GERANIACEAE (R. C. Carolin, Sydney)

Annual or perennial herbs (in Malesia) or shrubs with simple and capitate-glandular hairs. *Leaves* opposite or alternate, petioled, usually stipulate: blade dentate and/or lobed, dissected or even compound (very rarely entire but not so in Malesia). *Flowers* bisexual, regular or irregular, protandrous, solitary and terminal or arranged in terminal cymes which appear to be axillary due to sympodial growth. *Sepals* 5 (rarely 4 and not so in Malesia), persistent. *Petals* equal in number to sepals (rarely absent), free. *Stamens* as many as petals or twice as many (rarely three times as many but not in Malesia), free or connate, some frequently staminodal, hypogynous. *Ovary* usually 5-locular with 1–2 ± superposed pendulous ovules in each cell. *Fruit* a schizocarp (sometimes a capsule but not so in Malesia) splitting into 5 one-seeded mericarps each bearing part (an awn) of the elongated style (rostrum). *Seeds* with or without endosperm.

Distribution. Genera 11 and *c.* 600 *spp.*, centred in southern Africa but very widespread in temperate parts of the world, in the tropics mainly at higher altitudes, in Malesia exclusively so.

All Malesian species belong to a complex group—containing KNUTH's sections *Chilensia*, *Australiensia*, and fragments of *Striata* and *Columbinum*—extending from India, through Malesia, temperate Australia, New Zealand, and the Subantarctic islands, to southern America, with some links with the species grouped around *Geranium carolinianum* in North America.

Phytochemistry. At present it is impossible to characterize *Geraniaceae* chemically. The best we can do is to point out what is known about the four genera hitherto investigated.

Geranium. Tannins are present in especially high amounts in subterranean organs of perennial species. Gallic acid, ellagic acid and catechins have been isolated from a few species. The information available indicates that, as a rule, the tannins are mixtures of gallitannins, ellagitannins and condensed tannins. Quercetin, kaempferol and caffeic acid are probably ubiquitous and myricetin has been found hitherto in two species. Essential oils produced in glandular hairs are known for a few species; from *G. macrorrhizum* L. the so-called 'Zdravetz oil' is produced.

Pelargonium. Most species are accumulators of tartaric acid; this is a generic character; *Geranium* and *Erodium* do not accumulate it. Some species and hybrids produce large amounts of essential oils in glandular hairs of the leaves. The plants known as 'Geranium rosat' are cultivated widely for the production of the so-called 'Geranium oils'. The polyphenols seem to be similar to those of *Geranium*; gallic acid, ellagic acid, catechins and myricetin have, however, not yet been found in *Pelargonium*.

Erodium. All investigations were performed with *E. cicutarium* (L.) L'HÉRIT., which is used therapeutically in Europe. Probably this species contains a little tannin resembling *Geranium*-tannins; gallic acid has been definitely identified; furthermore traces of caffeine have been demonstrated to be present.

Sarcocaulon. In this xerophytic genus of southern Africa and Madagascar the bark is very rich in aromatic resins and waxes. In *S. rigidum* SCHINZ the resinous material was demonstrated to be a complex mixture of tannins, resins (containing phytosterols) and waxes (containing cerulic alcohol and feruloylcerulate).

For a chemotaxonomical discussion our present knowledge about the chemistry of *Geraniaceae* is far from sufficient.—R. HEGNAUER.

KEY TO THE GENERA

1. Fertile stamens 10. Awns without long hairs on the inner surface. Leaves palmately lobed. **1. Geranium**

1. Fertile stamens 5 with 5 alternating staminodes. Awns with long hairs on the inner surface. Leaves bipinnatifid . . . . . **2. Erodium**

1. GERANIUM

LINNÉ, Gen. Pl. ed. 5 (1754) 306; Sp. Pl. (1753) 676; BENTH. Fl. Austr. 1 (1863) 295; KNUTH, Pfl. R. Heft 53 (1912) 43; in E. & P. Pfl. Fam. ed. 2, 19a (1931) 43; ALLAN, Fl. New Zeal. 1 (1961) 233.

Herbs with simple or branched basal stems ('rhizomes') from which arise ±

short-lived flowering stems. *Leaves* opposite or sometimes alternate (but not in Malesia), palmately lobed. *Flowers* solitary or twinned. *Stamens* 10, all fertile (in Mal. *spp.*), free. *Mericarps* remaining attached to the rostrum after splitting by the curved (but not spiral) awn which is almost glabrous on the inner surface. *Seeds* reticulate, usually ejaculated from the separating mericarp through a ventral dehiscense line.

Distr. About 250 *spp.*, very widely distributed, particularly in temperate regions. The infrageneric groupings adopted by KNUTH are not, in general, reliable.

KEY TO THE SPECIES

1. Bracteoles ovate to suborbicular, imbricate at the base even in the flowering stage. **1. G. monticola**
1. Bracteoles linear-lanceolate to lanceolate, scarcely imbricate in the flowering stage.
2. Flowers solitary . . . . . **2. G. potentilloides**
2. Flowers twinned . . . . . **3. G. homeanum**

1. Geranium monticola RIDL. Trans. Linn. Soc. Lond. Bot. II, 9 (1916) 23; STEEN. Bull. Jard. Bot. Btzg III, 13 (1934) 210.—*G. dissectum* (*non* L.) HEMSLEY, Kew Bull. (1899) 98.—*G. papuanum* RIDL. Trans. Linn. Soc. Lond. Bot. II, 9 (1916) 23, *incl. var. alpestris* RIDL.; STEEN. Bull. Jard. Bot. Btzg III, 13 (1934) 210.—*G. clemensiae* KNUTH in Fedde, Rep. 45 (1938) 61.

Perennial, (sometimes compact and cushion-like) herb with thick, ascending, often much-branched, rhizome covered with persistent petioles and stipules. *Flowering stems* prostrate, stoloniferous, frequently producing secondary erect rhizomes at the nodes, pubescent at least in the young stages *or* very short and ascending, 2½–40 cm long. Stipules ovate to orbicular, 3–2½ by 3–3½ mm, pubescent membranous, brown, obtuse or with a minute mucro. *Leaves* usually uniform in outline, hirsute particularly on the undersurface or almost glabrous, deeply palmately 3–5-lobed or dissected, 3–7 by 4–12 mm, the lobes sometimes toothed towards the apex; petiole covered with retrorse-appressed hairs. *Flowers* solitary. Pedicel pubescent with retrorse-appressed hairs, 2½–5 mm. Bracteoles ovate to orbicular, imbricate *c.* 2 mm ø, usually obtuse or slightly acuminate, ± pubescent, membranous, brown. *Sepals* elliptic to oblong, *c.* 3 by 1 mm, surmounted by a short mucro, pubescent with soft, appressed hairs. *Petals* spathulate, distinctly ungulate, 4 by 1½–2 mm, glabrous towards the base, pink. *Stamens* 10; filaments lanceolate, *c.* 3 mm, ciliate, bearing a subglobular anther, the outer whorl sometimes with two teeth on the shoulders. *Mericarps* and *seeds* not seen.

Distr. *Malesia*: New Guinea (Mts Carstensz, Wilhelmina, Giluwe, Saruwaged).

Ecol. Alpine grasslands and rocky outcrops, boggy grounds, sandy banks of grassland streams, 3225–4700 m, one of the flowering plants found at greatest height on Mt Carstensz.

Notes. Variable particularly in the degree of hairiness of the leaves. *G. papuanum* is based upon a more glabrous specimen, *G. monticola* on one which is hirsute particularly on the undersurface of the leaves. There seems to be gradations between these two, possibly influenced by degree of exposure. At higher altitude the plants have a much more compact habit, the basis for *G. papuanum var. alpestris*; again there seem to be gradations linking the loose and compact forms. It has not been possible to trace the type of *G. clemensiae* but from the (inadequate) description it appears to belong here.

Differs from *G. potentilloides* in the broader bracteoles, distinctly clawed petals which are glabrous towards the margin towards the base.

2. Geranium potentilloides L'HÉRIT. *ex* DC. Prod. 1 (1824) 639; HOOK. *f.* Fl. Nov. Zel. 1 (1852) 40; Fl. Tasm. 1 (1860) 57, *non* SPRENG. 1826, *nec* BONPL. *ex* WEDD. 1855, *nec non* KLOTSCH, 1862. —*G. philonothum* DC. Prod. 1 (1824) 639.—*G. microphyllum* HOOK. *f.* Fl. Antarct. (1844) 8; KNUTH, Pfl. R. Heft 53 (1912) 151; ALLAN, Fl. New Zeal. 1 (1961) 235.—*G. pilosum* [*non* (SOL.) FORST.] F. v. M. J. Bot. 31 (1893) 324.—*G. sarawaketense* KNUTH in Fedde, Rep. 45 (1938) 61.—**Fig. 1.**

Perennial herb with short ± erect rhizome and thin, fusiform or branched tap-root. *Flowering stems* decumbent to ascending, 2½–50 cm, pubescent with retrorse hairs, often rooting at the nodes. Stipules lanceolate, 3–10 mm, long-acuminate, often 2-fid, pubescent, subherbaceous on midrib becoming membranous towards margin. *Leaves* opposite, deeply palmately 5–7-lobed, semi-orbicular or reniform to broad ovate in outline, 1–3 by 1–5 cm, pubescent on both surfaces, often purplish on the lower surface; lobes oblong to narrow-obovate in outline; petiole slender, 1–3½ cm, pubescent. *Flowers* solitary. Pedicels pubescent with retrorse-appressed hairs, 2–4 cm, with two linear to lanceolate, subherbaceous, pubescent bracteoles 2½–4 mm long at midpoint or lower, geniculate at the bracteoles when mature. *Sepals* narrow-elliptic-oblong to lanceolate, 4–7 by 1½–2½ mm, pubescent with short, ± appressed hairs and sometimes some longer divergent ones. *Petals* obovate, 5–8 by 3–3½ mm, ciliate at base, pink, sometimes white. *Stamens* 10; filaments lanceolate-acuminate, 3 by

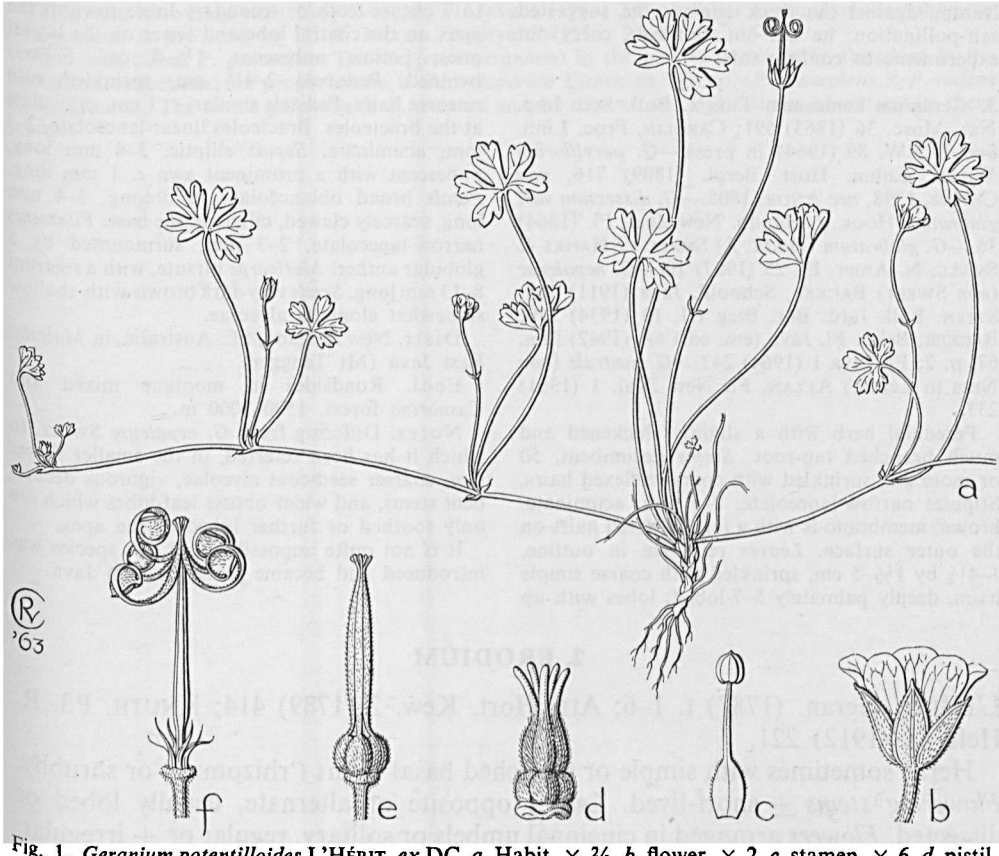

Fig. 1. *Geranium potentilloides* L'HÉRIT. *ex* DC. *a.* Habit, × ⅔, *b.* flower, × 2, *c.* stamen, × 6, *d.* pistil, × 6, *e.* young fruit, × 2, *f.* dehisced fruit without seed, × 2 (*a*, *e* PULLEN & HOOGLAND 5708, *b–d* BORGMANN 92, *f* CRUTWELL 1030).

½ mm. *Mericarps* oblong *c.* 3½ mm, with a rostrum 8–15 mm long. *Seeds* dark brown, *c.* 2 mm long, covered with shallow somewhat elongated alveolae.

var. **potentilloides.** For synonyms see above.

Secondary lobes of the leaves oblong to obovate. Sepal hairs all or almost all short and appressed.

Distr. Antarctic Islands, New Zealand, SE. Australia, in *Malesia*: eastern half of New Guinea.

Ecol. Subalpine and montane woodlands and grasslands, burned treefern grassland, moist hollows, forest edges, often on damp soil, 2250–4250 m.

var. **ardjunense** (ZOLL. & MOR.) CAROLIN, *Comb. et stat. nov.* — *G. ardjunense* ZOLL. & MOR. Nat. & Geneesk. Arch. N.I. 2 (1845) 585; BACKER, Schoolfl. Java (1911) 169; KNUTH, Pfl. R. Heft 53 (1912) 150; WELSEM, Trop. Natuur 2 (1913) 10, f. 8; STEEN. Bull. Jard. Bot. Btzg III, 13 (1934) 210; BACKER, Bekn. Fl. Java (em. ed.) 4A (1942) fam. 67, p. 2; LAM, Blumea 5 (1945) 570; BACKER, Fl. Java 1 (1964) 243.—*G. affine* (*non* W. & A.) BRITTEN in Forbes, Wand. (1885) 501.—*G. nepalense* (*non* SWEET) DOCTERS VAN LEEUWEN, Verh. Kon. Ak. Wet. A'dam, sect. ii, 31 (1931) 255.

Secondary lobes of the leaves linear. Hairs of the sepals short and appressed but becoming stiff and ± divergent towards the margin.

Distr. *Malesia*: N. Sumatra (Atjeh), Central-East Java (Mt Merbabu to Mt Tengger), SW. Celebes (Bonthain), Timor.

Ecol. Light montane forest mixed or of *Casuarina* or *Eucalyptus*, also in open grasslands, along roadsides, sometimes in fields as an apophyte, 1900–3200 m.

Notes. The specimens from Celebes show some intermediate characteristics between these two varieties. Those from Timor show some differences, particularly in the apparently frequent occurrence of twinned flowers. In most characteristics, however, they resemble the Javanese specimens of *var. ardjunense*.

DOCTERS VAN LEEUWEN, *l.c.*, suggested self-pollination in this species which he observed on Mt Lawu, Central Java. He observed the anthers already open at 10 *a.m.* to be empty the next day. As he did not observe insects on the flowers and as he found in most flowers one or two anthers

leaning against the thick stigmas, he suggested self-pollination; he did not, however, carry out experiments to confirm this.

3. Geranium homeanum TURCZ. Bull. Soc. Imp. Nat. Mosc. 36 (1863) 591; CAROLIN, Proc. Linn. Soc. N.S.W. 89 (1964) in press.—*G. parviflorum* WILLD. Enum. Hort. Berol. (1809) 716, *non* CURTIS, 1798, *nec* ANDR. 1805.—*G. dissectum var. glabratum* HOOK. *f.* Handb. New Zeal. Fl. (1864) 36.—*G. glabratum* (HOOK. *f.*) SMALL *ex* HANKS & SMALL, N. Amer. Fl. 25 (1907) 10.—*G. nepalense* (*non* SWEET) BACKER, Schoolfl. Java (1911) 168; STEEN. Bull. Jard. Bot. Btzg III, 13 (1934) 210; BACKER, Bekn. Fl. Java (em. ed.) 4A (1942) fam. 67, p. 2; Fl. Java 1 (1964) 243.—*G. australe* (*non* NEES in Lehm.) ALLAN, Fl. New Zeal. 1 (1961) 233.

Perennial herb with a slightly thickened and much branched tap-root. *Stems* decumbent, 50 or more cm, sprinkled with coarse reflexed hairs. Stipules narrow-lanceolate, 3–5 mm, acuminate, brown, membranous with a few scattered hairs on the outer surface. *Leaves* reniform in outline, 1–4½ by 1½–5 cm, sprinkled with coarse simple hairs, deeply palmately 5–7-lobed; lobes with up to 7 obtuse teeth or secondary lobes towards the apex on the central lobe and fewer on the lateral ones; petiole pubescent, 1½–8 cm. *Flowers* twinned. Peduncle 2–4½ cm, sprinkled with retrorse hairs. Pedicels similar, *c.* 1 cm, geniculate at the bracteoles. Bracteoles linear-lanceolate, 2–3 mm, acuminate. *Sepals* elliptic, 3–4 mm long, pubescent with a prominent awn *c.* 1 mm long. *Petals* broad oblanceolate to oblong, 3–4 mm long, scarcely clawed, ciliate at the base. *Filaments* narrow-lanceolate, 2–3 mm, surmounted by a globular anther. *Mericarps* hirsute, with a rostrum 8–13 mm long. *Seeds* very dark brown with shallow somewhat elongate alveolae.

Distr. New Zealand, SE. Australia, in *Malesia*: East Java (Mt Tengger).

Ecol. Roadsides in montane mixed and *Casuarina* forest, 1500–2000 m.

Notes. Differing from *G. nepalense* SWEET, to which it has been referred, in the smaller flower size, coarser seed-coat alveolae, vigorous decumbent stems, and wider obtuse leaf-lobes which are only toothed or further lobed at the apex.

It is not quite impossible that this species was introduced and became naturalized in Java.

2. ERODIUM

L'HÉRIT. Geran. (1787) t. 1–6; AIT. Hort. Kew. 2 (1789) 414; KNUTH, Pfl. R. Heft 53 (1912) 221.

Herbs sometimes with simple or branched basal stems ('rhizomes') or shrubby. *Flowering stems* ± short-lived. *Leaves* opposite or alternate, usually lobed or dissected. *Flowers* arranged in cincinnal umbels or solitary, regular or ± irregular. *Fertile stamens* 5, alternating with 5 staminodes. *Mericarps* separating completely from rostrum, surmounted by a spiral awn with ± long stiff hairs on the inner surface. *Seed* retained within the mericarp.

Distr. About 80 *spp.*, widely distributed in temperate regions particularly of the Old World, extending into tropical areas only rarely.

1. Erodium cicutarium (L.) L'HÉRIT. *ex* AIT. Hort. Kew. 2 (1789) 414; WILLD. Sp. Pl. 3 (1801) 629; DC. Prod. 1 (1824) 646; KNUTH, Pfl. R. Heft 53 (1912) 274; BACKER, Bekn. Fl. Java (em. ed.) 4A (1942) fam. 67, p. 3; Fl. Java 1 (1964) 244.

Annual or biennial herb (in Mal.). *Stems* decumbent ascending or erect, hirsute or glandular. Stipules membranous, lanceolate-deltoid to ovate-acuminate, white brown or red. *Leaves* basal and mostly opposite on the flowering stems, pinnate-compound, each leaflet deeply pinnatifid, ovate to oblong in outline up to 10 cm long, hirsute or glandular; lobes of the leaflets acute, often ± dentate. *Flowers* in umbels of 2–7 or solitary. Bracts connate into a wide funnel-shaped tube, ciliate. Pedicels variously hairy or even glabrous. *Sepals* oblong to elliptic, 5–7 mm long, hirsute or glandular with a short awn. *Petals* obovate to oblanceolate ± unequal, pink to white sometimes with dark spots or lines towards the base on the posterior ones. *Staminal filaments* lanceolate, 5 mm; staminodes narrow-lanceolate to narrow-elliptic 2½–3 mm. *Mericarps* surmounted by an awn 3–4½ cm long with a shallow pit on either side at the base of the awn occasionally with an additional furrow beneath each pit.

Distr. A very variable cosmopolitan weed, in *Malesia*: East Java (Mts Ardjuno: Lalidjiwo, and Tengger–Smeru), introduced.

Ecol. A weed of disturbed land, in fields and between grass, 2100–2600 m.

Cultivated

A few species of *Pelargonium* L'HÉRIT. are cultivated, either as ornamentals in pots or for the scented oil. The genus is easily distinguished from the two others by the prominent nectary spur which is adnate to the pedicel.

Three taxa have been treated by BACKER, Fl. Java 1 (1964) 244. A fuller account of the cultivated *Pelargoniums* is provided by H. E. MOORE, Baileya 3 (1955) 71–97, fig. 23–38.

What was called *P. graveolens* THUNB. (*rose geranium*) in the past is particularly abundant in the herbarium collections; its proper name is *P.* × *asperum* EHRH. *ex* WILLD. (*P. graveolens* × *P. radens* H. E. MOORE). The *lemon geranium* is *P. crispum* and its derivatives. Hybrids are abundant in these groups.