

## MOLLUGINACEAE

### *ADENOGRAMMA NATANS*, A REMARKABLE NEW AQUATIC SPECIES FROM WESTERN CAPE, SOUTH AFRICA

#### INTRODUCTION

A small, primarily tropical family, Molluginaceae comprises 11 genera and  $\pm$  90 species (Heywood *et al.* 2007). The genera are primarily polycarpellate with capsular fruits, and only *Adenogramma* Rchb. has a unilocular, uniovulate carpel ripening into a nutlet. This small genus is confined to southern Africa and currently comprises  $\pm$  10 species of annual or perennial herbs with leaves in false whorls and subtended by filiform stipules (Adamson 1955; Dreyer & Jordaan 2000). The

small, white and green flowers lacking petals are borne in sessile, seemingly axillary cymes. *Adenogramma* is largely confined to the coastal plain and lower mountain slopes of the winter rainfall parts of Northern and Western Cape (Adamson 1955) and divides readily into a group of perennial species with stems  $\pm$  woody, at least towards the base, and another of delicate, herbaceous annuals. The latter are characteristic of seasonally damp or shaded situations (Adamson 1955; Goldblatt & Manning 2000).

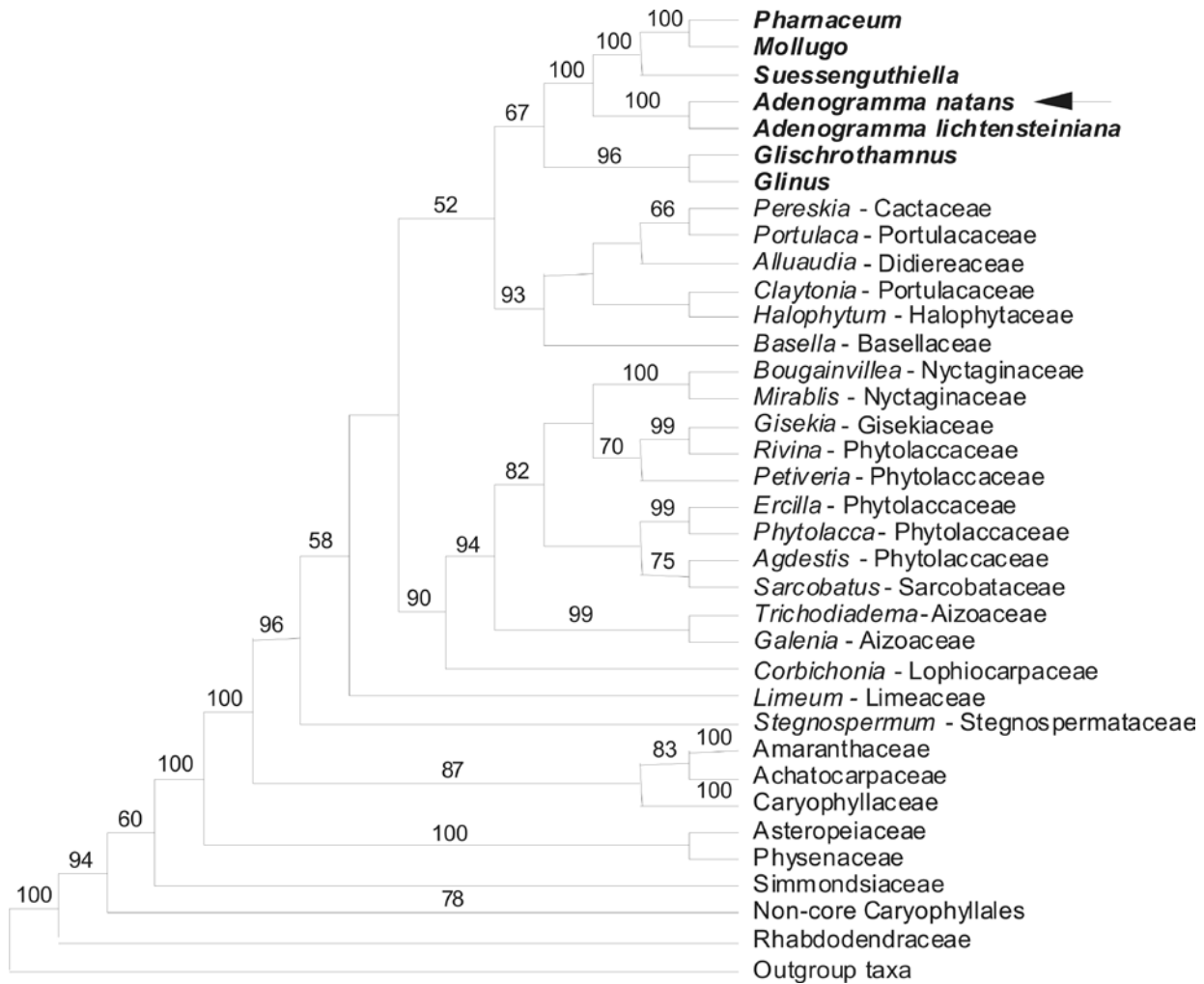


FIGURE 10.—One of the two most parsimonious phylogenetic trees obtained from the analysis of Caryophyllales based on *rbcL* and *matK* (5 310 steps; CI=0.34; RI=0.62). Bootstrap percentages above 50% are shown above branches. Species currently assigned to family Molluginaceae are in bold. The arrow points to the new species *Adenogramma natans*.

Recent intensive exploration of Elandsberg Nature Reserve near Wellington in Western Cape resulted in the discovery of an unknown, emergent aquatic herb. This delicate, bottom-rooted annual produces long, wiry stems with floating clusters of whorled leaves at the branch tips. It conforms to the genus *Adenogramma* in essential morphological features of the foliage and flowers but differs strikingly in its truly aquatic habit. The growth form of the species is so anomalous in the genus that a plastid molecular analysis was undertaken to corroborate its phylogenetic and taxonomic placement.

No earlier collections of the species could be located in local herbaria and it is described here as *Adenogramma natans* in allusion to its unique aquatic habit. It is the second unusual aquatic to be described from the southwestern coastal plain in recent years (Manning *et al.* 2008). Elandsberg Nature Reserve itself includes the largest remaining areas of Swartland Alluvial Fynbos and Renosterveld plant communities (Mucina & Rutherford 2006). The fynbos vegetation unit in particular, especially the wetlands, includes several endemic species, a number of which have only recently been described, notably *Brunsvigia elandsmontana* (Amaryllid-

daceae), *Marasmodes spinosa* (Asteraceae) and *Lotononis complanata* (Fabaceae).

#### MATERIALS AND METHODS

**Morphology:** the description and illustration were prepared from freshly collected material. Examination of herbarium collections at BOL, NBG, PRE and SAM, failed to reveal additional collections (herbarium acronyms after Holmgren *et al.* 1990).

**Molecular analysis:** DNA extraction, polymerase chain reaction (PCR) amplification, and DNA sequencing were performed as in Manning *et al.* (2009). The *rbcL* sequence obtained for *Adenogramma natans* was incorporated into a published *rbcL-matK* combined analysis of order Caryophyllales (Cuénoud *et al.* 2002). The other Molluginaceae accessions included in the study of Cuénoud and colleagues for which only *matK* was available, as well as the only other available *rbcL* sequence for *Adenogramma* (*A. lichtensteinia*; GenBank accession number AM235030), were also included in our analysis. The program SEQUENCHER 4.1 (Gene Codes Corp., Ann Arbor, Michigan, USA) was used

to assemble complementary strands and verify base-calling. The *rbcL* sequence was readily aligned by eye in PAUP\* (version 4.0b10; Swofford 2002). Phylogenetic analyses were performed using the maximum parsimony criterion as implemented in PAUP\* (Swofford 2002); a heuristic search was conducted using 1 000 random addition replicates, tree bisection and reconnection (TBR) branch swapping, and saving 10 trees per replicate. Support for each clade was assessed using the bootstrap method (Felsenstein 1985) as implemented in PAUP\* with 1 000 bootstrap replicates, TBR branch swapping, simple addition sequence with MulTrees option in effect (keeping only 10 trees per replicate).

## RESULTS

**Molecular analysis:** the combined *rbcL-matK* matrix comprises 2 356 characters of which 1 057 are constants, 1 299 are variable and 943 (40 %) are potentially parsimony informative. The analysis resulted in only two most parsimonious trees, of 5 310 steps with a consistency index of 0.34 (excluding uninformative sites) and a retention index of 0.62 (Figure 10). The only difference between these two trees does not concern the family Molluginaceae. Most of the genera traditionally included in Molluginaceae, with the exception of *Limeum* (now Limeaceae) and *Corbichonia* (now Lophiocarpaceae), comprise a weakly supported clade (66 % bootstrap support) corresponding to the modern, narrow circumscription of the family (e.g. Haston *et al.* 2007). *Adenogramma natans* is retrieved as sister to the other species of *Adenogramma* that was included (*A. lichtensteiniana*; 100 % bootstrap support), both nested within the family, and sister to a clade comprising genera *Pharnaceum* L., *Mollugo* L. and *Suessenguthiella* Friedr. The phylogenetic analysis thus supports the identification of the newly described species as a member of genus *Adenogramma*.

***Adenogramma natans* J.C.Manning & Goldblatt, sp. nov.**

Herba annua subtilis aquatica caulibus submersis ramis ex nodis superioribus productis, foliis 3 in verticillum dispositis sessilibus ovato-lanceolatis 3–5 × 1.5–2.0 mm planis pallide viridibus marginibus membranaceis angustis, stipulis subulatis minutis ± 0.5 mm longis, floribus 1(2) axillaribus folio mediano oppositis, pedicello 0.5–0.75 mm longo, sepalis (4)5 imbricatis obovate-cucullatis ad basem arcte connatis 1.5–2 × 0.5–1.0 mm, marginibus latis translucetibus, in fructu persistentibus, staminibus (4)5 ad basem connatis filiformibus ± 1 mm longis quam perianthio brevioribus, antheris ± 0.2 mm longis rubro-aurantiacis, ovario oblique compresso-ovoideo ± 1 mm longo ruguloso uniloculari, ovulo solitario lateraliter affixo, fructu oblique pyriformi vel virguliformi ± 2 × 1 mm, acuto nec manifeste rostrato, incluso vel vix ex perianthio exserto, granulato-ruguloso brunneo.

TYPE.—Western Cape, 3319 (Worcester): Bo-Hermon, Elandsberg Farm, seasonal streams, (–AC), 16 Oct. 2009, *Parker sub Manning 3233* (NBG, holo.; MO, K, PRE, iso.).

Delicate aquatic annual with submerged stems and

floating apical leaf clusters. *Stems* filiform-capillary, up to 200 mm long, glabrous, leafy only near tips, often flushed pinkish, becoming dry and wiry later, simple below and branching from upper nodes. *Leaves* in whorls of 3, sessile, ovate-lanceolate, 3–5 × 1.5–2.0 mm, flat, incurved when young, later spreading, apiculate-mucronulate but not aristate, truncate-cordate at base, congested apically and more distant below, median leaf inserted immediately below lateral pair, soft-textured, pale green with narrow membranous margins, persistent but soon decaying. *Stipules* minute, awl-like, ± 0.5 mm long. *Flowers* 1(2), axillary, arising opposite median leaf between lateral leaf pair, shortly pedicellate; pedicel 0.5–0.75 mm long, not elongating in fruit. *Sepals* (4)5, imbricate, obovate-cucullate, connate basally, 1.5–2 × 0.5–1 mm, with narrow, fleshy, green median region ±  $\frac{3}{4}$  total length and broad, translucent membranous margins flushed pink in distal half, remaining tightly furled and persistent in fruit. *Stamens* (4)5, connate at base in ring, filiform, ± 1 mm long, shorter than perianth; anthers ± 0.2 mm long, orange-red. *Ovary* obliquely compressed-ovoid, ± 1 mm long, rugulose, 1-chambered with solitary, laterally attached ovule; style falcate, curving away from placental side, scarcely 0.5 mm long, pink, stigmatic in distal half. *Fruit* obliquely pyriform or comma-shaped, compressed, ± 2 × 1 mm, with narrow marginal keel in distal half, acute but not evidently beaked, included or just protruding from perianth, granular-rugulose, brown, soon deciduous and falling with enveloping perianth. *Flowering time:* July–October. Figure 11.

**Distribution and ecology:** currently known only from Elandsberg Nature Reserve near Bo-Hermon in Western Cape (Figure 12), where it occurs at the foot of the Elandskloof Mtns in shallow, seasonal streams draining the western slopes of the mountains. The streams begin to run during the winter with the onset of the seasonal rains but are entirely dry during the summer months. *Adenogramma natans* co-occurs in some streams with other locally restricted hydrophytes, including *Oxalis natans* (Oxalidaceae) and *Lachenalia bachmannii* (Hyacinthaceae), both of which are endemic to seasonal ponds and streams along the West Coast between Piketberg and the Cape Peninsula (Goldblatt & Manning 2000).

*Adenogramma natans* is evidently cleistogamous, as the flowers remain closed, with the anthers dehiscing directly onto the stigma within the perianth, and all flowers develop ripe nutlets. As such, the species is extremely inconspicuous, which probably explains why it has been overlooked until now. We have not encountered the species in our investigation of vernal pools along the West Coast and it thus appears to be restricted to seasonally flowing streams.

**Diagnosis and relationships:** *Adenogramma natans* is instantly recognizable as the only aquatic species in the genus. The thread-like stems of this annual herb are rooted in the bottom substrate of shallow seasonal streams, with the terminal leafy portions of the stems floating on the surface. Increasing inundation of the stems leads to loss of the submerged foliage so that only the terminal portions of the stems remain leafy. The ovate, pale green, thin-textured leaves are borne in whorls of three at the nodes, with one or two minute, cleistogamous flowers at each of the upper nodes. Plants are unbranched at the base but develop one or two

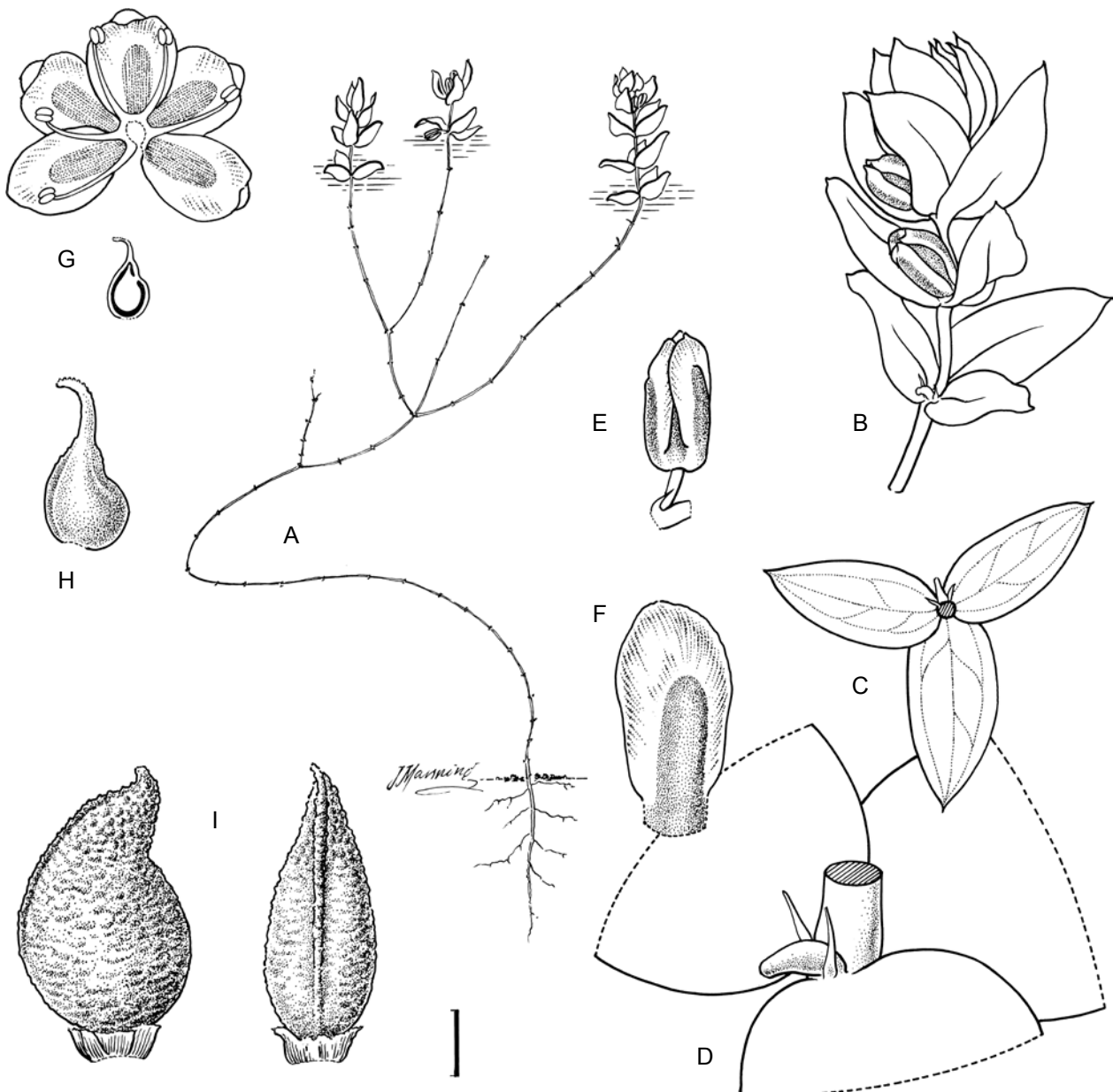


FIGURE 11.—*Adenogramma natans*, Parker sub Manning 3233 (NBG). A, whole plant; B, stem apex; C, single leaf whorl; D, detail of stipules and pedicel insertion; E, single flower at anthesis; F, sepal; G, flattened perianth and 1/5 of pistil; H, pistil, side view; I, nutlet. Scale bar: A, 10 mm; B, C, 1.5 mm; E, G, 1 mm; D, F, H, I, 0.5 mm. Artist: J. Manning.

branches from some of the nodes along the stem. The species is morphologically unusual in the genus in having the leaves in whorls of 3, and in its highly reduced axillary cymes, producing mostly one (sometimes two) flowers at each node. Other species mostly have whorls of 4–6 leaves and typically develop three or more flowers at each node.

The immediate relationships of *Adenogramma natans* are unclear but the species most closely resembles two other annual, herbaceous species, *A. glomerata* (L.f.) Druce and *A. littoralis* Adamson. In all three species the perianth is persistent in fruit, remaining wrapped around the nutlets, which have poorly developed or very short apical beaks. Both *A. glomerata* and *A. littoralis*, however, are truly terrestrial species, favouring seasonally damp sandy flats. *A. natans* most closely approaches *A. littoralis* in its relatively broad, flat, ovate-lanceolate,

acute-mucronulate leaves lacking the characteristic apical arista of all other members of the genus. The leaves of *A. littoralis*, however, are distinctly narrowed towards the base, unlike the truncate-cordate leaves of *A. natans*, and they are borne in whorls of four to six rather than in whorls of three. *A. glomerata* has whorls of mostly six, narrower, linear-lanceolate leaves with an apical arista. In fruit *A. natans* is also more similar to *A. littoralis*, both species developing compressed-pyriform nutlets with acute apices, although the nutlets in *A. littoralis* have a characteristic punctuate-reticulate sculpturing rather than the more irregular granular-rugulose sculpturing of *A. natans*.

Several of the known *Adenogramma* species are evidently rarely collected. *A. littoralis*, for instance, although cited by Adamson (1955) as occurring from Hondeklip Bay to Cape Hangklip, is still unrepresented

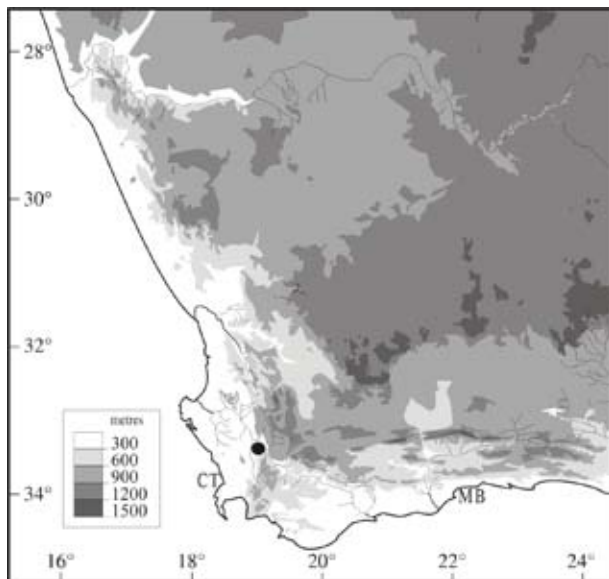


FIGURE 12.—Known distribution of *Adenogramma natans*.

at NBG, and *A. physocalyx* Fenzl. is another poorly known species. The insignificant character of many of the species is likely to be a partial explanation for their poor representation in herbaria but they may also be truly rare.

#### ACKNOWLEDGEMENTS

We are grateful to Elizabeth Parker of Elandsberg Nature Reserve for her ongoing support and Ian Maclachlan for laboratory assistance. Material was collected with a permit from CapeNature.

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MS. received: 2010-02-02.