

X C  
0497  
#34  
1999

# COMPOSITAE

# NEWSLETTER

Number 34

21 December 1999

Scientific Editor: BERTIL NORDENSTAM  
Technical Editor: GUNNEL WIRÉNIUS NOHLIN  
Published and distributed by The Swedish Museum of Natural History,  
Department of Phanerogamic Botany,  
P.O. Box 50007, SE-104 05 Stockholm, Sweden  
(Director: Professor BERTIL NORDENSTAM)

ISSN 0284-8422

### CONTENTS

J. F. PRUSKI: Novelties in <i>Angelphytum</i> and <i>Oyedaea</i> (Compositae: Heliantheae: Ecliptinae) from South America	1
M. S. AYODELE: Studies on the reproductive biology of <i>Vernonia</i> SCHREB. (Asteraceae). V. Fruit production and fruit-set strategies among growth forms	9
M. S. AYODELE: Studies on the reproductive biology of <i>Vernonia</i> SCHREB. (Asteraceae). VI. Seed germination strategies among growth forms	19
B. NORDENSTAM: New combinations in <i>Monticalia</i> (Compositae-Senecioneae) from Colombia	29
M. RAI & D. ACHARYA: Screening of some Asteraceous plants for antimycotic activity	37
M. RAI & D. ACHARYA: Diversity of arbuscular mycorrhizae in naturally growing plants of family Asteraceae in India	44
H. BELTRAN: New combinations in <i>Dendrophorbium</i> and <i>Pentacalia</i> (Senecioneae - Asteraceae) from Peru	50
A. N. SENNIKOV & I. D. ILLARIONOVA: Reclassification of <i>Prenanthes pendula</i> (Asteraceae: Lactuceae)	53
J. KAYODE: Phytosociological investigation of Compositae weeds in abandoned farmlands in Ekiti State, Nigeria	62
<b>New taxa and combinations published in this issue</b>	69



# Novelties in *Angelphytum* and *Oyedaea* (Compositae: Heliantheae: Ecliptinae) from South America

JOHN F. PRUSKI

United States National Herbarium  
Department of Botany, MRC-166  
Smithsonian Institution  
Washington, DC. 20560-0166, U.S.A.

## Abstract

*Oyedaea cuatrecasatii* from Colombia and *Oyedaea neei* from Bolivia are described as new and their relationships are discussed. The new combinations *Angelphytum apense* and *Angelphytum herzogii* are made for species formerly placed in *Zexmenia*.

## Introduction

Ecliptinae LESSING, a subtribe of Compositae: Heliantheae has been delimited by ROBINSON (1981), although most of its genera were more recently treated under the name Verbesininae by KARIS & RYDING (1994), who did not subtribally place *Eclipta*. Generic additions and adjustments of ROBINSON (1984a, 1984b, 1992, and literature cited therein), STROTHER (1991 and literature cited therein), PRUSKI (1996 and literature cited therein), and most of the suggestions in PANERO et al. (1999) are accepted as emendations to the Ecliptinae as defined by ROBINSON (1981). The subtribe Verbesininae treated as a synonym of the Ecliptinae by ROBINSON (1981), STROTHER (1991), and PRUSKI (1996), was recently resurrected by PANERO et al. (1999) and includes only *Verbesina* and three small Mexican and Central American genera. The following novelties in genera with winged fruits are the result of routine identifications of species mostly from Andean South America.

## *Angelphytum*

*Angelphytum* BARROSO was originally described for a disciform species, but the generic concept has been expanded by ROBINSON (1984b) to include several species with winged fruits and fertile ray florets from South America once referred to *Zexmenia* LA LLAVE. *Angelphytum* differs from *Zexmenia* most notably (ROBINSON 1984b) by being largely

xylopodial herbs, less commonly shrubs, by abaxially glanduliferous, strongly recurved (vs. non-glandular, gradually curving) style branches, and by non-constricted (vs. apically constricted) cypselas. *Dimerostemma* CASS. in broad disk corollas, winged fruits, and leafy involucre is similar to *Angelphytum*, but differs in sterile ray florets. The two radiate species transferred here fall within *Angelphytum* as delimited by ROBINSON (1984b). The generic limits of *Angelphytum* are currently being studied by MARTA D. MORAES (UEC), a student of Dra. GRAZIELA BARROSO. As presently circumscribed, *Zexmenia* contains only two species, both Central American (STROTHER 1991). The two new combinations proposed here raises to 16, the number of species in *Angelphytum*.

*Angelphytum apense* (CHODAT) PRUSKI, comb. nov. Basionym: *Aspilia apensis* CHODAT, Bull. Herb. Boiss., Ser. 2, 3: 721. 1903. *Zexmenia apensis* (CHODAT) HASSLER, Repert. Spec. Nov. Regni Veg. 14: 177. 1915. Syntypes: PARAGUAY: Prope Valenzuela (protologue), in regione cursus superioris fluminis Y-acá (label), Feb 1900, HASSLER 7096 (syntype: G n.v., photograph: US!); In regione cursus superioris fluminis Apa, Nov 1901, HASSLER 7731 (syntype: G n.v., photograph: US!).

This species is a shrubby herb with fertile ray florets and occurs in Paraguay and adjacent Mato Grosso do Sul, Brazil. It and the one following are similar by opposite, broad, long-petiolate leaves. *Angelphytum apensis* differs most noticeably from the closely related *A. herzogii* by serrulate to weakly serrate (vs. serrate to dentate) leaves, by cypselas with poorly (vs. well) developed pappus awns, and by smaller capitula commonly with shorter leafy outer phyllaries. Lectotypification is deferred until both syntype collections are examined.

*Angelphytum herzogii* (HASSLER) PRUSKI, comb. nov. Basionym: *Zexmenia herzogii* HASSLER, Repert. Spec. Nov. Regni Veg. 7: 357. 1909. Type: BOLIVIA. Santa Cruz: Halbstrauch im Bergwald von Samaipata (Ostkordillere), ca. 1700 m, Dec 1907, HERZOG 704 (G n.v., HBG?).

This Bolivian shrub with fertile ray florets was known only from the type, until plants matching the protologue were recently rediscovered by MICHAEL NEE (NY) in several localities, these and the type all from Depto. Santa Cruz, Bolivia. Also other material from Depto. Santa Cruz, Bolivia under the name *Zexmenia apensis* is determined here as *Angelphytum herzogii*. The type of *Zexmenia herzogii* was not seen, but a photocopy and a drawing of the flowers by GISELA SANCHO (LP) of the type number in G on loan to ALCIDES SAENZ (LP) has been recently sent to me. Examination of this material and other collections from Bolivia show this taxon to be a species of *Angelphytum*. The specimen of *Zexmenia herzogii* in G is fragmentary and no specimens of this collection were found in Z. Thus, it seems that a full sheet (the holotype?) is elsewhere, perhaps in HBG or as a second sheet in G.

### *Oyedaea*

*Oyedaea* DC., revised by BLAKE (1921) and characterized in part by winged fruits and sterile ray florets, is largely Andean, although at present not known from Ecuador (PRUSKI 1997, H. ROBINSON, pers. comm.). One species (*O. verbesinoides* DC., the type) extends from the Andes eastward into the Venezuelan coastal ranges and north into Central America, and three others are endemic to the Guayana Highland (PRUSKI 1996, 1997). The other Central American species of *Oyedaea* (*O. steyermarii* S.F. BLAKE, *O. mexicana* RZEDOWSKI, *O. ovalifolia* A. GRAY, and *O. lundellii* H. ROB.,) have been transferred to *Lundellianthus* H. ROB. (ROBINSON 1979, STROTHER 1989), *Otopappus* BENTH. (ROBINSON 1979), *Perymeniopsis* H. ROB. (ROBINSON 1978, STROTHER 1991), and *Zyzyxia* STROTHER (STROTHER 1991), respectively. The Brazilian species once placed in *Oyedaea* have been removed to *Dimerostemma* CASS. by ROBINSON (1984a), the latter differing by its leafy involucre and broader disk corollas. *Oyedaea* was recently treated by PRUSKI (1996, 1997) as containing about 16 species (including *O. neei*), this number plus *O. cuatrecasasii* now increases to 17, the number of species in the genus.

*Oyedaea cuatrecasasii* PRUSKI, sp. nov. Type: COLOMBIA. Meta: La Serranía entre los ríos Ariari y Meta, Los Churrubayes, 300 m, 24 Nov 1939, J. CUATRECASAS 7853 (holotype: US-1774514!; isotypes: BC n.v., F n.v.).

*Oyedaeae verbesinoideae* affinis, sed ab ae lamina foliorum basi rotunda vel acuta, capitulisque paucis diversa.

Subshrubs to shrubs 0.8–3 m tall; stems subterete, strigose, the internodes 2–11 cm long, commonly slightly shorter than the subtending leaves. Leaves simple, opposite; petioles 2–8 mm long, strigose; blades elliptic-lanceolate, (2.5) 3.5–9.5 × 1–4.5 cm, chartaceous, eglandular, weakly to moderately triplinerved from well above base, venation strongly reticulate, basally rounded to acute, apically acute to sometimes narrowly so, the margins subentire to serrulate, adaxially green, scabrous, abaxially paler green, strigose, especially on larger veins. Capitulescences corymbiform to rarely monocephalous, somewhat compact and not loose and spreading, terminal or sometimes also axillary from uppermost leafy node, with 1–5 capitula held above the subtending leaves, less commonly overtopped by uppermost leaves; peduncles 0.5–4.5 (6) cm long, densely hispid to strigose. Capitula radiate, 45–119-flowered; involucre campanulate, 8–11 × 8–12 mm; phyllaries 16–19, in 2–3 series, subequal, 8–11 × 2–3.5 mm, rigid, the outer series herbaceous, lanceolate to oblanceolate, strigose, the apex acute to obtuse, the inner series lanceolate to elliptic-lanceolate, strigose or only so apically, scarious at base, the apex acute, herbaceous; receptacles flat, 3–4 mm diam., paleate, the pales conduplicate, lanceolate, to ca. 7.8 × 1 mm, firm, scarious

with a brownish-greenish strigose central nerve extending to near tip, the apex acute. Ray florets 10–12, sterile, lacking styles; corollas yellow, ca. 10–19 × 3 mm, the tube 1.5–2 mm long, glabrous, the limb 8.5–17 × 3–5.6 mm, 8–13-veined with 2 veins larger than the others, glabrous or weakly abaxially puberulent, shortly 2-lobed at apex, apical lobes ca. 0.6 mm long. Disk florets 35–107, bisexual; corollas actinomorphic, yellow, tubular-funnelform, 5.3–6.6 mm long, the tube 1.2–2 mm long, glabrous, the throat 3.3–3.8 mm long, glabrous, the lobes ca. 0.8 mm long, triangular, weakly puberulent; anthers included, 2.5–3 mm long, the thecae black, the apical appendages deltoid, becoming cream-colored, glanduliferous, the connectives black, the filaments ca. 1.5 mm long; style branches ca. 1.5 mm long, papillose, slightly spreading to recurved, with paired stigmatic lines, the apices sterile, lanceolate. Ray ovaries sterile, 2–2.6 mm long, obconic, 1–3-awned, the awns (0.8) 2–3 mm long, subequal to unequal. Disk cypselas (immature, thus wings not formed) compressed, ca. 3 mm, the body brown to black, weakly puberulent, the margins ciliate; pappus stoutly 2-awned, the awns scabridulous, subequal to unequal, 2.6–4 mm long, these about as tall as the involucre and pales, the squamellae between the awns to ca. 0.5 mm long.

Paratypes: COLOMBIA. Meta: Mun. La Macarena, Reserva de La Macarena, 20 km NO en la vía a Conejos, 450 m, 2°15'N, 73°45'W, 7 Aug 1988, R. CALLEJAS & O. MARULANDA 6966 (US!); Mun. La Macarena, 5 km O de La Macarena, vía a Conejos, 410 m, 2°16'N, 73°11'W, 7 Aug 1988, R. CALLEJAS & O. MARULANDA 7052 (US!); San Juan de Arama, valle a la izquierda del río Güejar frente a la parte norte de la Sierra de La Macarena, 500 m, 23 Aug 1950, J.M. IDROBO 467 (US!); Reserva Biológica de la Macarena, río Guayabaro 4 km al suroeste del Refugio, 350 m, 26–28 Oct 1976, R. STARR 74 (US!); 35 km al E de San Martín, en ruta hacia, 16 Jun 1989, F.O. ZULOAGA 4009 (US!).

**Distribution and ecology:** This species is known only from savannas and gallery forests in the region of Sierra de la Macarena, Meta, Colombia. It occurs from 300–500 m in elevation and has been collected in flower in June, August, October and November.

This species is named for its discoverer, the late (ROBINSON et al. 1996) Dr. José CUATRECASAS. DON JOSÉ was the foremost Colombian taxonomist of modern times, and he specialized in Compositae. It is thus fitting and proper that I dedicate this new species to him.

*Oyadea cuatrecasasii* is very similar in leaf shape and size to extra-Guayana Venezuelan *O. maculata* S.F. BLAKE and *O. obovata* S.F. BLAKE, both of which differ from the new species, however, by pinnately veined leaves. In its generally triplinerved leaves

the new species is similar to the northern Andean and Guayanan group including *O. huilensis* CUATR., *O. reticulata* S.F. BLAKE, *O. tepuiana* (V.M. BADILLO) PRUSKI, *O. verbesinoides* DC., and *O. wurdackii* PRUSKI. The new species generally has longer pedunculate capitula and less pubescent ray limbs than the other species. Additionally, *Oyedaea cuatrecasii* differs from *O. verbesinoides* by acute to rounded (vs. attenuate) leaf bases and by few (vs. several) capitula per branch. By leaf shape Colombian *O. huilensis* and *O. reticulata* are similar to *O. verbesinoides* but they differ from it and the new species by leaves abaxially harshly pilose-hispid and by unequal phyllaries. Additionally, *O. huilensis* and *O. reticulata* differ from the new species by larger leaves and by a larger capitulescence with many capitula. *Oyedaea cuatrecasii* differs from *O. wurdackii* by yellow (vs. white) ray corollas and from *O. tepuiana* by larger and longer pedunculate capitula. *Oyedaea scaberrima* (BENTH.) S. F. BLAKE from the Guayana Highland differs from the new species by unequal phyllaries and pinnately veined leaves.

*Oyedaea neei* PRUSKI, sp. nov. Type: BOLIVIA. Santa Cruz: Prov. Florida, 4 km N of center of Samaipata, 18°08'S, 63°52'W, 2000—2100 m, 31 Dec 1992, M. NEE & I. VARGAS C. 43442 (holotype: US-3362069!; isotypes: LPB n.v., NY!, USZ n.v.).  
Fig. 1.

*Oyedaeae bolivianae* affinis, sed ab ea foliis minoribus ellipticis acutis, capitulis paucis, pedunculisque longioribus diversa.

Low shrubs; stems subterete or subhexagonal, strigose, the internodes 0.5–3.5 cm long, usually shorter than the subtending leaves. Leaves simple, opposite; petioles 2–3 mm long, strigose, stout and much broadened at base, those of the same node often connected by a narrow rim; blades elliptic, 1–2.5 × 0.4–1.3 cm, chartaceous, eglanduliferous, triplinerved from well above base, basally cuneate to attenuate, apically acute, the margins serrulate to subentire, adaxially green, scabrous, abaxially pale green, weakly strigose especially on larger veins, nearly glabrescent with age. Capitulescence monocephalous or cymose, open, terminal, of 1 or less commonly 2 capitula held above the subtending leaves; peduncles 1.5–3.5 cm long, strigose. Capitula radiate, ca. 30-flowered; involucre campanulate to hemispherical, 6–7.5 × 9–13 mm; phyllaries ca. 17, in 2–3 series, subequal or weakly graduate, lanceolate to oblanceolate, 6–7.5 × 1.5–3 mm, rigid, broad and scarious at base, the apex broadly acute to obtuse, herbaceous, strigose; receptacles flat, ca. 5 mm diam., paleate, the pales conduplicate, often keeled near the apex, ca. 8.5 mm long, firm, scarious throughout, attenuate. Ray florets ca. 11–13, sterile, lacking styles; corollas yellow, the tube ca. 1.6 mm long, glabrous, the limb ca. 9.5 × 3–4 mm, minutely 2- or 3-lobed at apices, ca. 17-veined with ca. 4 veins larger than the others, smaller veins often anastomosing, abaxially glabrous or weakly puberulent to weakly pilose near tube. Disk florets ca. 15–19,

bisexual; corollas actinomorphic, yellow, tubular-funnelform, 4–4.5 mm long, the tube ca. 1 mm long, glabrous, the throat 2.5–3 mm long, glabrous, the lobes ca. 0.5 mm long, triangular, puberulent-papillose to densely so; anthers slightly to much-exserted, ca. 2.5 mm long, the thecae black, the apical appendages ovate, tan, eglandular; style branches ca. 1 mm long, densely papillose or weakly so, laxly recurved, with paired stigmatic lines, the apices acuminate to attenuate. Ray ovaries sterile, ca. 2.5 mm long, obconic, 3-awned, the awns 1.5–2.5 mm long, subequal to unequal. Disk cypselas compressed, slightly winged, ca. 4 1.5 mm, the body black, puberulent, the wings ciliate, cream colored, brown-spotted; pappus stoutly 2-awned, the awns weakly scabridulous, subequal to unequal, 2–3 mm long, these exerted from the involucre and often reaching to the top of the pales, the squamellae between the awns 7–10, to ca. 0.8 mm long.

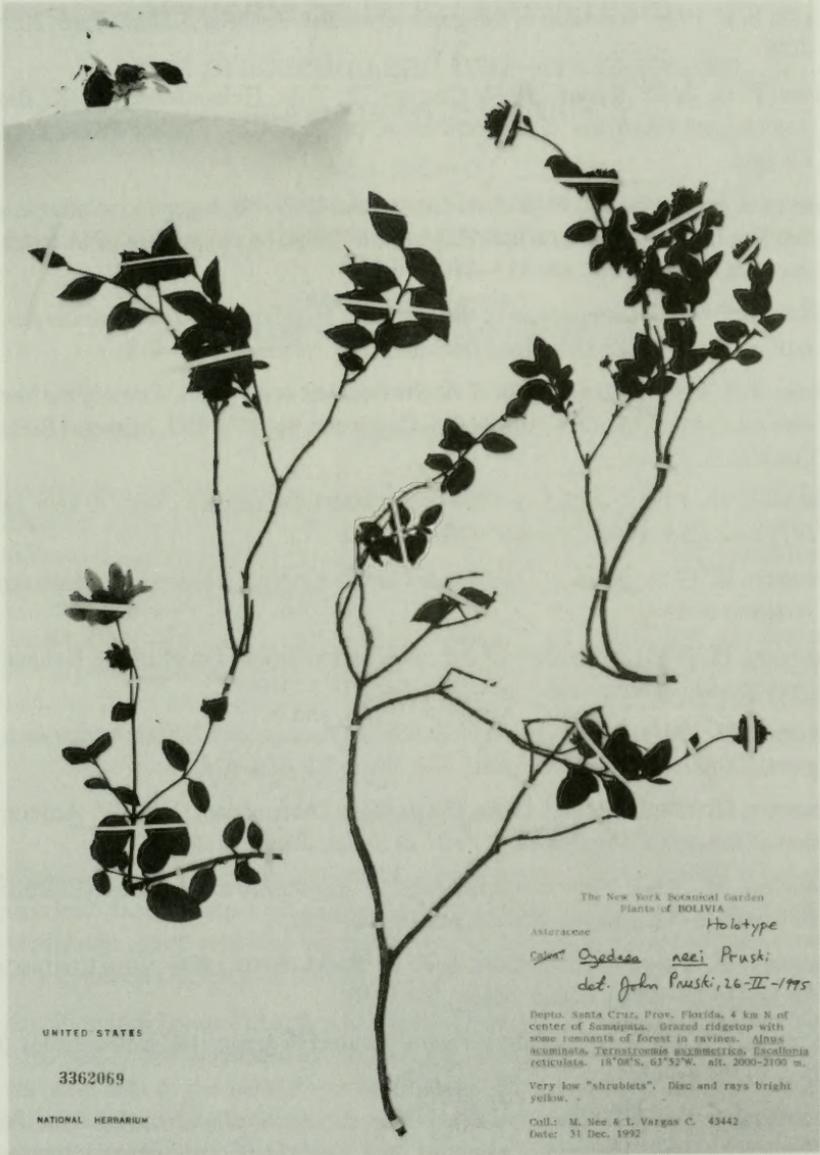
**Distribution and ecology:** This species is known only from the type collection, from grazed ridge tops in the area near Samaipata in Depto. Santa Cruz, Bolivia. It occurs from 2000–2100 m and was collected in flower in December.

I am happy to name this new *Oyedaea* for the collector of the type material, my friend Dr. MICHAEL NEE of the New York Botanical Garden. MICHAEL's fine collections from Depto. Santa Cruz, Bolivia also resulted in the rediscovery of *Zexmenia herzogii*, transferred here to *Angelfhytum*.

By its triplinerved leaves Bolivian *O. neei* is most closely related to *Oyedaea boliviana* BRITTON. However, the new species clearly differs from shrubby arborescent *O. boliviana* by low stature, by very small elliptic (vs. lanceolate) acute (vs. acuminate) leaves, by fewer or solitary capitula with shorter ray limbs, and by longer peduncles. Bolivian *O. bullata* KOSTER is another species with triplinerved leaves, but differs from the two former species by its involucre. The other Andean species of *Oyedaea* from Peru and Bolivia have pinnately veined leaves and are less closely related.

### Acknowledgements

I thank PEDRO ACEVEDO, RUPERT BARNEBY, MICHAEL NEE, DAN NICOLSON, and HAROLD ROBINSON for reviewing this paper; RUPERT BARNEBY for correcting the Latin diagnoses; GISELA SANCHO for her drawing of the type of *Zexmenia herzogii*; GISELA SANCHO and ALCIDES SAENZ for sending me a xerox of the type collection of *Zexmenia herzogii*; and DON HURLBERT, VICTOR KRANTZ, and JOHN STEINER for the photograph of the type of *Oyedaea neei*.



UNITED STATES

3362069

NATIONAL HERBARIUM

The New York Botanical Garden  
Plants of BOLIVIA

Asteraceae Holotype

Collected *Oyedaea neei* Pruski  
det. John Pruski, 26-II-1995

Depto. Santa Cruz, Prov. Florida, 4 km N of center of Samaipata. Grazed ridgetop with some remnants of forest in ravines. *Alnus acuminata*, *Ternstroemia aximmedica*, *Eucodelmia reticulata*. 18°08'S, 63°52'W. alt. 2000-2100 m.

Very low "shrublets". Disc and rays bright yellow.

Coll.: M. Nees & L. Vargas C. 43442  
Date: 31 Dec. 1992

Fig. 1. Photograph of the holotype of *Oyedaea neei* (NEE & VARGAS 43442, US).

## References

- BLAKE, S. F. 1921. Revision of the genus *Oyedaea*. *Contr. U.S. Natl. Herb.* 20: 411–422.
- KARIS, P. O. & O. RYDING 1994. Chapter 22, Tribe Heliantheae. In: K. BREMER *Asteraceae: Cladistics & Classification*, pp. 559–624. Timber Press, Portland, Oregon.
- PANERO, J. L., JANSEN, R. K. & J. A. CLEVINGER 1999. Phylogenetic relationships of subtribe Ecliptinae (Asteraceae: Heliantheae) based on chloroplast DNA restriction site data. *Amer. J. Bot.* 86: 413–427.
- PRUSKI, J. F. 1996. Compositae of the Guayana Highland-XI. *Tuberculocarpus* gen. nov. and some other Ecliptinae (Heliantheae). *Novon* 6: 404–418.
- PRUSKI, J. F. 1997. Asteraceae. In: J. A. STEYERMARK et al. (eds.), *Flora of the Venezuelan Guayana*, Volume 3. Araliaceae–Cactaceae, pp. 177–393. Missouri Botanical Garden, St. Louis.
- ROBINSON, H. 1978. Studies in the Heliantheae (Asteraceae). XIII. A new genus, *Perymeniopsis*. *Phytologia* 40: 495–496.
- ROBINSON, H. 1979. Notes on *Oyedaea* in Central America (Heliantheae: Asteraceae). *Wrightia* 6: 43–45, pl. 82.
- ROBINSON, H. 1981. A revision of the tribal and subtribal limits of the Heliantheae (Asteraceae). *Smithsonian Contr. Bot.* 51: i–iv, 1–102.
- ROBINSON, H. 1984a. Studies in the Heliantheae (Asteraceae). XXXI. Additions to the genus *Dimerostemma*. *Proc. Biol. Soc. Wash.* 97: 618–626.
- ROBINSON, H. 1984b. Studies in the Heliantheae (Asteraceae). XXXIV. Redelimitation of the genus *Angelphytum*. *Proc. Biol. Soc. Wash.* 97: 961–969.
- ROBINSON, H. 1992. New combinations in *Elaphandra* STROTHER (Ecliptinae-Heliantheae-Asteraceae). *Phytologia* 72: 144–151.
- ROBINSON, H., FUNK, V. A., PRUSKI, J. F. & R. M. KING 1996. JOSÉ CUATRECASAS ARUMÍ (1903–1996). *Comp. Newsl.* 29: 1–30.
- STROTHER, J. L. 1989. Expansion of *Lundellianthus* (Compositae: Heliantheae). *Syst. Bot.* 14: 544–548.
- STROTHER, J. L. 1991. Taxonomy of *Complaya*, *Elaphandra*, *Iogeton*, *Jefea*, *Wamalchitamia*, *Wedelia*, *Zexmenia*, and *Zyzyxia* (Compositae-Heliantheae-Ecliptinae). *Syst. Bot. Monogr.* 33: 1–111.

# **Studies on the reproductive biology of *Vernonia* SCHREB. (Asteraceae)**

## **V. Fruit production and fruit-set strategies among growth forms**

**M. S. AYODELE**  
**Biological Sciences Department**  
**University of Agriculture**  
**P.M.B. 2240**  
**Abeokuta, Nigeria**  
**e-mail: segmuy@unaab.edu.ng**

### **Abstract**

Fruit production performance was found associated with a number of vegetative and reproductive characteristics of *Vernonia* plants. A prolific production of small size achenes was recorded on individual plant basis. This cuts across different growth forms, but the values were higher in shrubs than in herbaceous species.

The incidence of good quality fruits (high fruit-set % per capitulum) was recorded consistently among the herbs. Habitats with moisture stress encouraged the production of small size fruits which were characteristic of the herbs. These traits were noted as those of weedy plant colonizers.

### **Introduction**

Fruit/Seed production is important, because according to JANZEN (1969), it provides the plant with the prominent functions of escape, genetic recombination and dispersal for colonization. Each seed is an independent colonizer and seeds are adapted in many ways for dispersal (INGROUILLE 1992).

The condition and exposure of a plant during the flowering and fruiting phase determines much the quality of fruits produced and the seeds set. In fact, BURTT (1975) emphasized that the demands of the flowering and fruiting phase of a plant interact. AYODELE (1994b) highlighted the protectoral role of some floral parts in the flowering and fruiting phases of the plant life.

The call for more studies, earlier solicited for by BURTT (1975) on the co-evolution of these two phases, has remained very relevant even now for a deeper understanding of the reproductive strategies in the array of plants dotting our terrain.

The genus *Vernonia* is widely reported for its versatility with respect to its morphological characteristics, ecological distribution and extensive speciation (FAUST 1972, JONES 1979, and AYODELE 1995). This recommends the genus for a comparative observation of the trends in fruit production and fruit-set quality among its species and within the different growth forms.

AYODELE (1997) identified five of such growth forms in Nigeria, among the 15 species collected from different ecological zones. These were: - Erect tall woody tree, Erect woody shrub, Straggling woody shrub, Erect annual herb and Erect perennial herb.

The objective of this paper is to put on record the fruit production potentials of some investigated species of *Vernonia* in Nigeria. The quality of fruits produced by the different species is also being elucidated with a view to identifying any plant survival strategies associated with fruit production and quality of fruits in *Vernonia*.

## Materials and Methods

### Estimation of Fruit Production Performance in *Vernonia* Plants

An overall estimate of fruit production per plant for each of the species investigated, was made by collecting data on:

- a. the number of branches per plant
- b. the number of terminal capitulum-clusters per branch (ex canopy view) or the number of inflorescences per branch, for some species
- c. the number of capitula per terminal cluster [or the number of 'spikes' (AYODELE 1994a) per inflorescence branch for some species]
- d. the number of set (filled) fruits per capitulum.

The data were collected from plants with luxurious growth and deliberate pruning or accidental breakage of any of the branches had not tampered with. Calculated values for fruit production indices in species of *Vernonia* were obtained from the multiplication of the values for a-d above i.e.  $(a) \times (b) \times (c) \times (d)$ .

### **Assessment of Fruit Quality in Species of *Vernonia***

'Seed-lots' in batches or in single heads (depending on the mode of harvest) were inspected for mature fruits filled with embryo. *Vernonia* fruits (achenes) were classified into two groups for the purpose of this study namely: -the large (2.5–5.5 mm length) and small (0.5–2.5 mm) fruit types (AYODELE 1987).

The large fruit type was assessed by visual/physical observation of fruit plumpness. Each fruit was held between the thumb and the first finger, or by means of a pair of forceps and pressed to feel whether fruits were filled or empty. The smaller fruit type was observed in batches under a dissecting microscope by means of a pair of forceps.

Filled and empty/shriveled fruits were separated and counted by means of a tally counter.

### **Analysis of Data**

The mean of the Fruit Production Potential Index obtained for each plant among the species was estimated. Any significant differences among the species in fruit production were analyzed by Duncan Multiple Range Test. The fruit set values for each of the species were obtained as the percentage of all the fruits examined which were filled with embryos. Fruits observed were obtained from at least 25 randomly selected ripe capitula per species.

## **Observations and Results**

### **Achenes Production Potentials in Some Species of *Vernonia***

The calculated values of achenes produced on individual plant basis for each of the species investigated, were derived from a combination of floral attributes and vegetative traits (Table 2) associated with flower production in the plants. The values can be separated into four distinct but overlapping groups (Table 1) on the basis of the significant differences obtained (Table 3).

While group A was clearly distinct from the other three groups, the difference between group B and C, group B and D, and group C and D, were not statistically significant ( $P=0.0\%$  level). The shrubby and arborescent species were clearly the most prolific fruit (achenes) producers on individual plant basis (Table 1). The herbaceous species were relatively poor in achene production. They were mainly the constituents of group D (i.e. the fourth group) with the lower range of achenes production index values.

### Quality Evaluation of Achenes Produced by Some Species of *Vernonia*

Achenes that contained embryos were considered "filled" or "set" (i.e. of good quality). These were hard to touch and plump. The bad achenes were shriveled and chaffy and contained no embryos when dissected. Many of the herbaceous species were observed to be among the species producing good quality (i.e. filled) achenes. The special observation recorded on the herb *V. galamensis* was that the incidence of well-set achenes was higher in plants growing under water stress condition.

The general trend on achene quality was that species producing the small size fruits recorded a higher incidence of set fruits. This observation however, cuts across the different growth forms especial as in *V. biafrae*, a shrub, and *V. migeodi*, an herb (Table1).

The values for *V. colorata*, *V. nestor*, *V. purpurea* and *V. glaberrima* were discountenanced because their achene production rate could not be monitored continuously. These species were difficult to raise in the garden and were mostly restricted to their habitats. The results obtained from the field and the garden for the other species were however, observed to be compatible.

**Table 1. Mean Fruit Production Potential Index & % Fruit-Set in *Vernonia***

DMRT*	Species	Mean	% Fruit-Set		Growth Form
			No. Examined	% Fruit-Set	
A	<i>V. biafrae</i>	291,538	720	100	Straggling shrub
B	<i>V. stenostegia</i>	44,456	3,300	79.6	Erect Shrub
B	<i>V. amygdalina</i>	29,491	1,280	62.1	Erect Shrub /Arborescent+
B	<i>V. colorata</i>	19,554	-	-	Arborescent
C	<i>V. conferta</i>	17,011	1,125	42.0	Arborescent
	<i>V. perrottetii</i>	6,822	1,400	97.1	Erect Herb
	<i>V. tenoreana</i>	4,583	4,050	92.9	Erect Shrub
	<i>V. migeodi</i>	3,834	3,835	100	Erect Herb
	<i>V. cinerea</i>	3,829	1,575	95.2	Erect Herb
D	<i>V. galamensis</i>	3,601	2,870	67.1	Erect Herb
	<i>V. ambigua</i>	1,406	790	97.9	Erect Herb
	<i>V. kotschyana</i>	1,176	1,167	30.9	Erect Shrub
	<i>V. nestor</i>	607	-	-	Erect Herb
	<i>V. purpurea</i>	592	-	-	Erect Herb
	<i>V. glaberrima</i>	571	-	-	Erect Shrub

\* Duncan Multiple Range Test

+ Depending on age of plant &amp; level of growth disturbance

**Table 2. Mean Values of Vegetative/Reproductive Attributes Associated with Fruit Production in *Vernonia***

Species	Mean # Stem branches/plant	Mean # Terminal capitula clusters	Mean # Capitula/terminal cluster	Mean # Fruit-set per capitulum
<i>V. biafrae</i>	4.2800	5.200	468.760	34.0 (34.9)*
<i>V. stenostegia</i>	9.4000	17.1600	2.400	45.0 (131.6)
<i>V. amygdalina</i>	5.0000	21.5200	21.440	4.0 (13.88)
<i>V. colorata</i>	4.3200	18.3200	15.240	- (19.2)
<i>V. conferta</i>	4.3200	24.1600	15.240	3.0 (13.32)
<i>V. perrottetii</i>	5.1500	14.1200	1.520	35.0 (38.0)
<i>V. tenoreana</i>	4.4000	6.0000	1.360	128.0 (135.44)
<i>V. migeodi</i>	4.5600	4.4000	7.240	29.0 (29.4)
<i>V. cinerea</i>	4.4400	5.5200	7.400	20.0 (21.8)
<i>V. galamensis</i>	5.0000	6.4000	1.880	55.0 (81.0)
<i>V. ambigua</i>	5.5200	4.5600	2.240	38.0 (39.2)
<i>V. kotschyana</i>	2.0800	1.7200	2.720	42 (146.2)
<i>V. nestor</i>	1.0000	7.3200	5.520	- (17.9)
<i>V. purpurea</i>	1.0000	3.3600	1.800	- (98.2)
<i>V. glaberrima</i>	8.0400	6.4000	3.920	- (4.1)

\*Numbers in parenthesis are values for # Florets/Capitula

**Table 3. Analysis of Variance (Anova) in Fruit Production/Species of *Vernonia***

Character	Source of Variation	Sums of squares (SS)	Degree of Freedom (DF)	Mean Square (MS)	F-Value
Estimated Fruit Production/Species	Model	1925441323703.59	12	128362754913.59	63.11*
	Error	781071404367.60	384	2034040115.54	
	Corrected Total	2706512728071.19	399		

\* Significant at 0.05 % level.

### Discussion

#### Type of Fruits and Factors Associated with Fruit Production Performance in *Vernonia*

The type of fruits produced in *Vernonia* is achenes. Fruit production performance in the species investigated was observed to be associated with a number of vegetative and reproductive characteristics of the plants. These include the type of inflorescence; the incidence of stem branching and number of such branches in a plant; the number of terminal capitulum clusters on a plant or the number of inflorescence branches and the number of capitula per such clusters or inflorescence branches.

AYODELE (1994a) reported eight distinct types of capitula arrangement found among plants of 15 species of *Vernonia*. The various arrangements of capitula on *Vernonia* plants were reported to enhance terminally clustered small-size capitula as found in the arborescent species, while clustering of capitula was not too conspicuous in the big-size capitula-producing herbs or shrubs. The variation in the pattern of inflorescence was also reported to be associated with the type of habitat.

The herbaceous species of *Vernonia* growing in humid habitats were observed to have more stem branching than similar species growing in drier habitats. Flowering and fruit development were slower during the rainy season. On the other hand, capitula produced during the dry season or under moisture stress condition were maturing faster. These had a greater value of good quality fruit production index in the herbs. The faster maturing capitula of shrubs and arborescent species usually contained fewer well-filled fruits. This was particularly true of those shrubs which have the big size fruits e.g. *V. kotschyana* and to some extent *V. stenostegia*.

Hastened fruit development and ripening due to the onset of the dry season usually resulted in the production of many malformed fruits in the shrubby species with the big-size fruits. The fruits of *V. galamensis*, an herb, ranged in size among those of the shrubs with big fruits. However, fruits produced by plants of this species when under moisture stress condition were usually smaller but with a higher incidence of well-set fruits.

In fact, the quality of fruits especially in *V. galamensis*, was observed to be associated with the stage of growth of the plant. The early-developed capitula had few and well formed fruits. The plants within a community had more set fruits in the capitula than those in the periphery. The issue about the centrifugal development of heads (i.e. capitula) on a plant and the centripetal development within a capitulum earlier reported in *Vernonia* by JONES (1977) becomes very helpful in explaining some of these observations. The capitula more centrally positioned on a plant in a community had a better fruit-set quality. These observations also suggest outcrossing characteristics in most *Vernonia* species (AYODELE 1977).

### **The Relationship Between Fruit Size and Quantity/Quality of Fruits Produced**

The small fruit-size achenes are produced in large quantities on individual plant basis. This is evident in the performance of *V. biafrae*, a straggling shrub which ranked topmost in both fruit production capacity and the quality of fruits produced (Table 1). A higher incidence of well-set fruits was also noted in species producing small fruits especially among the shrubby and arborescent species like *V. amygdalina*, *V. conferta* and *V. stenostegia*. The quantity of such fruits produced on individual plant basis by the herbaceous species was lower, as evident in *V. perrottetii*, the best performer among the herbs (Table 1).

It is however pertinent to mention that the attribute of small fruit-size coupled with a high fruit-set % cuts across different growth forms (Table 1). Obviously small fruits (or seeds) require less metabolic energy for their production and hence less food is stored in them (SALISBURY 1942). Generally, a high fruit-set % seems advantageous for plants to survive and produce in moisture-distress situation. This is a property of weedy colonizers (BAKER 1965). The observations on *V. stenostegia* and *V. galamensis* are two interesting cases in this regard.

The former, a shrub, is domicile in the dry savanna zone while the latter can thrive in both dry and humid vegetations. However, *V. stenostegia* in its natural environment produces smaller achenes and a higher fruit-set % than when raised in the humid zone. *Vernonia galamensis* displays a more luxuriant vegetative growth in humid habitats but a higher fruit-set % is only recorded among its plants in the dry savanna.

Clearly the shrubby and arborescent species are the most prolific fruit producers on individual plant basis. This was observed as enhanced by the branching attributes of the plant stem and the inflorescence upon which numerous capitula are borne ((Table 2). It is usually presumptuous of reproduction biologists to associate small seed size with a higher number of seed productions in herbaceous species (SALISBURY 1942, JANZEN 1969 and HILL 1977). The observation in this study cannot ascribe such an attribute to the herbs at least on individual plant basis. The usually dense populations of the herbs resulting from the highly efficient though relatively few seeds, seem to overshadow the fruit production potentials of the other plant growth forms.

### References

- AYODELE, M. S. 1987. *Cytological and Morphological Studies on some species of Vernonia SCHREB. in Nigeria*. M. Sc. Thesis Obafemi Awolowo University, Ile-Ife, Nigeria. 98 pp.
- AYODELE, M. S. 1994a. Studies on the reproductive biology of *Vernonia* SCHREB. (Asteraceae). I. Types of inflorescence among different habits. *Comp. Newsl.* 25: 15–23.
- AYODELE, M. S. 1994b. Studies on the reproductive biology of *Vernonia* SCHREB. (Asteraceae). II. Flowering and post-pollination developments in the capitulum. *Comp. Newsl.* 25: 24–30.
- AYODELE, M. S. 1995. Studies on the reproductive biology of *Vernonia* SCHREB. (Asteraceae). III. Floret shapes/number, pappus types and surface structure among different growth habits. *Comp. Newsl.* 26: 26–39.
- AYODELE, M. S. 1997. Studies on the reproductive biology of *Vernonia* SCHREB. (Asteraceae). IV. Seasonal flowering sequence among plant forms of *Vernonia* in Nigeria. *Comp. Newsl.* 30: 5–14.
- BAKER, H. G. 1965. Characteristics and modes of origin of weeds. In: BAKER, H. G. & G. L. STEBBINS (eds.), *Genetics of colonising species*, pp. 147-168. Academic Press, New York.
- BURTT, B. L. 1975. Patterns of structural change in the flowering plants. *Trans. Bot. Soc. Edinb.* 42: 133–142.
- FAUST, W. Z. 1972. A biosystematic study of the Interiores species group of the genus *Vernonia* (Compositae). *Brittonia* 24: 363-378.
- INGROUILLE, M. 1992. *The study of diversity and evolution of land plants* I: 3–10. Chapman & Hall, London, UK.

- JANZEN, D. H. 1969. Seed-eaters versus seed size, number, toxicity and dispersal. *Evolution* 23: 1-27.
- JONES, S. B. JNR. 1977. Vernonieae - Systematic review. In: HEYWOOD, V. H., HARBORNE, J. B. & B. L. TURNER (eds.), *The Biology and Chemistry of the Compositae*, pp. 503-521. Academic Press, London & New York. Jones,
- JONES, S. B. JNR. 1979. Synopsis and pollen morphology of *Vernonia* (Compositae: Vernonieae) in the New World. *Rhodora* 81: 425-447.
- SALISBURY, E. J. 1942. *The reproductive capacity of plants. Studies in quantitative Biology*. G. Bell & Sons Ltd. 244 pp.

**Studies on the reproductive biology of  
*Vernonia* SCHREB. (Asteraceae)  
VI. Seed germination strategies among  
growth forms**

**M.S. AYODELE  
Biological Sciences Department  
University of Agriculture  
P.M.B. 2240  
Abeokuta, Nigeria  
e-mail: segmuy@unaab.edu.ng**

**Abstract**

Four germination-related components of fitness and three general trends in the relationship between fruit-set attribute and seed germination performance were recorded among the species of *Vernonia* investigated.

Adaptations for safety and variable dormancy of propagules were identified as important germination strategies in *Vernonia*. The discrepancy between the observed high seed production potentials and scanty populations of some species in the wild is accounted for largely by seed wastage arising from the non-availability of suitable germination sites.

**Introduction**

The ecological versatility of *Vernonia* has been widely reported and the genus conclusively described as capable of occupying varying vegetation zones, by many workers (FAUST 1972, JONES 1979 and AYODELE 1995, to mention a few). AYODELE (1997) reported that some of the species of *Vernonia* in Nigeria also display some considerable degree of ecological preferences to which populations of such species are commonly restricted. These observations seem to confirm the tremendous diversity that has occurred during the evolution of the genus (JONES 1979).

The pollen efficiency and the high rate of seed (achenes) production among some species of the genus have also been reported (AYODELE 1999). These various attributes of *Vernonia* presuppose high populations, especially of the prolific seed-producing

taxa in their various domains compared with other plants in the community. The absence of such high populations calls for an investigation on the efficiency or otherwise, of the seed germination performance among the species of the genus.

There are reports on plant seed-production capabilities in relation to seed longevity attribute as well as the plant strategy towards seed wastage due to predators on one hand, and the immediate lack of appropriate environment/substrate for germination, on the other hand (SALISBURY 1942, JANZEN 1969). Another possible motive for high seed production in plants has been expressed as a major component attribute of an aggressive colonizing species (e.g., JANZEN 1969). None of the plants on which these conclusions were drawn is in the genus *Vernonia*.

A couple of reports noted the prevalence of initial seed germination and seedling growth rate problems in some species of *Vernonia* (BERRY & LESSMAN 1969 and PERDUE 1986 & 1987). SALISBURY (1961) had earlier identified the variability in the mode of seed germination even if conditions are favourable. Generally, the recorded observations on seed germination behaviour from the point of view of the plant strategy for survival are rather meagre except for some economic plants. Even for such, they are liable to be based upon common strains in the particular areas, although strains with other physiological features may occur elsewhere. More emphasis is therefore required on seed germination studies to reflect some continuity in biological research in this area.

The objective of this paper is to document the seed germination performance studies on some species of *Vernonia* in Nigeria. This is with a view to providing a clearer understanding of the various strategies involved in the observed high seed production and fewer plant populations among different growth forms of *Vernonia* species.

## Materials and Methods

### Field Collection and Processing of Fruit (Achenes) Specimens

Ripe capitula were harvested from field plant populations and bagged in sachets labelled according to their accession numbers. The fruits (achenes) were separated from each capitulum by manual threshing. This also detached the pappi from the achenes. The threshed material was then winnowed to separate the seeds from the chaffs of involucre bracts and detached pappi.

### Germination Trials on *Vernonia* Achenes

Three disposable plastic Petri dishes were cleaned and the inside lined with moist filter paper. Twenty-five to fifty seeds (the higher number of seeds being for the small-

sized seeds) were put on the moist filter paper in each Petri dish. This was done for each of the species investigated. The dishes were kept on laboratory benches at room temperature for germination. The filter paper was kept moist (but not wet) regularly by adding more distilled water using a wash bottle.

Germination observations were recorded daily for up to 30 days. The experiment was repeated three times at different intervals of the study. The cumulative percentage germination values for each species were estimated at 7, 14, 21 and 28 days after sowing respectively. A pre-trial sowing was conducted to identify any species that may require any pre-treatment aid for germination to occur. Such pre-treatment included soaking achenes in water; soaking in 10 ml concentrated sulphuric acid in a staining block for 3-10 min., depending on seed size and seed coat toughness. Seeds soaked in acid were thereafter rinsed in three changes of tap water contained in a staining block.

Seeds were also pre-treated for germination by first soaking in water for 1-3 days, followed by embryo excision through manual removal of the outer coat by means of a mounted needle. Twelve of the 16 species collected were used for the germination trials. Those species, whose seeds were not sufficiently available or could not be raised in the experimental garden, were not included in the trials.

## Results

### Features of the Ripe *Vernonia* Capitulum

A ripe capitulum is usually dry and crowned with the characteristic pappus of the species. This gives the capitulum the appearance of a full bloom flower. The colour of the pappus varied among the species from cream to black, with shades of the two extremes.

### Germination Performance at 7 Days after Sowing

*Vernonia cinerea* seeds were quick in germination (2-4 days after sowing) and had the highest germination performance (69.9 %). This was followed by *V. amygdalina* (45.6 %) and *V. perrottetii* (42.3 %) respectively (Fig. 1). The germination of the seeds of *V. ambigua* and *V. migeodi* did not commence during this period. Seed germination in *V. stenostegia* and *V. conferta* was considerably poor at 6.0 % and 2.7 %, respectively.

### Germination Performance at 14 Days after Sowing

*Vernonia cinerea* and *V. perrottetii* maintained an increase in the cumulative number of seeds which germinated. However, while the increase in *V. perrottetii* was steady,

there was a slight fall in the rate of increase of germination performance in *V. cinerea* (Fig. 1.). *Vernonia tenoreana* showed a conspicuously sharp increase in the number of seeds which germinated between 7 and 14 days; rising from 10.8 % at 7 days after sowing to 63.0 % at 14 days after sowing (Fig. 1.).

There was a steep fall in the rate of increase in germination observed in *V. amygdalina*. The germination performance in *V. perrottetii* (76.0 %) was now considerably higher than that in *V. amygdalina* (51.3 %), a significant departure from the occurrence between the two species during the first seven days after sowing. The performance in *V. stenostegia* and *V. conferta* remained poor, even though there was a steady rise in the number of seeds that germinated (Fig. 1). The germination of the seeds of *V. ambigua* and *V. migeodi* did not commence until after 7 days with an initial poor value of 3.3 % for *V. ambigua*, despite the relative lateness in germination commencement. This occurrence was repeated in all the trials conducted.

### Germination Performance at 21 Days after Sowing

*Vernonia cinerea* remained at its top-ranking germination performance during the period of the trial. There was a continuous and steady increase in the number of seeds which germinated between 14 and 21 days and later. In some trials 100 % germination was attained just before or by 21 days. Even in those trials with less than 100 % at 21 days, there was no further germination of such seeds thereafter.

For *V. perrottetii*, *V. biafrae*, *V. migeodi* and *V. conferta*, seeds that were viable did germinate by or just after 14 days. There was a sudden upsurge in the number of *V. amygdalina* seeds germinating between 14 and 21 days after sowing (Fig. 1). This case of a sudden upsurge also occurred and in a greater dimension, in the germination of *V. kotschyana* seeds. In fact, the sudden increase was so much as to give this species the second best performance (89 %) next to *V. cinerea* (95 %) in the overall germination performance. The sudden increase in the number of *V. tenoreana* seeds germinating between 7 and 14 days slowed down in tempo after 14 days (Fig. 1). The poor germination rate of the seeds of *V. migeodi*, *V. stenostegia* and *V. conferta* remained so throughout the experiment.

## Discussion

### A summary of Observed Seed Germination Trend in *Vernonia*

Generally, varying modes of seed germination were encountered, cutting across growth forms and associated with seed-size type in species of *Vernonia* studied. There were

those seeds that commenced germination almost as soon as a favourable environment for germination prevailed, e.g. *V. cinerea* and *V. perrottetii*. For such species, germination progressed steadily until all the viable seeds had germinated.

For some species, germination was characterized by an initial flush within the first seven days or thereabout of exposure to favourable conditions. This was soon followed by a drop, after which another flush of germinating seeds occurred, e.g. *V. amygdalina*. This multi-peaked germination performance continued until all the viable seeds in the seedlot had germinated. The next mode of germination was that characterized by an initial slow rate lasting up to 7 days after sowing. A flush of germination then followed and was steadily maintained until all the viable seeds had germinated, e.g. *V. tenoreana* and *V. kotschyana*. Other species manifested poor germination performances in form of late commencement of germination and subsequent relatively poorer rate and number of seed germinated. *Vernonia ambigua*, *V. migeodi*, *V. conferta* and *V. stenostegia* belong to this group (Fig. 1).

This explains the poor colonization ability of these species, especially *V. ambigua* and *V. stenostegia*. They were also the species found restricted only to their natural habitats – *V. conferta* in the rain forest; *V. ambigua* and *V. stenostegia* in the savanna and usually in sparse populations.

### **Fruit-set Attribute and Germination Performance**

There were three general trends in the relationship between fruit-set attributes and the overall seed germination performance observed in the species investigated. Some species noted for the production of well-set fruits, had poor germination performance recorded for the fruits e.g. *V. stenostegia*. A seedlot of this species with fruit-set value of 76.9 % had only 17.6 % seed germination performance. Other notable species in this regard were *V. migeodi* (100 % & 14 %), *V. galamensis* var. *ethiopica* (85.3 % & 49.2 %); the values in parenthesis being for fruit-set and seed germination respectively. When some non-germinating, but plump seeds of *V. stenostegia* were dissected to excise the embryos, a corky or woody substance was found instead of a fleshy embryo. The cause and the degree of the incidence of corky tissue in place of an embryo in some seeds of *V. stenostegia* deserve some investigation.

The second trend was that some species had poor fruit-set attributes, but efficient germination of the few quality seeds produced e.g. *V. kotschyana* (30.9 % & 89.0 %). The third trend was that in some species fruit-set attribute and germination performance were both good, e.g. *V. cinerea* (95.2 & 95.0 %). *Vernonia cinerea* is a fast colonizer of open fields and lawns.

### Adaptive Significance of Reproductive Strategies Related to Germination

The species of *Vernonia* which produce small-sized fruits were observed to have a high incidence of well-set fruits. This cuts across growth forms e.g. *V. cinerea*, *V. migeodi*, *V. biafrae* and *V. amygdalina*. *V. galamensis* from habitats with different moisture status demonstrated in their fruit-set and fruit-size attributes relationship, the emphasis on the balance between the advantage of more (but smaller) seeds in open habitats and less (but larger) seeds with greater competitive capacity in the closer communities of the rain forest. The difference in germination performance of the two *V. galamensis* materials (Fig. 1) corroborates the report that the Nigerian accession was a better performer in seed germination and seedling development than the material from Kenya (PERDUE, pers. comm.).

The four germination-related components of fitness observed among the species of *Vernonia* are adaptations for ensuring the safety, longevity and effective utilization of propagules. These are all relevant to the individual species seed-production capabilities and the efficiency of germination of its seeds. The immediate high peak germination in *V. cinerea* is good for the species that produce small fruits. Such fruits have highly limited food stored in them (SALISBURY 1942). This stored food must be utilized as soon as the seeds find a favourable environment. Finding a favourable environment is an important determinant of the germination performance of the small-seed-size species of *Vernonia*. This will explain the lack of relatively large populations of the prolific small-seed-species like *V. biafrae* and *V. conferta* in the natural habitats, whereas, *V. biafrae* seedlings were observed to be common pollutants ('weeds') in other pots in the screen house. This conclusively indicates that the small-seed-size species do not readily find suitable environment for germination in the wild and hence loose their viability.

The intermittent burst or spurts in the germination of *V. amygdalina* seeds are favourable adaptation for such a widely dispersed species in an environmental mosaic. *Vernonia amygdalina* is a cultivated species that is effectively raised from both seeds and stem cuttings. The deductions from these observed strategies related to germination show that the herbaceous weedy colonizers among the species of *Vernonia*, combine the good qualities of a high fruit-set value with an effective germination performance as in *V. cinerea*, *V. perrottetii* and to some extent *V. galamensis*.

A combination of the strategy of seed dispersal (AYODELE 1995) and germination in *Vernonia* serve more of a colonization function than escape from pests. There were no significant or noticeable insect pest or any plant diseases of the seeds (fruits) observed during this study. The bitter chemicals in *Vernonia* plant parts (including the fruits) that BURTT (1977) reported, would not make the fruits vulnerable to predators.

The larger seeds are dispersed close to the parent plants and could remain in the soil pending an opening in the community before germinating as in *V. tenoreana*. The small size seeds are dispersed far from the parent plants to suitable sites for colonization. Such favourable sites may, however, not be readily available for the longevity of the seeds. Even where the seeds germinate, not many of the seedlings reach adult stage because of the low rate of seed germination or growth of seedlings earlier mentioned. Other plants in the community soon overtake them and they get smothered.

The survival strategy against this problem in *V. migeodi* is a pertinent example. This species usually takes off either from rootstocks or through seed germination as soon as the rains commence after the dry season. The other plants in the community, especially the tall grasses, are usually in an active vegetative growth stage when *V. migeodi* would have started flowering and fruiting. By so doing the species is able to overcome the competition from other plants in its community and so ensure the continuity of existence and spread of the species to other opened-up areas. This might explain the readily observed preponderance of the species on the roadsides of newly constructed highways, particularly those highways adjourning previously identified habitat locations.

### References

- AYODELE, M. S. 1995. Studies on the reproductive biology of *Vernonia* SCHREB. (Asteraceae). III. Floret shapes/number, pappus types and surface structure among different growth habits. *Comp. Newsl.* 26: 5–14.
- AYODELE, M. S. 1997. Studies on the reproductive biology of *Vernonia* SCHREB. (Asteraceae). IV. Seasonal flowering sequence among plant forms of *Vernonia* in Nigeria. *Comp. Newsl.* 30: 5–14.
- AYODELE, M. S. 1999. Studies on the reproductive biology of *Vernonia* SCHREB. (Asteraceae). V. Fruit production and fruit-set strategies among growth forms. *Comp. Newsl.* 34: 9–18.
- BERRY, C. D. & K. J. LESSMAN 1969. Dehulling and seed germination in *Vernonia anthelminitica* (L.) WILLD. *Crop Science* 9: 247–248.
- BURTT, B. L. 1977. Aspects of diversification in the capitulum. In: HEYWOOD, V. H., HARBORNE, J. B. & B. L. TURNER (eds.), *The Biology and Chemistry of the Compositae*, pp. 41–59. Academic Press, London & New York.
- FAUST, W. Z. 1972. A biosystematic study of the Interiores species group of genus *Vernonia* (Compositae). *Brittonia* 24: 363–378.
- JANZEN, D. H. 1969. Seed-eaters versus seed size, number, toxicity and dispersal. *Evolution*: 23: 1–27.
- JONES, S. B. JR. 1979. Synopsis and pollen morphology of *Vernonia* (Compositae: Vernonieae) in the New World. *Rhodora* 81: 425–447.
- PERDUE, R. E. JR. 1986. *Vernonia gamagensis* Foreign Travel Report: Ethiopia, Zimbabwe and Kenya. June 18 - July 28, 1986. USDA Agricultural Research Services. Plant Genetics and Germplasm Institute, Maryland, USA.
- PERDUE, R. E. JR. 1987. Response of *Vernonia gamagensis* to poorly drained soils or excessive precipitation. *Update Report Ref.* 081. USDA Germplasm Introduction and Evaluation Laboratory, Beltsville, Maryland, USA. 2 pp.
- SALISBURY, E. 1942. *The reproductive capacity of plants. Studies in quantitative Biology.* G. Bell & Sons Ltd. London. 244 pp.
- SALISBURY, E. 1961. *Weeds and aliens.* St. James Place, London. 384 pp.

**Table 1. Key to nomenclatural abbreviations in Fig. 1.**

S/N	Abbreviation	Full name	Growth form
1.	conf	<i>Vernonia conferta</i>	Tree
2.	amyg	<i>V. amygdalina</i>	Tree/Shrub*
3.	teno	<i>V. tenoreana</i>	Shrub
4.	steno	<i>V. stenostegia</i>	Shrub
5.	kots	<i>V. kotschyana</i>	Shrub
6.	biaf	<i>V. biafrae</i>	Shrub
7.	mige	<i>V. migeodi</i>	Shrub
8.	cine	<i>V. cinerea</i>	Herb
9.	gala	<i>V. galamensis</i> **	Herb
10.	ambi	<i>V. ambigua</i>	Herb
11.	perr	<i>V. perrottetii</i>	Herb
12.	ethi	<i>V. galamensis</i> var. <i>ethiopica</i> ***	Herb

\* Determined by level of plant growth disturbance through topping

\*\* Collected in Nigeria

\*\*\* Collected in Kenya (PERDUE's accession)

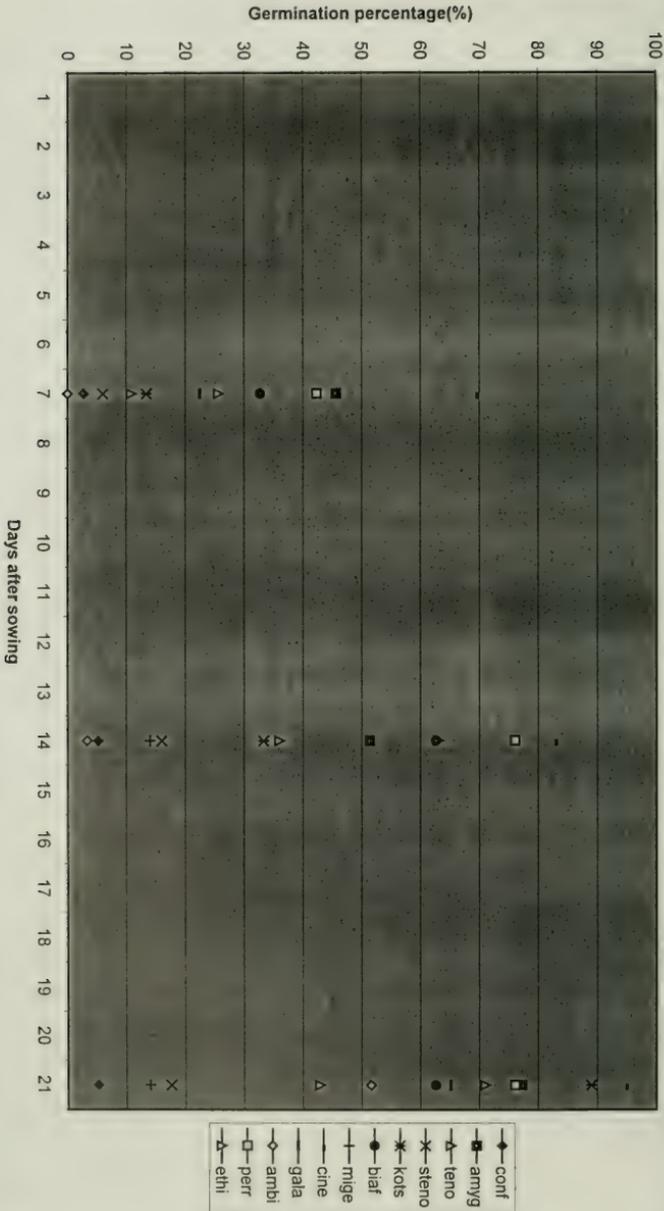


Fig. 1. Cumulative seed germination trend in some species of *Vernonia*

## New combinations in *Monticalia* (Compositae-Senecioneae) from Colombia

BERTIL NORDENSTAM

Department of Phanerogamic Botany

Swedish Museum of Natural History

P. O. Box 50007, SE-104 05 Stockholm, Sweden

e-mail: bertil.nordenstam@nrm.se

### Abstract

In a recent treatment of a part of the Senecioneae of Colombia, covering the genera *Dendrophorbium* and *Pentacalia* (DÍAZ-PIEDRAHITA & CUATRECASAS 1999), the genus *Monticalia* was included in *Pentacalia* as subgenus *Microchaete*. However, *Monticalia* is better treated as a distinct genus, and hence a number of new combinations are required for the Colombian taxa of this group. In this paper 24 such new combinations are published.

### Introduction

The genus *Monticalia* was established by JEFFREY (1992) for a widespread group of Central and South American senecioid species. The genus comprises ca. 70 species of erect shrubs or shrublets with usually small leaves which are closely set to imbricated, and white to yellow capitula which may be radiate or discoid. The genus has been widely accepted as separate from *Senecio* and *Pentacalia* (e.g., BREMER 1994, JØRGENSEN & ULLOA ULLOA 1994, NORDENSTAM 1996, 1999), although some authors prefer to have it as a subgenus under *Pentacalia*, viz. subgenus *Microchaete*.

In a recent excellent treatment of Colombian Senecioneae (Part I), DÍAZ-PIEDRAHITA & CUATRECASAS (1999) have adopted the wider generic concept of *Pentacalia*, but accepted *Dendrophorbium* as a distinct genus. They account for 44 species of *Pentacalia* subgenus *Microchaete* and some infraspecific taxa. Many of these have valid names under *Monticalia*, but several new combinations are required when the genus is kept separate.

### New Combinations

(The sequence of taxa follows that of DÍAZ-PIEDRAHITA & CUATRECASAS 1999)

#### 1. *Monticalia romeroana* (DÍAZ & BUENO) B. NORD., comb. nov.

Basionym: *Pentacalia romeroana* DÍAZ & BUENO, Rev. Acad. Colomb. Cienc. 21(80): 202-204 (1997). - Orig. coll.: Colombia, Magdalena, municipality of Ciénaga, Santa Marta region, W side of Sierra Nevada, 16.I.1954, R. ROMERO 4551 (COL holotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASAS 1999: 188 ff.

#### 2. *Monticalia subarachnoidea* (WEDD.) C. JEFFREY var. *pauciflora* (DÍAZ & BUENO) B. NORD., comb. nov.

Basionym: *Pentacalia subarachnoidea* (SCH. BIP.) CUATR. var. *pauciflora* DÍAZ & BUENO, Rev. Acad. Colomb. Cienc. 21(80): 202 (1997). - Orig. coll.: Colombia, Magdalena, Sierra Nevada de Santa Marta, village of San Sebastián, 2400 m, 5.XII.1978, O. RANGEL, H. STURM & E. WEDLER 1868 (COL holotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASAS 1999: 198.

#### 3. *Monticalia juajibioyi* (DÍAZ & CUATR.) B. NORD., comb. nov.

Basionym: *Pentacalia juajibioyi* ("juajibioy") DÍAZ & CUATR., Rev. Acad. Colomb. Cienc. 17(67): 688 (1990). - Orig. coll.: Colombia, Magdalena, Sierra Nevada de Santa Marta, surroundings of río Sevilla township, 3360-3410 m, 26.I.1959, H. BARCLAY & P. JUAJIBIOY 6709 (COL holotype, US isotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASAS 1999: 198 ff.

Note: The original epithet, formed from the name of a person, is here changed to the genitive case.

#### 4. *Monticalia schultzei* (CUATR.) B. NORD., comb. nov.

Basionym: *Pentacalia schultzei* CUATR., Phytologia 57: 169 (1981). - Orig. coll.: Colombia, Magdalena, Sierra Nevada de Santa Marta, Siminchucúá, 3400 m, VI.1928, A. SCHULTZE 1285 (B holotype, B isotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASAS 1999: 201 ff.

**5. *Monticalia schultzei* (CUATR.) B. NORD. subsp. *sevillana* (CUATR.) B. NORD.,  
comb. nov.**

Basionym: *Pentacalia schultzei* CUATR. subsp. *sevillana* CUATR., Phytologia 57: 171 (1985). - Orig. coll.: Colombia, Magdalena, Sierra Nevada de Santa Marta, W peaks, río Sevilla townships, 3495 m, 20-30.I.1959, H. G. BARCLAY & P. JUAJIBIOY 6594 (US holotype, COL isotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASAS 1999: 203 f.

**6. *Monticalia harrietae* (CUATR.) B. NORD., comb. nov.**

Basionym: *Senecio harrietae* CUATR., Proceed. Biol. Soc. Washington 74: 19 (1961). - Syn.: *Pentacalia harrietae* (CUATR.) CUATR., Phytologia 49: 255 (1981). - Orig. coll.: Colombia, Magdalena, Sierra Nevada de Santa Marta, río Sevilla townships, W peaks, 3400 m, I.1959, H. BARCLAY & P. JUAJIBIOY 6690 (US holotype, COL isotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASAS 1999: 205 ff.

**7. *Monticalia abietina* (WILLD. EX WEDD.) C. JEFFREY var. *aciculata* (CUATR.)  
B. NORD., comb. nov.**

Basionym: *Senecio aciculatus* CUATR., Notas Fl. Colombia 6: 24, Trabajos Comis. Bot. Secret. Agric. Valle, Cali (1944). - Syn.: *Pentacalia abietina* (WILLD. EX WEDD.) CUATR. var. *aciculata* (CUATR.) CUATR., Phytologia 49: 252 (1981). - Orig. coll.: Colombia, Norte de Santander, Cordillera Oriental, páramo de Tamá, above La Cueva, 3100-3200 m, 27.X.1941, J. CUATRECASAS, R. E. SCHULTES & E. SMITH 12612 (COL holotype, COL, US isotypes).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASAS 1999: 213 ff.

**8. *Monticalia elatoides* (WEDD.) B. NORD., comb. nov.**

Basionym: *Senecio elatoides* WEDD., Chloris Andina 1: 101 (1856). - Syn.: *Pentacalia elatoides* (WEDD.) CUATR., Phytologia 49: 254 (1981). - Orig. coll.: Colombia, Santander, Prov. Pamplona, páramo near La Baja, 3900-4000 m, J. SCHLIM 2 (P?).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASAS 1999: 215 ff.

**9. *Monticalia carupana* (DÍAZ) B. NORD., comb. nov.**

Basionym: *Pentacalia carupana* DÍAZ, Rev. Acad. Colomb. Cienc. 22(83): 187-192 (1998). - Orig. coll.: Colombia, Cundinamarca, municipality of Carupa, páramo de Guargua, W part, 3720 m, 5.II.1987, ROBERTO SÁNCHEZ 071 (COL holotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASAS 1999: 223 f.

**10. *Monticalia carrikeri* (CUATR.) C. JEFFREY var. *macrophylla* (DÍAZ)  
B. NORD., comb. nov.**

Basionym: *Pentacalia carrikeri* (CUATR.) CUATR. var. *macrophylla* DÍAZ, Rev. Acad. Colomb. Cienc. 22(83): 192 (1998). - Orig. coll.: Colombia, Magdalena, Sierra Nevada de Santa Marta, Buritaca "transect", edge of La Cumbre, 3700 m, 15.VIII.1977, O. RANGEL, A. M. CLEEF et al. 985 (COL holotype, COL isotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASAS 1999: 240 f.

**11. *Monticalia pulchella* (H.B.K.) C. JEFFREY subsp. *guantivana* (CUATR.)  
B. NORD., comb. nov.**

Basionym: *Senecio guantivanus* CUATR., Notas Fl. Colombia VI: 23, Trab. Comis. Bot. Secret. Agric. Valle, Cali (1944). - Syn.: *Pentacalia pulchella* (H.B.K.) CUATR. subsp. *guantivana* (CUATR.) CUATR., Phytologia 49: 258 (1981). - Orig. coll.: Colombia, Boyaca, páramo de Guantiva, Alto de Canutos, 3200-3400 m, 3.VIII.1940, J. CUATRECASAS 10344 (COL holotype, NY, US isotypes).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASAS 1999: 255 ff.

**12. *Monticalia vaccinioides* (H.B.K.) C. JEFFREY var. *microdentata* (CUATR.)  
B. NORD., comb. nov.**

Basionym: *Senecio vaccinioides* H.B.K. var. *microdentatus* CUATR., Notas a la Flora de Colombia VI: 23 (1944). - Syn.: *Pentacalia vaccinioides* (H.B.K.) CUATR. var. *microdentata* (CUATR.) CUATR. & DÍAZ in DÍAZ & CUATR., Asteraceas de la Flora Colombia, Senecioneae-I: 266 f. (1999). - Orig. coll.: Colombia, Santander, cordillera Oriental, páramo de Almorzadero, NE slope, 3800-3900 m, 20.VII.1940, J. CUATRECASAS & H. GARCIA 10027 (COL holotype, US isotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASAS 1999: 266 f.

**13. *Monticalia iguaquensis* (DÍAZ & CUATR.) B. NORD., comb. nov.**

Basionym: *Pentacalia iguaquensis* DÍAZ & CUATR., Rev. Acad. Colomb. Cienc. 19(73): 254-256 (1994). - Orig. coll.: Colombia, Boyaca, municipality of Villa de Leyva, Reserva Natural de Iguaque, near la Laguna, 3400-3600 m, 27.III.1993, O. RANGEL et al. 9804 (COL holotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRE CASAS 1999: 267 ff.

**14. *Monticalia summapacis* (CUATR.) B. NORD., comb. nov.**

Basionym: *Senecio summapacis* CUATR., Feddes Repert. 55(2/3): 150 (1953). - Syn.: *Pentacalia summapacis* (CUATR.) CUATR., Phytologia 49: 256 (1981). - Orig. coll.: Colombia, Cundinamarca, summit of San Juan highlands, 18 km E Cabrera, páramo de Sumapaz, 4200 m, 1943, F. R. FOSBERG 20791 (F holotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRE CASAS 1999: 284 ff.

**15. *Monticalia almorzana* (DÍAZ & CUATR.) B. NORD., comb. nov.**

Basionym: *Pentacalia almorzana* DÍAZ & CUATR., Rev. Acad. Colomb. Cienc. 19(72): 22 (1994). - Orig. coll.: Colombia, Santander, páramo de Almorzadero, moist meadows, 3700-3750 m, km 50-51, 20.IX.1969, J. CUATRE CASAS & L. RODRÍGUEZ 27888 (COL holotype, US isotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRE CASAS 1999: 298 ff.

**16. *Monticalia ledifolia* (H.B.K.) C. JEFFREY var. *lanata* (H.B.K.)  
B. NORD., comb. nov.**

Basionym: *Cacalia lanata* H.B.K., Nov. Gen. Sp. Pl. 4: 127, ed. folio: 162 (1820). - Syn.: *Senecio lanatus* (H.B.K.) DC., Prodr. 6: 422 (1837); *Pentacalia ledifolia* (H. B. K.) CUATR. var. *lanata* (H. B. K.) DÍAZ & CUATR., Asteraceas de la Flora de Colombia, Senecioneae-I: 311 (1999). - Orig. coll.: Colombia, Cundinamarca, Monserrate "Crescit locis frigidis in declivitate montis Chingasa juxta sanctuarium Montserratense, alt. 1500 hex" (2920 m), A. HUMBOLDT & A. BONPLAND s.n. (P holotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRE CASAS 1999: 311 ff.

**17. *Monticalia ledifolia* (H.B.K.) C. JEFFREY var. *glabrata* (DÍAZ & MÉNDEZ)  
B. NORD., comb. nov.**

Basionym: *Pentacalia ledifolia* (H.B.K.) var. *glabrata* DÍAZ & MÉNDEZ in DÍAZ & CUATR., Asteraceas de la Flora de Colombia, Senecioneae-I: 313 (1999). - Orig. coll.: Colombia, Cundinamarca, Neusa dam, 3000 m, 4.II.1966, L. URIBE U. 5527 (COL holotype, US isotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASES 1999: 313 f.

**18. *Monticalia albi-panquei* (DÍAZ & CUATR.) B. NORD., comb. nov.**

Basionym: *Pentacalia albi-panquei* DÍAZ & CUATR., Rev. Acad., Colomb. Cienc. 17(67): 689 (1990). - Orig. coll.: Colombia, Boyaca, road Soatá-Onzaga, San Antonio ravine, 3140 m, 3.VIII.1958, R. JARAMILLO et al. 826 (COL holotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASES 1999: 316 ff.

**19. *Monticalia cacaosensis* (CUATR.) B. NORD., comb. nov.**

Basionym: *Senecio cacaosensis* CUATR., Phytologia 31: 324 (1975). - Syn.: *Pentacalia cacaosensis* (CUATR.) CUATR., Phytologia 49: 253 (1981). - Orig. coll.: Colombia, Boyaca, páramo de Pisba, road Socha-La Punta, Cacaos, km 77, subpáramo, 3430 m, 20.VI.1972, A. M. CLEEF 4776 (US holotype, COL, U isotypes).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASES 1999: 318 ff.

**20. *Monticalia hammenii* (DÍAZ & CUATR.) B. NORD., comb. nov.**

Basionym: *Pentacalia hammenii* DÍAZ & CUATR., Rev. Acad. Colomb. Cienc. 19(73): 256 (1994). - Orig. coll.: Colombia, Cesar, Sierra Nevada de Santa Marta, valley of río Donachuy, road Corisa-Lago Naboba glacial valley, 4200-4300 m, 17.X.1958, TH. VAN DER HAMMEN 1197 (COL holotype, US isotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASES 1999: 322 ff.

**21. *Monticalia taironae* (DÍAZ & CUATR.) B. NORD., comb. nov.**

Basionym: *Pentacalia taironae* DÍAZ & CUATR., Rev. Acad. Colomb. Cienc. 17(67): 687 (1990). - Orig. coll.: Colombia, Magdalena, Sierra Nevada de Santa Marta,

surroundings of río Sevilla townships, 3520-3770 m, 28.I.1959, H. G. BARCLAY & P. JUAJIBIOY 6766 (COL holotype, US isotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASAS 1999: 322 ff.

**22. *Monticalia guadalupe* (CUATR.) C. JEFFREY subsp. *caucana* (CUATR.)  
B. NORD., comb. nov.**

Basionym: *Pentacalia guadalupe* (CUATR.) CUATR. subsp. *caucana* CUATR., Phytologia 52: 163 (1982). - Orig. coll.: Colombia, Cauca, Central Colombian massif, páramo de las Papas, hills SE of Magdalena lagune, slopes at Magdalena river, 3350-3450 m, 12.IX.1958, J. M. IDRIBO, P. PINTO & H. BISCHLER 3250 (COL holotype, COL isotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASAS 1999: 334 ff.

**23. *Monticalia fimbriifera* (DÍAZ & MÉNDEZ) B. NORD., comb. nov.**

Basionym: *Pentacalia fimbriifera* DÍAZ & MÉNDEZ, Rev. Acad. Colomb. Cienc. 21(81): 404 (1997). - Orig. coll.: Colombia, Nariño, El Tablón municipality, Doña Juana volcano, 3200-3500 m, 3.IV.1997, G. NARVÁEZ & F. ROSERO 06 (COL holotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASAS 1999: 336 ff.

**24. *Monticalia tolimensis* (CUATR.) C. JEFFREY var. *colombiana* (CUATR.)  
B. NORD., comb. nov.**

Basionym: *Senecio colombianus* CUATR., Caldasia 1(1): 9 (1940). - Syn.: *Pentacalia colombiana* (CUATR.) CUATR., Phytologia 49: 253 (1981); *Dendrophorbium colombianum* (CUATR.) C. JEFFREY, Kew Bulletin 47: 66 (1992); *Pentacalia tolimensis* (SCH. BIP. ex WEDD.) CUATR. var. *colombiana* (CUATR.) DÍAZ in DÍAZ & CUATR., Asteraceas de la Flora de Colombia, Senecioneae - I: 343 (1999). - Orig. coll.: Colombia, Cundinamarca, páramo de Cruz Verde, Chipaque gap, 3150 m, 7.X.1938, J. CUATRECASAS 422 (COL holotype, US isotype).

Further syn.: *Senecio pavonicus* BADILLO, Bol. Soc. Venez. Cienc. Nat. 10: 318 (1946). - Orig. coll.: Venezuela, Táchira, J. STEYERMARK 57379 (VEN holotype).

Ref.: DÍAZ-PIEDRAHITA & CUATRECASAS 1999: 343 ff.

### References

- BREMER, K. 1994. *Asteraceae. Cladistics and Classification*. Timber Press, Oregon.
- DÍAZ-PIEDRAHITA, S. & J. CUATRECASAS 1999. *Asteraceas de la Flora de Colombia, Senecioneae-I. Géneros Dendrophorbium y Pentacalia*. Santafe de Bogota, D. C.
- JEFFREY, C. 1992. Notes on Compositae, VI. The tribe Senecioneae (Compositae) in the Mascarene Islands with an annotated world check-list of the genera of the tribe. *Kew Bulletin* 47: 49-109.
- JØRGENSEN, P. M. & C. ULLOA ULLOA 1994. *Seed Plants of the High Andes of Ecuador - a checklist*. AAU Reports 34, Aarhus.
- NORDENSTAM, B. 1996. New combinations in Ecuadorean Senecioneae. *Comp. Newsl.* 29: 47-50.
- NORDENSTAM, B. 1999. Senecioneae (except *Gynoxys*). In: JØRGENSEN, P. M. & LEÓN-YÁNEZ: *Catalogue of the Vascular Plants of Ecuador*. Missouri Bot. Garden, St. Louis.

# Screening of some Asteraceous plants for antimycotic activity

MAHENDRA RAI & DEEPAK ACHARYA  
Department of Botany  
Danielson College  
Chhindwara-480 001, M. P., India

## Abstract

In vitro activity of extract of 31 plant species of family Asteraceae was evaluated against *Fusarium oxysporum* and *Trichophyton mentagrophytes*. The sensitivity of both fungi was tested by dry weight method. Both fungi were sensitive to extracts of all the plants, except *Launaea acaulis* and *Elephantopus scaber*, extracts of which accelerated the rate of growth. The maximum antimycotic activity against *F. oxysporum* and *T. mentagrophytes* was exhibited by flower extract of *Tagetes erecta* followed by whole plant of *T. patula* and leaf extract of *T. erecta*. The minimum inhibition of *F. oxysporum* was shown by extracts of *Spilanthes acmella* followed by *Emilia sonchifolia* and *Vernonia divergens*, whereas extracts of *Emilia sonchifolia*, *Tridax procumbens* and *Cichorium intybus* exhibited the minimum inhibitory effect on *T. mentagrophytes*.

## Introduction

There are many antimycotics available in the market including some plant-based antifungal agents. Increasing interest in plant-derived antimycotics all over the world has attracted botanists/pharmacologists to discover newer herbal antimycotics. One clear reason behind it is that most of synthetic drugs are only useful for local treatment because of their toxic nature. They are broad spectrum antibiotics which are effective in the treatment of the most important groups of fungi that infect human beings. In the treatment of mycosis, this kind of active agent is preferred because here a broad spectrum therapy is required. Increasingly, allergic reactions of the skin are observed today. The reason is high rate of sensitization power of these antifungal agents. Moreover, synthetic antifungals are costly and exhibit side-effects. Therefore, the awared people are turning towards herbal antimycotics.

The literature survey on the antifungal therapy reveals that a lot of contribution has been made in India and abroad (BHAKUNI et al. 1971, DHAR et al. 1974, RAY & MAJUMDAR 1975, JAIN & AGRAWAL 1976, DHAWAN et al. 1977, MISRA & DIXIT 1979, WAHAB et al.

1981, SINGH & DESHMUKH 1984, MARES 1989, MARES & FASULO 1990, RAHALISON et al. 1994, VILLARREAL 1994, RAI 1995, ADAMS et al. 1996, NARAYANARAO et al. 1996, GOPALAKRISHNAN et al. 1997, RAI et al. 1999).

Asteraceae constitutes one of the largest vascular plant families with about 30,000 species and over 1100 genera. Usually, the members of the family exhibit antimicrobial activity. Phytochemical research in the recent past revealed that sesquiterpene lactones are the principal secondary metabolites responsible for antimicrobial activity (GOREN et al. 1996).

The present investigation was aimed to screen the plant/plant-parts of family Asteraceae against an opportunistic human pathogen *Fusarium oxysporum* and a potential human fungal pathogen *Trichophyton mentagrophytes*.

## Materials and Methods

### The Test Fungi

The test fungi were isolated from local patients suffering from skin infections. These fungi include *F. oxysporum* and *T. mentagrophytes*. The former is basically a plant pathogen but now it has become human pathogen while the latter is a potential human pathogen.

### The Test Plants

The Asteraceous plants of Chhindwara and suburbs were selected for antimycotic activity. These include: *Acanthospermum hispidum*, *Ageratum conyzoides*, *Blainvillea acmella*, *Blumea balsamifera*, *B. mollis*, *Caesulia axillaris*, *Carthamus tinctorius*, *Cichorium intybus*, *Cyathocline purpurea*, *Dahlia pinnata*, *Echinops echinatus*, *Eclipta alba*, *E. prostrata*, *Elephantopus scaber*, *Emilia sonchifolia*, *Erigeron asteroides*, *Eupatorium triplinerve*, *Galinsoga parviflora*, *Gnaphalium luteo-album*, *G. purpureum*, *Launaea acaulis*, *Parthenium hysterophorus*, *Spilanthes acmella*, *Synedrella nodiflora*, *Tagetes erecta*, *T. patula*, *Tithonia diversifolia*, *Tridax procumbens*, *Vernonia cinerea*, *V. divergens* and *Xanthium strumarium*.

### Plant Extracts

Ten g sample (leaves, flowers or whole plant) of each test plant was collected and washed first in tap water and thereafter in distilled water. The test samples were cut into small pieces and boiled in 100 ml of distilled water for 5 minutes in an autoclave at 15 lb. pressure and 121° C. The extracts were filtered and centrifuged at 5,000 rpm

for 10 minutes. The supernatant was taken as extract sample and used for test.

### Determination of CFU/ml

Sabouraud dextrose agar medium was prepared and *F. oxysporum* and *T. mentagrophytes* were inoculated on it. After one week, spores were washed in sterilized normal saline solution by glass-wool filter apparatus. The suspension thus obtained was treated as parent suspension. The latter was utilized for tenfold serial dilution. Nine ml of normal saline solution was taken in 5 test tubes. In first test tube, 1 ml of spore suspension (PS) was poured by pipette under aseptic conditions. The solution of first test tube was homogenized with the help of pipette and 1 ml of this solution was transferred to second test tube containing 9 ml of normal saline solution. This process was repeated up to 5th test tube. In each case, sterilized pipette was used. From every test tube (for each dilution) 0.1 ml suspension was transferred to sterilized SDA petri-plates. Triplicates of each dilution were maintained. The SDA seeded petri-plates were incubated at  $28 \pm 2^\circ\text{C}$  for 24 hours. The colonies formed in each petri-plate were counted in colony counter. The average of 3 petri-plates was taken in each case. The test inocula was adjusted between  $1.5 \times 10^5$  spores/ml.

### Inoculation of Test Fungus

The test fungus was grown on Sabouraud broth (40 g glucose, 10 g peptone, 0.5 mg/ml chloramphenicol, pH 6.5). Each 250 ml flask was filled with 50 ml of broth and 5 ml of extract. Triplicate flasks were run for each test plant. After the sterilization of flasks at 15 lb pressure for 10 minutes, all flasks were inoculated by test inocula (1 ml) of definite CFU/ml. The inoculated flasks were kept for a week at  $28 \pm 2^\circ\text{C}$ . Mycelia from each flask was harvested on a preweighed Whatman filter paper No. 42. The actual mycelial growth of each test fungus was calculated and is given in Table 1.

## Results and Discussion

It is evident from Table 1 that both species of *Tagetes*, viz., *T. erecta* and *T. patula* were found to be the most effective inhibitors of mycelial growth of *Fusarium oxysporum* and *Trichophyton mentagrophytes*. This suggests a strong antimycotic potential in especially *T. erecta*, as also stated by KHAN & EVANS (1996). The plant has been in use as a traditional medicine in India since time immemorial. Among the two species of *Tagetes*, *T. erecta* was found to be more effective mycelial inhibitor as compared to *T. patula*. In the former, extract of the flowers showed the maximum inhibition, whereas the leaves exhibited the least growth. It is probably due to presence of more bio-active principles in flowers as compared to other parts of the plant.

The other Asteraceous species after *T. erecta* and *T. patula* which were found to be effective inhibitors of mycelial growth of *F. oxysporum* include: *Cyathocline purpurea*, followed by *Parthenium hysterophorus*, *Blumea balsamifera*, *B. mollis*, *Eupatorium triplinerve*, *Tithonia diversifolia*, *Eclipta prostrata*, *Ageratum conyzoides*, and *Galinsoga parviflora*, whereas the minimum inhibition was exhibited by extracts of *Spilanthes acmella* followed by *Emilia sonchifolia* and *Vernonia divergens*. In case of *T. mentagrophytes*, other plant species containing potential for mycelial inhibition were *E. triplinerve*, followed by *P. hysterophorus*, *G. luteo-album*, *B. balsamifera*, *B. mollis*, *C. purpurea* and *E. alba*, while the minimum inhibition was represented by extracts of *E. sonchifolia*, *T. procumbens*, and *C. intybus*. However, it was interesting to note that extracts of *Elephantopus scaber* and *L. acaulis* enhanced the growth of *T. mentagrophytes*.

**Table 1. In vitro evaluation of different extracts of plants of Asteraceae against *F. oxysporum* and *T. mentagrophytes***

Name of plant	Plant part/used	Dry weight in mg	
		FO	TM
<i>Acanthospermum hispidum</i>	WP	358.6 (14.65 %)	266.4 (23.83 %)
<i>Ageratum conyzoides</i>	WP	265.2 (36.88 %)	255.2 (27.89 %)
<i>Blainvillea acmella</i>	WP	357.5 (14.9 %)	290.5 (16.9 %)
<i>Blumea balsamifera</i>	WP	232.2 (44.73 %)	236 (32.52 %)
<i>B. mollis</i>	WP	233.5 (44.42 %)	239.3 (31.57 %)
<i>Caesulia axillaris</i>	WP	332.4 (20.88 %)	252.2 (27.89 %)
<i>Carthamus tinctorius</i>	WP	335.1 (20.25 %)	271.5 (22.37 %)
<i>Cichorium intybus</i>	WP	312.8 (25.5 %)	295.3 (15.58 %)
<i>Cyathocline purpurea</i>	WP	220.4 (47.55 %)	245 (29.95 %)
<i>Dahlia pinnata</i>	WP	378.5 (9.91 %)	267 (23.65 %)
<i>Echinops echinatus</i>	WP	287.3 (31.62 %)	285 (18.51 %)
<i>Eclipta alba</i>	WP	275.5 (34.42 %)	248.4 (28.97 %)
<i>E. prostrata</i>	WP	258.3 (38.52 %)	280 (19.94 %)
-"	L	357.5 (14.91 %)	275.5 (21.22 %)
<i>Elephantopus scaber</i>	WP	327 (22.17 %)	398.5 (-13.93 %)
<i>Emilia sonchifolia</i>	WP	395.4 (5.8 %)	323.5 (7.5 %)
<i>Erigeron asteroides</i>	WP	337.7 (19.62 %)	247 (29.37 %)

<i>Eupatorium triplinerve</i>	WP	231.4 (44.92 %)	225.5 (35.52 %)
<i>Galinsoga parviflora</i>	WP	265.2 (36.88 %)	285.5 (18.37 %)
<i>Gnaphalium luteo-album</i>	WP	315.2 (24.98 %)	235 (32.8 %)
<i>G. purpureum</i>	WP	310.5 (26.09 %)	255.5 (26.94 %)
<i>Launaea acaulis</i>	WP	332.5 (20.86 %)	432.5 (-23.65 %)
<i>Parthenium hysterophorus</i>	WP	220.8 (47.44 %)	230.7 (34.03 %)
<i>Spilanthes acmella</i>	WP	409.5 (2.53 %)	266.4 (23.8 %)
-"	F	348 (17.17 %)	252 (27.94 %)
<i>Synedrella nodiflora</i>	WP	285.4 (32.07 %)	280.2 (19.88 %)
<i>Tagetes erecta</i>	WP	232.2 (44.73 %)	220 (37.09 %)
-"	L	218.2 (48.06 %)	239 (31.66 %)
-"	F	197.9 (52.9 %)	201 (42.6 %)
<i>T. patula</i>	WP	215.2 (48.78 %)	211 (37.67 %)
-"	L	229.3 (45.42 %)	237.8 (32 %)
-"	F	215.2 (48.78 %)	220 (37.09 %)
<i>Tithonia diversifolia</i>	WP	245.9 (41.47 %)	285.4 (18.4 %)
<i>Tridax procumbens</i>	WP	360 (14.31 %)	315.3 (9.84 %)
<i>Vernonia cinerea</i>	WP	368.4 (12.31 %)	285 (18.5 %)
<i>V. divergens</i>	WP	387.2 (7.84 %)	270 (22.8 %)
<i>Xanthium strumarium</i>	WP	311.5 (25.86 %)	239.5 (31.52 %)
<b>Control</b>		<b>420.16</b>	<b>349.75</b>

**Note:** WP - Whole Plant            L - Leaf            F - Flower  
Percentage inhibition is given in parentheses

### Acknowledgements

We are grateful to Professor BERTIL NORDENSTAM, Director, the Swedish Museum of Natural History, Stockholm, Sweden for encouragement and to Professor S. A. BROWN, Principal, Danielson College, Chhindwara, M.P. State, India for providing laboratory facilities. The financial assistance provided by University Grants Commission, New Delhi is thankfully acknowledged.

### References

- ADAMS, S., KUNZ, B. & M. WEIDENBORNER 1996. Mycelial deformations of *Cladosporium herbarum* due to the application of Eugenol or Carvacrol. *J. Essent. Oil Res.* 8: 535–540.
- BHAKUNI D. S., DHAR, M. L., DHAR, M. M., DHAWAN, B. N., GUPTA, B. & R. C. SRIMAL 1971. Screening of Indian plants for biological activity, part III. *Indian J. Experimental Biol.* 9: 91–102.
- DHAR, M. L., DHAWAN, B. N., PRASAD, C. R., RASTOGI, R. P., SINGH, K. K. & J. S. TANDON 1974. Screening of Indian plants for biological activity, part IV. *Indian J. Experimental Biol.* 12: 512–523.
- DHAWAN, B. N., PATNAIK, G. K., RASTOGI, R. P., SINGH, K. K. & J. S. TANDON 1977. Screening of Indian plants for biological activity, part V & VI. *Indian J. Experimental Biol.* 15: 208–219.
- GOPALAKRISHNAN, G., BANUMATHI, B. & G. SURESH 1997. Evaluation of the antifungal activity of natural xanthenes from *Garcinia mangostana* and their synthetic derivatives. *Journal of Natural Products* 60 (5): 519–524.
- GOREN, NEZHUN, WOERDENBAG, H. J. & CANDAN BOZOK-JOHANSSON 1996. Cytotoxic and antibacterial activities of sesquiterpene lactones isolated from *Tanacetum praeteritum* subsp. *praeteritum*. *Planta Medica* 62: 419–422.
- JAIN, P. C. & S. C. AGRAWAL 1976. Activity of plant extracts against some keratinophilic species of *Nannizzia*. *Indian Drugs* 13 (12): 25–26.
- KHAN, M. T. & F. J. EVANS 1996. Clinical evaluation of *Tagetes erecta* in the treatment of parakeratosis. *Phytotherapy Research* 10: 186–188.
- MARES, D. 1989. Electron microscopy of *Microsporium cookei* *in vitro* treatment with protoanemonin: a combined SEM and TEM study. *Mycopathologia* 108: 37–46.

- MARES D. & MARIA P. FASULO 1990. Ultrastructural alterations in *Epidermophyton floccosum* and *Trichophyton mentagrophytes* exposed *in vitro* to protopneumonin. *Cytobios* 61: 89–95.
- MISRA, S. S. & S. N. DEXIT 1979. Antifungal activity of leaf-extracts of some higher plants. *Acta Bot. Indica* 7: 147.
- NARAYANARAO, A., PADMASRI, K. & R. C. ANANADKUMAR 1996. Antifungal activity of extracts from *Azadirachta indica* JUSS. against *Drechslera oryzae* BRED. DE HANN. *Geo-bios new Reports* 15: 126–128.
- RAHALISON, L., HAMBURGER, M., MONOD, M., FRENK, M. & K. HOSTETTMANN 1994. Antifungal tests in phytochemical investigations: Comparison of bioautotrophic methods using phytopathogenic and human pathogenic fungi. *Planta Medica* 69 (1): 41–44.
- RAI, M. K. 1995. Comparative antimycotic activity of different parts of *Parthenium hysterophorus*. *World Weeds* 2 (1): 45–52.
- RAI, M. K., QURESHI, S. & A. K. PANDEY 1999. *In vitro* susceptibility of opportunistic *Fusarium spp.* to essential oils. *Mycoses* 42 (in press).
- RAY, P. G. & S. K. MAJUMDAR 1975. New antifungal substance from *Alpinia officinarum*. *Indian J. Exp. Biol.* 13 (4): 489.
- RAY, P. G. & S. K. MAJUMDAR 1976. Antifungal flavonoid from *Alpinia officinarum*. *Indian J. Exp. Biol.* 14 (6): 712–714.
- SINGH, K. V. & S. K. DESHMUKH 1984. Volatile constituents from members of Liliaceae and spore germination of *Microsporium gypseum* complexes. *Fitoterapia* 55 (5): 297–299.
- VILLARREAL, M. L., ALVAREZ, L., ALONSO, D., NAVARRO, V., GARCIA, P. & G. DELGADO 1994. Cytotoxic and antimicrobial screening of selected terpenoids from Asteraceae species. *J. Ethnopharmacology* 42: 25–29.
- WAHAB, S., TANDON, R. N., JACOB, Z., SAGAR, P. & O. P. SRIVASTAVA 1981. *In vitro* activity of a phytochemical alantolactone from *Inula racemosa* HOOK. f. against some pathogenic and opportunistic fungi. *J. Indian Bot. Soc.* 60: 278–281.

# Diversity of arbuscular mycorrhizae in naturally growing plants of family Asteraceae in India

MAHENDRA RAI & DEEPAK ACHARYA

Microbiology Research Lab.

Danielson College

Chhindwara - 480 001, M. P., India

## Abstract

Twenty-six plants of family Asteraceae were screened for occurrence of AM fungi. The percentage of mycorrhizal colonization was determined. All plants screened in the present investigation were found to be associated with *Glomus pallidum*, *G. macrocarpum*, *G. mosseae*, *G. pulvinatum*, *Acaulospora laevis* and *Sclerocystis*. The maximum colonization (90 %) was recorded in the roots of *Spilanthes calva*; moderate (60–70 %) in *Aster amellus*, *Echinops echinatus*, *Emilia sonchifolia*, *Guizotia abyssinica* and *Tagetes patula*, whereas the minimum percentage of colonization was observed in *Gnaphalium luteo-album* and *Zinnia elegans* (30 %).

## Introduction

Most plants on the earth including Angiosperms, Conifers (except Pinaceae), Pteridophytes, and Bryophytes are associated with arbuscular mycorrhizal fungi. AM fungi infect fine feeder roots and colonize the cortical region from where they extend their mycelia in rhizosphere soil. Increasing interest in AM fungi has focused on the effectiveness of various species to promote plant health. Many researchers have proved that plants harbouring AM fungi are more efficient in acquiring phosphorus than non-mycorrhizal plants (MOSSE 1973, O'KEEFE & SYLVIA 1991, DURGA & GUPTA 1995, VARMA & JAMALUDDIN 1995).

A survey of literature vouches that there are few reports on occurrence of AM fungi on medicinal plants (GOVIND RAO et al. 1989, SULOCHANA et al. 1991, SAMBANDAN 1995) in general and family Asteraceae in particular (WARCUP & MCGEE 1983, WARCUP 1990). In the present investigation, plants of family Asteraceae have been screened to assess the colonization of various arbuscular mycorrhizal fungi in roots.

### Materials and Methods

The root samples of 26 Asteraceous plants were collected from various parts of Chhindwara district. The plants were recovered from different types of soil, such as, cultivated fields, wastelands, riverbanks, ponds, sandy areas, garden soil, etc. The samples of fine feeder roots were thoroughly washed to remove soil, organic matter, and debris. Roots were cut into small pieces of 1 cm length and stored in individual vials containing Formalin, Acetic acid and Alcohol (1:1:18, V/V/V). In some plants, quick processing was done and hence samples were not preserved in FAA. The root samples were autoclaved at 120° C after addition of 10 % KOH. Thereafter, the roots were covered with 1 N HCl which is poured off after 3 minutes. Washing of roots was avoided as an acidic medium is required by the stain. Later, roots samples were stained with 0.05 % trypan blue in lactophenol (PHILLIPS & HAYMAN 1970).

The percentage of the root colonization was evaluated as per method suggested by READ et al. (1976).

$$\% \text{ infection} = \frac{\text{No. of AMF infected roots}}{\text{Total No. of root-bits examined}} \times 100$$

The percentage frequency of AMF was calculated as per method suggested by RAUNKIER (1934). AMF were classified into 5 classes on the basis of percentage frequency, viz., class A = 10–20 %; B = 21–40 %; C = 41–60 %; D = 61–80 %; E = 81–100 %.

Table 1. AMF association with roots of Asteraceous plants

Host plant	Type of soil	Locality	FC	% Colonization
<i>Acanthospermum hispidum</i> DC.	Sandy soil	Bharatadeo	C	42.7 ( $\pm 5.353$ )
<i>Ageratum conyzoides</i> L.	Garden soil	College garden	B	40.0 ( $\pm 5.812$ )
<i>Aster amellus</i> L.	Sandy soil	Bharatadeo	D	71.5 ( $\pm 7.140$ )
<i>Blumea lacera</i> (BURM. f.) DC.	Wasteland	Shukludhana	B	35.3 ( $\pm 3.365$ )
<i>Caesulia axillaris</i> ROXB.	Riverbank	Bodri river	C	55.6 ( $\pm 4.117$ )
<i>Echinops echinatus</i> ROXB.	Wasteland	Atarwada	D	69.3 ( $\pm 5.108$ )
<i>Eclipta prostrata</i> L.	Bank of pond	Chhota talaab	C	46.9 ( $\pm 8.654$ )
<i>Elephantopus scaber</i> L.	Wasteland	Bharatadeo	C	46.8 ( $\pm 2.498$ )
<i>Emilia sonchifolia</i> (L.) DC.	Garden soil	College garden	D	68.8 ( $\pm 5.398$ )
<i>Eupatorium triplinerve</i> VAHL	Garden soil	Bharatadeo	C	54.8 ( $\pm 2.412$ )
<i>Galinsoga parviflora</i> CAV.	Wasteland	Chandangaon	C	56.9 ( $\pm 6.776$ )
<i>Gnaphalium luteo-album</i> L.	Sandy soil	Bharatadeo	B	34.7 ( $\pm 5.498$ )
<i>Guizotia abyssinica</i> CASS.	Cultiv. field	Bhanadehi	D	67.3 ( $\pm 5.32$ )
<i>Lagascea mollis</i> CAV.	Wasteland	Chandangaon	B	39.9 ( $\pm 6.462$ )
<i>Launaea nudicaulis</i> L.	Wasteland	Chhindwara	D	62.6 ( $\pm 3.543$ )
<i>Parthenium hysterophorus</i> L.	Wasteland	Kundalikala	B	35.6 ( $\pm 5.303$ )
<i>Sonchus asper</i> L.	Sandy soil	Gangiwada	C	54.2 ( $\pm 2.229$ )
<i>Spilanthes acmella</i> HOOK.	Near nullah	Vivek. Colony	D	62.6 ( $\pm 5.877$ )
<i>S. calva</i> DC.	Cultiv. field	Choubitkar Farm	E	90.0 ( $\pm 8.5$ )
<i>Tagetes erecta</i> L.	Garden soil	College garden	C	54.0 ( $\pm 4.837$ )
<i>T. patula</i> L.	Garden soil	Geet colony	D	71.9 ( $\pm 5.134$ )
<i>Tridax procumbens</i> L.	Wasteland	Chandangaon	C	50.6 ( $\pm 5.86$ )
<i>Vernonia cinerea</i> L.	Garden soil	College garden	D	67.8 ( $\pm 2.4$ )
<i>Vicoa indica</i> L.	Cultiv. field	Bhanadehi	D	62.3 ( $\pm 3.653$ )
<i>Xanthium strumarium</i> L.	Wasteland	Bhanadehi	C	51.5 ( $\pm 5.792$ )
<i>Zinnia elegans</i> JACQ.	Garden soil	Ekta park	B	31.1 ( $\pm 4.311$ )

Note: FC = Frequency Class

Numbers in parenthesis are Standard Deviation

## Results and Discussion

It is obvious from Table 1 that roots of all the Asteraceous plants screened in the present study were found to harbour arbuscular mycorrhizal fungi. The maximum colonization (90 %) was exhibited by *Spilanthes calva* followed by *Aster amellus* (71.5 %), *Echinops echinatus* (69.3 %), and *Emilia sonchifolia* (68.8 %), while the minimum by *Zinnia elegans* (31.1%) followed *Gnaphalium luteo-album* (34.7 %) and *Parthenium hysterophorus* (35.6 %). KEHRI et al. (1987) reported that roots of *Ageratum conyzoides* were colonized by 40 %. Similarly, in the present study, *A. conyzoides* was found to be associated with 40 per cent AMF. Moreover, *Tagetes erecta* was reported to have 61 per cent colonization while in the present survey it showed 54 per cent colonization. KEHRI et al. (1987) stated that soil and environmental factors are likely to affect the plants as well as their association with symbiont. RAUNKIER (1934) suggested a frequency class system for ecological distribution to evaluate homogeneity and heterogeneity in an ecosystem. In the present studies, frequency class E showed higher value which was represented by only one species. The present findings are in agreement with earlier reports on occurrence of AMF in roots of medicinal plants (STREZEMSKA 1975, GOVIND RAO et al. 1989, SULOCHANA et al. 1991). On the other hand, KUMAR, MOHAN & MAHADEVAN (1984) did not find AMF colonization in roots of medicinal plants. They stated that absence of AMF in roots of medicinal plants is due to the presence of secondary metabolites in them. It seems that the absence of colonization is not due to the presence of secondary metabolites in roots, as it has been found that plants containing AMF in their roots were also reported to exhibit antimycotic activity (RAI 1993, RAI & UPADHYAY 1988, RAI & VASANTH 1995). SULOCHANA et al. (1991), however, remarked that the chemical substances present in plants may not affect AMF colonization in roots. However, absence of AMF in roots of medicinal plants may be due to non-availability of these fungi in particular soil samples. Recent findings provide evidence that non-mycotrophic plant species lack molecular signals necessary for stimulating AM fungi (SCHREINER & KOIDE 1993). It seems that stimulatory compounds essential for AMF penetration of roots largely depend upon the environmental factors, particularly pH, temperature, moisture, etc.

It can be concluded that the biotechnology of AMF may be applied not only for the promotion of plant health, but also for the conservation of rare and endangered Asteraceous plants by mycorrhization of tissue-culture-derived plants. This will help to develop tolerance against transient transplant shock.

### Acknowledgements

We thank Professor S. A. BROWN, Principal, Danielson College, Chhindwara, for providing laboratory facilities, and SIVALIAH KATTA for help in collection of plants.

### References

- DURGA, V. V. K. & S. GUPTA 1995. Effect of Vesicular arbuscular mycorrhiza on the growth and mineral nutrition of Teak (*Tectona grandis* LINN. f.). *Indian Forester* 121 (1): 518–526.
- GOVIND RAO, Y. S., SURESH, C. K., SURESH, N. S., MALLIKARJUNAIAH, R. R. & D. J. BAGYARAJ 1989. Vesicular arbuscular mycorrhizae in medicinal plants. *Indian Phytopath.* 42: 476–478.
- KEHRI, H. K., CHANDRA, S. & S. MAHESHWARI 1987. Occurrence and intensity of VAM in weeds, ornamentals and cultivated plants at Allahabad and areas adjoining it. *Mycorrhizae Round Table*, Proceedings of the workshop held at Jawaharlal Nehru University, New Delhi, 13–15 March, pp. 273–283.
- KUMAR MOHAN, V. & A. MAHADEVAN 1984. Do secondary substances inhibit mycorrhizal association? *Current Science* 53: 377–378.
- MOSSE, B. 1973. Advances in the study of Vesicular Arbuscular Mycorrhiza. *Annual Review of Phytopathology* 11: 171.
- O'KEEFE, D. M. & D. M. SYLVIA 1991. Mechanisms of the vesicular arbuscular mycorrhizal plant growth response. In: D. K. ARORA et al. (eds.), *Handbook of Applied Microbiology*, pp. 35 ff. Marcel Dekker, New York.
- PHILLIPS J. M. & D. S. HAYMAN 1970. Improved procedure for cleaning roots and staining parasitic and VAM fungi for rapid assessment of infection. *Trans. British Mycol. Soc.* 55: 158–161.
- RAI, M. K. 1993. Laboratory evaluation of fungitoxic activity of crude extract of *Parthenium hysterophorus*. *J. Environ. Biol.* 14 (1): 41–44.
- RAI, M. K. & SUSHIL UPADHYAY 1988. Screening of medicinal plants of Chhindwara District against *Trichophyton mentagrophytes*, a causal organism of *Tinea pedis*. *Hindustan Antibiotics Bull.* 30 (1–2): 33–36.
- RAI, M. K. & S. VASANTH 1995. Laboratory evaluation of sensitivity of three keratinophilic fungi to some vicolides. *Hindustan Antibiotics Bull.* 37 (1–4): 48–50.

- RAUNKIER, C.** 1934. *The life form of plants and statistical plant geography: being the collected papers of RAUNKIER, C.* Clarendon Press, Oxford, England.
- READ, D. J., KOUCHEKI, H. K. & J. HODGSON** 1976. Vesicular Arbuscular Mycorrhiza in natural vegetation systems. *New Phytologist* 77: 641–653.
- SAMBANDAN, K.** 1995. *Investigations on VAM association of Neem (Azadirachta indica).* Ph. D. Thesis, University of Madras, 140 pp.
- SCHREINER, R. P. & R. T. KOIDE** 1993. Antifungal compounds from the roots of mycotrophic and non-mycotrophic plant species. *New Phytologist* 123: 99–105.
- STREZEMSKA, J.** 1975. Occurrence of mycorrhiza in cultivated plants. In: *Endomycorrhiza* (Ed.: SANDERS et al.), pp. 537–543. Academic Press, New York.
- SULOCHANA, K. K., SHIVAPRASAD, P. & G. SHRIKANTAN NAIR** 1991. Occurrence of Vesicular-Arbuscular Mycorrhiza in medicinal plants. *Ancient Science of Life* 1 (1 & 2): 38–39.
- VARMA, R. K. & JAMALUDDIN** 1995. Associational activity of Arbuscular Mycorrhizae of Teak (*Tectona grandis*) in Central India. *Indian Forester* 21 (6): 533–539.
- WARCUP, J. H.** 1990. The mycorrhizal association of some Australian Inuleae. *Muelleria* 7: 179–187.
- WARCUP, J. H. & P. A. MCGEE** 1983. The mycorrhizal association of some Australian Asteraceae. *New Phytologist* 95: 667–672.

# New combinations in *Dendrophorbium* and *Pentacalia* (Senecioneae - Asteraceae) from Peru

HAMILTON BELTRAN  
Museo de Historia Natural  
Universidad Nacional Mayor de San Marcos  
Av. Arenales 1256 Apartado 14-0434 Lima, Peru  
e-mail: hamilton@musm.edu.pe

## Abstract

Eight new combinations in Peruvian taxa of *Dendrophorbium* and *Pentacalia* are made.

## Resumen

Se hacen ocho nuevas combinaciones para especies peruanas en los generos *Dendrophorbium* y *Pentacalia*.

## Introduction

Generic circumscription in Peruvian Senecioneae (Asteraceae) has been recently modified (ROBINSON & CUATRECASAS 1992, 1993; BELTRAN & DE MERA 1997, 1998; NORDENSTAM & PRUSKI 1995; DILLON & SAGÁSTEGUI 1996, 1999). Due to the splitting of the core genus *Senecio* into several segregates (JEFFREY 1992, a.o.), such as *Dendrophorbium*, *Aequatorium*, and *Pentacalia*, a few Peruvian species in need of transfer out of *Senecio* are here transferred to the correct segregate genera.

The Senecioneae tribe in Peru includes approximately 16 genera and 326 species, with a high percentage of endemic species with a restricted distribution (VISION & DILLON 1996). A tribal revision of Peruvian Senecioneae is currently being prepared by DILLON & SAGÁSTEGUI (in prep.).

Study of the species of the Senecioneae from Peru was carried out in different Herbaria such as US, F, USM, MICH, MO, and following to the classification of JEFFREY (1992) it is necessary to transfer the following species of *Senecio* to *Dendrophorbium* and to provide the correct name to *Pentacalia balsasana* according to ICBN.

### New Combinations

- Dendrophorbium argutidentatum*** (CUATREC.) H. BELTRAN, comb. nov.  
 Basionym: *Senecio argutidentatus* CUATREC., Collect. Bot. (Barcelona) 3: 281. 1953. Typus: Peru; Cuzco, Urubamba, C. VARGAS 2916A (F).
- Dendrophorbium cosnipatense*** (CABRERA) H. BELTRAN, comb. nov.  
 Basionym: *Senecio cosnipatense* CABRERA, Notas Mus. La Plata, Bot. 18: 236. 1955. Typus: Peru; Cuzco, Paucartambo, O. VELARDE 1451 (LP).
- Dendrophorbium goodspeedii*** (CUATREC.) H. BELTRAN, comb. nov.  
 Basionym: *Senecio goodspeedii* CUATREC., Fieldiana, Bot. 27(2): 51. 1951. Typus: Peru; Huanuco, Pillao, A. TUESTA DÍAZ & F. WOYTKOWSKI 34097 (F).
- Dendrophorbium llewelynii*** (CUATREC.) H. BELTRAN, comb. nov.  
 Basionym: *Senecio llewelynii* CUATREC., Fieldiana, Bot. 27(2): 45. 1951. Typus: Peru; Amazonas, Chachapoyas, L. WILLIAMS 7589 (F).
- Dendrophorbium trigynum*** (CUATREC.) H. BELTRAN, comb. nov.  
 Basionym: *Senecio trigynus* CUATREC., Brittonia 8: 189. 1956. Typus: Peru; Cuzco, CL. GAY 2051 (P).
- Dendrophorbium vanillodorum*** (CABRERA) H. BELTRAN, comb. nov.  
 Basionym: *Senecio vanillodorus* CABRERA, Notas Mus. La Plata, Bot. 18: 238. 1955. Typus: Peru; Cajamarca, Celendín, C. A. RIDOUTT 512 (LP).
- Dendrophorbium vargasii*** (CABRERA) H. BELTRAN, comb. nov.  
 Basionym: *Senecio vargasii* CABRERA, Notas Mus. La Plata, Bot. 9: 225. 1944. Typus: Peru; Cuzco, La Convención, C. VARGAS 3481 (Herb. Cabrera).
- Pentacalia petiolincrassata*** (CABRERA & ZARDINI) H. BELTRAN, comb. nov.  
 Basionym: *Senecio petiolincrassatus* CABRERA & ZARDINI, Bol. Soc. Argent. Bot. 16: 383-385. Fig. 4. 1975. Typus: Peru; Cajamarca, Hualgayoc Tahona, R. FERREYRA 8518 (LP). *Pentacalia balsasana* CUATREC. & H. ROBINSON, Novon 3(3): 293. 1993. Typus: Peru; Cajamarca, Celendín, Canyon Balsas, HUTCHINSON & WRIGHT 5212 (US, F, USM, MICH, UC).

### Acknowledgements

I thank J. PRUSKI for the revision of this manuscript and H. ROBINSON for his valuable comments on *Pentacalia balsasana*.

## References

- BELTRAN, H. & G. DE MERA 1997. *Senecio icaensis* sp. nov. (Asteraceae) un nuevo endemismo de las lomas costaneras del Peru. *Anales Jard. Bot. Madrid* 55(1): 168–170.
- BELTRAN, H. & G. DE MERA 1998. *Senecio larahuinensis* sp. nov. (Asteraceae) una nueva especie de los andes peruanos. *Anales Jard. Bot. Madrid* 56(1): 168–169.
- DILLON, M. & A. SAGÁSTEGUI 1996. Revision of the dioecious genus *Chersodoma* PHIL. (Senecioneae, Asteraceae), including a new species and status change. *Brittonia* 48(4) : 582–604.
- DILLON, M. & A. SAGÁSTEGUI 1999. *Caxamarca*, New Monotypic Genus of Senecioneae (Asteraceae) from northern Peru. *Novon* 9: 156–161.
- JEFFREY, C. 1992. The tribe Senecioneae (Compositae) in the Mascarene islands with an annotated world check-list of the genera of the tribe. Notes on Compositae VI. *Kew Bull.* 47(1) : 49–109.
- NORDENSTAM, B. & J. F. PRUSKI 1995. Additions to *Dorobaea* and *Talamancalia* (Compositae-Senecioneae). *Comp. Newsl.* 27: 31–42.
- ROBINSON, H. & J. CUATRECASAS 1992. Additions to *Aequatorium* and *Gynoxys* (Asteraceae: Senecioneae) in Bolivia, Ecuador and Peru. *Novon* 2: 411–416.
- ROBINSON, H. & J. CUATRECASAS 1993. New species of *Pentacalia* (Senecioneae: Asteraceae) from Ecuador, Peru, and Bolivia. *Novon* 3: 284–301.
- VISION, T. J. & M. DILLON 1996. Sinopsis de *Senecio* L. (Senecioneae, Asteraceae) para el Peru. *Arnaldoa* 4(1): 23–46.

## Reclassification of *Prenanthes pendula* (Asteraceae: Lactuceae)

ALEXANDER N. SENNIKOV & IRENE D. ILLARIONOVA

Herbarium

Komarov Botanical Institute

Prof. Popov str. 2

Saint Petersburg, 197 376 Russia

e-mail: sennikov@herb.bin.ras.spb.ru

### Abstract

The species with uncertain taxonomic position, *Prenanthes pendula* SCH. BIF., was studied in respect of morphology, anatomy and surface ultrasculpture of achenes. The structure of its pericarp is similar to that in species of *Sonchus* subgen. *Dendrosonchus* to which this species is to be attributed.

### Introduction

The taxonomic position of *P. pendula*, endemic to the Canary Islands, has always been unclear. First described as a member of the genus *Prenanthes* (WEBB & BERTHELOT 1842-1850), this species remains static in the Lactuceae (Cichorieae), even though the protologue of this name includes the remark by P. WEBB on its possible relationship to *Sonchus*: "*Sonchus (Picrosonchus) pendulus* WEBB, in litt." (l. c.: 421).

This characteristic species is the only member of *Prenanthes* from the Canary Islands, inhabiting mountain cliffs on Gran Canaria (BRAMWELL & BRAMWELL 1974). This species is characterized by a woody basal stem, pinnatisect leaves with large triangular lobes, corymbose inflorescence with small calathidia of 5-6 florets (each), smooth, 4-5-striate achenes and thin white subglabrous submonomorphic pappus setules. Considering its special habit, *P. pendula* is rather similar to Canarian species of *Sonchus* sect. *Atalanthus* (D. DON) DC. (syn. *Taeckholmia* BOULOS) and *S. tuberifer* SVENT. (sect. *Tuberiferi* BOULOS).

In recent years doubt was thrown upon the former position of *P. pendula*. Some morphological and biological data (PEREZ DE PAZ 1976) facilitated the suggestion that *P. pendula* is closely related to *Sonchus* and *Sventenia* (small monotypic segregate close to *Sonchus*). A naturally occurring hybrid between *Sventenia bupleuroides* FONT

QUER and *P. pendula* was reported by SVENTENIUS (1960). The relationships drawn from the results of the study of sequences from the internal transcribed spacer region of nuclear ribosomal DNA (KIM et al. 1996) connect *P. pendula* with *Sventenia*, *Babcockia platylepis* (WEBB) BOULOS (= *Sonchus platylepis* WEBB) as well as *S.* sect. *Tuberiferi*, *S.* subgenus *Dendrosonchus*, and *Taeckholmia*. To further clarify the position of *P. pendula*, we have undertaken studies of morphology and anatomy of its fruits. Carpological method is well-established in systematics of Asteraceae (cf. LAVIALLE 1912, and for example, PAK & KAWANO 1990 a, b), and usually provides good results in studies on Lactuceae.

### Materials and Methods

The achenes of *P. pendula* were studied in respect of morphology, anatomy and surface ultrasculpture. The achenes were taken from herbarium specimen, the syntype of *P. pendula*: "In montibus Canariae, WEBB" (LE).

The achenes were treated in an alcohol-glycerine-water solution (1:1:1) during three days and cut with freezing microtome through their middle (through cotyledons) and basal parts. Sections were made at a thickness of 10–16  $\mu\text{m}$ ; prepared slices were coloured with safranin. Drawings were made with drawing device RA-7 by the second author. Surface ultrasculpture was studied with scanning electron microscope JSM-35C.

### Morphological and Anatomical Data

#### Fruit

The mature achenes of *P. pendula* are homomorphic, 4–4.5 mm long., 1.1–1.2 mm wide, stramineous, cylindrical, broadly conical at the base and rounded at the apex, round in cross section, smooth, 4–5-striate with furrows (Fig. 1). Pappus 2.5–3 mm long, uniseriate or partly biseriate, subhomomorphic. Pappus setules are 0.02–0.03 mm thick, most of them are thin with few slightly thickened ones, white, slightly denticulate, rather fragile, slender.

#### Pericarp

Cross section of mature achenes shows more or less round outline (Fig. 2). The pericarp is 80–100  $\mu\text{m}$  in thickness. The layout of the achene is 4–5-merous (from achenes in the same calathidium). Pericarp is clearly divided in section into 4–5 lobes with narrow furrows. It is composed by exocarp and well differentiated mesocarp. Each mesocarp

lobe contains three strands of sclereids, which are separate, round and nearly equal in the base of achene, and fused into trilobed band in the center of the achene. This band is homogeneous, consisting of 10–12 layers of strands and of (1) 3–4 layers between them, underlain by obliterated parenchyma cells (Fig. 3). One or two layers of the elongated sclerified parenchyma with prominent pores in the walls overlay the sclerenchyma bands and converge between them. Exocarp consists of a single layer of epidermic tissue. The epidermic cells are rather narrow, 4–6  $\mu\text{m}$  high, 8–12  $\mu\text{m}$  wide, cuticularized, with concave upper walls.

### Seed Coat

There are some rows of the seed coat cells obliterated, being present as cell walls only.

### Endosperm

The endosperm is two-layered, consisting of thin-walled cells with grained substance within.

The study of ultrasculpture of achene surface shows the epidermic cells to be rather narrow, 50–120  $\mu\text{m}$  long, 8–12  $\mu\text{m}$  wide, elongated in axial direction, without apical outgrowths (Fig. 4). The cell surface is slightly rugose, without prominent cuticle structures.

## Discussion

Analysis of morphological and anatomical data provides more evidence in favour of the inclusion of *P. pendula* into the subtribe Sonchinae K. BREMER (BREMER 1993, 1994), rather than keeping it within *Prenanthes*. All species of Sonchinae possess achenes with pericarp divided in section into 4–5 lobes with rather prominent (at least at the base of achenes) furrows, complemented with soft or slender, heteromorphic or subhomomorphic pappus setules (SENNIKOV & ILLARIONOVA, in press) whereas species of *Prenanthes* (SENNIKOV 1997, in press) have achenes without furrows, with hard, homomorphic pappus setules (SENNIKOV & ILLARIONOVA, in press). Plant morphology allows us to suggest *P. pendula* be compared with *S. tuberifer* by its pinnatisect leaves with large lobes, as well as with *S. sect. Atalanthus* by small calathidia, inflorescence shape and basally woody stem. Judging by the most distinguishing feature in Lactuceae, *S. platylepis* (sect. *Babcockia* (BOULOS) SENNIK.) is the species most closely similar to *P. pendula* by the structure of its achenes. The achenes of *S. platylepis* have 4 pericarp lobes without ribs (WEBB & BERTHELOT 1842-1850); every lobe possesses 5 subequal sclerenchymatous strands (ALDRIDGE 1976). In our opinion, *P. pendula* is characterized

by a rather primitive achene structure of *Sonchus*-type, because the pericarpium is not differentiated into ribs though the number of sclerenchymatous strands is reduced from 5 (primarily) to 3 (as in *S. leptcephalus* CASS. from sect. *Atalanthus*), and the strands are partly fused. Thus, this species shares the most important features of some species of subgen. *Dendrosonchus* and may belong there. We support the opinion to unite some segregates close to *Sonchus* with *Sonchus* s. str. into a single genus according to morphological and anatomical features, and to treat the subgenus *Dendrosonchus* in broader sense (WEBB & BERTHELOT 1842-1850, ALDRIDGE 1976, REIFENBERGER & REIFENBERGER 1996). To this treatment, *P. pendula* should be placed into subgen. *Dendrosonchus*, forming a section of its own.

### Nomenclatural Conclusions

*Sonchus* sect. *Chrysoprenanthes* (SCH. BIP.) SENNIK., **comb. nov.**

Basionym: *Prenanthes* subgen. *Chrysoprenanthes* SCH. BIP. in WEBB et BERTH., Hist. Nat. Iles Canar. 3, 2, 2: 420 (1849).

Type: *Prenanthes pendula* SCH. BIP. (= *Sonchus pendulus* (SCH. BIP.) SENNIK.).

*S. pendulus* (SCH. BIP.) SENNIK., **comb. nov.**

Basionym: *Prenanthes pendula* SCH. BIP. in WEBB et BERTH., Hist. Nat. Iles Canar. 3, 2, 2: 421 (1849). – Syntype: “In montibus Canariae, WEBB” (LE!).

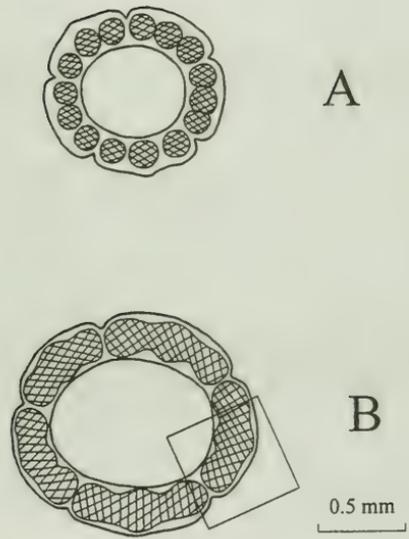
### References

- ALDRIDGE, A. E. 1976. Anatomy and evolution in the Macaronesian *Sonchus* subgenus *Dendrosonchus* (Compositae: Lactuceae). *Bot. Journ. Linn. Soc.* 76 (4): 349–285.
- BRAMWELL, D. & Z. BRAMWELL 1974. *Wild flowers of the Canary Islands*. Stanley Thornes (Publishers) Ltd., London.
- BREMER, K. 1993. New subtribes of the Lactuceae (Asteraceae). *Novon* 3: 328–330.
- BREMER, K. 1994. *Asteraceae: Cladistics and Classification*. Timber Press, Portland, Oregon.
- KIM, S.-C., CRAWFORD, D. J. & R. K. JANSEN 1996. Phylogenetic relationships among the genera of the subtribe Sonchinae (Asteraceae): Evidence from ITS sequences. *Syst. Bot.* 21 (3): 417–432.
- LAVIALLE, P. 1912. Recherches sur le developpement de l’ovaire en fruit chez les Composées. *Ann. Sci. Nat. (Paris)*. Sér. 9, 15: 39–149.

- PAK, J.-H. & S. KAWANO 1990 a. Biosystematic studies on the genus *Ixeris* (Compositae – Lactuceae), I. Fruit wall anatomy and its taxonomic implications. *Acta Phytotax. Geobot.* 41 (1-3): 43–60.
- PAK, J.-H. & S. KAWANO 1990 b. Biosystematic studies on the genus *Ixeris* and its allied genera (Compositae – Lactuceae), III. Fruit wall anatomy and karyology of *Crepidiastrum* and *Paraixeris*, and their taxonomic implications. *Acta Phytotax. Geobot.* 41 (3-6): 109–128.
- PÉREZ DE PAZ, J. 1976. Observaciones sobre la biología y relaciones de *Sventenia bupleuroides* F. Q. *Botanica Macaronésica* 1: 51–65.
- REIFENBERGER, U. & A. REIFENBERGER 1996. Vereinigung der Gattung *Taeckholmia* BOULOS mit der Gattung *Sonchus* L. (Compositae) und Emendation des Subgenus *Dendrosonchus* SCH. BIP. *Feddes Repert.* 107 (5-6): 311–319.
- SENNIKOV, A. N. 1997. The species of the genera *Prenanthes* and *Cicerbita* group (Asteraceae) in the Caucasus. *Bot. J. (St. Petersburg)* 82 (2): 106–114 (in Russian).
- SENNIKOV, A. N. (in press). De generibus ex affinitate *Prenanthes* L. (Asteraceae). *Novit. Syst. Pl. Vasc. (St. Petersburg)* (in Russian).
- SENNIKOV, A. N. & I. D. ILLARIONOVA (in press). Morphological and anatomical structure of achenes in the genus *Sonchus* s. l. (Asteraceae). *Bot. J. (St. Petersburg)* (in Russian).
- SVENTENIUS, E. R. S. 1960. *Additamentum ad floram canariensem*. Madrid, Spain.
- WEBB, P. & S. BERTHELOT 1842-1850. *Histoire naturelle des Iles Canaries*. 3 (2, sect. 2): 1-496, Pt. 37–136 b.



**Fig. 1.** An achene of *P. pendula* (SEM micrograph),  $\times 20$ .



**Fig. 2.** Simplified cross section of achene of *P. pendula*. A: at the base part of the achene. B: at the middle part of the achene. Sclerenchyma tissue is crossed.

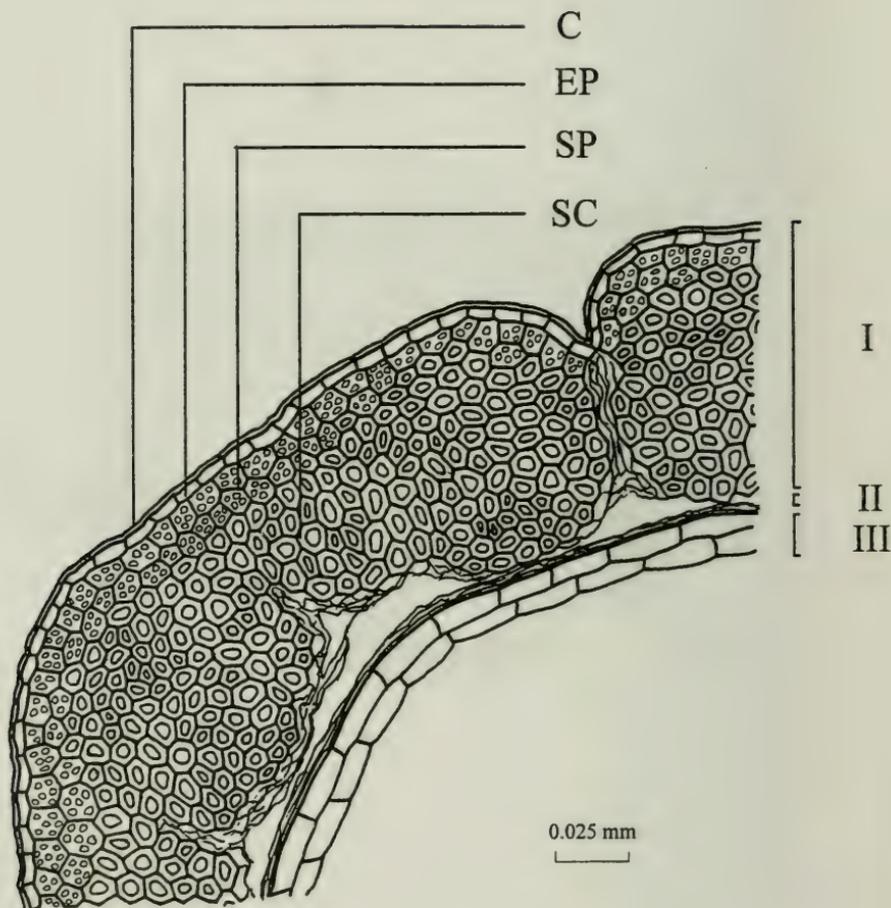


Fig. 3. Part of cross section of mature achene of *P. pendula* with anatomical details. I – pericarp; II – seed coat obliterated; III – endosperm. Cuticle of epidermic cells (C); epidermal cells of pericarp (EP); sclerified elongated parenchyma (SP); sclerenchymatous cells of pericarp (SC).

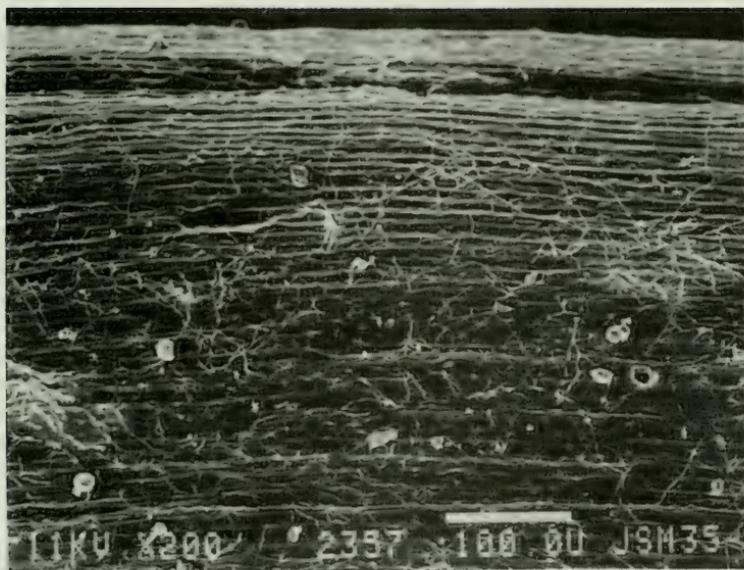


Fig. 4. Structure of achene surface of *P. pendula* (SEM micrograph),  $\times 200$ .

# Phytosociological investigation of Compositae weeds in abandoned farmlands in Ekiti State, Nigeria

JOSHUA KAYODE  
Department of Botany  
Ondo State University  
Ado Ekiti, Nigeria

## Abstract

Weed species belonging to the family Compositae were studied among other plant weeds present in three abandoned farmlands in Ekiti State, Nigeria. *Tridax procumbens*, *Chromolaena odorata* and *Ageratum conyzoides* are the dominant Compositae weed species in the study area.

## Introduction

In southwestern Nigeria, the prevalent agricultural system has been, and will most likely continue to be, shifting cultivation. After the fields have been cultivated for one or two years, they are left to fallow, and the fallow areas are immediately invaded by a dense mass of weeds, most of which are members of the family Compositae.

The various colonization strategies employed by weeds have been widely studied but a limited number of quantitative studies on their phytosociology and ecology have been published. In Nigeria some investigations so far reported are those of AFOLAYAN (1988) and AFOLAYAN & AYODELE (1990).

The present study was undertaken to elucidate the phytosociology of Compositae weeds in Ekiti State of southwestern Nigeria.

## Materials and Methods

The study area is situated in Ekiti State, between latitude 7°25' and 8°20'N and longitude 5°00' and 6°00'E. This state has a contiguous land mass of about 7,000 sq. kilometers and over 75 % of its 1.6 million inhabitants are farmers (EKSG 1997). There are two climatic seasons, viz., a rainy season which lasts from March to October, and a dry

season which lasts from November to February, and the annual rainfall is about 1150 mm (KAYODE & FALUYI 1994).

**Methods:** Three study sites designated A, B and C were chosen within 20 km radius from Ado Ekiti, the Ekiti State capital. Site A was an abandoned farm in Ado Ekiti, Site B was an abandoned farm in Ikere-Ekiti about 20 km south of the state capital, and Site C was an abandoned farm in Ifaki-Ekiti, about 20 km north of the state capital.

In each site, a 100 m by 100 m study plot was investigated in January, 1998. Prior to the study, each of the sites had been cropped continuously for a period of two to three years for cassava, yams, maize, rice or vegetables, alone or in mixtures.

Also in each site, a quadrat sized 50 cm by 50 cm was tossed fifty times, and Compositae weeds in each quadrat were observed, identified and recorded on an abundance scale defined by BONGERS et al. (1988) as follows: Less than 5 individuals as rare (R); 5 to 10 as occasional (O), 11 to 30 as frequent (F), 31 to 100 individuals as abundant (A), and over 100 individuals as very abundant (VA).

The importance value index (IVI), which is the sum total of the relative density, relative frequency and relative basal area, was also determined for each Compositae weed species.

The Index of Similarity (IS) between the sampling sites, i.e. Sites A and B, A and C, and B and C, were determined as

$$IS = 2C \times 100 / A + B$$

where A is the number of species in one site; B is the number of species in the other site; C is the number of species common to both sites.

## Results and Discussion

The results obtained revealed that a total of 36 different weed species were sampled in the three study sites, out of which 21 weedy species were members of Compositae. Table 1 shows that Compositae made up of over 60 % of the total number of weed species and the numbers of weed individuals in the study area.

The ten most dominant Compositae weed species in the study area are shown in Table 2. The species were ranked in order of their decreasing IVI value. *Tridax procumbens*, *Chromolaena odorata* and *Aspilia africana* were the most dominant Compositae weeds in the study area, with IVI values of 89.26, 46.62 and 44.19 respectively.

On the abundance scale, these dominant species were very abundant in all the three sites sampled in this study (Table 2).

The indexes of similarity between sites A and B, A and C, and B and C were 82.05 %, 89.47 % and 92.68 % respectively (Table 3). These values revealed that the Compositae weed species were common to all the serial communities sampled.

The predominance of *Tridax procumbens* in the study area could be a function of its method of dispersal which occurs by wind. Previous investigation by AFOLAYAN (1988) had also revealed that this weed easily adapts itself to the climatic and edaphic conditions prevailing in the study area. Apart from this rain of seeds, it could also be a function of *Tridax* seeds stored already in the soil during cultivation of the fields, and the dormancy of which is easily broken by light.

*Chromolaena odorata* is an efficient colonizer of disturbed sites (EPP 1987). Its predominance in the study area could be attributed to its rapid dispersal by wind which usually occurs between January and March, and its ability to establish easily in the study area (ETEJERE 1980). Also previous research efforts had established that a bank of *C. odorata* seeds exists in the soil of early successional communities (RAMAKRISHNAN & MISHRA 1982). Longevity of these seeds which is increased by enforced dormancy after burial in the soil (YADAV & TRIPATHI 1982) is broken in full sunlight (AULD & MARTINS 1975).

Similarly, *Ageratum conyzoides* is widely known to appear in the month of January (GUPTA & MUKERJI 1995), which is the month when this study was carried out. Thus its appearance at this time of the year explains its predominant status.

The indexes of similarity between the study sites (Table 3) show that a lot of the Compositae weeds were common to the three sites. Thus it could be inferred that areas with the same climatic conditions will enhance the growth of related weed species. In conclusion, phytosociological information on the Compositae weed species in a given vegetation type will surely contribute to the comprehensive understanding of their ecology.

### References

- AFOLAYAN, A. J.** 1988. Phytosociological investigations of three abandoned farmlands in Oyo, Ondo and Kwara States of Nigeria. *Nig. J. Weed Science* 1: 77–82.
- AFOLAYAN, A. J. & G. AYODELE** 1990. Phytosociophysiological study of the weed flora of cassava (*Manihot esculenta* CRANTZ) in Kwara State, Nigeria. *Bioscience Research Communications*.
- AULD, B. A. & P. M. MARTINS** 1975. The autecology of *Eupatorium adenophorum* SPRENG. in Australia. *Weed Research* 15: 27–31.
- BONGERS, F., POPMA, J., MEAVE DEL CASTILLO, J. & J. CARABIAS** 1988. Structure and floristic composition of the lowland rain forest of Los Tuxtlas, Mexico. *Vegetatio* 74: 55–80.
- EKSG** 1997. First Anniversary Celebrations of Ekiti State Government. 22 pp.
- EPP, G. A.** 1987. The seed bank of *Eupatorium odoratum* along a successional gradient in a tropical rainforest in Ghana. *Journal of Tropical Ecology* 3: 139–149.
- ETEJERE, E. O.** 1980. Viability of herbicide-treated seeds of *Eupatorium odoratum* L. *Weed Research* 20: 361–368.
- GUPTA, R. & K. G. MUKERJI** 1995. Studies on weeds of Delhi III - Compositae. *Compositae Newsletter* 27: 1–6.
- KAYODE, J. & M. A. FALUYI** 1994. Studies on self and cross compatibility in soyabeans (*Glycine Max*) in a tropical environment. *Nigerian Journal of Botany* 7: 55–61.
- RAMAKRISHNAN, P. S. & B. K. MISHRA** 1982. Population dynamics of *Eupatorium adenophorum* SPRENG. during secondary succession after slash and burn agriculture in Northeast India. *Weed Research* 22: 77–84.
- YADAV, A. S. & R. S. TRIPATHI** 1982. A study on seed population dynamics of three weedy species of *Eupatorium*. *Weed Research* 22: 69–76.

**Table 1. Demographic features of weeds in abandoned farmlands in Ekiti State, Nigeria.**

<b>Description</b>	<b>Site A</b>	<b>Site B</b>	<b>Site C</b>	<b>Total</b>
Total number weed species/site	29	33	36	36
Number of Compositae weed species /site	18	21	20	21
% Composition of Compositae weed species to the total number of weed species/site	62 %	64 %	56 %	61 %
Total number of weed individuals/site	8387	8349	9200	26936
Total number of Compositae weed individuals/site	5638	5677	5520	16565
Percentage of Compositae weeds of total number of weeds	64 %	68 %	60 %	64 %

Table 2. Attributes of ten dominant Compositae weed species in abandoned farmlands in Ekiti State, Nigeria.

S/N	Species	Plant* growth form	Species ** Abundance/Site			IVI/Site ***			Average IVI Value
			A	B	C	A	B	C	
1	<i>Tridax procumbens</i> L.	H	VA	VA	VA	90.25	92.28	82.25	89.26
2	<i>Chromolaena odorata</i> (L.) K. & R.	H	VA	VA	VA	50.49	45.29	44.10	46.62
3	<i>Ageratum conyzoides</i> L.	H	VA	VA	VA	45.04	40.46	47.07	44.19
4	<i>Aspilia africana</i> (PERS.) C. D. ADAMS	H	VA	VA	A	24.86	30.11	19.85	24.94
5	<i>Bidens pilosa</i> L.	H	VA	VA	VA	20.13	28.27	26.12	24.84
6	<i>Emilia sonchifolia</i> (L.) DC.	H	A	F	O	38.25	4.57	3.11	15.31
7	<i>Vernonia amygdalina</i> DEL.	S	F	O	A	19.67	2.04	21.64	14.45
8	<i>Galinsoga ciliata</i> (RAF.) BLAKE	H	A	O	R	27.48	3.57	0.60	10.55
9	<i>Emilia coccinea</i> (SIM) G. DON	H	O	A	F	0.78	21.31	9.35	10.48
10	<i>Sonchus schweinfurthii</i> OLIV. & HIERN	H	F	F	O	8.63	16.98	4.06	9.89

\* H = Herb, S = Shrub

\*\* VA = Very abundant; A = Abundant; F = Frequent; O = Occasional and R = Rare.

\*\*\* IVI = Importance Value Index. Values calculated based on the Compositae weeds only.

**Table 3. Index of similarity (IS) between the three sample sites.**

<b>Site</b>	<b>IS %</b>
<b>A and B</b>	<b>82.05</b>
<b>A and C</b>	<b>89.47</b>
<b>B and C</b>	<b>92.68</b>

## New taxa and combinations published in this issue

*Angelphytum apense* (CHODAT) PRUSKI, comb. nov.: p. 2.

*Angelphytum herzogii* (HASSLER) PRUSKI, comb. nov.: p. 2.

*Dendrophorbium argutidentatum* (CUATREC.) H. BELTRAN, comb. nov.: p. 51.

*Dendrophorbium cosnipatense* (CABRERA) H. BELTRAN, comb. nov.: p. 51.

*Dendrophorbium goodspeedii* (CUATREC.) H. BELTRAN, comb. nov.: p. 51.

*Dendrophorbium llewelynii* (CUATREC.) H. BELTRAN, comb. nov.: p. 51.

*Dendrophorbium trigynum* (CUATREC.) H. BELTRAN, comb. nov.: p. 51.

*Dendrophorbium vanillodorum* (CABRERA) H. BELTRAN, comb. nov.: p. 51.

*Dendrophorbium vargasii* (CABRERA) H. BELTRAN, comb. nov.: p. 51.

*Monticalia abietina* (WILLD. ex WEDD.) C. JEFFREY var. *aciculata* (CUATR.) B. NORD.,  
comb. nov.: p. 31.

*Monticalia albi-panquei* (DÍAZ & CUATR.) B. NORD., comb. nov.: p. 34.

*Monticalia almorzana* (DÍAZ & CUATR.) B. NORD., comb. nov.: p. 33.

*Monticalia cacaoensis* (CUATR.) B. NORD., comb. nov.: p. 34.

*Monticalia carrikeri* (CUATR.) C. JEFFREY var. *macrophylla* (DÍAZ) B. NORD., comb.  
nov.: p. 32.

*Monticalia carupana* (DÍAZ) B. NORD., comb. nov.: p. 32.

*Monticalia elatoides* (WEDD.) B. NORD., comb. nov.: p. 31.

*Monticalia fimbriifera* (DÍAZ & MÉNDEZ) B. NORD., comb. nov.: p. 35.

*Monticalia guadalupe* (CUATR.) C. JEFFREY subsp. *caucana* (CUATR.) B. NORD., comb.  
nov.: p. 35.

*Monticalia hammenii* (DÍAZ & CUATR.) B. NORD., comb. nov.: p. 34.

*Monticalia harrietae* (CUATR.) B. NORD., comb. nov.: p. 31.

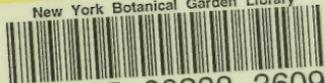
*Monticalia iguaquensis* (DÍAZ & CUATR.) B. NORD., comb. nov.: p. 33.

- Monticalia juajibioyi* (DÍAZ & CUATR.) B. NORD., comb. nov.: p. 30.
- Monticalia ledifolia* (H. B. K.) C. JEFFREY var. *glabrata* (DÍAZ & MENDEZ) B. NORD., comb. nov.: p. 34.
- Monticalia ledifolia* (H. B. K.) C. JEFFREY var. *lanata* (H. B. K.) B. NORD., comb. nov.: p. 33.
- Monticalia pulchella* (H. B. K.) C. JEFFREY subsp. *guantivana* (CUATR.) B. NORD., comb. nov.: p. 32.
- Monticalia romeroana* (DÍAZ & BUENO) B. NORD., comb. nov.: p. 30.
- Monticalia schultzei* (CUATR.) B. NORD., comb. nov.: p. 30.
- Monticalia schultzei* (CUATR.) B. NORD. subsp. *sevillana* (CUATR.) B. NORD., comb. nov.: p. 31.
- Monticalia subarachnoidea* (WEDD.) C. JEFFREY var. *pauciflora* (DÍAZ & BUENO) B. NORD., comb. nov.: p. 30.
- Monticalia summapacis* (CUATR.) B. NORD., comb. nov.: p. 33.
- Monticalia taironae* (DÍAZ & CUATR.) B. NORD., comb. nov.: p. 34.
- Monticalia tolimensis* (CUATR.) C. JEFFREY var. *colombiana* (CUATR.) B. NORD., comb. nov.: p. 35.
- Monticalia vaccinioides* (H. B. K.) C. JEFFREY var. *microdentata* (CUATR.) B. NORD., comb. nov.: p. 32.
- Oyedaea cuatrecasatii* PRUSKI, sp. nov.: p. 3.
- Oyedaea neei* PRUSKI, sp. nov.: p. 5.
- Pentacalia petiolincrassata* (CABRERA & ZARDINI) H. BELTRAN, comb. nov.: p. 51.
- Sonchus* sect. *Chrysoprenanthes* (SCH. BIP.) SENNIK., comb. nov.: p. 56.
- Sonchus pendulus* (SCH. BIP.) SENNIK., comb. nov.: p. 56.



Faint, illegible text, possibly bleed-through from the reverse side of the page.

New York Botanical Garden Library



3 5185 00288 3609

**LIBRARY**

**JAN 3 2000**

**NEW YORK  
BOTANICAL GARDEN**