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Architecture of the genus *Gutierrezia* (Asteraceae: Astereae, Solidagininae)

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Summary: An architectural study of the genus *Gutierrezia* Lag. was carried out, and seven different models were established. Differences in architecture between North American and South American species are pointed out. A key to differentiate the models is provided.

Key words: Asteraceae, Astereae, *Gutierrezia*, plant architecture

Resumen: Arquitectura del género *Gutierrezia* (Asteraceae: Astereae, Solidagininae). Se llevó a cabo el estudio de la arquitectura del género *Gutierrezia* Lag. y se establecieron siete modelos. Se señalan las diferencias arquitecturales entre las especies de Norteamérica y Sudamérica. Se provee una clave para diferenciar los modelos propuestos.

Palabras clave: Asteraceae, Astereae, *Gutierrezia*, arquitectura de plantas

Introduction

Plant architectural studies, according to Hallé *et al.* (1978), Bell (1991) and Sattler (1991), have been mainly employed for describing and comparing the habit of species.

For practical reasons, a study of herbarium plants is limited to the examination of fragments and is minimally related to development. Architectural analysis can make a systematic description more complete and may provide new characters for diagnostic purposes (Tomlinson, 1987).

Architectural concepts provide several characters useful for making taxonomic decisions and whose states can be coded and usefully employed in phylogenetic analysis (Aagesen, 1999).

It is worthwhile considering architectural studies in taxonomic analysis as Bartoli & Tortosa (2003) did with genus *Grindelia* Willd (Asteraceae). Some years later, Bartoli (2007) conducted a phylogenetic study of Xanthocephalum group (Asteraceae, Astereae) which included morphological characters related to the architecture of plants of the genus *Grindelia* and related (*Isocoma* Nutt*., Olivaea* Sch. Bip. ex Benth.*, Rayjacksonia* R. L. Hartm & M. A. Lane*, Stephanodoria* Greene and *Xanthocephalum Willd).*

Gutierrezia is a New World xerophytic genus of the tribe Asteraeae subtribe Solidagininae. It has an area of distribution in North America, where it is represented by 18 species (Nesom, 2006), it does not occur in Central America, but reappears in South America (Argentina, Bolivia, and Chile) with about 17 species (Ratto & Bartoli, 2014; 2015; 2016a, 2016b, 2016c).

The genus comprises herbaceous annuals and perennial subshrubs or shrubs that show a great variability in habit, from cushion bushes to shrubs near 1 m high, some of them developing a taproot. Also, the position of the stems varies from decumbent to erect.

The aim of the present work is to study the architecture of the species of *Gutierrezia*. This analysis, which leads to the setup of seven different models, may contribute –along with other morphological, cytological and molecular traits- to making taxonomic decisions.

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Material and Methods

North American species have been studied from specimens sent on loan by

PH, RSA and TEX. South American species have been observed in the field by a member of the team (FR) and others from specimens deposited in the following herbaria: BA, BAA, BAB, BBB, CONC, MCNS, MERL, LIL, LP, SI.

We also had access to digital collection of type specimens that were deposited in the following institutions: BR, COL, CORD, E, F, G, GH, GOET, K, LP, LPS, MERL, MPU, NY, P, S, SGO, US.

Results

Species of *Gutierrezia* are annual herbs (only from North America) or perennial ramified prostrate or erect subshrubs or shrubs up to 1 m high (North American and South American species). Representatives of the genus have sympodial shoots that end either in a solitary head (e.g. *G. tortosae* Ratto & A. Bartoli) or in a corymb-like or panicle-like inflorescesce [e.g. *G. sarothrae* (Pursh) Britton, *G. taltalensis* Phil.]. Heads may be pedunculate (*G. mendocina* Ratto & A. Bartoli) or sessile (*G. chubutense* Ratto & A. Bartoli).

Most perennial species have a taproot [e. g., *G. isernii* (Phil.) Phil.], some of them also form a crown [*G. mandonii* (Sch. Bip.) Solbrig*, G. spathulata* (Phil.) Kurtz], and in some cases they develop rhizomes [*G. mendocina* Ratto & A.Bartoli*, G. californica* (DC.) Torr. & A. Gray*, G. repens* Griseb.]. In *Gutierrezia mandonii* the herbaceous stems die after flowering season and new shoots develop afterwards from the woody base of the plant.

In the following description the terms orthotropic and plagiotropic are used as defined by Halle *et al.* (1978) to indicate the direction of the stems' growth. Orthotropic stems grow vertically, while plagiotropic ones grow horizontally, over or below the soil surface.

The architectural study of the species of *Gutierrezia* has led to the establishment of seven different models which are described below:

MODEL 1 - Fig. 1.

Annuals. North American species of *Gutierrezia*.

Submodel A: Branches arise from the proximal zone of the primary stem: *G. arizonica* (A. Gray) M. A. Lane.

Submodel B: Proximal region of primary stem lacks branches; branching zone develops conspicuous, long internodes: *G. sphaerocephala* A. Gray*, G.texana* (DC.) Torr. & A. Gray.

Submodel C: Proximal region of primary stem lacks branches; branching zone is more condensed than the one in submodel B due to shorter internodes: *G. wrightii* A. Gray.

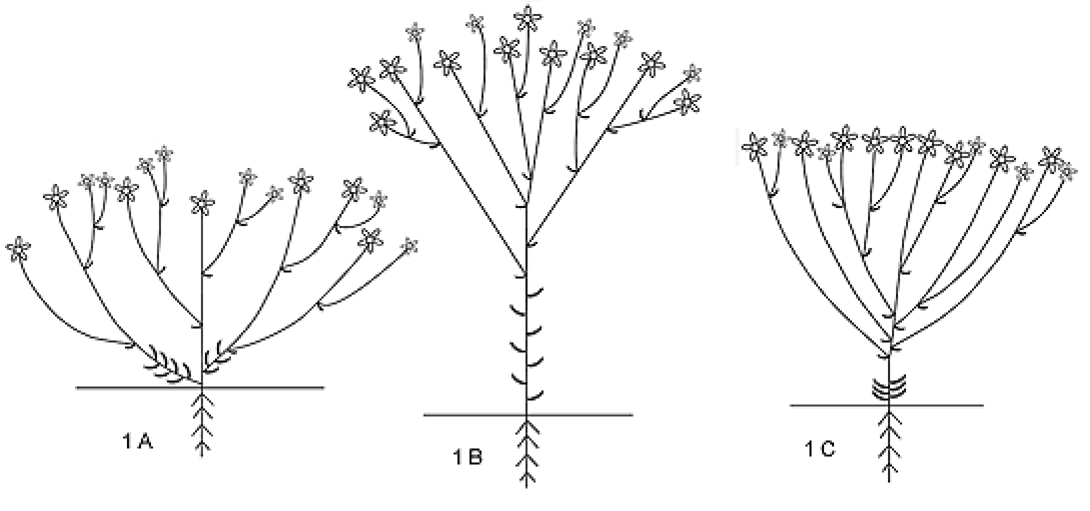

Fig. 1. **Model 1**, annuals, North American species. 1 A: branches arise from the proximal zone of the primary stem. 1 B: proximal region of primary stem without branches, branching zone with long internodes. 1 C: proximal region of primary stem lacks branches; branching zone with short internodes.

MODEL 2 - Fig. 2.

Perennial shrubs with taproot and orthotropic woody ramified stems that bear orthotropic herbaceous or subwoody branches. Subsequent branches are divaricated.

Submodel A: plant shape hemispherical, primary branches arise in an open angle: *G. resinosa* (H. & A.) Blake*, G.serotina* Greene, *G.ramulosa* (Greene) M. A. Lane.

Submodel B: plant shape conical, primary branches develop forming an acute angle: *G. isernii, G. microcephala* (DC.) A. Gray*, G. gayana* (J. Remy) Rieche.

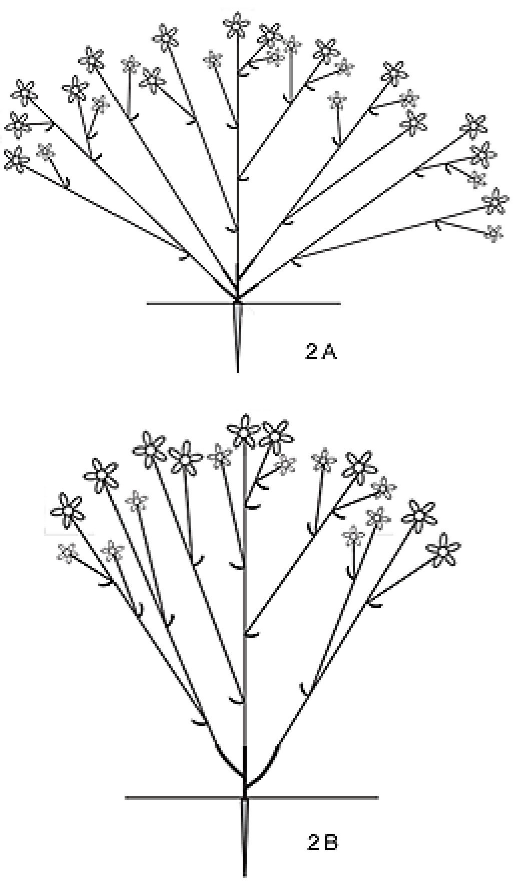

Fig. 2. **Model 2**, perennial shrubs with taproot and orthotropic woody ramified stems that bear orthotropic herbaceous or subwoody branches; subsequent branches are divaricated. 2 A: plant shape hemispherical, primary branches arise in an open angle. 2 B: plant shape conical, primary branches develop forming an acute angle.

MODEL 3 - Fig. 3.

Perennial shrubs with taproot and orthotropic stems that arise from the proximal ligneous region of the plant. These leafy branches ramify in their distal part: *G. sarothrae, G. grandis* S. F. Blake*, G. petradoria* (S. L. Welsh & Goodrich) S. L. Welsh*, G. pomariensis* (S. L. Welsh) S. L. Welsh.

MODEL 4 - Fig. 4.

Perennial shrubs with taproot and orthotropic stems that arise from a crown. Internodes are conspicuous and therefore secondary branches develop on distant nodes.

Submodel A: narrow crown, stems with long internodes. Stems end in solitary heads, the lower level branches are always shorter than the higher level ones: *G. leucantha* Cabrera.

Submodel B: narrow crown, plants more ramified and with shorter internodes than in Submodel A. Stems end in solitary heads, the lower level branches are shorter than the higher level ones: *G. argyrocarpa* Greenman*, G.gillesii* Griseb. Stems end in solitary heads, the lower level branches are longer than the higher level ones: *G. solbrigii* Cabrera*, G. chubutense* Ratto & A. Bartoli.

Submodel C: plagiotropic woody stems arising from crown which is wider and more extended than the ones described in submodels A and

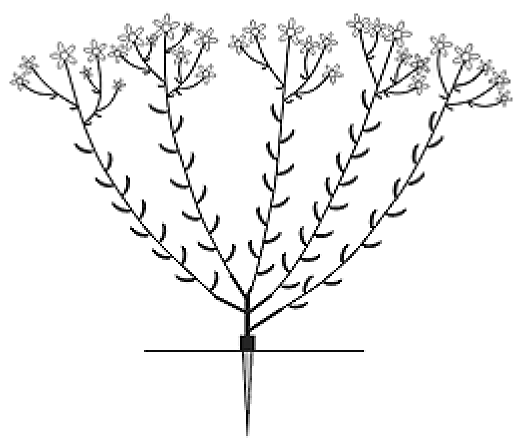

Fig. 3. Model 3, perennial shrubs with taproot and orthotropic stems that arise from the proximal ligneous region of the plant; these leafy branches ramify in their distal part.

B. Stems end in solitary heads, the lower level branches are shorter than the higher level ones: *G. spathulata*.

MODEL 5 - Fig. 5.
Perennial shrubs with taproot and long decumbent stems. Lower order stems are shorter (*) or longer (**) than the higher order ones, depending on the species.
Submodel A: both plagiotropic and orthotropic branches developing from the woody base of the plant: *G. taltalensis (**), G. mandonii (**), G. espinosae* Acevedo (*).
Submodel B: decumbent stems arise from primary axis and spread radially. These underground plagiotropic stems (rhizomes) develop adventitious roots: *G.mendocina (**), G. californica (**), G. repens (*), G. alamani* A. Gray *var. alamani (**), G. alamani var. megalocephala* (Fernald) M. A. Lane. *(*), G. conoidea* (Hemsl.) M. A. Lane (*).

MODEL 6 - Fig. 6.
Perennial shrubs with taproot. Orthotropic, scarcely branched leafy 2nd and higher order stems that end in solitary heads: *G. tortosae.*

MODEL 7 - Fig. 7.
Perennial rhizomatous cushion bushes. Decumbent stems with short internodes, ending in sessile to subssessile heads: *G. baccharoides* Sch. Bip*., G.ameghinoi.*Speg.

Key

A- Annuals.
B- Branches arising from the proximal zone of the primary stems. .... **Model 1 Submodel**
BB- Proximal region of primary stems without branches.
C- Branched zone developing conspicuous, long internodes. ....**Model 1 Submodel B**
CC- Branched zone without conspicuous internodes. .... **Model 1 Submodel C**
AA- Perennials.
D- Cushion bushes. Decumbent stems with short internodes, ending in sessile heads. .... **Model 7**
DD- Shrubs or subshrubs with taproot, not cushion bushes.
E– Perennial shrubs with only orthotropic stems.
F- Orthotropic stems arising from a crown.
G- Narrow crown.
H- Long internodes, plants loosely branched. Stems ending in solitary heads, lower level branches always shorter than the higher level ones. .... **Model 4 Submodel A**
HH- Internodes short. .... **Model 4 Submodel B**
GG- Wide crown. .... **Model 4 Submodel C**
FF- Primary branches arise from the proximal ligneous region of the plant, crown absent.
I- Second and higher order divaricated branches developing at distant scattered nodes. . **Model 2**
II- Second and higher order branches develop not like in I.
J- Orthotropic, scarcely branched leafy 2nd and higher order stems ending in solitary sessile heads. Hemispherical plants, broom-like when herborized. .... **Model 6**
JJ- Orthotropic stems arising from the proximal woody region of the plant. These leafy branches ramified at their distal part forming a corymb like inflorescence. .... **Model 3**
EE- Perennial shrubs with orthotropic and plagiotropic stems.
K- Plagiotropic and orthotropic branches developing at the base of the plant. . **Model 5 Submodel A**
KK- Decumbent stems arising from primary axis and spreading radially. Underground plagiotropic stems (rhizomes) developing adventitious roots. .... **Model 5 Submodel B**

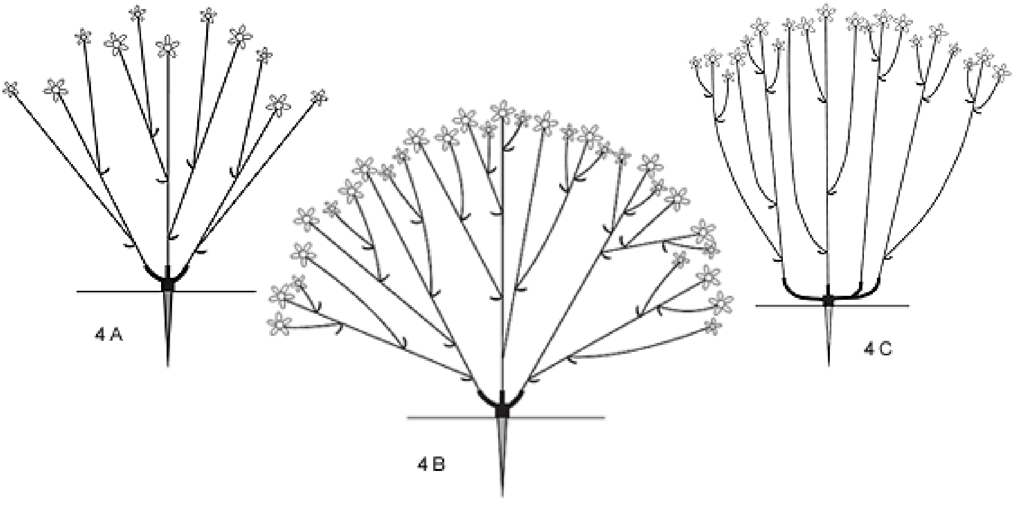

Fig. 4. **Model 4**, perennial shrubs with taproot and orthotropic stems that arise from a crown; internodes are conspicuous; therefore secondary branches develop on distant nodes; stems end in solitary heads. 4 A: narrow crown, stems with long internodes; the lower level branches are always shorter than the higher level ones. 4 B: narrow crown, plants more ramified and with shorter internodes than in A; the lower level branches may be shorter or longer than the higher level ones, depending on the species. 4 C: plagiotropic woody stems arising from crown which is wider and more extended than the ones described in submodels A and B; the lower level branches are shorter than the higher level ones.

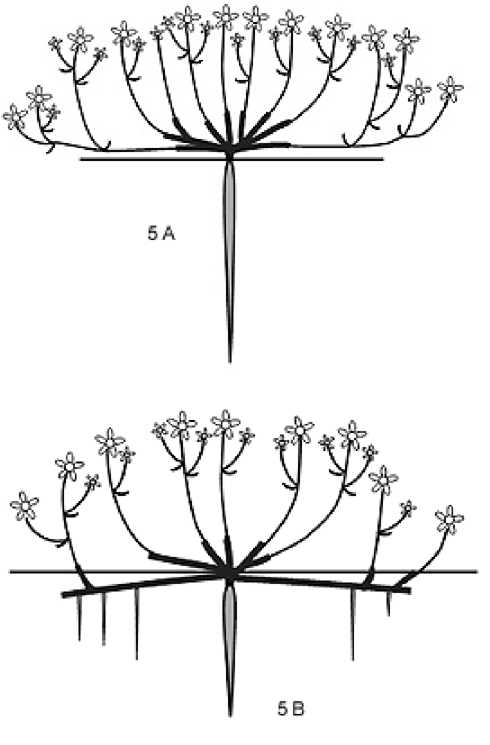

Fig. 5. Model 5, perennial shrubs with taproot and long decumbent stems; lower order stems are shorter or longer than the higher order ones, depending on the species. 5 A: both plagiotropic and orthotropic branches developing from the woody base of the plant. 5 B: decumbent stems arise from primary axis and spread radially; these rhizomes develop adventitious roots.

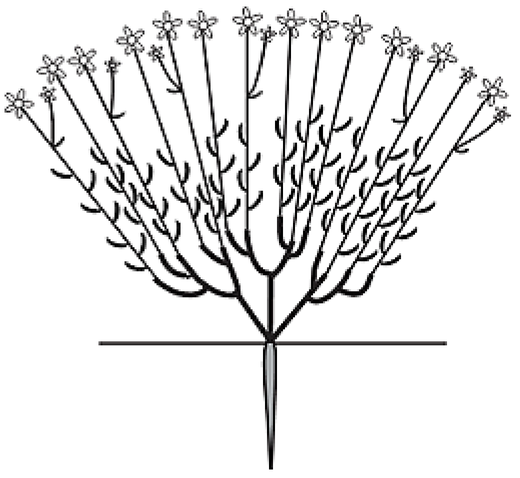

Fig. 6. Model 6, perennial shrubs with taproot; orthotropic, scarcely branched leafy second and higher order stems that end in solitary heads.

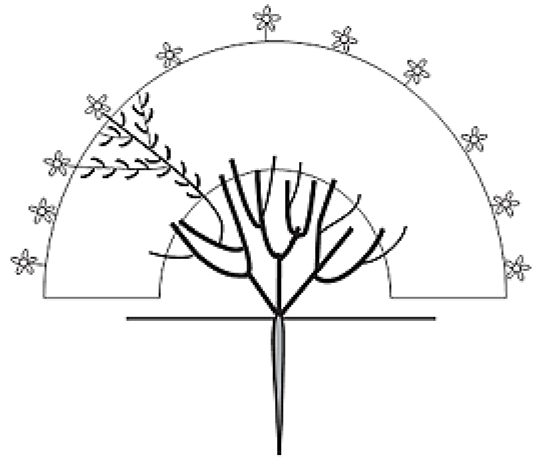

Fig. 7. Model 7, perennial rhizomatous cushion bushes; decumbent stems with short internodes, ending in sessile to subssessile heads.

Discussion

Species of *Gutierrezia* show variations in plants architecture. It comprises herbs, subshrubs or shrubs with morphological adaptations to the xerophytic habitats. Rhizomes, woody stems with taproots, very small and narrow leaf blades and root systems several times larger than the aerial portion are adaptive strategies to handle stress, fire and herbivory (Bartoli & Tortosa, 2003).

Some North American species of *Gutierrezia* are annuals (Model 1) or perennial subshrubs or shrubs (Models 2 to 5), with renewal buds located on the stems, above or under the ground (Model 5) or on woody old branches (Model 2 to 4). The annual models are found only in North American species.

Rhizomatous or stolonifer species (Model 5) and species with taproot (Model 2 to 5) are present in North and South America. On the other hand, perennial cushion subshrubs are present only in South America (Model 7), as well as plants with taproot and orthotropic stems.

Conclusions

The study of the architecture of plants of the genus *Gutierrezia* and all the characters involved in this analysis could be useful in phylogenetic studies. We conclude that an architectural analysis provides more diagnostic characters which can be coded in order to contribute to making taxonomic decisions.

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