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Arctotis gazanioides (Asteraceae: Arctotideae), a new species from the Bokkeveld Plateau, Northern Cape Province, South Africa

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Background: A taxonomic revision of *Arctotis* L. (Asteraceae) is ongoing. A previous botanical survey of the Avontuur Nature Reserve on the Bokkeveld Plateau, Northern Cape, located a potentially unnamed *Arctotis* taxon associated with seasonally wet sites.

Objectives: To compare the morphology of the *Arctotis* from the Avontuur Nature Reserve with morphologically comparable species of *Arctotis* and to determine its taxonomic status.

Method: The morphology of fresh collections, herbarium specimens, and relevant type material was examined. All relevant literature was consulted.

Results: The Avontuur *Arctotis* is morphologically distinct from *A. acaulis* L. var. *acaulis*, *A. acaulis* var. *undulata* DC. and *A. verbascifolia* Harv.

Conclusion: *Arctotis gazanioides* R.J.McKenzie & Helme is described as a new species distinguished by its branching rhizomatous root system with abundant fibrous adventitious roots, and discolorous leaves that are simple lanceolate, lanceolate-ovate to lanceolate-elliptic, or pinnatisect with a lanceolate to lanceolate-elliptic terminal lobe.

Keywords: Asteraceae; Arctotidinae; *Arctotis gazanioides*; new species; South Africa; morphology; taxonomy.

Introduction

Arctotis L. (Asteraceae, Arctotideae) is the largest genus in the subtribe Arctotidinae, comprising approximately 70 species endemic to southern Africa (Karis et al. 2009). *Arctotis* is diagnosed by female ray florets, hermaphrodite outermost disc florets, male or sterile innermost disc florets, smooth filaments, cypselae with the abaxial longitudinal ribs elaborated into two or three wings that create one or two 'cavities' or furrows, and a biseriate pappus of scales. As presently circumscribed, the genus is paraphyletic with *Arctotheca* J.C.Wendl., *Cymbonotus* Cass. and the core elements of *Haplocarpha* Less. (McKenzie & Barker 2008). A taxonomic revision of the genus by the corresponding author is ongoing. In this article, a geographically localised and ecologically specialised species from the Bokkeveld Plateau in the Northern Cape Province of South Africa is described. The species was discovered by the second author in 2012 during botanical surveys of the Avontuur 641 farm, following its purchase by the WWF South Africa and establishment of the Avontuur Nature Reserve. A comparative assessment of all morphologically similar species proved that the Avontuur *Arctotis* was morphologically distinct and supported its recognition at species rank. The species is here formally described and named in accordance with the *International Code of Nomenclature for algae, fungi, and plants* (ICN; Turland et al. 2018).

Materials and methods

Type material and relevant herbarium specimens housed in BOL, G, G-DC, GRA, K, MEL, NBG, P, PRE, S, SAM, UPS-THUNB and W were examined (herbarium acronyms follow Thiers 2021). Populations were observed in the field and fresh collections made from the Northern Cape Province during the winter–spring growing period. Samples were collected with the permission of the Northern Cape Department of Environment and Nature Conservation (permit no. FLORA 0006/2018) from a maximum of four individuals per population. Vouchers are lodged in GRA, K, NBG and PRE.

Microscopic characters were observed using a SMZ800N stereomicroscope and an Eclipse E200 brightfield microscope (Nikon, Tokyo, Japan). For brightfield microscopic observation, dried plant material was rehydrated in hot water containing a drop of dishwashing detergent and temporarily mounted in water on a microscope slide. Measurements were recorded from fresh or rehydrated material using either a digital vernier caliper (for macromorphological characters) or NIS-Elements D software (for microscopic characters; Nikon). Character measurements reported are derived from 1–6 samples per specimen and from 3–5 specimens. Morphological terminology mostly follows Stearn (1992) and Roque et al. (2009).

Taxonomy

Key to species allied to *Arctotis gazanioides*

This key is to the perennial *Arctotis* species with scapigerous shoots and an '*acaulis*'-type cypsela in which the cypsela is conspicuously constricted at the base, with three abaxial wings fused above the cypsela base, and crowned with a biseriate pappus of scales. Wherever possible, material from mature (ideally fruiting) plants should be used for reliable identification in *Arctotis*. Young plants of rhizomatous species might appear taprooted but are identifiable from leaf characters.

1a. Rootstock taprooted, woody, ± turbinate, often lacking secondary roots in upper portion; aerial shoots arising from rootstock crown:

2a. Mature leaves discolorous, adaxial surface pilose or glabrescent, not densely lanate, abaxial surface densely lanate, either simple (lamina outline ovate to elliptic) or pinnatisect or lyrate-pinnatisect (lamina outline obovate to elliptic; terminal lobe ovate, rarely ovate-lanceolate or lanceolate-elliptic), with 0–5(–7) pairs of lateral lobes 2–35 mm long, the longest lobes typically similar in length to terminal lobe width; apical appendage of outer involucral bracts 3.0–8.5(–10.5) mm long, ascending or reflexed . . . . . *Arctotis acaulis* L. var. *acaulis*

2b. Mature leaves densely lanate on adaxial and abaxial surfaces, usually simple (lamina outline ovate to subcordate), rarely lyrate-pinnatisect (lamina outline obovate to obovate-elliptic; terminal lobe ovate to subcordate) with 1–2 pairs of lateral lobes 2–15 mm long and considerably shorter than terminal lobe width; apical appendage of outer involucral bracts 0.5–2.5(–7.0) mm long, appressed or ascending or shortly reflexed . . . . . *Arctotis verbascifolia* Harv.

1b. Rootstock rhizomatous, rhizomes stout, woody, branching, with abundant fibrous adventitious roots; aerial shoots terminal on rhizome branches:

3a. Leaves simple (lamina outline lanceolate to lanceolate-elliptic), or pinnatisect (lamina outline lanceolate-elliptic or obovate-elliptic; terminal lobe lanceolate, lanceolate-elliptic or lanceolate-ovate), lateral lobes usually longer or of similar length to terminal lobe width, lobe apex frequently curved towards leaf apex; cypsela abaxial and lateral (radial) surfaces sparsely to moderately lanate . . . . . **Arctotis gazanioides** sp. nov.

3b. Leaves simple (lamina outline ovate to subcordate) or lyrate-pinnatisect (lamina outline obovate to obovate-elliptic; terminal lobe ovate to subcordate), lateral lobes similar in length or shorter than terminal lobe width, lobe apex not curved towards leaf apex; cypsela abaxial and lateral (radial) surfaces glabrous . . . . . .*Arctotis acaulis* var. *undulata* DC.

Arctotis gazanioides R.J.McKenzie & Helme, sp. nov. Type: SOUTH AFRICA, **Northern Cape**, Nieuwoudtville (3119): Avontuur Nature Reserve (–AC), 29 Sept. 2019, *R.J. McKenzie 3536* (NBG, holo.; GRA, K, PRE, iso.)

Evergreen herb initially rosulate, caespitose with age, clumps to ± 400 mm diameter and 100–200 mm tall. *Rootstock* of young plants taprooted, rhizomatous with age, rhizome cylindrical, stout, branching, woody, to ± 15 mm diameter, bearing abundant fibrous adventitious roots. *Stems* terminal on rhizome branches, internodes indistinct. *Leaves* crowded basally, spreading to ascending, lamina simple to pinnatisect (typically varying on the same plant), lamina simple (outline lanceolate or lanceolate-elliptic) or pinnatisect (outline lanceolate-elliptic or obovate-elliptic), (40–)60–180 × (6–)10–27 mm, length:width ratio 1.9–6.7, terminal lobe when present lanceolate, lanceolate-ovate

or lanceolate-elliptic, 20–60(–80) × 6–25 mm, length:width ratio 1.5–7.1, acute to obtuse, lateral lobes 0–4 pairs, longest lobes usually exceeding terminal lobe width, decreasing in length towards leaf base, oblong to oblong-triangular, often antrorse (i.e., lobe apex curved towards leaf apex), 2.5–15 × 1.5–14 mm wide at base, obtuse, lamina plane or subcanaliculate, margin plane or weakly undulate, dentate-crenate to incised, mucronate, discolorous, adaxial surface with soft short dense pilose pubescence, developing leaves

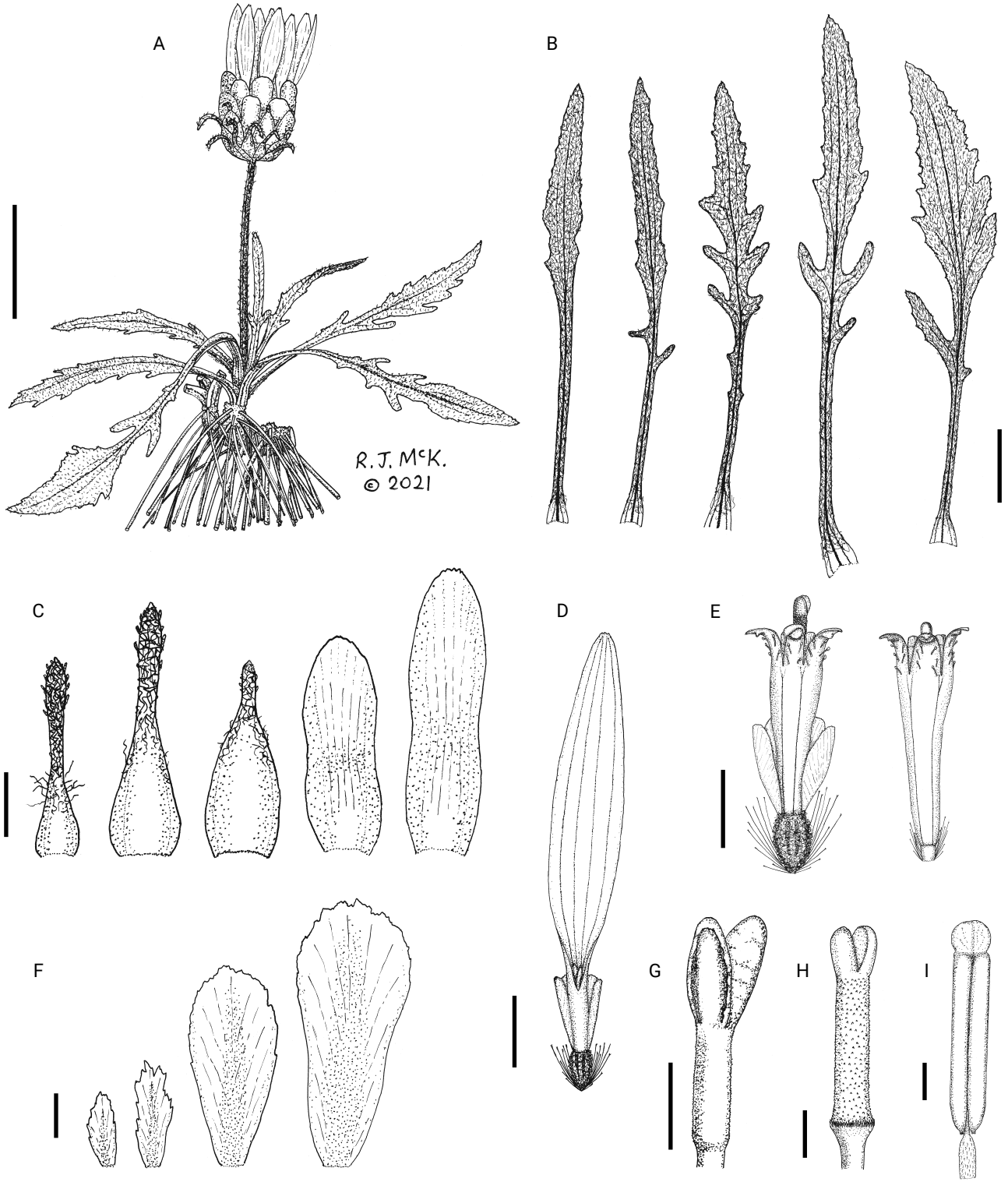

Figure 1. Morphology of *Arctotis gazanioides*. A, flowering shoot and portion of rhizome branch; B, leaves, adaxial surface; C, involucral bracts, abaxial surface, series from outermost (left) to innermost (right); D, ray floret; E, disc florets, peripheral (left) and central (right); F, ray floret pappus scales, smallest and largest scales from outer whorl (left) and inner whorl (right); G, style of ray floret; H, style of peripheral disc floret; I, stamen. Pappus scales and twin hairs on the abaxial side are not depicted in D and E for visual purposes. Scale bars: A, 50 mm; B, 20 mm; C, D, 5 mm; E, 2 mm; F, 1 mm; G–I, 0.5 mm. [*R. J. McKenzie 3536/1* (NBG)]. Artist: R. J. McKenzie.

sparsely–moderately lanate becoming glabrescent, abaxial surface densely lanate between major veins, pseudopetiolate, pseudopetiole 20–70 × 2–4 mm, whitish green or reddish purple, adaxial surface sparsely lanate, abaxial surface densely lanate between ribs, often with dense translucent pilose pubescence on both surfaces, base broadened, 3–6 mm wide, semi-amplexicaul, exauriculate, base densely lanate on both surfaces. *Capitulum* terminal, scapose, radiate, 40–55 mm diameter across open rays. *Peduncle* erect, longitudinally ribbed, densely lanate between ribs, dense dark red-purple pilose pubescence along entire length, 90–150 mm long, elongating until fruit maturation, naked. *Involucre* multiseriate, 14–18 × 18–21 mm; outer bracts triangular to triangular-ovate, appendiculate, glabrous to sparsely lanate, margins often flushed red-purple, base 1.5–5.6 × 1.2–4.2 mm, apical appendage linear, reflexed, 2.0–8.8 × 0.5–2.5 mm, obtuse, adaxial surface moderately lanate and pilose, abaxial surface densely lanate, appendage length:base length ratio 1.0–2.0; medial bracts ovate-triangular, margins flushed red-purple, obtuse to rounded, appendage rudimental or lacking, glabrous; inner bracts ovate-oblong to obovate-oblong, glabrous, obtuse to rounded, occasionally retuse, 10–16 × 2–5 mm, margin entire to erose, usually flushed red-purple, glabrous. *Receptacle* hemispherical, shallowly alveolate, alveolae to 1.25 mm high, fimbriate, fimbria to 4.3 mm long. *Ray florets* 21–27, functionally female, ray limb 18–24 × 4.4–4.9 mm, acute to obtuse, tridentate, limb adaxial surface orange or yellow-orange with black spot at base, adaxial lobe absent, abaxial surface flushed red-purple, abaxial surface with moderate glandular hairs, corolla tube glabrous, 3.9–4.0 × 1.1–1.2 mm; staminodes ovate-lanceolate, blackish; style arms ovate-lanceolate, blackish green, 1.0–1.2 × 0.4–0.5 mm; cypsela obovoid-obconical, base conspicuously constricted below the cavities, 3.0–3.5 mm long × 2.2–2.4 mm wide (tangential) × 2.1–2.5 mm wide (radial), abaxial surface with three wings fused above the base and forming two cavities, medial wing equal in length to or slightly longer than lateral wings, lateral wings hardly incurved, cavities 1.5–1.6 × 0.5–0.6 mm, triangular-linear, obtuse at base, wing margin entire or with incurved acute triangular-linear teeth to 0.5 mm long, partially to ± fully occluding cavity in lower half, medial wing margin entire or rugose-dentate; abaxial surface sparsely lanate, lateral (radial) surfaces moderately lanate, adaxial surface densely lanate; basal whorl of twin hairs ± equal in length to or slightly longer than

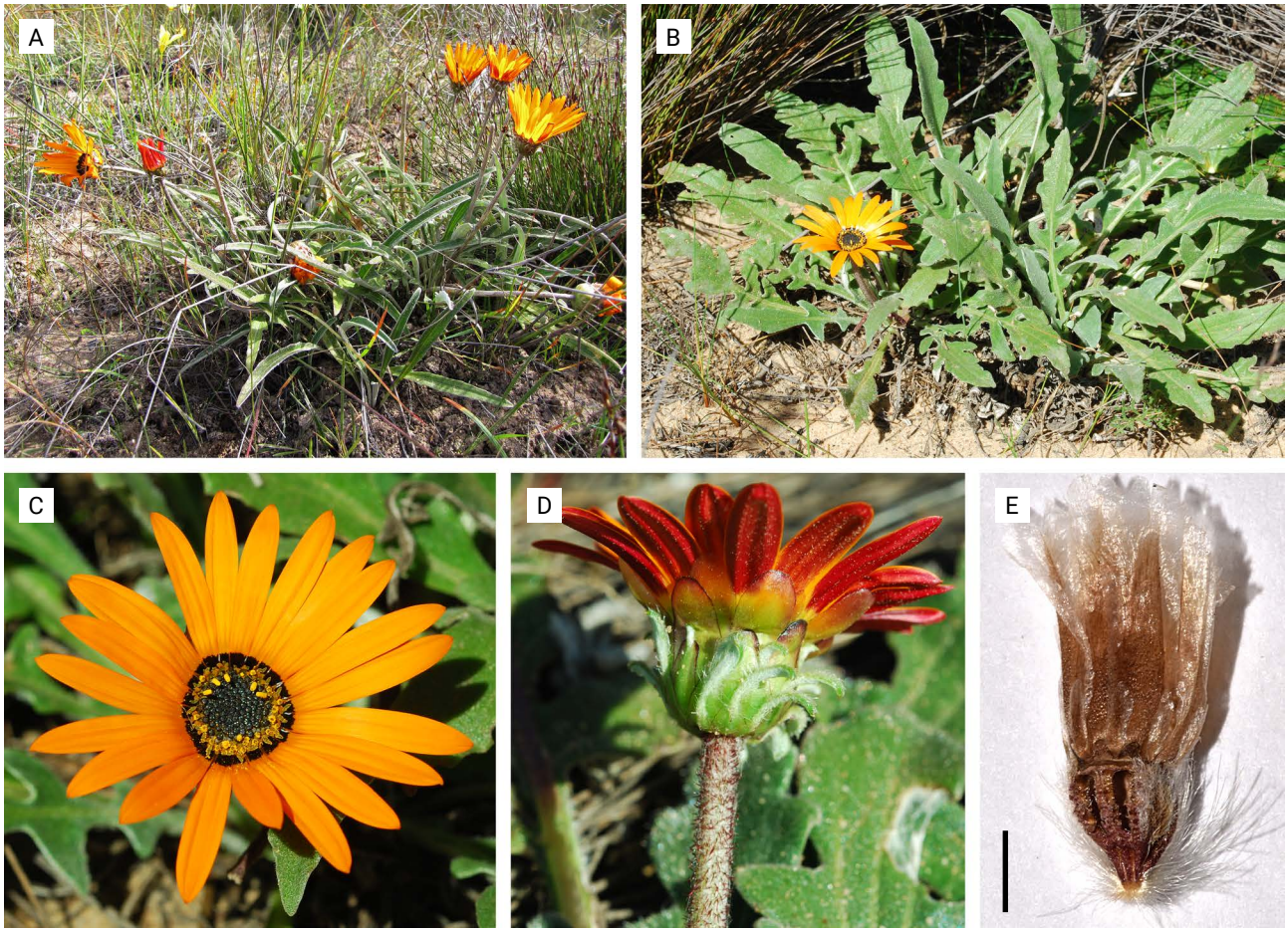

Figure 2. Morphology of *Arctotis gazanioides*. A, B, Plants in habitat, showing variation in leaf form; C, capitulum, face view; D, capitulum, lateral view; E, ray floret cypsela, abaxial/radial surfaces (note that the basal twin hairs on the abaxial side have been removed for visual purposes). Scale bar: 2 mm. Photographs: A, N.A. Helme; B–E, R.J. McKenzie.

Figure 3. Root system of *Arctotis acaulis* and *A. gazanioides*. A, branch of rhizome of *A. gazanioides* (*McKenzie 3536/3*, NBG); B, rootstock of *A. acaulis* var. *acaulis* (*McKenzie 3458*, NBG); C, branch of rhizome of *A. acaulis* var. *undulata* (*McKenzie 3203/2*, NBG). Scale bar: 10 mm.

cypsela, to 3.8 mm long, twin hair apex shortly forked (to 0.1 mm) of unequal or equal length; apical plate shortly pubescent, twin hairs to 0.6 mm long; pappus of scales, biseriate, pigmented purple-brown, straw-brown or ± translucent, outer whorl 0.4–2.1 × 0.4–0.8 mm, longer on adaxial side, lanceolate to obovate-oblong, acute to obtuse, lacerate to erose, inner whorl longer than cypsela, 3.7–7.5 × 1.5–2.5 mm, longer on abaxial side, obovate to obovate-oblong, rounded to obtuse, erose, outer surface acutely papillate. *Disc florets* ∞, outer florets hermaphrodite, inner florets functionally male, corolla funnelform, corolla tube 4.0–5.0 × 1.4–1.5 mm, glabrous, corolla lobes abaxial surface black, adaxial surface greenish orange, 1.2–1.8 × 0.7–0.9 mm, glandular trichomes sparse–moderate; anthers blackish, apical appendage subrotund-ovate, rounded, pollen orange-yellow; style thickening blackish grey, 1.9–2.2 mm long, arms oblong-ovate, to 0.4 mm long; cypsela of outer florets as for ray florets. Figures 1–3.

Distribution and habitat

Known only from a small area on the Bokkeveld Plateau north of Nieuwoudtville in the Northern Cape Province of South Africa (Figure 4). The species is associated with seasonally wet loamy sands in the Bokkeveld Sandstone Fynbos (FFs 1) vegetation unit (Rebelo et al. 2006).

Ecology

The species grows in seasonally wet, deep loamy sand at approximately 800 m elevation. The seasonally wet areas constitute discrete localised areas within a matrix of the surrounding fynbos and transitional renosterveld vegetation. Average annual rainfall at Avontuur is approximately 400 mm falling predominantly in winter (March–October), but with a strong rainfall gradient from the edge of the Bokkeveld Escarpment eastwards and marked inter-annual variability in the Nieuwoudtville area (Snijman & Perry 1987; Oettlé et al. 2019). The flowering period is August–October.

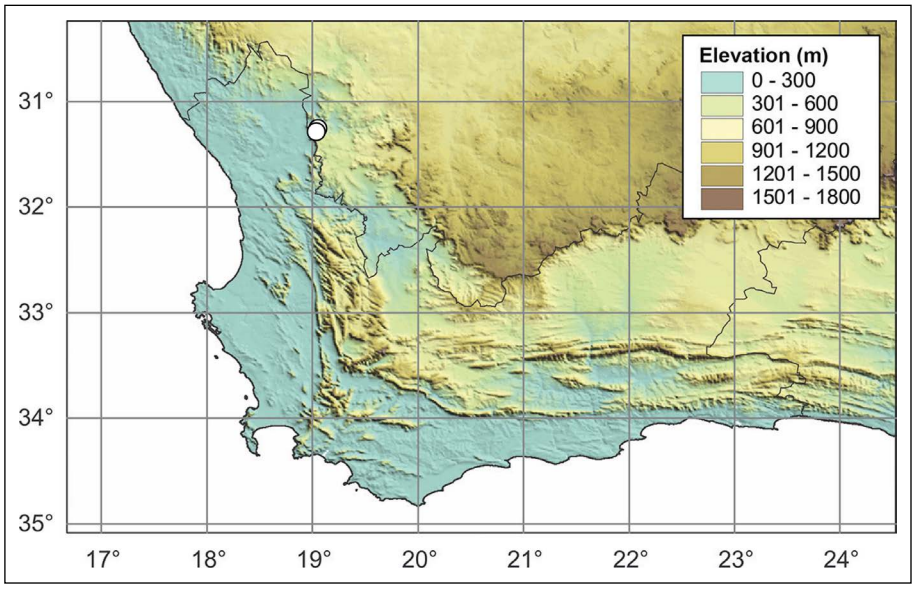

Figure 4. Distribution of *Arctotis gazanioides*.

Etymology

The epithet is an adjective derived from the genus name *Gazania* and the suffix *-oides*, indicating resemblance, alluding to the superficial resemblance to certain *Gazania* Gaertn. species in producing dimorphic leaves (simple and pinnatisect forms).

Illustration

Oettlé et al. (2019): 122 ("*Arctotis* species nova").

Diagnosis and relationships

Perennial herb differing from *Arctotis acaulis* L. var. *undulata* DC. in having leaves with a lanceolate to lanceolate-elliptic lamina (when simple) or terminal lobe (when pinnatisect) (versus ovate to subcordate in both cases), and cypselae lanate on all surfaces (versus cypselae glabrous or lanate only on adaxial surface); and from *Arctotis acaulis* L. var. *acaulis* in having a branching rhizome bearing abundant fibrous adventitious roots (versus ± turbinate taproot), and leaf lamina lanceolate to lanceolate-elliptic in outline (versus variable in outline but never lanceolate to lanceolate-elliptic).

Arctotis gazanioides is hypothesised to be closely allied to *A. acaulis* on the basis of cypsela morphology (see McKenzie et al. 2005). *Arctotis gazanioides* is diagnosable by the combination of a rhizomatous habit, leaves with a lanceolate to lanceolate-elliptic lamina (when simple) or lanceolate to lanceolate-elliptic terminal lobe (when pinnatisect), and cypselae lanate on all surfaces. *Arctotis gazanioides* and *A. acaulis* var. *undulata* are hypothesised to have arisen independently from *A. acaulis*-like progenitors as adaptations to seasonally inundated habitats. *Arctotis gazanioides* is distinguishable from other morphologically similar species by caulescence, lamina shape, pubescence and involucral bract characters (Table 1).

Conservation status

The species is geographically localised, being currently known from a single property, and is ecologically specialised. It is currently protected within the Avontuur Nature Reserve, which contains the last extensive area of relatively undisturbed Bokkeveld Sandstone Fynbos on the northern Bokkeveld Plateau (Oettlé et al. 2019). Currently, the reserve is partly managed for sustainable agricultural production. Most of the similar habitat on nearby properties in the area has been transformed by cultivation, and it is likely that most other potential subpopulations have thus been lost, but much of this loss probably occurred more than 30 years ago. Predicted climate change as a result of global warming, leading to a warmer and drier regional climate with a shorter rainfall season (Engelbrecht et al. 2009), may impact on the future extent of available habitat. The Extent of Occurrence (EOO) is < 10 km^2 and Area of Occupancy (AOO) is < 2 km^2. Given the plausible potential threats noted here, a conservation status of VU D2 (IUCN 2012) is warranted.

Additional specimens examined

SOUTH AFRICA. **Northern Cape**: **Nieuwoudtville** (3119): 20 km NW of Nieuwoudtville, Avontuur 641, 1 km E of Klipvlei (–AC), 9 Sept. 2012, *N.A. Helme 7620* (NBG); Avontuur Nature Reserve (–AC), 25 Sept. 2019, *R.J. McKenzie 3524*, *3533*, *3535* (NBG).

Acknowledgements

The curators and staff of the cited herbaria are thanked for allowing access to their holdings or for making digitised images available. The Northern Cape Department: Agriculture, Environmental Affairs, Rural Development and Land Reform is thanked for permission to collect

Table 1. Selected morphological differences among *Arctotis gazanioides* and morphologically similar perennial *Arctotis* species

Character	*A. gazanioides* sp. nov.	*A. acaulis* L. var. *acaulis*	*A. acaulis* var. *undulata* DC.	*A. adpressa* DC.	*A. campanulata* DC.	*A.* sp. E[1]	*A.* sp. 2[2]	*A. verbascifolia* Harv.
Root system	Rhizome	Taproot	Rhizome	Taproot	Rhizome	Rhizome	Taproot	Taproot
Aerial shoot caulescence	Acaulescent	Acaulescent	Acaulescent or shortly caulescent	Shortly caulescent	Shortly caulescent	Shortly caulescent	Shortly caulescent	Acaulescent to shortly caulescent
Leaf lamina shape (simple leaves)	Lanceolate, lanceolate-ovate to lanceolate-elliptic	Ovate to elliptic	Ovate to subcordate	N/A	Ovate to obovate	Linear, oblanceolate	Ovate	Ovate to subcordate
Leaf lamina shape (pinnatisect leaves)	Obovate-elliptic to lanceolate-elliptic	Obovate to obovate-elliptic	Obovate to obovate-elliptic	Obovate to obovate-elliptic	Obovate to obovate-elliptic	Lanceolate-elliptic to obovate-elliptic	Obovate to obovate-elliptic	Obovate
Terminal lobe shape	Lanceolate to lanceolate-elliptic to lanceolate-ovate	Ovate, rarely ovate-lanceolate or lanceolate-elliptic	Ovate to subcordate	Ovate to ovate-elliptic	Ovate	Lanceolate to ovate	Ovate to ovate-elliptic	Ovate to subcordate
Mature leaf pubescence – adaxial surface	Shortly, softly pilose, rarely sparsely lanate	Shortly, softly pilose	Shortly, softly pilose	Densely lanate	Densely lanate	Densely lanate	Densely lanate	Densely lanate
Involucre – outer bract apical appendage	Reflexed or ascending	Reflexed or ascending	Reflexed	Appressed	Reflexed	Absent	Appressed or shortly reflexed	Appressed or shortly reflexed
Involucre – outer bract appendage pubescence	Pilose and lanate	Pilose and lanate	Pilose and lanate	Lanate	Lanate	Absent	Lanate	Lanate
Ray limb colour	Orange	White, yellow, orange, occasionally pastel shades, rarely pale pink	Orange, yellow-orange	Yellow	Orange	White	White, yellow, orange	White, yellow

[1] McKenzie & Herman (2013)
[2] McKenzie (2012)
N/A, not applicable

plant specimens in the Northern Cape Province. Noel Oettlé is thanked for permission to access the Avontuur Nature Reserve. David Gwynne-Evans and Suna Verhoef are gratefully thanked for assistance with field work.

Competing interests

The authors declare that they have no conflict of interest.

Authors' contributions

N.A.H. discovered the species in the field, R.J.McK. performed field and experimental work, and both authors wrote the manuscript.

Ethical considerations

This study followed all ethical standards for research without direct contact with human or animal subjects.

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Data availability statement

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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