectar flow (dates or duration). Nectar secretion. Sugar concentration * (low <21% / medium 21—60% / high 61+%. Sugar value *, mg/flower/day (low <0.1 / medium 0.1—2 / high 3+). Sugar analysis. Other characteristics.

Honey flow
Specimen honey yield *, kg/colony/season (high 30+ / moderate <30). Honey potential *, kg/ha/season (high 500+ / moderate <500).

Pollen
value to bees *: high: Pl rating reported (e.g. high nutritive value to bees; produced in large quantities); pollen recorded as collected by bees; warnings — toxic pollen, sticky pollen, pollen inadequate for brood rearing
representation of grains in honey *: under-represented (<20 000 per 10 g)/over-represented (>100 000 per 10 g)

Honeydew *
honeydew produced on plant
honey yield from honeydew: surplus recorded either numerical or not

Recommendation for propagation as a bee plant
Recommendation for planting has been published *

Honey composition
water *: low <16 / medium 16—20 / high 21)FAO max) and over
glucose *: low <31 / medium 31—39 / high 40+
fructose *: low <35 / medium 35—42 / high 43+
sucrose *: low <1 / medium 1—4 / high 5 (FAO max) and over
reducing sugars *: low <65 (FAO min) / high 65 and over
ash *: low <0.1 / medium 0.1—1.0 / high 1.0 (FAO max) and over
free acids * (meq/kg): low <15.0 / medium 15—39 / high 40 (FAO max) and over
amylase * (Gothe): low <3 (FAO min) / high 3 and over
HMF * (ppm): high 40 (EEC max) and over / low below 40 (HMF not included in FAO/WHO Codex)
fermentation on storage *: likely / unlikely / never
vitamins * present

Honey: physical and other properties
toxicity * any information on adverse reactions, e.g. when fed to bees
colour: any unusual tinges *

Pfund * (mm):
white 0—34 (includes grades water white to white)
amber 35—114 (includes grades extra light amber to amber)
dark 115+ (grade dark amber)
granulation * complete within:
<2 wks = rapid / 2—52 wks = medium / 1 yr = slow
flavour descriptions:
bland or strong *, very sweet *, objectionable *, unusual flavour *

Table 2 is a specimen entry from the **Directory**, for *Echium vulgare* L.; it shows that records for the plant are also included which rate the plant as a medium or minor honey source (N2 or N3), and also unrated records (N). References are cited in the Directory.

Characteristics of an important honey source are that it covers a large area of land, has many flowers per hectare, and a high total sugar production per flower per season. Trees are likely candidates because their flowers are in a three-dimensional array. All plants in the **Directory** are reported as important honey sources from which honeybee colonies can store a good surplus of honey.

Tables 3—6 summarize information available in the **Directory** on the following characteristics that are related to honey yield:

total sugar concentration in nectar
sugar composition of nectar (sugar analysis)
nectar secreted per flower per 24 h
total sugar production per flower per 24 h
(calculated) honey potential per unit area of land.

The most commonly measured characteristic is nectar sugar concentration, and the Tables list the 154 plants in the **Directory** for which values were avalable, starting with 'high' values (Table 3) and ending with 'low' values (Table 6). Apart from sugar composition of nectar, each column on the right of the Tables gives the value, or the range of values, reported by different authors; references are cited in the **Directory**.

One purpose in publishing the present paper is to interest bee botanists and sugar chemists in studying some of the many important honey sources for which no results are yet available; this is discussed later.

NECTAR SUGAR CONCENTRATION

High, medium and low nectar sugar concentrations were search fields (see Table 1), limits between classes being selected arbitrarily:

high, over 60% medium, 21—60% low, 20% or less

Table 3 lists 24 plants for which at least one 'high' nectar sugar concentration was recorded, with (column 3) the range of values in the **Directory**, quoted from the publications cited there.

A large number of plants fell into to 'medium' range (21—60%), and for the present paper they are divided into two groups, 41—60% and 21—40% (39+10 plants in Table, 4 and 75 in Table 5). The remaining 6

140 **Echium vulgare L.; Boraginaceae**
viper's bugloss; blue thistle, blueweed (En/USA); viborera (Es/CHL); viperine (Fr); Natternkopf (De); erba viperina (It)
Herb, 20—90 cm, biennial/perennial; fls blue/bluish-violet
Distribution temperate Europe, N America, S America, Oceania; native to Europe. Habitat dry, open places: sand-dunes, roadsides, cultivated fields, dry pastures, chalky hills, sea cliffs; altitudes <2000 m

Economic and other uses
Medicinal

Warning
Invasive weed in Canada (How/79)

Nectar rating; blooms, nectar flow; composition
N1 CAF/ONT(Tow/76); CHL(Kot/38a; Vaq/39); POL(Dem/64a); URS(Fed/55)
N2 FRA(Lou/81); GFR(Gle/77); USA/MD(Die/71)
N3 ITA(Ric/78); ROM(Cir/77); USA/MD,NY,VA(Lov/56; Pel/76);
N3 ITA(Ric/78); ROM(Cir/77); USA/MD,NY,VA(Lov/56; Pel/76);
Blooms vi-viii (ROM); vi-vii (UK, How/79). Nectar secretion 0.5—8.8 mg/fl/day, max at 15.00 h (Han/80; Maz/82); diurnal variations studied (AA162, 163/79). Sugar concentration [medium] 17—43% (Han/80); 35.7% (Pek/80); 20—35% (AA162, 163/79); 23—41% (AA526/82). Sugar value (mg/fl/day) [medium] 1.64 (Cra/75); 0.09—1.3 (Cra/75); 0.23—2.56 (Han/80; Maz/82). Sugar analysis (Maz/82; Pec/61; AA526/82)

Honey flow
Honey potential (kg/ha) [moderate] 128.8 (BUL, Pek/80); 400 (GDR, Bek/67); 182—429 (EUR, Maz/82); > 400 (POL, Dem/64a); 380—400 (ROM, Apc/68); 180—430 (ROM, Cir/80); 300 (URS, Glu/55)

Pollen
P2 FRA; GFR; ITA. P3 ROM. Colour of load light to dark blue (Han/80); dark bluish-grey (Hod/74). Pollen grain illustrated and described (Hod/74; Saw/81). Reference slide

Recommended for planting to increase honey production
UK (How/79). Propagate by sowing in wasteland; also on embankments of roads/railways. See Warning

Honey: chemical composition
Water [medium] 16.4% (1 sample, age 17 mths, Whi/62)
Glucose [medium] 31.27%. Fructose [medium] 37.30%. Sucrose [medium] 1.28%. Maltose 8.43%. Higher sugars 2.53%. Contents of individual sugars expressed as % of total sugars (Maz/64)
Ash [low] 0.039%
pH 3.8 (Lan/66); 3.88 (Whi/62). Total acid 16.50 meq/kg (Whi/62). Free acid [low] 11.81 meq/kg. Lactone 4.69 meq/kg
Nitrogen 0.033% (Whi/62)

Honey: physical and other properties
Colour white to light golden (Cra/75); dull white (Mao/82). Pfund amber (Cha/48); 24.2 mm, white (bulk honey, Lan/66); water white (Lov/56); 8—12 mm, extra white (Whi/62)
Electrical conductivity 0.000111/ohm cm (Vor/64)
Granulation slow (Mao/82); fine, colour then dull (Wal/78)
Flavour delicate (Cra/75); flat (Wal/78)

Table 3

Important honey sources for which a 'high' nectar sugar concentration is reported (over 60%)

Column 1 gives the **Directory** entry number.

Columns 3—6 give the extreme range of values found by different authors.

Ranges of nectar sugar concentration are included only for Table 3 (high) and Table 6 (low).

No	Plant name, authority, family	Nectar sugar conc. %	Nectar secreted mg/flower/24 h	Sugar value mg/flower/24 h	Honey potential kg/ha
020	*Aesculus hippocastanum* L.; Hippocastanaceae sugar analysis: Maurizio, 1959; Percival, 1961; Wykes, 1952	30—76%	1.0—5.0	0.58—3.57	30—100
054	*Brassica campestris* L.; Cruciferae	38—71%	0.2—0.4	0.12—0.27	—
056	*Brassica campestris* L. var. *sarson* Prain	32—69%	—	—	—
060	*Brassica napus* L. var. *oleifera* DC.; Cruciferae sugar analysis: Cambridge Agricultural Publishing, 1981; Free, 1970; Maurizio, 1959; Wanic & Mostowska, 1964; Wykes, 1952	5—84%	0.6	0.29—0.90	35—100
149	*Eriobotrya japonica* (Thunb.) Lindl.; Rosaceae	31—65%	—	—	—
156	*Eucalyptus camaldulensis* Dehnh.; Myrtaceae	17—81%	4.1—15.4	0.56—2.90	—
189	*Eucalyptus tereticornis* Smith; Myrtaceae	30—80%	—	—	—
202	*Geranium pratense* L.; Geraniaceae sugar analysis: Percival, 1961	57—71%	1.3—1.5	0.3—1.1	28—100
213	*Grevillea robusta* A. Cunn. ex R.Br.; Proteaceae sugar analysis: Deodikar et al., 1957; Wakhle et al., 1981	15—79%	—	—	—
256	*Lavandula angustifolia* Miller x *latifolia* Medicus; Labiatae sugar analysis: Battaglini et al., 1973	38—67%	—	—	>150
258	*Leonorus cardiaca* L. subsp. *villosus* (Desf. ex Sprengel) Hyl.; Labiatae	42—76%	0.2—2.4	0.06—0.78	610
268	*Litchi chinensis* Sonner.; Sapindaceae	>62%	—	—	—
274	*Lythrum salicaria* L.; Lythraceae sugar analysis: Kartashova & Novikova, 1964; Maurizio & Grafl, 1982; Percival, 1961	29—72%	0.27—0.64	0.19—0.36	13—265
282	*Malus domestica* Borkh.; Rosaceae sugar analysis: Battaglini Bernadini & Battaglini, 1971; Maurizio & Grafl, 1982; Mommers, 1966; Wykes, 1952	27—87%	1.73—7.09	0.60—1.38	20—42
337	*Prosopis farcta* (Sol. ex Russell) J.F. Macbride; Leguminosae	75%	—	—	—
354	*Robinia pseudoacacia* L.; Leguminosae sugar analysis: Battaglini & Bosi, 1972; Haragsim, 1974; Maurizio & Grafl, 1982; Sănduleac & Lăzărescu, 1960; Wanic & Mostowska, 1964; Wykes, 1952	20—63%	1.6—3.7	0.76—4.0	48—1600

No	Plant name, authority, family	Nectar sugar conc. %	Nectar secreted mg/flower/24 h	Sugar value mg/flower/24 h	Honey potential kg/ha
364	*Salix caprea* L.; Salicaceae sugar analysis: Maurizio & Grafl, 1982; Percival, 1961	15—79%	0.02	0.02—0.23	100—200
387	*Sinapis alba* L.; Cruciferae sugar analysis: Pryce-Jones, 1950; Wykes, 1953; Yakovleva & Zauralov, 1973	19—68%	0.14—1.1	0.05—0.42	21—110
388	*Sinapis arvensis* L.; Cruciferae sugar analysis: Jula et al., 1964; Percival, 1961	17—73%	0.15—0.36	0.04—0.2	17—100
395	*Syzygium cuminii* (L.) Skeels; Myrtaceae	9—72%	—	—	—
398	*Taraxacum officinale* Weber; Compositae	12—73%	—	—	25—1000
418	*Tilia europaea* L.; Tiliaceae sugar analysis: Maurizio & Grafl, 1982; Southwick et al., 1981	33—71%	2.72	0.80	—
430	*Trifolium pratense* L.; Leguminosae sugar analysis: Bailey et al., 1954; Battaglini et al., 1973; Käpylä, 1978; Maurizio, 1959; Percival, 1961; Wykes, 1952; Yakovleva & Zauralov, 1973	17—70%	0.05—0.90	0.02—0.3	6—100
431	*Trifolium repens* L.; Leguminosae sugar analysis: Bailey et al., 1954; Free, 1970; Maurizio & Grafl, 1982; Palmer-Jones & Forster, 1969; Percival, 1961; Southwick et al., 1981; Wanic & Mostowska, 1964; Wykes, 1952	20—64%	0.05—0.40	0.01—0.20	16—200

plants, with a 'low' nectar sugar concentration (20% or less, are in Table 6.

The entries show that plants yielding nectar with a surprisingly wide range of sugar concentrations can be important honey sources. A very high sugar concentration in nectar does not give the bees the energy advantage that might be expected. Simpson (1964) showed that honeybees add liquid when ingesting a sucrose solution whose concentration is over 50%. Waller (1972) found that honeybees preferred 30—50% sucrose solutions to those with concentrations above or below this range. For many of the honey sources in Tables 3—6, the nectar sugar concentration was in the 30—50% range, but many nectars contained either more or less sugar. The sugar composition of nectar is also relevant to the bees' preference, see e.g. Maurizio (1975); Waller, (1972).

If nectar sugar concentration is low, bees lose much energy in converting the nectar to honey, both by carying excess water to the hive and by evaporating excess water within the hive. Nevertheless some plants with a very low nectar sugar concentration can be important honey sources. Table 6 includes *Bombax ceiba* 6% and *Melaleuca leucadendron* 8%

Table 4

Important honey sources for which the nectar sugar concentration is reported to be 41—60%

The 10 plants in brackets could equally well have been allocated to Table 4 or Table 5. See also note to Table 3.

No	Plant name, authority, family	Nectar secreted	Sugar value	Honey potential
		mg/flower/24 h		kg/ha
011	*Acer circinatum* Pursh; Aceraceae	—	—	—
012	*Acer macrophyllum* Pursh; Aceraceae	—	—	—
013	*Acer platanoides* L.; Aceraceae	0.42—0.95	0.12—0.47	100—200
014	*Acer pseudoplatanus* L.; Aceraceae sugar analysis: Maurizio & Grafl, 1982	0.41—1.16	0.31—0.58	200
015	*Acer tataricum* L.; Aceraceae	0.23—0.41	0.13—0.96	50—600
021	*Aesculus turbinata* Bl.; Hippocastanaceae	0.89	0.53	—
031	*Anchusa officinalis* L.; Boraginaceae sugar analysis: Wykes, 1952	1.3—4,4	0.6—2.5	50—515
040	*Baccharis dracunculifolia* DC.; Compositae	—	—	—
055	*Brassica campestris* L. var. *dichotoma* Prain; Cruciferae	—	—	—
057	*Brassica juncea* (L.) Cosson; Cruciferae	—	—	50—60
061	*Brassica nigra* (L.) Koch; Cruciferae	—	—	—
072	*Calluna vulgaris* (L.) Hull; Ericaceae sugar analysis: Wanic & Mostowska, 1964	0.14—0.58	0.12—1.2	100—200
082	*Ceiba pentandra* (L.) Gaertn.; Bombacaceae	—	—	—
084	*Centaurea solstitialis* L.; Compositae	0.12	0.11—0.16	—
091	*Citrus grandis* (L.) Osbeck; Rutaceae	—	—	—
094	*Citrus medica* L.; Rutaceae	—	—	—
095	(*Citrus paradisi* Macfad.; Rutaceae)	—	—	—
115	*Croton floribundus* Spreng.; Euphorbiaceae	—	—	—
135	*Dracocephalum moldavica* L.; Labiatae sugar analysis: Jula et al., 1964	—	—	123—651
144	*Epilobium angustifolium* L.; Onagraceae sugar analysis: Battaglini et al., 1973; Käpylä, 1978; Kartashova & Navikova, 1964; Percival, 1961; Wykes, 1952	1.06—2.90	0.6—1.6	40—1000
157	*Eucalyptus citriodora* Hook.; Myrtaceae	—	0.03	—
184	(*Eucalyptus robusta* Smith; Myrtaceae) sugar analysis: Maurizio, 1959	—	—	—
186	*Eucalyptus saligna* Smith; Myrtaceae	—	—	—
205	*Gleditsia triacanthos* L.; Leguminosae	0.15	0.16—0.19	250
221	*Helianthus annuus* L.; Compositae sugar analysis: Battaglini et al., 1973; Bogoyavlenskii & Kovarskaya, 1956; Bosi, 1973; Wykes, 1952	0.2—0.5	0.10—0.27	13—140
257	*Leonurus cardiaca* L.; Labiatae sugar analysis: Jula et al., 1964	0.12	0.20—0.62	113—400
260	*Lespedeza bicolor* Turcz.; Leguminosae	—	—	—
266	(*Lippia triphylla* (L'Her.) Kuntze; Verbenaceae)	—	—	—

No	Plant name, authority, family	Nectar secreted	Sugar value	Honey potential
		mg/flower/24 h		kg/ha
290	(*Medicago sativa* L.; Leguminosae) sugar analysis: Bailey et al., 1954; Battaglini & Bosi, 1972; Krópačová & Laitová, 1965; Maurizio & Grafl, 1982; Walker et al., 1974; Wykes, 1952	0.24—0.83	0.07—0.25	25—1060
296	(*Melilotus alba* Desr.; Leguminosae) sugar analysis: Jula et al., 1964; Maurizio & Grafl, 1982; Wykes, 1952	0.1—1.1	0.02—0.05	56—678
297	*Melilotus officinalis* (L.) Pall.; Leguminosae sugar analysis: Battaglini et al., 1973	0.11	0.06	10—300
314	(*Onobrychis viciifolia* Scop.; Leguminosae) sugar analysis: Battaglini et al., 1973; Maurizio & Grafl, 1982; Wykes, 1952	0.1—0.9	0.01—0.28	66—600
321	*Persea americana* Mill.; Lauraceae	—	—	—
324	(*Phacelia tanacetifolia* Benth.; Hydrophyllaceae) sugar analysis: Maurizio & Grafl, 1982; Wanic & Mostowska, 1964; Wykes, 1952	0.8—1.6	0.27—0.51	100—1000
351	*Rhus glabra* L.; Anacardiaceae	—	—	—
353	*Rhus typhina* L.; Anacardiaceae	0.22	0.18	30—60
358	(*Rubus idaeus* L.; Rosaceae) sugar analysis: Battaglini et al., 1973; Maurizio & Grafl, 1982; Percival, 1961; Wykes, 1952	3.8—22	0.7—6.7	20—274
368	*Salvia mellifera* Greene; Labiatae	—	—	—
369	*Salvia nemorosa* L.; Labiatae sugar analysis: Maurizio & Grafl, 1982	0.07—0.39	0.05—0.25	243—300
370	*Salvia officinalis* L.; Labiatae sugar analysis: Battaglini et al., 1973; Maurizio & Grafl, 1982	2.55—3.20	0.98—2.43	65—400
390	*Stachys annua* (L.) L.; Labiatae sugar analysis: Battaglini et al., 1973; Jula et al., 1964; Maurizio & Grafl, 1982	—	0.12	88—550
403	*Thelepaepale ixiocephala* (Benth.) Bremk.; Acanthaceae sugar analysis: Wakhle et al. 1981	—	—	—
407	(*Thymus vulgaris* L.; Labiatae) sugar analysis: Wykes, 1952	0.13—0.14	0.05—0.06	100—200
417	*Tilia tomentosa* Moench; Tiliaceae sugar analysis: Sănduleac & Lăzărescu, 1960	2.4—7.3	0.63—3.38	560—1200
428	*Trifolium hybridum* L.; Leguminosae sugar analysis: Maurizio & Grafl, 1982; Percival, 1961	0.03	0.01	120—125
429	*Trifolium incarnatum* L.; Leguminosae sugar analysis: Maurizio & Grafl, 1982	0.04—0.23	0.02—0.07	8.6
436	*Vernonia polyanthes* Less.; Compositae	—	—	—
442	*Vitex agnus-castus* L.; Verbenaceae	—	0.48	—
448	*Ziziphus mauritania* Lam.; Rhamnaceae	—	—	—

Table 5

Important honey sources for which the nectar sugar concentration is reported to be 21—40%

See note to Table 3.

No	Plant name, authority, family	Nectar secreted	Sugar value	Honey potential
		mg/flower/24 h		kg/ha
003	*Acacia decurrens* (Wendl.) Willd.; Leguminosae	—	—	—
027	*Aloysia virgata* (Ruiz & Pav.) A. L. Juss.; Verbenaceae	—	—	—
028	*Ampelopsis arborea* (L.) Koehne; Vitaceae	—	—	—
032	*Andira inermis* (Wright) DC.; Leguminosae	—	—	—
034	*Antigonon leptopus* Hook. & Arn.; Polygonaceae sugar analysis: Van Handel et al., 1972	—	—	—
035	*Asclepias syriaca* L.; Asclepiadaceae sugar analysis: Southwick et al., 1981	3.09—10.39	2.22—3.63	187—600
036	*Astragalus sinicus* L.; Leguminosae sugar analysis: Echigo, 1977	—	—	—
045	*Bidens pilosa* L.; Compositae	—	—	—
047	*Borago officinalis* L.; Boraginaceae sugar analysis: Battaglini et al., 1973; Percival, 1961; Wykes, 1952	5.0—8.1	0.4—3.5	59—300
075	*Carica papaya* L.; Caricaceae sugar analysis: Rowley, 1976	—	—	—
076	*Carnegiea gigantea* (Engelm.) Britton & Rose; Cactaceae	—	—	—
077	*Carvia callosa* (Nees) Brem.; Acanthaceae sugar analysis: Wakhle et al., 1981	—	—	—
080	*Castanea sativa* Mill.; Fagaceae sugar analysis: Battaglini et al., 1973; Maurizio & Grafl, 1982	—	—	26—500
083	*Centaurea cyanus* L.; Compositae sugar analysis: Dustmann, 1969; Maurizio & Grafl, 1982	0.43	1.15	50—100
087	*Citrus aurantifolia* (Christm.) Swingle; Rutaceae	—	—	—
088	*Citrus aurantium* L.; Rutaceae sugar analysis: Van Handel et al., 1972	—	—	—
089	*Citrus bergamia* Risso & Poiteau; Rutaceae	—	—	—
090	*Citrus deliciosa* Ten.; Rutaceae	—	—	—
092	*Citrus limetta* Risso; Rutaceae	—	—	—
093	*Citrus limon* (L.) Burm. f.; Rutaceae	—	—	—
096	*Citrus reticulata* Blanco; Rutaceae	—	—	—
097	*Citrus sinensis* (L.) Osb.; Rutaceae sugar analysis: Kalman, 1977; Vansell, 1941	—	—	—
098	*Citrus unshiu* (Mak.) Marc.; Rutaceae sugar analysis: Echigo, 1977	—	—	—
099	*Clethra alnifolia* L.; Clethraceae	—	—	—

No	Plant name, authority, family	Nectar secreted	Sugar value	Honey potential
		mg/flower/24 h		kg/ha
104	*Cocos nucifera* L.; Palmae sugar analysis: Beyleveld, 1968; Rowley, 1976	—	—	—
105	*Coffea arabica* L.; Rubiaceae	—	—	—
111	*Cordia alliodora* (Ruiz & Pavon) Cham.; Boraginaceae	—	—	—
117	*Cucumis melo* L.; Cucurbitaceae	—	—	10—40
118	*Cucurbita pepo* L.; Cucurbitaceae	—	—	30—50
132	*Dipsacus fullonum* L.; Dipsacaceae sugar analysis: Percival, 1961	—	—	—
140	*Echium vulgare* L.; Boraginaceae sugar analysis: Maurizio & Grafl, 1982; Percival, 1961; Southwick et al., 1981	0.5—8.8	0.09—2.56	129—430
142	*Elaeagnus angustifolia* L.; Elaeagnaceae	0.41	0.94	100
151	*Eucalyptus alba* Reinw. ex Blume; Myrtaceae	—	—	—
166	*Eucalyptus globulus* Labill.; Myrtaceae sugar analysis: Maurizio, 1959	—	—	—
169	*Eucalyptus grandis* W. Hill ex Maiden; Myrtaceae	—	—	—
180	*Eucalyptus paniculata* Smith; Myrtaceae	—	—	—
199	*Fagopyrum esculentum* Moench.; Polygonaceae sugar analysis: Echigo, 1977; Maurizio & Grafl, 1982; Wykes, 1952; Zborowski, 1968	0.2—1.27	0.03—2.68	60—292
207	*Glycine max* (L.) Merr; Leguminosae	—	—	—
209	*Gossypium barbadense* L.; Malvaceae sugar analysis: Butler et al., 1972; Ivanova-Paroiskaya, 1950; McGregor, 1976	—	12.2 (irrigated)	50
210	*Gossypium hirsutum* L.; Malvaceae sugar analysis: Butler et al., 1972; Ivanova-Paroiskaya, 1950	18.13 (irrigated)	5.32 (irrigated)	29—90
216	*Guizotia abyssinica* Cass.; Compositae	—	—	—
219	*Hedychium coronarium* Koen.; Zingiberaceae sugar analysis: Rowley, 1976	—	—	—
222	*Heliconia aurantiaca* Ghiesb.; Heliconiaceae sugar analysis: Rowley, 1976	—	—	—
228	*Hyptis suaveolens* (L.) Poit.; Labiatae	—	—	—
232	*Ilex theezans* Mart.; Aquifoliaceae	—	—	—
252	*Lavandula angustifolia* Miller; Labiatae sugar analysis: Bosi, 1973; Wykes, 1952	—	—	50—183
262	*Leucas aspera* Link; Labiatae	—	—	—
264	*Linum usitatissimum* L.; Linaceae	0.79	0.26	10—12
265	*Lippia nodiflora* (L.) Michx.; Verbenaceae	—	—	—
267	*Liriodendron tulipifera* L.; Magnoliaceae	—	—	0.9—1 kg/tree

No	Plant name, authority, family	Nectar secreted	Sugar value	Honey potential
		mg/flower/24 h		kg/ha
272	*Lotus corniculatus* L.; Leguminosae sugar analysis: Battaglini et al., 1973; Käpylä, 1978; Maurizio, 1959; Percival, 1961	0.19—0.55	0.08—0.22	13—37
286	*Marrubium vulgare* L.; Labiatae sugar analysis: Percival, 1961	0.41	0.15	50—233
302	*Mimosa scabrella* Benth.; Leguminosae	—	—	—
306	*Musa* spp; Musaceae sugar analysis: Lüttge, 1961; Petrov, 1974	—	—	—
319	*Parkinsonia aculeata* L.; Leguminosae	—	—	—
342	*Prunus* × *yedoensis Matsum.;* Rosaceae sugar analysis: Echigo, 1977	—	—	—
343	*Psidium guajava* L.; Myrtaceae	—	—	—
355	*Rosmarinus officinalis* L.; Labiatae sugar analysis: Battaglini et al., 1973	0.8—1.1	0.27—0.94	100—130
357	*Rubus spp* [R. fruticosus L.]; Rosaceae sugar analysis: Maurizio & Grafl, 1982	0.8—6.1	0.3—3.4	5—50
373	*Sapindus mukorossi* Gaertn.; Sapindaceae	—	—	—
381	*Scrophularia nodosa* L.; Scrophulariaceae sugar analysis: Percival, 1961	max 24.4	5.48	400—1068
384	*Sesamum indicum* L.; Pedaliaceae	—	—	45
391	*Symphoricarpos albus* (L.) S. F. Blake; Caprifoliaceae sugar analysis: Corbet et al., 1979; Percival, 1961; Wykes, 1952	4.0—6.1	1.0—5.8	100—458
406	*Thymus serpyllum* L.; Labiatae sugar analysis: Battaglini et al., 1973	0.16—0.18	0.04—0.08	41—149
410	*Tilia cordata* Mill.; Tiliaceae sugar analysis: Käpylä, 1978; Maurizio & Grafl, 1982; Wanic & Mostowska, 1964	1.1—8.0	0.15—3.0	83—1000
415	Tila platyphyldos Scop.; Tiliaceae sugar analysis: Maurizio Groll 1982	1.8—13.2	0.5—3.3	250—800
419	*Tipuana tipu* (Benth.) O. Kuntze; Leguminosae	—	—	—
424	*Trichostema lanceolatum* Benth.; Labiatae	—	—	—
426	*Trifolium alexandrinum* L.; Leguminosae	—	—	165
432	*Trifolium resupinatum* L.; Leguminosae	0.01—0.07	0.006—0.021	70—100
435	*Vaccinium uliginosum* L.; Ericaceae	0.9—2.2	0.3—0.44	4—270
438	*Vicia faba* L.; Leguminosae sugar analysis: Wykes, 1952	—	—	20—60
440	*Vicia villosa* Roth; Leguminosae	0.35—0.89	0.31	30—100
443	*Vitex cymosa* Bert.; Verbenaceae	—	—	—
452	*Ziziphus spina-christi* (L.) Desf.; Rhamnaceae	0.2—2.6	0.12—0.66	—

Table 6

Important honey sources for which a 'low' nectar sugar concentration is reported (20% or less)

See note to Table 3.

No	Plant name, authority, family	Nectar sugar conc. %	Nectar secreted mg/flower/24 h	Sugar value mg/flower/24 h	Honey potential kg/ha
025	*Aloe mutans* Reynolds; Liliaceae	18—20%	—	—	—
046	*Bombax ceiba* L.; Bombacaceae	6%	—	—	—
182	*Eucalyptus polyanthemos* Schauer; Myrtaceae	19%	0.4	0.08	—
224	*Hibiscus rosa-sinensis* L.; Malvaceae sugar analysis: Kartashova & Novikova, 1964; Percival, 1961; Rowley, 1976; Van Handel et al., 1972	19—21%	—	—	—
291	*Melaleuca leucadendron* (L.) L.; Myrtaceae	8%	—	—	—
404	*Thunbergia grandiflora* (Roxb. ex Rottl.) Roxb.; Acanthaceae sugar analysis: Nair et al., 1964	13%	—	—	—

(in Burma, Zmarlicki, 1984), and *Thunbergia grandiflora* 13% (in the Philippines, Rowley, 1976).

One factor leading to a wide range of values for the nectar sugar concentration is that in many flowers the concentration may increase through evaporation of water, especially at high temperatures. Alternatively, it may decrease through absorption of water from a humid atmosphere, and such post-secretory changes have been studied in relation to ambient relative humidity by a number of authors. Corbet et al. (1979) published a graph (their Fig. 12) which shows that a 20% sucrose solution absorbs water from the atmosphere if the relative humidity is above 98%; for a 40% or 60% solution, the threshold RH is 96% or 89%, respectively.

NECTAR COMPOSITION

Nectar sugar composition was too complex to summarize in the **Directory**, so publications giving results of sugar analyses were listed, and these are quoted in Tables 3—6. Less than half the nectars in the Tables, and a few others in the **Directory**, have been analysed for sugars. Most of the plants concerned grow in temperate zones; nectars of almost all tropical species still await attention, as well as some from temperate regions.

References giving amino acid analyses of nectar are included in the **Directory**.

NECTAR SECRETED AND SUGAR VALUE

Both these parameters are related to the size of the flower or floret of the plant species concerned. The sugar value is normally measured in units of mg/flowed/24h. Nectar production is measured in mg/flower/24h, or µl/flower/24h, or total mg (or µl) per flower during the flowering period. Some figures in the literature were difficult to include in the **Directory** because the period of time was not stated, or because whether a single floret or a whole inflorescence was considered.

The sugar value is characteristic for each species, being unaffected by the atmospheric factors which alter the sugar concentration of nectar after secretion. It is therefore a useful parameter for evaluating how factors such as nutrition affect nectar secretion in a single species. For most plants the sugar value is well below 1. Maurizio (1975) lists values for 65 species. Sugar values were found in the literature for 65 of the 154 plants in Tables 3—6, with the range of values reported in the Tables. They are quoted in the **Directory** for four other plants:

	mg/flower/24h
Coriandrum sativum L.; Umbelliferae	0.022—0.045
Tilia amurensis Rupr.; Tiliaceae	0.71—1.07
Tilia japonica (Miq.) Simonk.; Tiliaceae	0.20—1.32
Tilia maximowicziana Shiras; Tiliaceae	0.67—0.92

Nectar production is also quoted for four other plants:

Tilia americana L.; Tiliaceae	5.39—6.73
Tilia amurensis Rupr.; Tiliaceae	3.86—9.24
Tilia japonica (Miq.) Simonk.; Tiliaceae	1.19—6.79
Tilia maximowicziana Shiras; Tiliaceae	5.84—15.41

The **Directory** quotes the references for all the data.

HONEY POTENTIAL

The honey potential of a plant is the number of kilograms of honey that could theoretically be obtained in the course of a season from a hectare of ground covered with the plant. It is calculated from the sugar value, the number of days each flower secretes nectar, and the number of flowers per plant and of plants per hectare. The honey potential has been used especially in estimating the prospective honey yield of large areas of a uniform crop, and in assessing the proper siting of migratory colonies of bees (Demianowicz et al., 1960, 1963).

Honey potential of plants in Tables 3—6 ranges widely; at least one figure over 500 kg/ha has been reported for the following:

	Table		Table
Acer tataricum	4	*Onobrychis viciifolia*	4
Anchusa officinalis	4	*Phacelia tanacetifolia*	4
Asclepias syriaca	5	*Robinia pseudoacacia*	3
Epilobium angustifolium	4	*Scrophularia nodosa*	5
Lconurus cardiaca subsp. *villosus*	3	*Taraxacum officinale*	3
Medicago sativa	4	*Tilia cordata*	5
Melilotus alba	4	*Tilia platyphyllos*	5
		Tilia tomentosa	4

A honey potential over 500 kg/ha was reported for three further plants (not in the Tables because no values for the nectar sugar concentration were found):

	kg/ha
Stachys annua (L.) L.; Labiatae	88—550
Tilia amurensis Rupr.; Tiliaceae	up to 1000
Tili mandschurica Rupr. & Maxim; Tiliaceae	680—900

SURVEY OF WORLD HONEY SOURCES

Preparation and publication of the **Directory** was Phase II of the above project, undertaken by the International Bee Research Association. Phase I, a preliminary recording of plants reported as honey sources world-wide, was funded by the International Union of Biological Sciences through the International Commission for Bee Botany, and carried out at IBRA in conjunction with the Commission.

Phase II was funded by the International Development Research Centre, Ottawa, in view of the need for collected information on honey sources in developing countries of the tropics and subtropics. IDRC accepted IBRA's proposal that it should not be confined to developing countries, but should include the whole world, to take advantage of the large amount of information on honey sources that grow in temperate zones. The amount of funding, however, limited Phae II to important honey sources.

In presenting nectar data from the **Directory** in this paper, we should like to urge bee botanists to take any opportunity to add to the relatively meagre scientific information on important honey sources of the tropics and subtropics.

Phase III of the project was to have extended the existing data base to include many more plants, and further data for the plants in the Directory. Funds have not yet been found for this work, but six *Honey Sources Satellites* to the Directory were published by IBRA in 1986:

1. Bibliography (with author reference codes); country codes; other abbreviations. E. Crane, P. Walker, J. Fish. 50 pages.
2. Plants listed alphabetically and by family; common name index; pollen grain information. E. Crane, P. Walker, R. Day. 47 pages.

3. Chemical composition of some honeys. E. Crane, P. Walker. 42 pages.
4. Physical properties, flavour and aroma of some honeys. Authors as 3. 54 pages.
5. Honeydew sources and their honeys. Authors as 3. 34 pages.
6. Drought-tolerant and salt-tolerant honey sources. Authors as 3. 94 pages.

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CHARAKTERYSTYKA OKREŚLONYCH WAŻNYCH ŹRÓDEŁ NEKTAROWYCH MIODU NA ŚWIECIE

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Streszczenie

Autorzy podali za książką „Główne światowe źródła miodu" charakterystykę 452 roślin wydzielających nektar, które uważane są za główne źródła, przynajmniej w dwu lub więcej krajach. Do takich roślin zalicza się te, które zajmują duże obszary, mają wiele kwiatów na hektarze powierzchni i odznaczają się wysoką produkcją nektaru w sezonie. Najczęściej stosowaną oceną przedstawionych roślin było stężenie cukru w nektarze, od wysokiego powyżej 60% poprzez średnie od 21 do 60%, do niskiego do 20%.

ХАРАКТЕРИСТИКА ОПРЕДЕЛЕННЫХ ВАЖНЫХ НЕКТАРНЫХ ИСТОЧНИКОВ МЕДА В МИРЕ

E. Crane, P. Walker

Резюме

Авторы, основываясь на книге „Главные мировые источники меда", представили характеристику 452 растений, выделяющих нектар, которые считаются главным источником хотя бы в двух или больше странах. К таким растениям причисляются такие, которые занимают большие территории, у них много цветов на гектаре поверхности и отличаются высокой нектаропродуктивностью в сезоне. Чаще всего применяемой оценкой представленных растений была концентрация сахара в нектаре, от высокой свыше 60% через средние от 21% до 60%, до низкой — до 20%.