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Cover picture: *Gymnocalycium schmidianum* subsp. *asperum* n. subsp.
MM 1297. Catamarca, N of Fiambalá, 5.5 km N Mesada de los Zárate.
(Photo Massimo Meregalli)

Editorial

Dear Gymnocalycium enthusiast!

In the meetings of the Gymnocalycium study group held in Carmagnola (Turin, Italy) in 2011 and 2012, the *Gymmnocalycium* of the subgenus *Scabrosemineum* (formerly *Microsemineum*) were intensively discussed. The first discussions presented a general survey of the subgenus, and a detailed study of the *G. hossei* - *G. ferrarii* species complex. The results started being published in 2013 on Schuetziana 4 (2), with a revision of taxonomy and distribution of *G. ferrarii*. The discussion was then extended to *G. catamarcense* and *G. pugionacanthum*. When the apparent variability and the geographical distribution of all the populations of this group was clearly understood by the participants of the meeting, it became increasingly clear that the plants described as *G. catamarcense* subsp. *schmidianum* do not fit properly in *G. catamarcense*, differing from this species in several characteristics. Unfortunately, the information about type locality and distribution of *G. schmidianum* was still incomplete, so we put this issue back until more detailed information on the type of this taxon and the distribution of its various populations was available. Thanks to extensive field research in the whole range, and study of plants in cultivation and seeds, now all available data on *G. schmidianum* can be presented in their entirety and this issue is here brought into a conclusion.

We would like to express our special thanks to Mrs Iris Blanz (Fernitz, Austria), to Mr Brian Bates (Bolivia) and to Mr Graham Charles (United Kingdom), who supports us with the English language and to Mr Daniel Schweich (France), who has mirrored our publication under:
http://www.cactuspro.com/biblio/.

Gymnocalycium schmidianum, a good species. Notes on its distribution and ecology and description of a new subspecies.

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ABSTRACT. Based on the study of the morphological characters, with main regard to the spination, the flower and the seed, *Gymnocalycium schmidianum* is raised to species rank, from subspecies of *G. catamarcense*. All the known populations are examined and characterized, and the new subspecies *G. schmidianum* subsp. *asperum* is described, based on plants from the mountains and hills north and north-west of Fiambalá, in the Catamarca province.

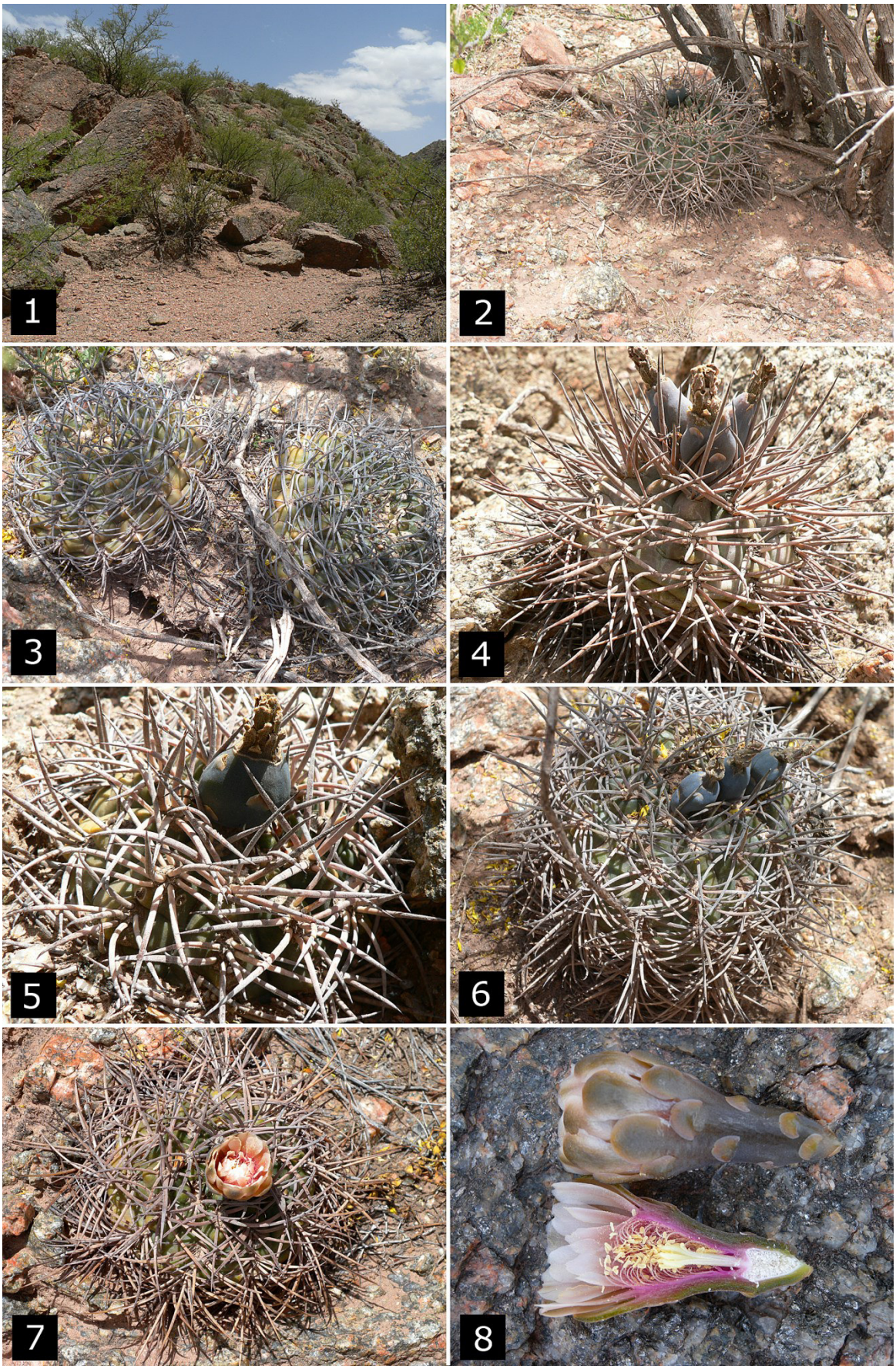
INTRODUCTION. H. Till & W. Till (1995) described *Gymnocalycium catamarcense* H. Till & W. Till, 1995. In the treatment of the species the authors also named a few infraspecific taxa, among which was *G. catamarcense* subsp. *schmidianum* H. Till & W. Till, 1995.
This subspecies was first collected during a field trip by Hans Till, Franz Strigl and Heinz Schmid. The name was based on the collection 87/60, the holotype being the plant numbered 1590 (this refers to Till's individual plant numbering). The type locality was indicated as south of Tinogasta. The field notes by Strigl detail that the plants were found on the first hills on the road south of Tinogasta towards Santa Cruz (that is, Ruta 3), near the border with La Rioja.
In the description the authors state that the same taxon was also found in the northern part of the Sierra de Zapata - evidently along the Ruta 3, the only road that crosses the Sierra de Zapata, joining Tinogasta with Ruta 40 near Londres, west of Belen.
Thus, even though no distribution map was provided, it can be deduced that the authors considered this species to be distributed along the Cuesta de Zapata and south of Tinogasta.
Gymnocalycium catamarcense subsp. *schmidianum* was differentiated from the other forms of the species mainly for its bluish and longer fruit, pinkish flower, and form of the seed (H. Till & W. Till 1995: 145).

Intense research carried out in recent years in the province of Catamarca allows us to revise the taxonomic status of this form, that does not seem to belong to *G. catamarcense*, redefine the significant morphologic traits and delimit its range. A new subspecific taxon was also identified.

The type population, 20 km south of Tinogasta

As said, *G. catamarcense* subsp. *schmidianum* was described based on the collection STO 60. The following notes are taken from Franz Strigl's travel diary: "Südlich Tinogasta links der Strasse ein Höhenzug, 1600 msm, nach beschwerlichen Anmarsch zunächst vergebliches Suchen. Schieβlich am Fuβe einer Bergrippe wildbedornte *G. hossei* v. *ferox*, kugelig bis leicht gestreckkugelig, 12–17 cm Ø, 13–18 cm hoch, z.T. schon abgeblüht, zuweilen mit unreifen blauen Früchten" [South of Tinogasta, left of the road, mountain range at 1600 m above sea level, after a difficult approach, initially fruitless researches. Finally at the foot of a mountain ridge strongly spiny *G. hossei* v. *ferox*, globose to slightly globose-elongated, 12–17 cm Ø, 13–18 cm height, some already flowered, sometimes with unripe blue fruits].

During field research carried out in 2010 one of the authors (Massimo Meregalli, together with Andrea Funetta) followed Ruta 3 south of Tinogasta. Almost 20 km south of the town the road approaches a hill chain, and (quite obviously!) researches were done along the slopes of the hills (MM 1150). A nearby location was also visited by L. Bercht (LB 1309). These hills are part of the Sierra de Copacabana, that extends for 38 km south to south-east of La Puntilla (Fig 180). According to Strigl's field notes, this is very probably the type locality of *G. catamarcense* subsp. *schmidianum*. The vegetation is composed of scattered *Larrea* and *Cercidium* shrubs, mainly in the lower alluvial area, in very sandy soil, and on the lower slopes of the hills, in granite gravel, together with some plants of *Acacia* (Fig. 1). The hills, mainly of granite rocks, have more plants of *Acacia*, always with scattered *Larraea* and *Cercidium*. *Gymnocalycium* of the subgenus *Scabrosemineum* were quite frequent on the slopes, but were absent from the alluvial flat plain. This may explain Strigl's sentence about the fruitless initial research. The other Cactaceae that were seen in this area are *G. saglionis*, *Echinopsis leucantha*, *Echinopsis strigosa*, and some Opuntioideae. Some of the *Gymnocalycium* were growing below shrubs, but quite a lot of plants were seen growing directly on the granite rocks. It was suggested by some other visitors to this habitat that the plants growing on the exposed rocks belong to a distinct species. During our research this could not be ascertained. In fact, the population is composed of quite variable plants, particularly in the shape of the spines, but it was not possible to clearly delimit significant and constant differences between the plants growing on the exposed rocks with respect to those in the shadow. The main taxonomic characters, such as structure of the flower, form and colour of the fruit, and shape of the seeds, did not show any difference. Quite reasonably, the plants growing in more exposed position have their bodies somewhat more shrunken, so that the spines seem to be longer, but on closer examination we did not see any clear-cut difference. Some cultivated plants labelled as HT 60, but not grown from habitat seeds, show differences from the plants in habitat. However, these might be F1 offspring of hybrid origin in cultivation.



Figs 1–8. *Gymnocalycium schmidianum*. Catamarca, Ruta 1, 19 km S Tinogasta, 1440 m. MM 1150. Photo M. Meregalli and A. Funetta.

DESCRIPTION (adult plants in habitat, Figs 2–7). Body globose or slightly flattened, seldom higher than broad, up to more than 20 cm in diameter; epidermis often dull or very moderately glossy green; ribs 13–20 or occasionally more, low; longitudinal furrows broad and moderately deepened, zigzagging between tubercles, transverse clefts deep and narrow, continuous across the whole width of the rib, clearly delimiting a series of globose or sub-polygonal, scarcely raised tubercles, often with a moderately prominent chin below the areoles; areoles oval, with greyish hair, placed on the upper half of tubercles; spines robust, aciculate, very strong, with acute apex, usually quite dense, up to more than 5 cm long, broadly oval in section; radial spines usually three pairs, the upper couple less strong, moderately prominent and distinctly curved laterally, reaching at least the mid-width of the adjacent rib, but often crossing the whole adjacent rib, sometimes even reaching the second rib on the sides, hence densely interlaced, sometimes more distinctly prominent on proximal part, always distinctly curved laterally but occasionally irregularly projecting or even semi-erect; central spine absent or often 1-2, mainly on the larger plants, erect, straight, when 2 spines present, upper and lower central spines divergent; a smaller and shorter upper central spine occasionally present; the lower spine straight or moderately curved downwards; all spines usually light matt greyish with a distinct, although very light, orange-cream shade, distal part usually darker; spines occasionally darker, greyish; flower bud typically covered with yellowish scales, flower (Fig. 8) up to 5 cm long, broadly funnel-form, pericarpel about half as long as perianth, olive green with semicircular acutely pointed pinkish scales, perianth segments light creamy-pinkish, throat distinctly dark pink; style yellow, shorter than anthers, filaments pink in proximal part and turning progressively to white-yellow, anthers yellow; fruit oval, 1.5 times as long as wide, dull bluish, with a broad flower scar (Figs 4–6); seed (Figs 137–140**)** black, about 1 mm across, matt, testa dark ferruginous to black, cells more or less regularly aligned in longitudinal rows, moderately and regularly convex, not conical, border of hilum regularly curved, hilum-micropilar region broadly oval, spongy coating quite dense and thick. At SEM (Figs 169–172) waxy coating forming small, densely packed, irregularly vermiculate structures.

VARIATION. The variation is limited and mainly regards the spination, that can be more or less strong and dense, depending on the length of the spines and the erectness of the lateral spines; in specimens with longer and irregularly curved spines they are also more densely interlaced and cover the body (Fig. 5); a few specimens have spines more regularly arranged (Fig. 3), others have long, erect spines (Fig. 4); part of the variation in growing habit appears to be related with the place where the plants grow, those living in crevices of the granite rock, fully exposed to the sun, having body more shrunk, thus apparently with a denser spination, with respect to those growing in the shade. The colour of the body is greenish (Fig. 2) or greyish (Fig. 4), nearly matt. Most of the plants have quite light grey spines, with the typical creamy shade, but some specimens have darker greyish spines.

Differences from *G. catamarcense* subsp. *catamarcense*. There are several characters that are relatively constant throughout the whole range of *G. catamarcense*, that allow an easy differentiation. In particular, the radial spines 2 and 3 in *G. catamarcense* are generally more or less distinctly flattened in section, they are straight, shorter, more

distinctly aciculate in the distal part, laterally inserted, not irregularly curved, prominent and interlacing as in *G. schmidianum*, their colour is light grey, lacking the very light cream-coloured shade, the flower usually has a shorter pericarpel, the anthers are from light reddish or pinkish to reddish, the style is often shorter, not reaching the mid-length of the filament of the upper anthers, the fruit is short, usually round, and is greenish. The seed in *G. catamarcense* - *G. pugionacanthum* is smaller, round, it has glossier surface, the cells are higher, more distinctly conical, the hilum-micropilar region is often more regularly oval, and has a thinner spongy coating (Figs 165–168). At SEM, the seed of *G. catamarcense* has a similar structure of wax coating (Figs 173–174).

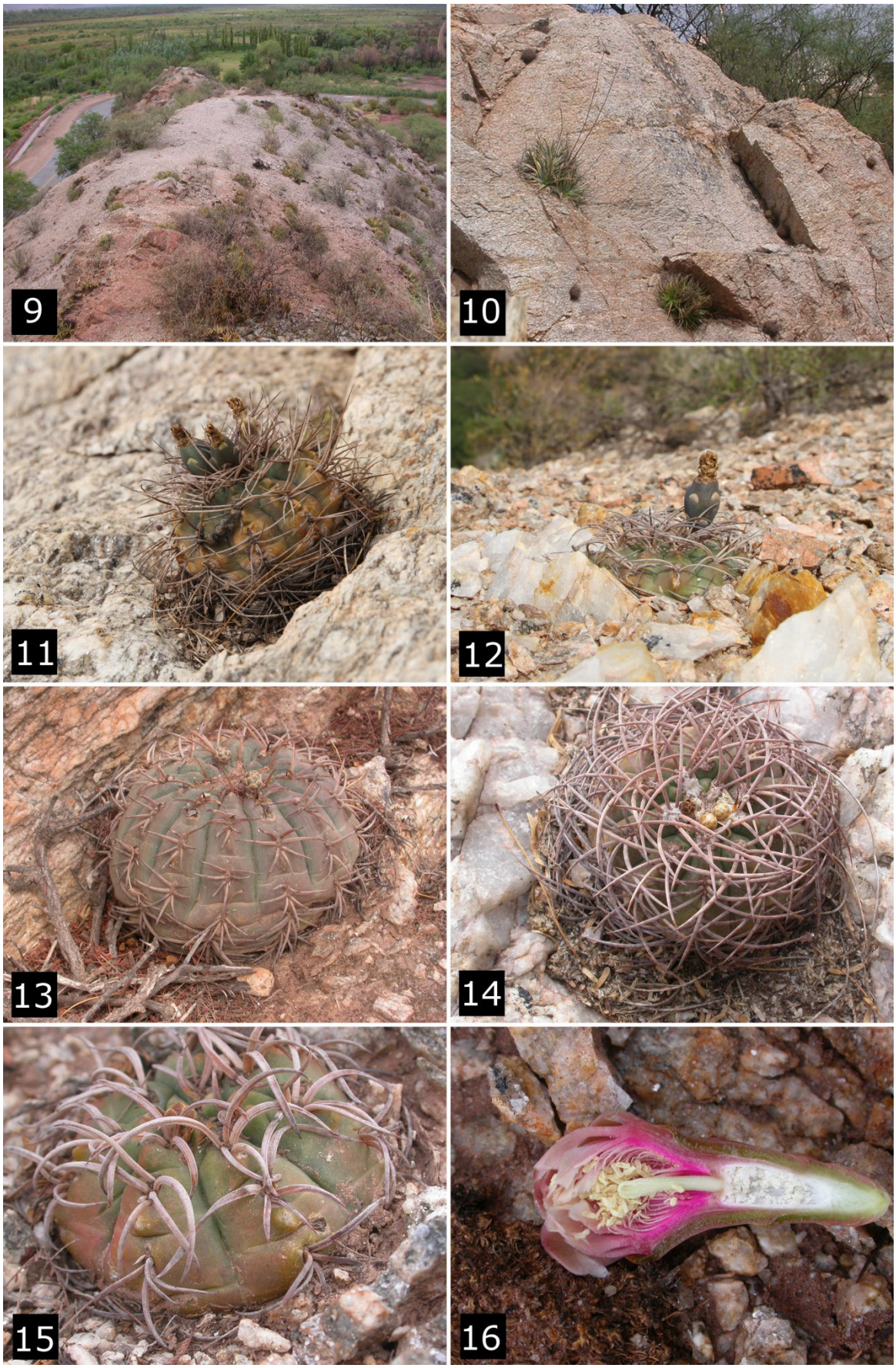
We consider that the distinctive characters of *G. schmidianum* indicate that this taxon does not belong to the *G. catamarcense* lineage. Particularly significant to consider are the longer flower, with yellow anthers, the blue fruit, and the different shape of the seed. Hence, we consider that *G. schmidianum* must be raised to the rank of species, as:

Gymnocalycium schmidianum (H. Till & W. Till) Meregalli & Kulhánek, stat. nov.

Basionym: *Gymnocalycium catamarcense* subsp. *schmidianum* H. Till & W. Till, 1995, *Gymnocalycium* 8(1): 145.

DISTRIBUTION (Fig 180). The type form of *G. schmidianum* is distributed around the town of Tinogasta, the type locality being the western-most part of the Sierra de Copacabana, about 20 km south of the city. No data are presently known from south of the type locality, but it is likely that the species extends through the whole western slopes, since there is no apparent habitat discontinuity. Around Tinogasta, it is known from La Puntilla, at the extremes north of the Sierra de Copacabana. North of Tinogasta *G. schmidianum* is present on the southern-most part of the Sierra de Fiambalá, that reaches the northern outskirts of the town. In a broader concept, populations of *G. schmidianum*, more or less differentiated from the typical form, extend to the eastern slopes of Cuesta de Zapata, along Ruta 3. No information is at present available for other sectors of the Sierra de Zapata, thus the northern and southern limits along the Sierra cannot be hypothesized. Further north, populations distinctly different from the type were recently discovered in the hills north of Fiambalá.

GENERAL ECOLOGY. The habitat where *G. schmidianum* occur is essentially part of the Monte ecoregion, a biome with arid climate, with dominant shrubs of *Larrea divaricata*, *Larrea cuneifolia*, *Zuccagnia punctate, Cercidium australe*, and species of *Acacia*. The rocks where the plants grow are mostly porphyritic granites or migmatitic gneiss or metamorphic phyllites. In part of the range, particularly along the Sierra de Copacabana, some specimens are capable of growing directly in the crevices of the rocks, in a fully exposed position. In the same localities, however, plants were also seen growing at the base of loose shrubs of *Larrea* and *Cercidium*, or *Acacia*, on coarse granite gravel, occasionally mixed with sand. In other parts of the range, where vegetation is more dense, such as along Cuesta de Zapata, most of the specimens grow in a more protected and



Figs 9–16. *Gymnocalycium schmidianum*. Catamarca, Ruta 60, about 3 km N of Copacabana and south of La Puntilla, 1150 m. MM 1301, MM 1502, Tom 12-682. Photo M. Meregalli, A. Funetta, T. Kulhánek.

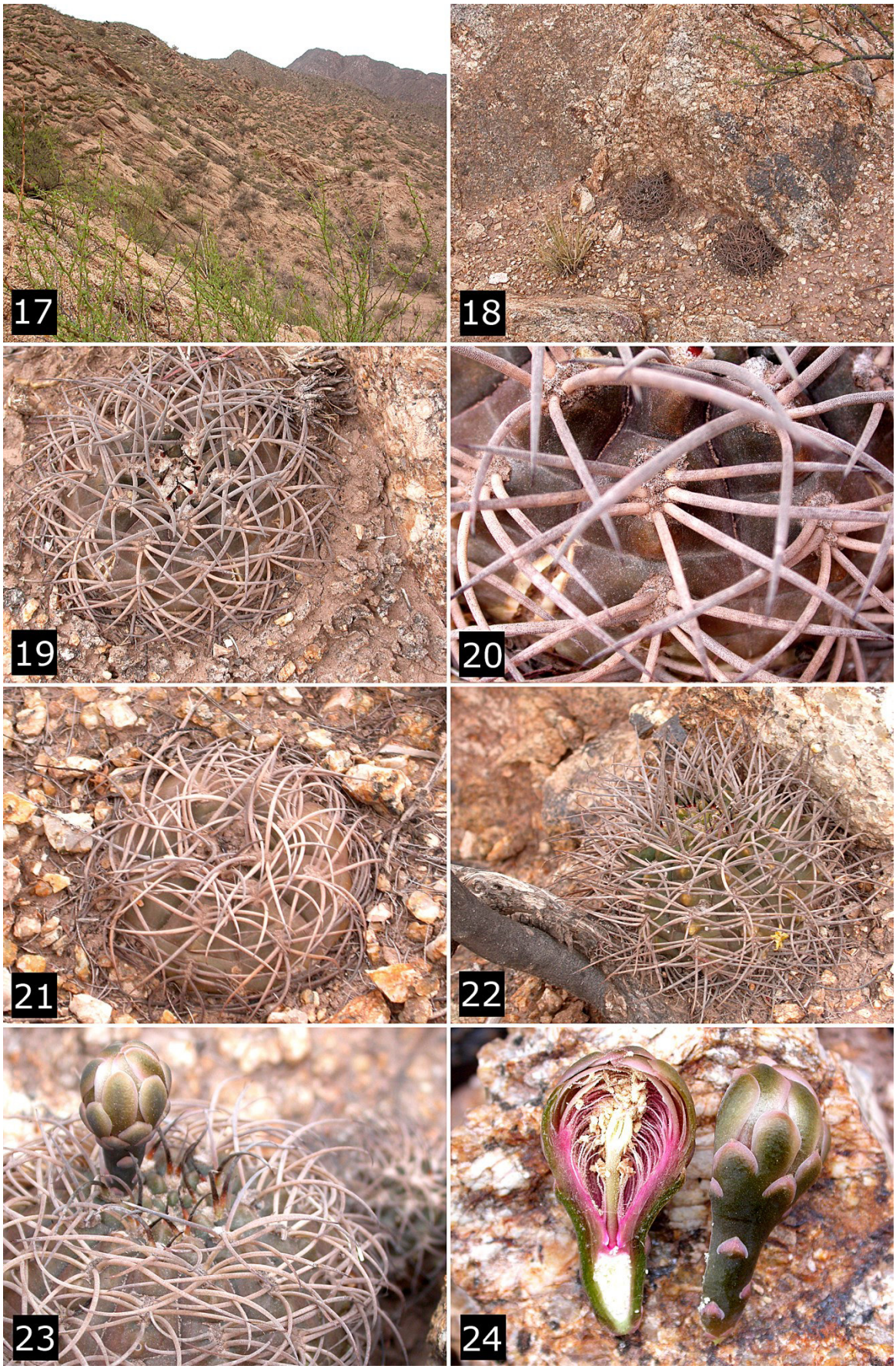
relatively humid environment, below the shrubs. More precise details about ecology of the typical subspecies of *G. schmidianum* will be discussed in the treatment of each population.

Analysis of some populations referable to *G. schmidianum*.

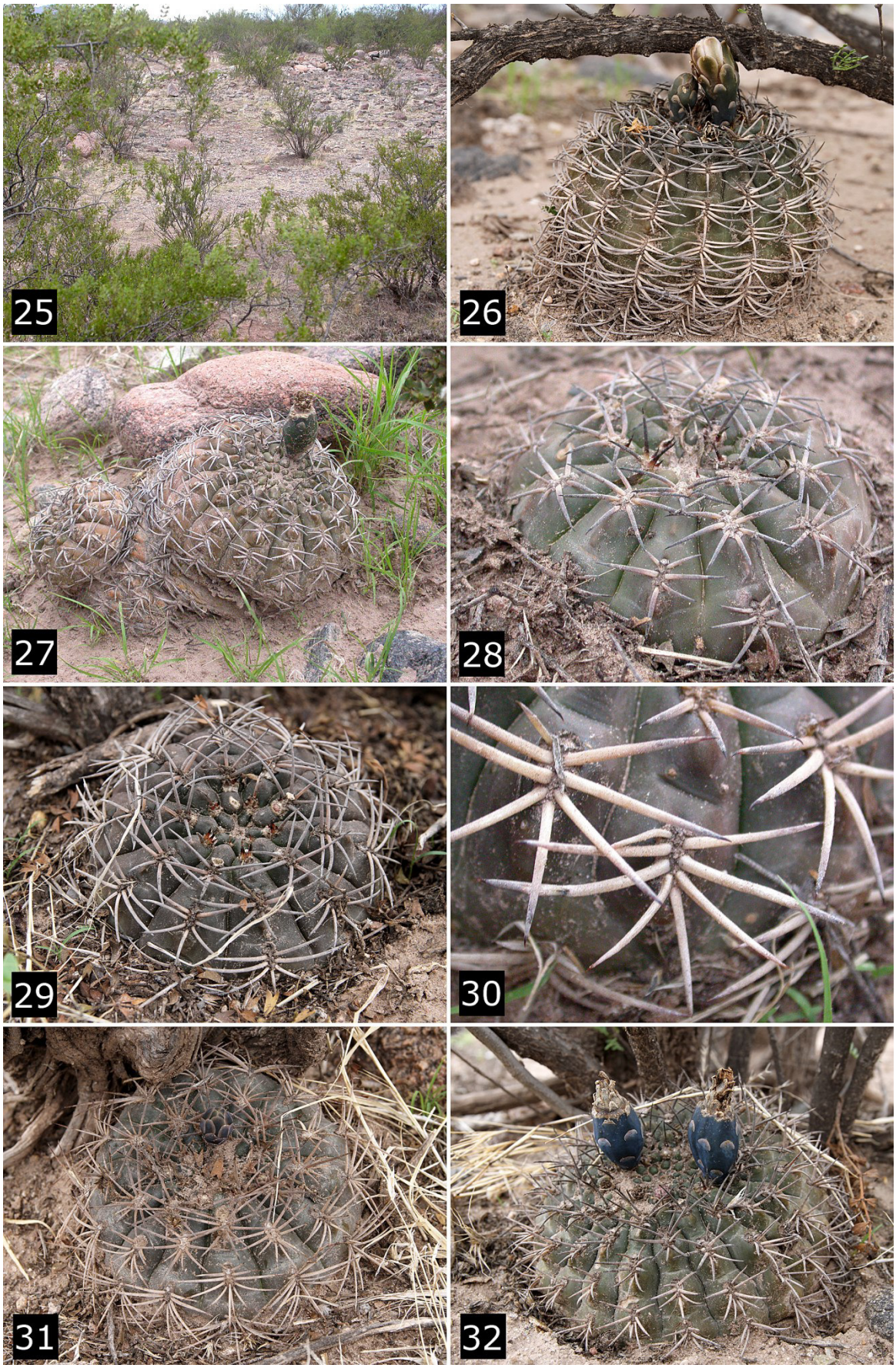
Northern part of Sierra de Copacabana. (LB 1307, LB 4498, MM 1301, MM 1502, Tom 07-288, Tom 12-682) (Figs 9–16).
In this region, at the south-eastern extreme of the mountain range, the plants mostly colonize porphyric granite, migmatitic gneiss or gneiss with large feldspar crystals, with very sparse vegetation (Fig. 9). Two populations were seen, less than two km distant (Fig. 180), and we treat them together. Most of the plants live on the top of the outcrop, on a very exposed ridge. Some of them are partly buried in the sandy-loamy substrate, with granite gravels around them, but several specimens grow against large rocks, or are rooted into the rock crevices. None was found on the lower part of the outcrop, or on the nearby loamy flat area. It seems likely that this population is present all along the hills, and reaches the main axis of the mountain ridge. Compared to those of the typical locality, these plants have shorter spines, that are sometimes also thinner; there is a good deal of variation in spine length, with (few) specimens having longer and somewhat twisted spines (Fig. 11), and other specimens having very short spines (Fig. 13), sometimes also rather strong (Fig. 15); however, they always have the typical light colour, with a faint creamy shade. The ribs appear to be more flattened, with scarcely prominent tubercles, and the furrows and transverse clefts are shallower. The locality was visited after a long period of rain, thus the bodies were quite plump and this may be the reason for more flattened ribs and shallower furrows and clefts. Flower (Fig. 16) and fruit do not show any particular difference from the type form, integument of seed can be ferrugineous to black (Figs. 141–144).

Southernmost part of Sierra de Fiambalá, North of Tinogasta, east of San José (MM 1291) (Figs 17–24).
The southernmost part of the Sierra de Fiambalá mostly consists of eroded porphyric granite hills, where *G. schmidianum* occurs in an habitat quite similar to that of La Puntilla (Fig. 17). Also in this region no plants were found on the plain, sandy areas near the hill, all of them growing amidst the granite rocks, occasionally below small shrubs of this reduced Monte vegetation, usually *Acacia*. Very probably *G. schmidianum* colonizes all the surrounding hills, that possess similar environmental conditions. The few plants from this population that were seen are quite uniform in their characters; they are scarcely differentiated from those from the type locality, even though the spines are more regularly arranged, less interlacing and less prominent. Seed could not be examined.

Ruta 3, 12 km north-east of Tinogasta, alluvial plain (LB 4520, MM 1505, Tom 12-690) (Figs 25–32).
This population lives in a completely different habitat, an alluvial plain with tertiary and quaternary deposits of stones, in sandy-loamy soil, Jarillal type shrub formation of Monte ecoregion (Fig. 25). This population is quite distinct from the type form of the species.



Figs 17–24. *Gymnocalycium schmidianum*. Catamarca, N Tinogasta, S. José, 1240 m. MM 1291. Photo M. Meregalli and A. Funetta.

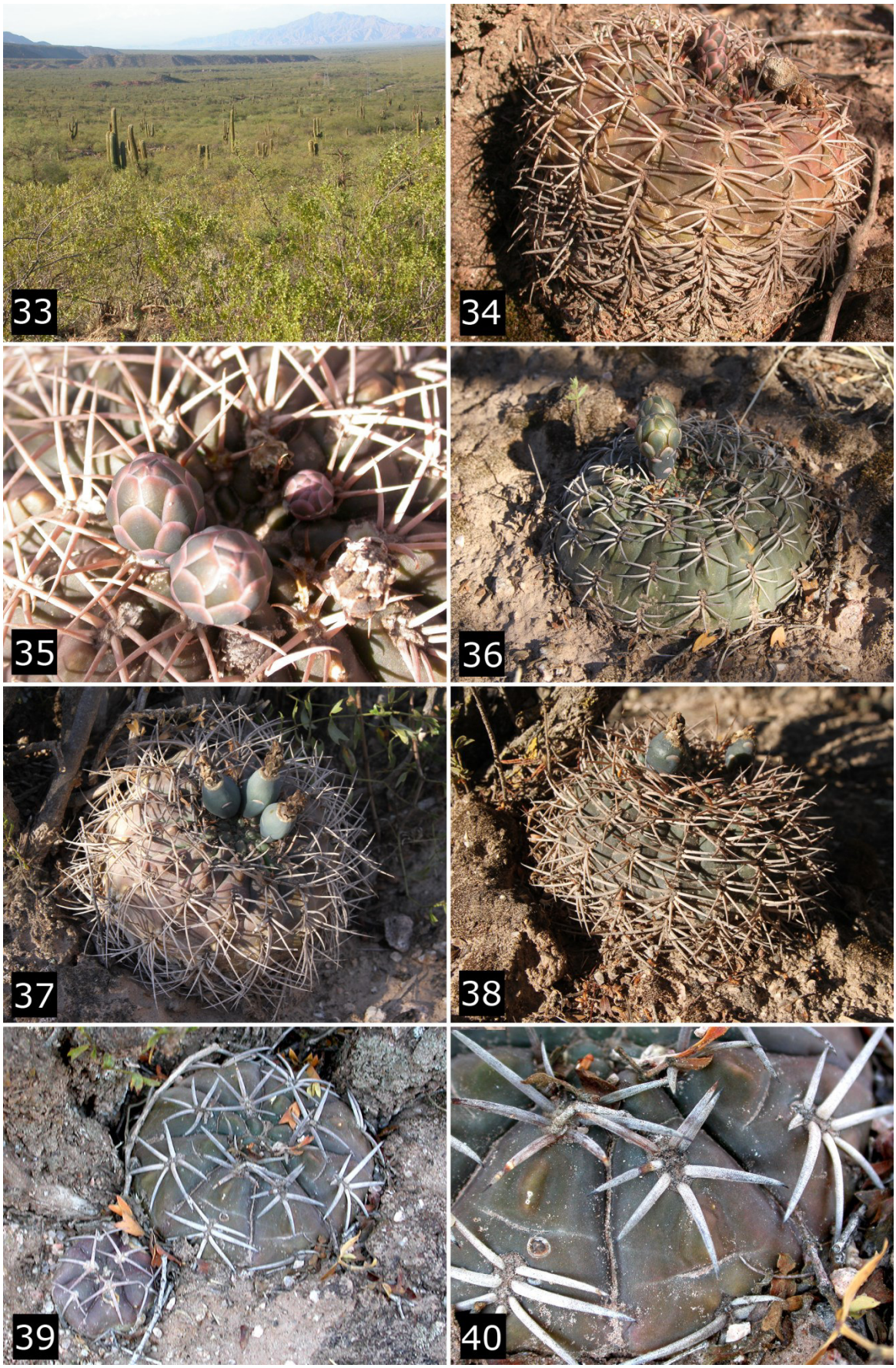


Figs 25–32. *Gymnocalycium schmidianum*. Catamarca, Ruta 3, 12 km NE of Tinogasta, 1345 m. MM 1505, Tom 12-690. Photo M. Meregalli and T. Kulhánek

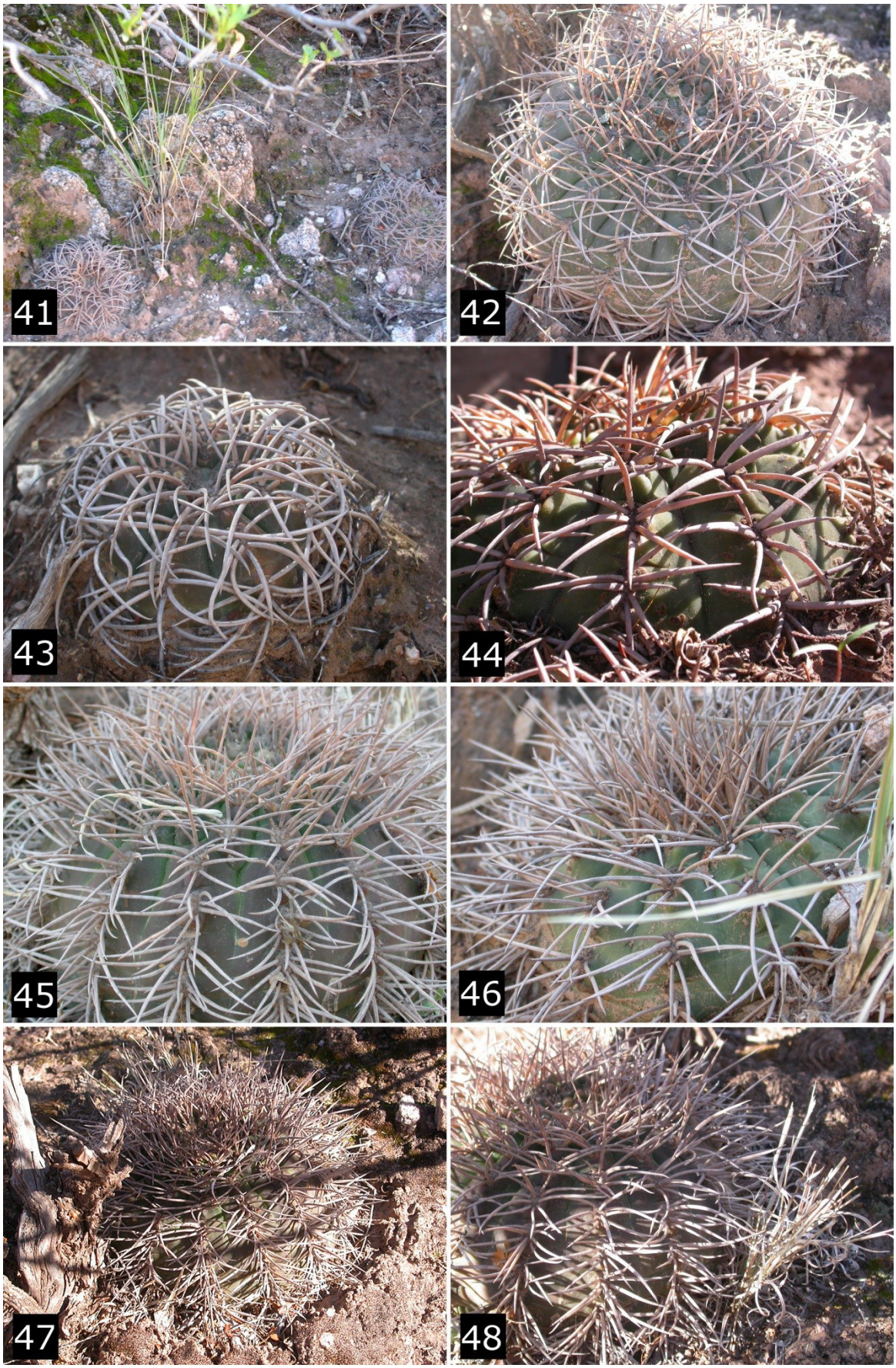
The body is large, the epidermis has often a greyish waxy coating, the ribs are low, broad, longitudinal furrows are rather shallow, and often almost rectilinear, seldom zigzagging between the ribs; the transverse clefts are also quite shallow, and usually only present in the median part of the ribs, not reaching the lateral margin. Spines are distinctly different. They are greyish, without the light creamy shade, sometimes clearly darker in the proximal half, the radial spines are very regularly disposed, always straight and almost appressed to the body, and are shorter, seldom reaching the mid-width of the nearest rib. No central spine was ever detected. At least one large specimen with thinner and longer spines was seen (Fig. 26). The areoles are narrower, more elongate. No flower was documented at the time of our research. The fruit is dark olive green (Fig. 27) to dark bluish (Fig. 32). Seed is black, slightly bigger, with moderately curved testa, and the cells are partly fused to one another on the longitudinal axes, remaining well isolated in the lateral axis (Figs 145–146). This makes cells less differentiated, and forming more distinct longitudinal rows; the hilum is a little larger than in the type form. Attribution of this form to *G. schmidianum* seems questionable, both for the different habitat colonized, a sandy alluvial plain, and the differences in morphology. For some aspects the plants are reminiscent of the new subspecies *G. schmidianum* subsp. *asperum* described here, or *G. pugionacanthum* from Cuesta Belen. However, the seed is evidently referable, in a broad sense, to *G. schmidianum* subsp. *schmidianum* (seed of *G. pugionacanthum*: Figs 167–168). More research is required to properly classify this peculiar population.

The populations from Cuesta de Zapata and Cuesta del Tambillo.

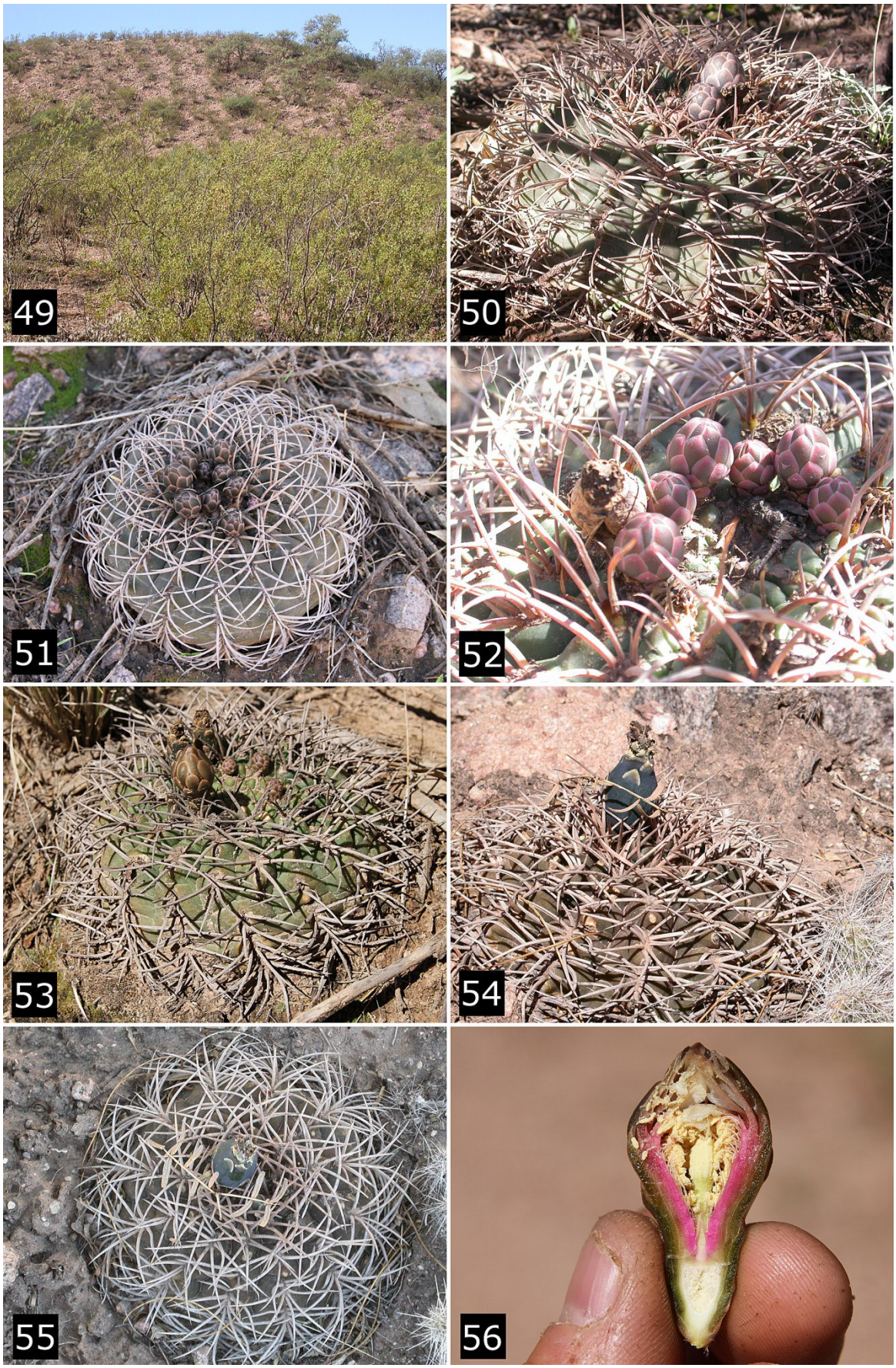
Cuesta de Zapata, western slopes (LB 4522, MM 1506, Tom 12-691).
The western slopes of the Cuesta de Zapata, in the lower part, are covered with a dense shrub vegetation of the Jarillal formation, on sandy to gravelly substrate of sedimentary origin. All *Gymnocalycium* live here in the shadow of the shrubs, and there are variations from the lower part to the upper part of the cuesta. A population at 1600 m, just at the beginning of the mountain slopes resembles, in most of its aspects, the population from the alluvial plain, excepting for the usually longer and stiffer spines, and the lighter body (Figs 33–40). The plants are quite uniform, have broad ribs, the chins are small, acute only in the upper part of the body, and the tubercles are very low. Some young plants, with stronger and shorter spines, are those that are more similar to the specimens from the alluvial plain (Figs 39–40), whereas other plants have longer spines, reaching the second furrow on sides (Fig. 37): these are more similar to the forms growing at higher altitude. A central spine is missing. Seed is dark reddish, the testa cells are matt, regularly convex, reciprocally isolated (Figs 147–148). Higher up, inside the cuesta, near the pass, at 1840 m (Tom 12-692; Figs 41–48), most of the plants have longer spines, their disposition in the areole is irregular, there can be up to 12 spines, some of the radial ones can be directed laterally, but they are usually upstanding and projecting (Figs 45, 46, 48), the lower spine is often more erect, looking like a central spine, and there can be one or two erect central spines. Their colour is uniform, the usual light greyish with a faint, yet distinct, very light cream shade. The ribs are broad, the longitudinal furrows shallow and linear, the transverse clefts usually short, the chins small, scarcely prominent. The flower of this form



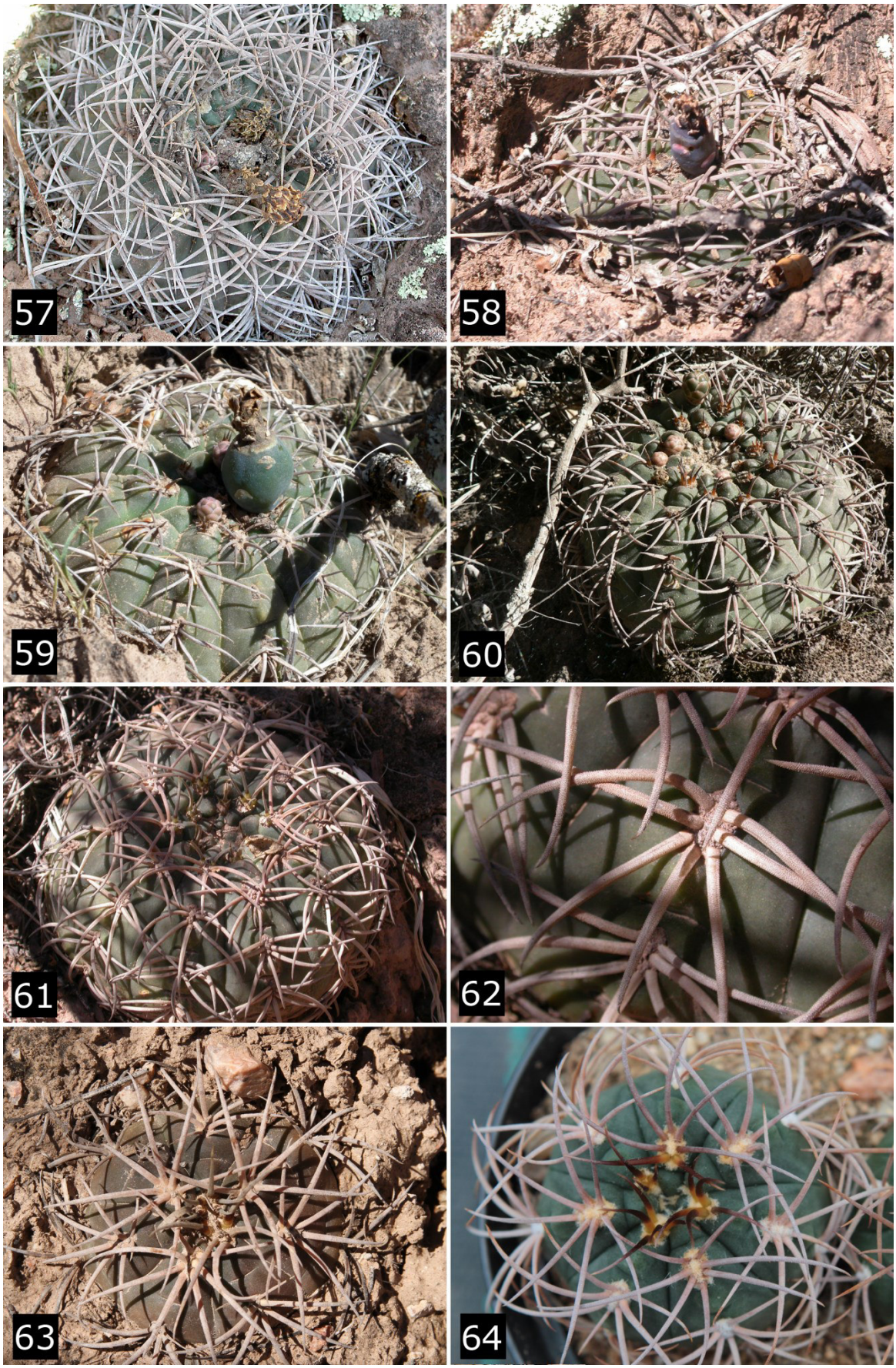
Figs 33–40. *Gymnocalycium schmidianum*. Catamarca, W slopes of Cuesta de Zapata, m 1610. MM 1506, Tom 12-691. Photo M. Meregalli and T. Kulhánek



Figs 41–48. *Gymnocalycium schmidianum*. Catamarca, W slopes of Cuesta de Zapata, near Abra de Zapata (the pass), 1840 m. Tom 12-692. Photo M. Meregalli.



Figs 49–56. *Gymnocalycium schmidianum*. Catamarca, E slopes of Cuesta de Zapata, m 1775–1715. MM 1142, MM 1143, Tom 12-693, Tom 12-694. Photo M. Meregalli, A. Funetta, T. Kulhánek



Figs 57–64. *Gymnocalycium schmidianum*. Catamarca, Cuesta del Tambillo, 1580 m. MM 1507, Tom 12-695. Photo M. Meregalli, T. Kulhánek.

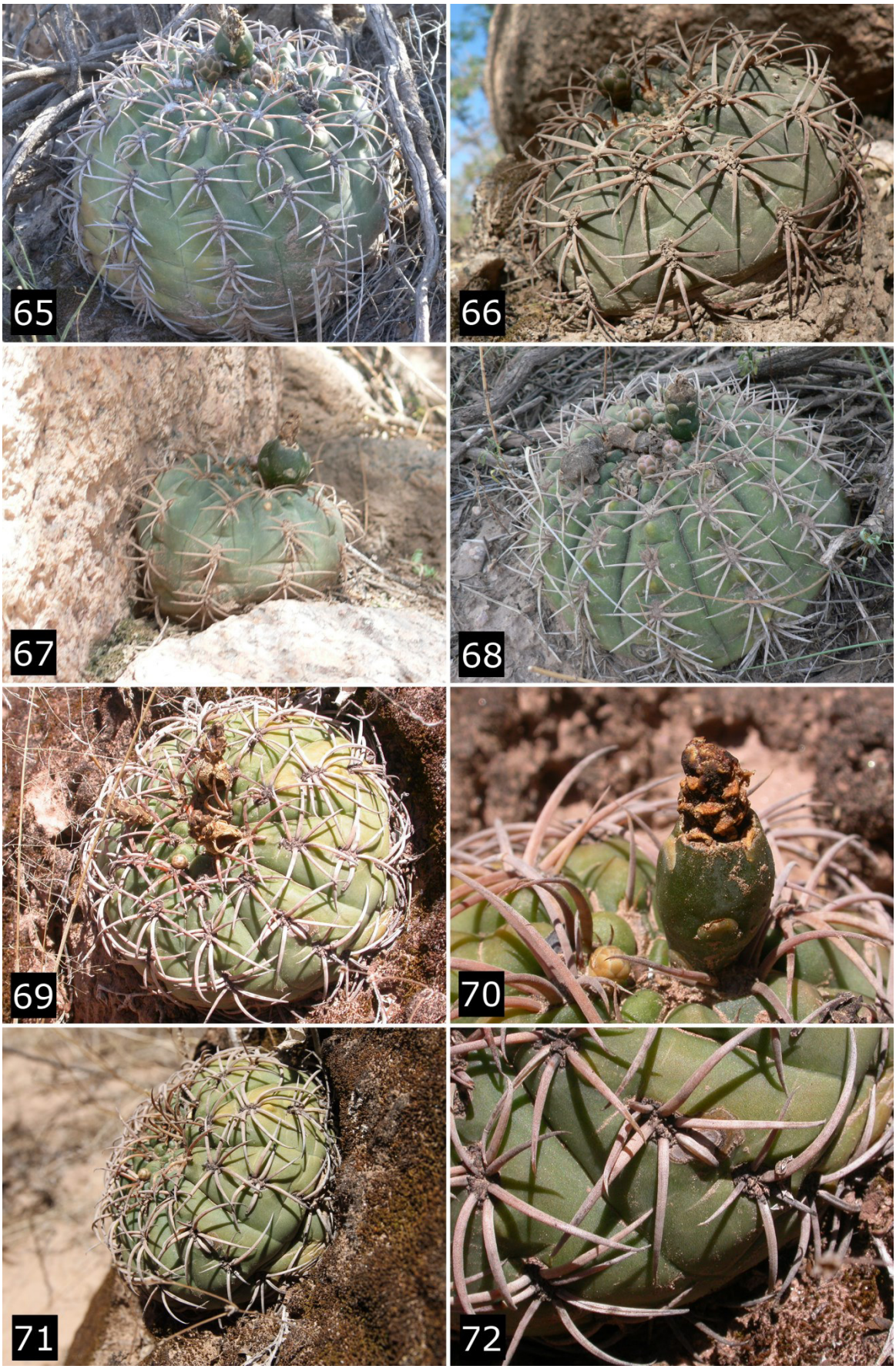
was not observed, however, flower buds differ in having pinkish scales instead of yellowish scales as in the forms from the surroundings of Tinogasta. Seeds are slightly glossier, with cells distributed in longitudinal rows, regularly convex. The hilum in both forms from the western side of the Cuesta de Zapata is rather broad, with a relatively dense spongy coating (Figs 149–152).

Cuesta de Zapata, eastern slopes – Cuesta del Tambillo (LB 4524, LB 4525, MM 1142, 1143, 1507; Tom 12-693, 12-694, 12-695).
On the eastern slopes of the Cuesta de Zapata, always along Ruta 3, *G. schmidianum* is widespread in the higher part. Around the pass the plants do not differ in any remarkable extent from those described above, from the upper part of the western slopes of the Cuesta de Zapata (Figs 49–56). The seeds examined have slightly thicker spongy tissue at the hilum-micropilar region. The easternmost population that is referred to *G. schmidianum* was seen at about 15 km west of the crossing of Ruta 40, west of Londres, at about 1580 m, in the Cuesta del Tambillo. In this eastern part of the Cuesta de Zapata there is reliably more rain and the Monte vegetation approaches the Monte espinoso type, partly with more Jarilla species. Here the plants have smaller and shorter spines, and the colour of the fruit can be blue-purplish, as typical of *G. schmidianum*(Fig. 58) or matt greenish (Fig. 59). A partial introgression with *G. catamarcense*, that was seen only a few km more east, cannot be excluded. However, the flower of this population has yellow anthers, and also the shape and colour of the spines (Fig. 62) and the shape and spination of the young plants, both in habitat and cultivation (Fig. 63 and Fig. 64, respectively) match *G. schmidianum*. The westernmost form clearly referable to *G. catamarcense* was seen only 2 km more east, about 13 km W from the crossing of Ruta 40, at 1470 m a.s.l. (MM 1140; Tom 12-696). These plants have the typical aspect of *G. catamarcense*, with flat ribs, shallow and linear longitudinal furrows, short spines, also in the young plants, flower with reddish anthers, fruit usually shorter, globose, glossy green, and seed with very scarce spongy border and with hilum-micropilar region more regularly ovate (Figs 65–72).

The populations from north of Fiambalá – Bolsón de Fiambalá.
Recent researches in the mountains north of Fiambalá led to the discovery of several populations of *Gymnocalycium* that were previously unknown from this area. The plants are distributed in all the mountains that surround the desert alluvial plain (Figs 180, 181), but they are far from being uniform. Indeed, two major forms can be recognized, one is distributed on the mountains east of the plain, on the foothills of the Sierra de Fiambalá, whereas a quite different form colonizes the mountains north and west of the plain.

Populations found in the eastern part.

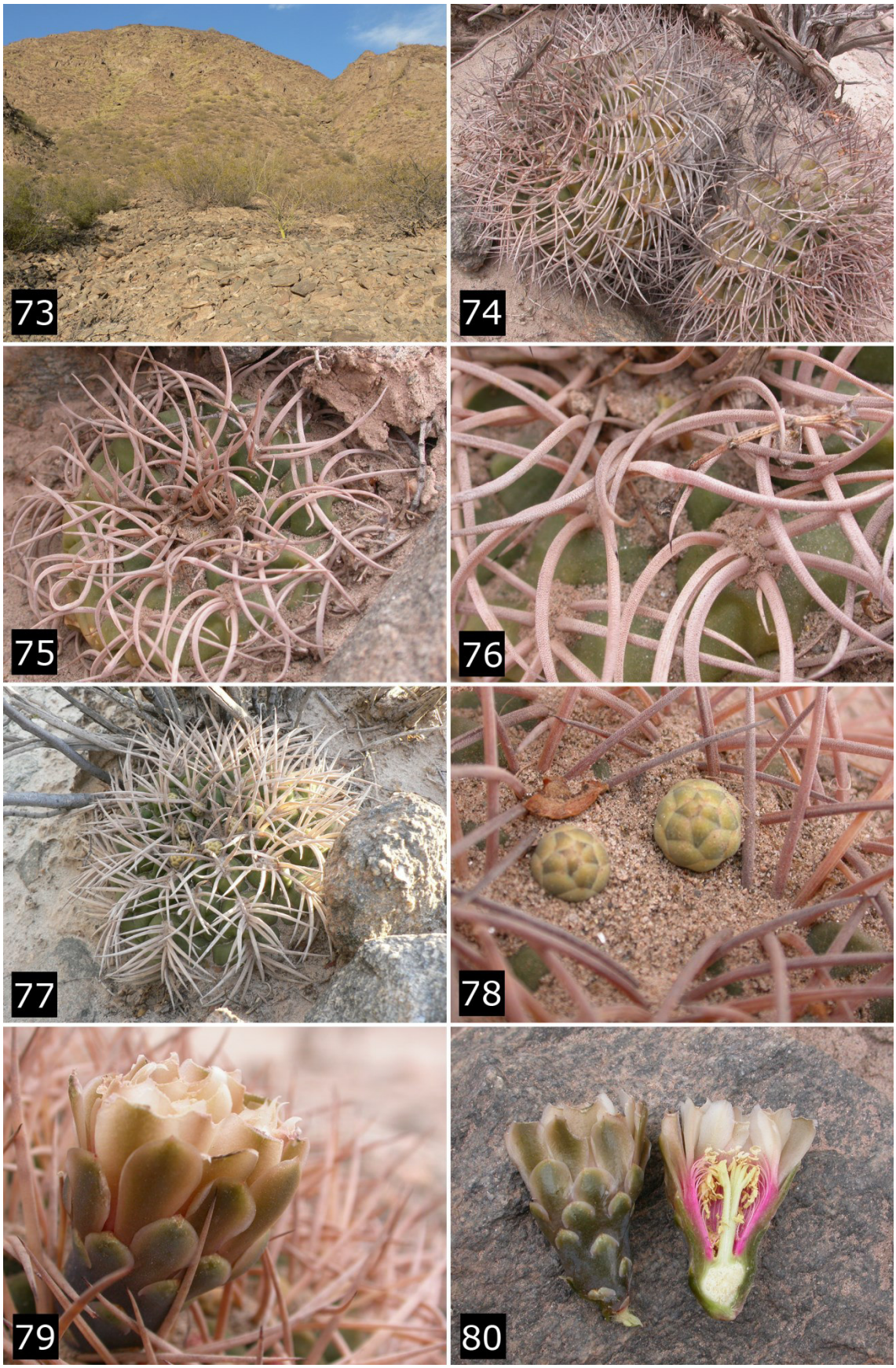
Taton and the valley east of the village (MM 1146, MM 1293, MM 1294) (Figs 73–80)**.**
The *Gymnocalycium* in this area are quite uniformly distributed all along the valley along the road that leads from Taton to the Estancia Rio Grande. These mountains are in the northern part of the Sierra de Fiambalá, that, at south, reaches Tinogasta. Unfortunately no data are known from intermediate localities, that are very difficult to reach



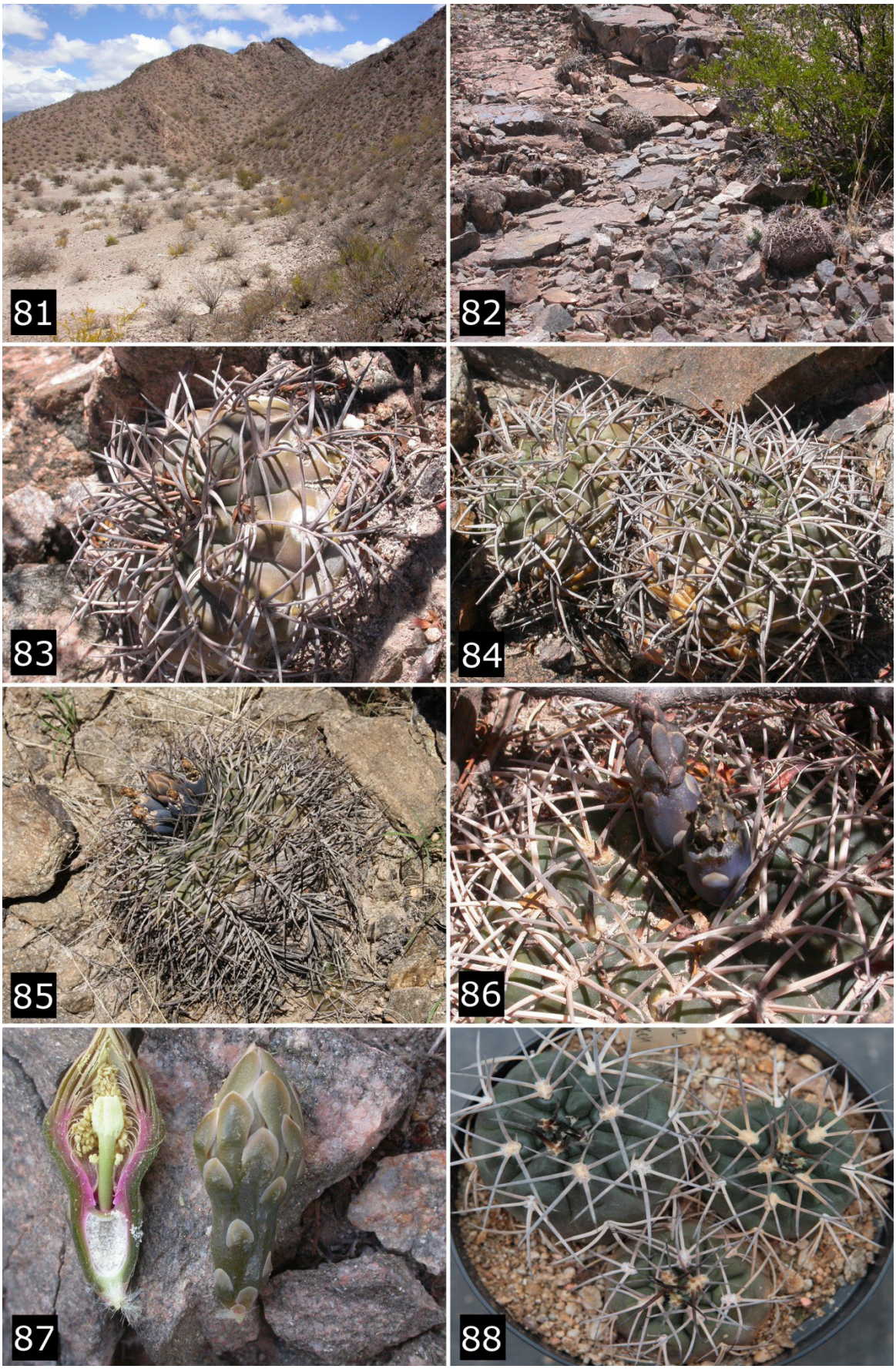
Figs 65–72. *Gymnocalycium catamarcense*. Catamarca, Cuesta del Tambillo, 1470 m. MM 1140, Tom 12-696. Photo M. Meregalli, A. Funetta, T. Kulhánek.

in the absence of any road or even path, but it is not impossible that some connecting populations exists. The first plants were found about 2 km south-east of Taton. Here the habitat is a very dry mountain slope, with scattered shrubs of *Cercidium australe*, and the *Gymnocalycium* are always growing in the partial shade of the shrubs. The habitat has a mean annual rainfall of only about 117 mm (data for Fiambalá, from http://en.climate-data.org). The ribs can be 15 or more in the largest plants, that reach 20 cm in diameter, they are relatively high, with deep, moderately sinuated longitudinal furrows and transverse clefts continuous through the whole rib, so that the ribs often show relatively prominent, well delimited tubercles, that in some plants are compressed into a chin below the areoles. The spines are light, not very strong but often quite long; there are usually 4 pairs of lateral spines, occasionally 5, the upper pair is shorter, the insertion into the areole is oblique and the spines are often directed laterally (Fig. 74), seldom almost straight and semi-erect (Fig. 77) or irregularly curved (Fig. 75); the 6 lower lateral spines reach the next longitudinal furrow, or even the mid-width of the adjacent rib, so they are densely interlaced; the lower spine is as long as the lateral spines; occasionally an erect central spine, inserted in the upper part of the areole, is present, or a lateral spine shifts towards the center of the areole and becomes erect. A few plants have shorter and less prominent spines. The flower bud is light yellowish (Fig. 78), the only flower seen was rather short (Figs 79–80), perianth segments are cream coloured, the anthers are yellow with pinkish filaments, darker near the throat; the throat is distinctly pink, and the fruit is bluish. The seed does not show any particular difference compared with the seed of the plants from the surroundings of Tinogasta (Fig. 160). This population is quite widespread all along the valley, up to about 2500 m a.s.l. and we refer it to *G. schmidianum* subsp. *schmidianum*.

Antinaco. (LB 4517, MM 1299, Tom 12-689) (Figs 81–88).
The habitat is very similar to the habitat in Taton, that lies 15 km in the south, but the plants were found on the slopes facing the desert plain, rather than more inside the valley (Fig. 81). Obviously, they might have a broader distribution more into the mountains. No apparent geographical or geological barriers seem to separate the two localities, thus it is likely that the plants have a more or less continuous distribution. Yet it is possible to recognize some small differences. The main characteristics are the same, but the Antinaco plants have often spines more regularly arranged in the areole, with lateral spines spreading from the areole rather than being almost parallel and laterally directed. They are also shorter and more straight and rigid, and less prominent from the body. The flower bud is yellow and the fruit has a saturated blue-purplish colour (Fig. 86). The flower does not show any particular difference from the flower of *G. schmidianum schmidiaum* (Fig. 87), whereas the seedlings in cultivation have rather short and straight greyish spines, most similar to the seedlings of the new subspecies here described. This population can still be referred to *G. schmidianum schmidianum*, however the spine structure, particularly in some plants (Fig. 83), and the aspect of the seedlings are intermediate with the new subspecies described here (Fig. 88).



Figs 73–80. *Gymnocalycium schmidianum*. Catamarca, N of Fiambalá, road Taton–Estancia Rio Grande, 1905–2445 m. MM 1146, MM 1293, MM 1294. Photo M. Meregalli, A. Funetta.



Figs 81–88. *Gymnocalycium schmidianum*. Catamarca, N of Fiambalá, Antinaco, 1950 m. MM 1299, Tom 12-689. Photo M. Meregalli, A. Funetta, T. Kulhánek.

Mountains north and west of the desert alluvial plain north of Fiambalá.
The first information about one of these populations came from an expedition by Czech collectors looking for mediolobivias in the mountains west of Palo Blanco (N of Saujil) in 2008. This was a very interesting discovery, since no *Gymnocalycium* was previously known from this area. Subsequent researches in this region were carried out along the road that proceeds further north from Mesada de los Zárate, then on hills to the west of the desert alluvial plain of the Rio Fiambalá, and in the alluvial valley west of the village of Palo Blanco. The plants detected here have most of their bodies buried into the soil, they have a long and strong taproot, and differ from all the other populations that are here referred to *G. schmidianum*. Also the seedlings of this form are very different from those of the typical form of *G. schmidianum*. This prompted us to describe it as a new subspecies of *G. schmidianum*, *G. schmidianum* subsp. *asperum* subsp. n. Indeed, their specific attribution was at first uncertain, because of the strong characterization of this form, that has some characters that are reminiscent of *G. spegazzinii*, particularly the spine structure. However, the most significant characters used for the species delimitation, that is, the general structure of the flower and the seed, are clearly referable to *G. schmidianum*. In particular, the seed of *G. spegazzinii* is smaller and glossier, has small cells, often polygonal and conical, its hilum-micropilar region is often obliquely cut, and is quite regularly oval, with very thin spongy tissue. At SEM it has a much thinner wax coating, not organized in a vermiculate structure (Figs 161–164, 175–176).

***Gymnocalycium schmidianum* subsp. *asperum* Meregalli & Kulhánek subsp. nov.**

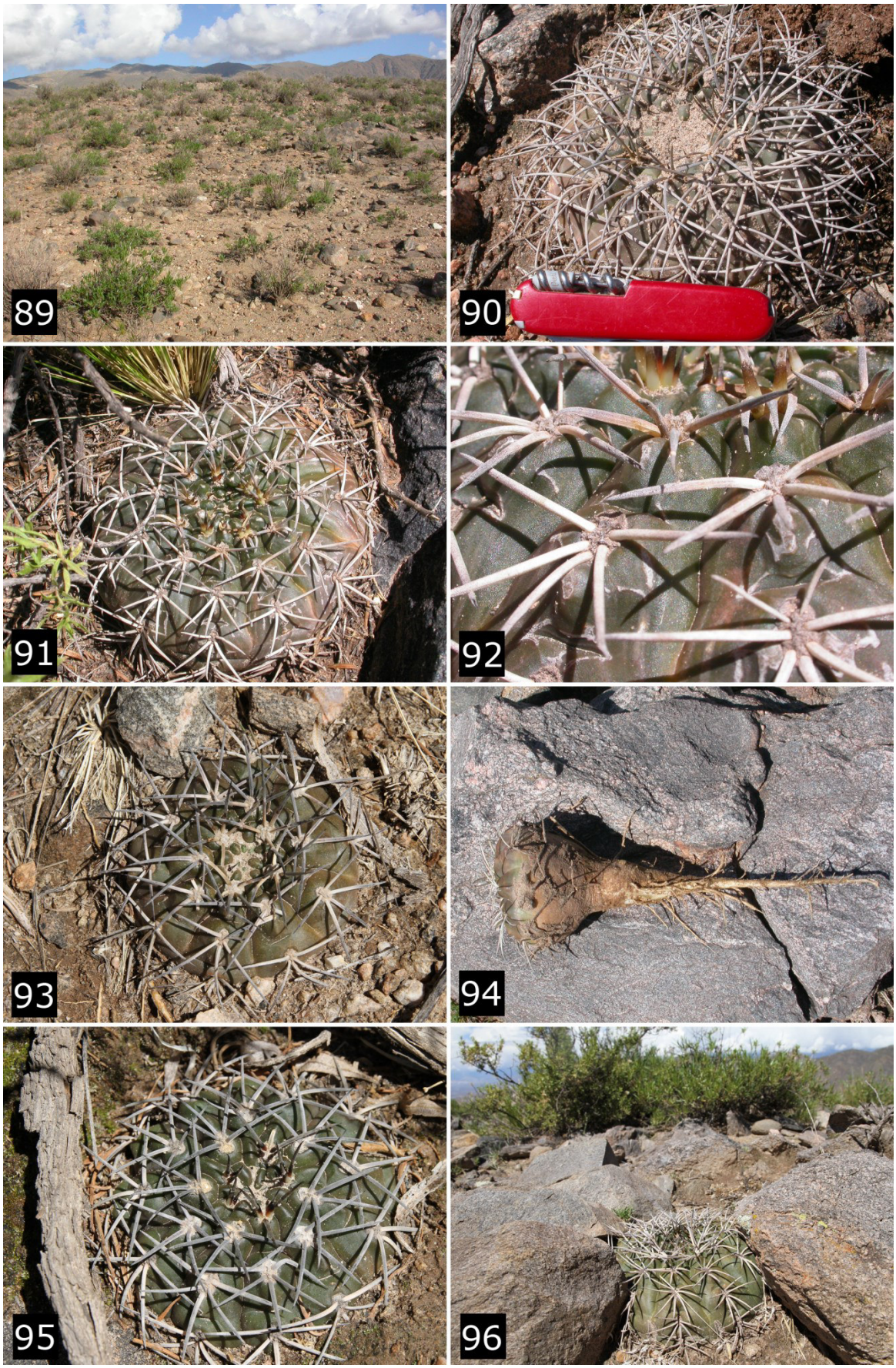
Holotype. Argentina, Catamarca, Fiambalá, 5.5 km north of Mesada de los Zárate, 2642 m, 27°03.983 S, 67°40.471 W, 22.01.2011, MM 1297, M. Meregalli and A. Funetta leg., habitat plant found dead, in good condition (TO-HG).

Other material examined from the type locality: LB 4514, Tom 12-687. Figs 89–96.

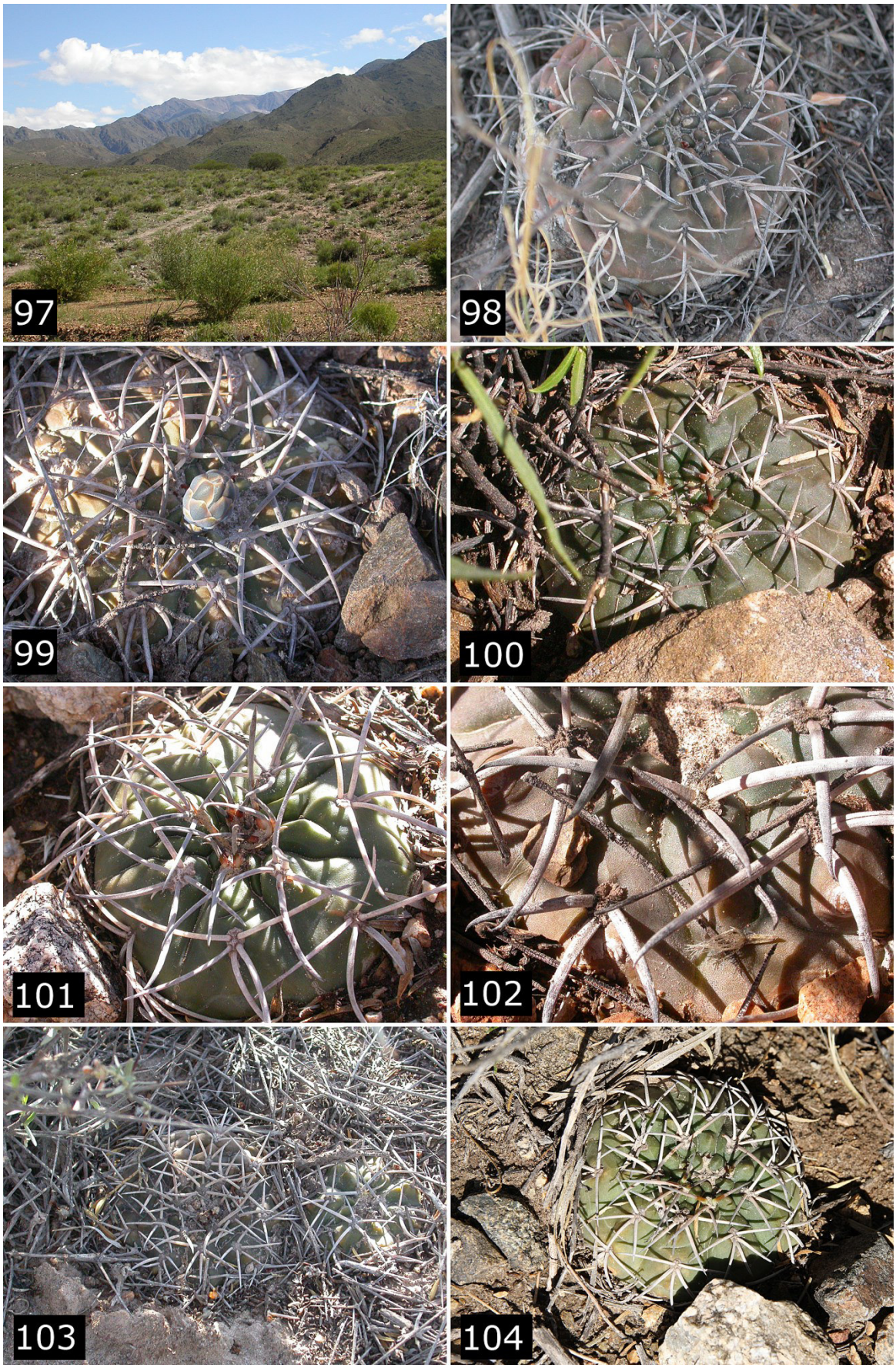
More populations examined: MM 1296 - Tom 12-686: 1.5 km N Mesada de los Zárate, 2380 m (Figs 97–104).

DIAGNOSIS. A subspecies of *G. schmidianum* differing from the typical subspecies by the stronger and shorter spines, never interlacing, light greyish in the proximal part and darkened distally, the radial spines often spreading laterally, the absence of central spine(s), the root forming a thick taproot not separated from the body, the seed dark reddish, with glossier testa, testa cells slightly, but distinctly, conical, hilum-micropilar region with a very dense spongy tissue. The one-year old seedlings have 3–5 short spines, flattened, laterally directed, usually darker in distal part, and are clearly different from seedlings of the same age of *G. schmidianum schmidianum* (Figs 177–178 vs 179).

DESCRIPTION (plants in habitat). Stem flat to strongly flattened, seldom globose, usually in large part buried in the soil, (80-)100-150(-180) mm in diameter; epidermis dull, dark green-brownish, sometimes slightly bluish, but never green; root showing a distinct taproot



Figs 89–96. *Gymnocalycium schmidianum* subsp. *asperum*. Type Locality. Catamarca, 5.5 km N of Mesada de los Zárate, 2642 m. MM 1297, Tom 12-687. Photo M. Meregalli, A. Funetta, T. Kulhánek



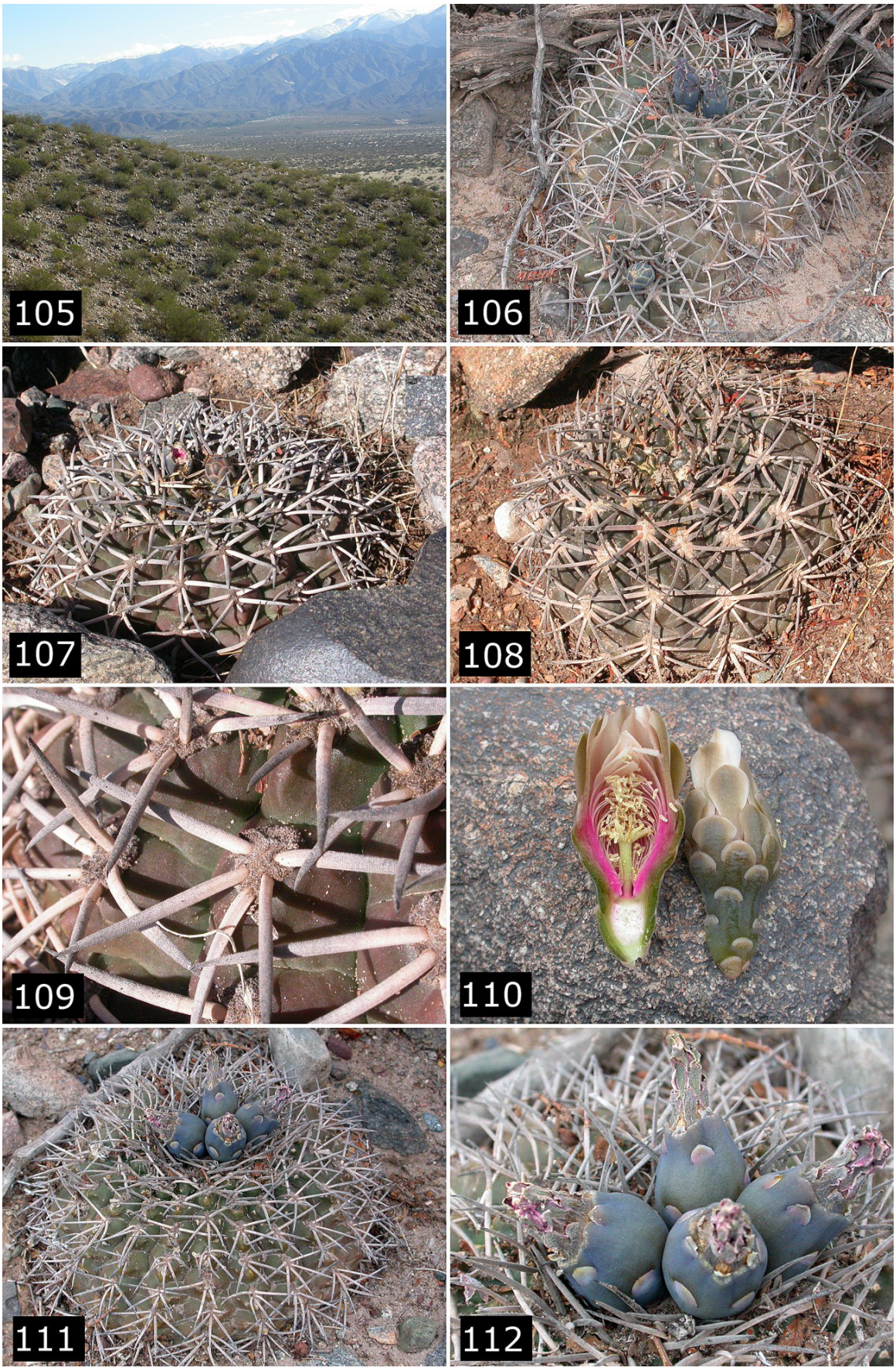
Figs 97–104. *Gymnocalycium schmidianum* subsp. *asperum*. Catamarca, 1.5 km N of Mesada de los Zárate, 2380 m. MM 1296, Tom 12-686. Photo M. Meregalli, A. Funetta, T. Kulhánek.

(Fig 94), strongly deepened into the soil; ribs in adult plants13–20, low; longitudinal furrows broad and moderately deepened, linear or weakly sinuated, transverse clefts moderately deepened, often scarcely distinct, tubercles usually moderately developed, low, occasionally with a scarcely prominent chin below the areoles, in a few plants (and in the drier season) ribs more compressed, with deeper longitudinal furrow and chins more developed and prominent, sub-acute; areoles broadly oval, not embedded, slightly embedded when old, with whitish or greyish wool, at a distance of (18-)-20-28(-32) mm from each other; spines robust, aciculate, strong, seldom about 5 cm long, but usually shorter, broadly oval in section; radial spines usually three pairs, less frequently two pairs, scarcely prominent, rigid and straight, often barely crossing the nearest longitudinal furrow, sometimes reaching mid-width of the next rib but very seldom extended to the second rib on the sides; central spine absent, as well as the small and short upper spines; all spines grey, uniformly coloured, seldom slightly darker distally; flower bud with green-reddish or light pinkish scales, flower bisexual, 45-60(-70) mm long and 40-50 mm wide, funnel-form, perianth about twice as long as pericarpel, this dark olive green with semicircular pinkish scales, perianth segments light creamy-pinkish, throat distinctly dark pink, walls thickened, greenish external part as wide as pink internal part, the two parts sharply separated; style yellow, reaching mid-length of the upper filament length, filaments yellowish, anthers yellow; fruit oval, longer than wide, dull bluish, matt, 10–12 mm long and 8–10 mm wide with broad scales; seed 0,9–1,1 mm long and 0.9–1 mm wide, dark reddish, matt, cells more or less regularly aligned in longitudinal rows, convex, slightly conical on the upper part, border of hilum regularly curved, barely but distinctly expanded laterally, hilum-micropilar region broad, completely hidden by the very thick and extremely dense spongy coating, thickened also on bridge separating hilum from micropile (Figs 153–156).

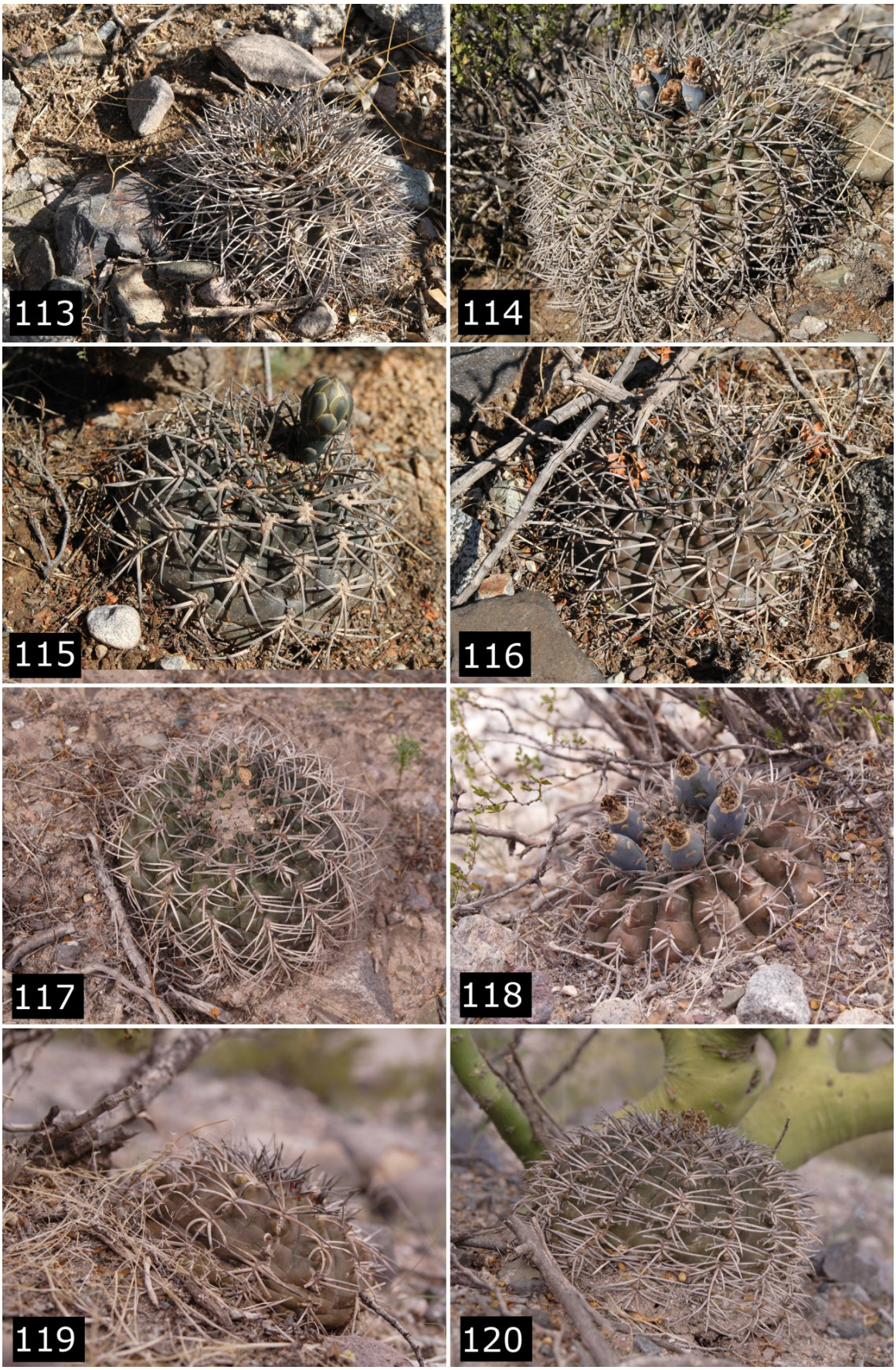
Etymology. The epithet given to the subspecies underlines the hard, strong aspect of the spines compared with the typical subspecies.

Variation. The adult plants of the type population show limited variation. The ribs can be more flattened (Fig. 95), and the spines vary in length and curvature, being usually quite straight, but sometimes slightly curved and thinner (Fig. 90); no plants with prominent spines were seen. The small plants are often very flat, nearly completely buried under the soil - probably completely buried after long periods of draught - and have seldom more than 5 spines, that are sometimes more flattened, particularly in proximal part, and are generally darker, with distinctly darker distal half; the ribs are less than 10, broad, with narrow and shallow longitudinal furrows and barely distinct transverse clefts (Fig 93).

Ecology. *G. schmidianum* subsp. *asperum* colonizes sedimentary elements of precambrian metamorphic basement, granites with tertiary and quaternary stony and sandy deposits preserved in Bolsón de Fiambalá and areas of foothills (Morlans 1995); the vegetation corresponds to the Monte shrubs formation “Jarillal” (Cabrera, 1971, 1976; Morlans & Guichón, 1995) with *Larrea divaricata*, *Larrea cuneifolia*, *Zuccagnia punctata* and *Baccharis glutinosa* as dominant species with *Cercidium praecox* or *C. australe*,



Figs 105–112. *Gymnocalycium schmidianum* subsp. *asperum*. Catamarca, N Fiambalá, crossing to Antofagasta da Sierra, m 2055. MM 1295, Tom 09-529, 12-685. Photo M. Meregalli, A. Funetta, T. Kulhánek.



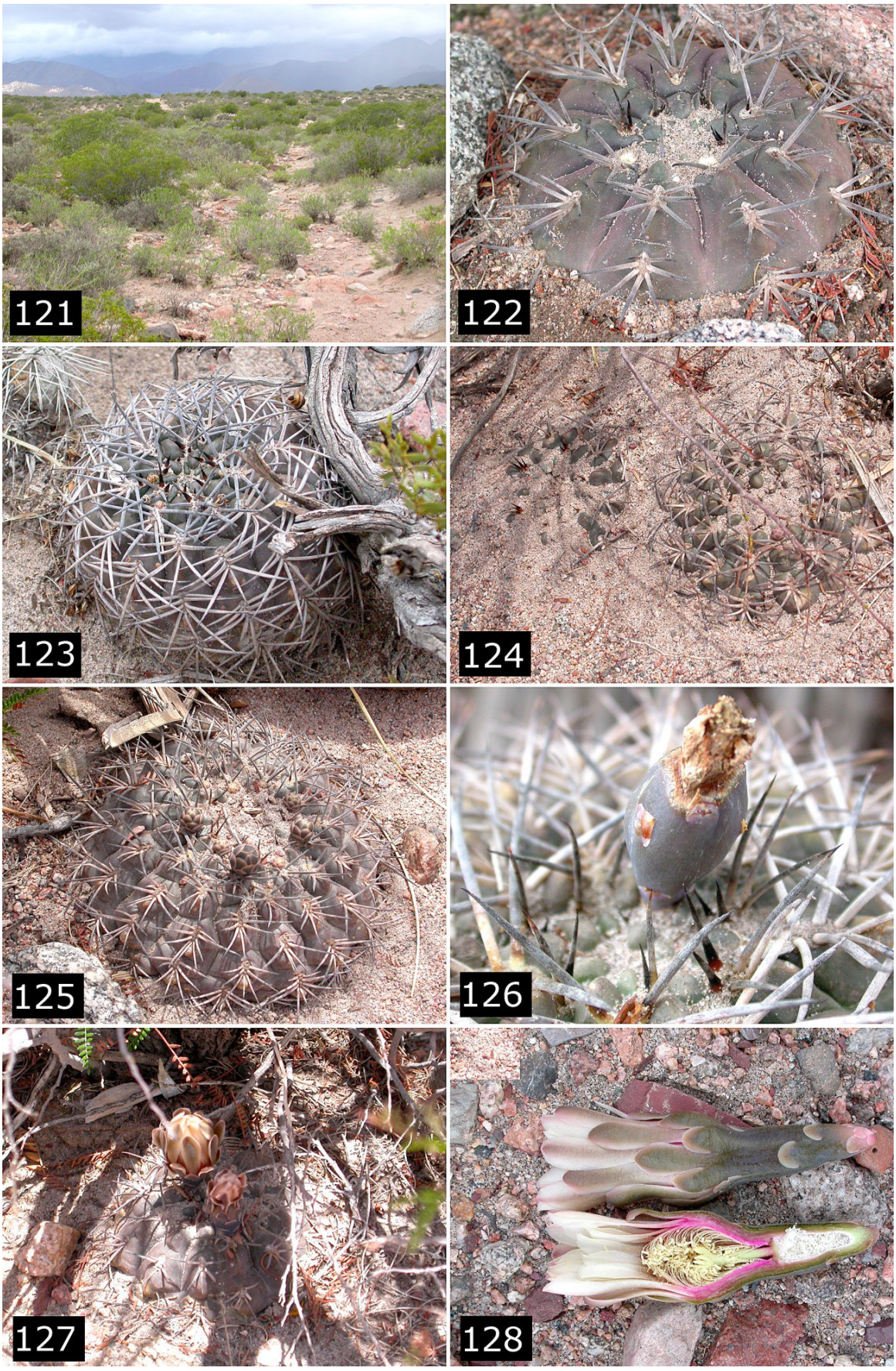
Figs 113–120. *Gymnocalycium schmidianum* subsp. *asperum*. Catamarca, N Fiambalá, crossing to Antofagasta da Sierra, m 2055. MM 1295, Tom 09-529, 12-685. Photo M. Meregalli, A. Funetta, T. Kulhánek.

Cassia aphylla, *Suaeda divaricata* as codominant species; in the higher parts of the range *Baccharis glutinosa var. angustissima* dominates (Figs 89, 97). Plants are mostly found under the shrubs, but in the localities at higher altitude they often avoid the shade and are deeply embed into the soil or between stones (Fig. 96). Accompanying Cactaceae in the habitats at lower altitude (2050 – 2350 m) are *Echinopsis leucantha*, *E. strigosa* and *Tephrocactus alexanderi*. In the habitats at higher altitude (2380 – 2650 m), North of Mesada de los Zárate, the plants reach the border of the Prepuna ecoregion, and are associated with with *Lobivia* sp., *Denmoza rhodacantha*, *Soehrensia* sp., *Echinopsis strigosa* and *Tunilla* aff. *soehrensii*

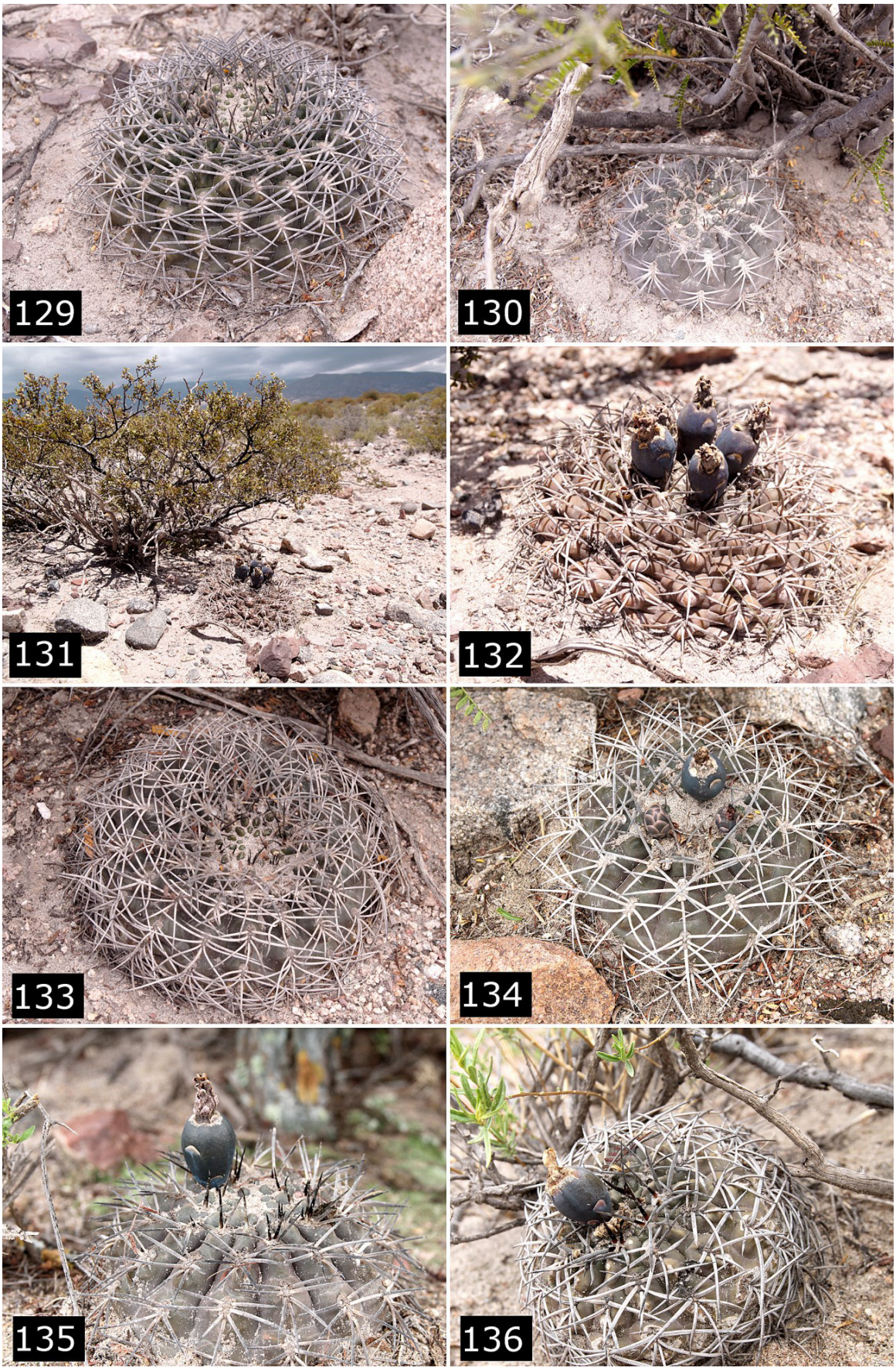
Distribution. The plants start to appear in the hills just north of Mesada de los Zárate, and have an apparent continuous distribution as far as about 6 km north of the village.

Two more populations were found (Figs 180, 181). They are slightly differentiated, but share most of the characters with the plants from Mesada de Zárate, and we have no doubts in referring them to *G. schmidianum* subsp. *asperum*.
The nearest population was seen in the extreme part of the hills south-west of Mesada de Zárate, at the junction between the road coming from Fiambalá and the road going to Antofagasta de Sierra via the Rio Las Papas (LB 4509, MM 1295, Tom 09-529, Tom 12-685, Figs 105–120). Here the plants often grow larger, and are more globose and scarcely buried into the soil (Figs 106, 111, 113, 114). This is probably due to the habitat characteristics, with harder, more rocky substrate, with a more distinct declivity, and scarce presence of sand. The body is often quite dark, matt (Figs 107, 108, 115), with broad and deep, sinuate longitudinal furrows, transverse clefts are often more deepened, and continuous across the entire rib, so that tubercles are rather prominent (Fig 109, 114). The spines are quite strong, greyish in the proximal part and more darkened towards the apex, sometimes slightly shorter than in the populations from Mesada de los Zárate (Fig. 118) but occasionally relatively long, stiffer and more prominent (Fig. 113). The flower has cream coloured perianth segments, the scales on the pericarpel are semicircular, green to light green (Fig. 110). The fruit is deep matt blue (Figs 111, 112, 118). The seed has the same general shape of the type population, with dark reddish colour and relatively conical, slightly glossy cells; the hilum-micropilar region has a less dense spongy coating (Fig. 159).

Another population was found in the alluvial plain from 5 to 8 km west of Palo Blanco (LB 4507, MM 1144, MM 1145, MM 1300, Tom 09-527, Tom 09-528, Tom 12-684, Figs 121–136). The habitat is a plain with relatively dense shrubs, the substrate is the typical tertiary and quaternary sands with fine gravels. Here most of the plants are flattened, and even large plants disappear almost completely under the soil when long periods of drought occur (Fig. 124). Only a few older plant reach a globular shape. The main morphologic characters do not vary a great extent from the other populations that were examined, with particular regard to the population on the hills at the crossing towards Antofagasta de Sierra, but the spines are generally more regularly pectinate, and are usually stronger, shorter and darker grey, particularly in the distal part. The flower (Fig. 128) is sometimes longer, particularly the perianth, and subsequently, also the fruit is more elongated, about twice as long as wide (Fig. 126); the seed is similar to that of the population more north (Figs 157–158).



Figs 121–128. *Gymnocalycium schmidianum* subsp. *asperum*. Catamarca, N of Fiambalá, 5–8 km W of Palo Blanco, 2200 m. MM 1144, MM 1145, MM 1300, Tom 09-527, Tom 09-528, Tom 09-684. Photo M. Meregalli, A. Funetta, T. Kulhánek.

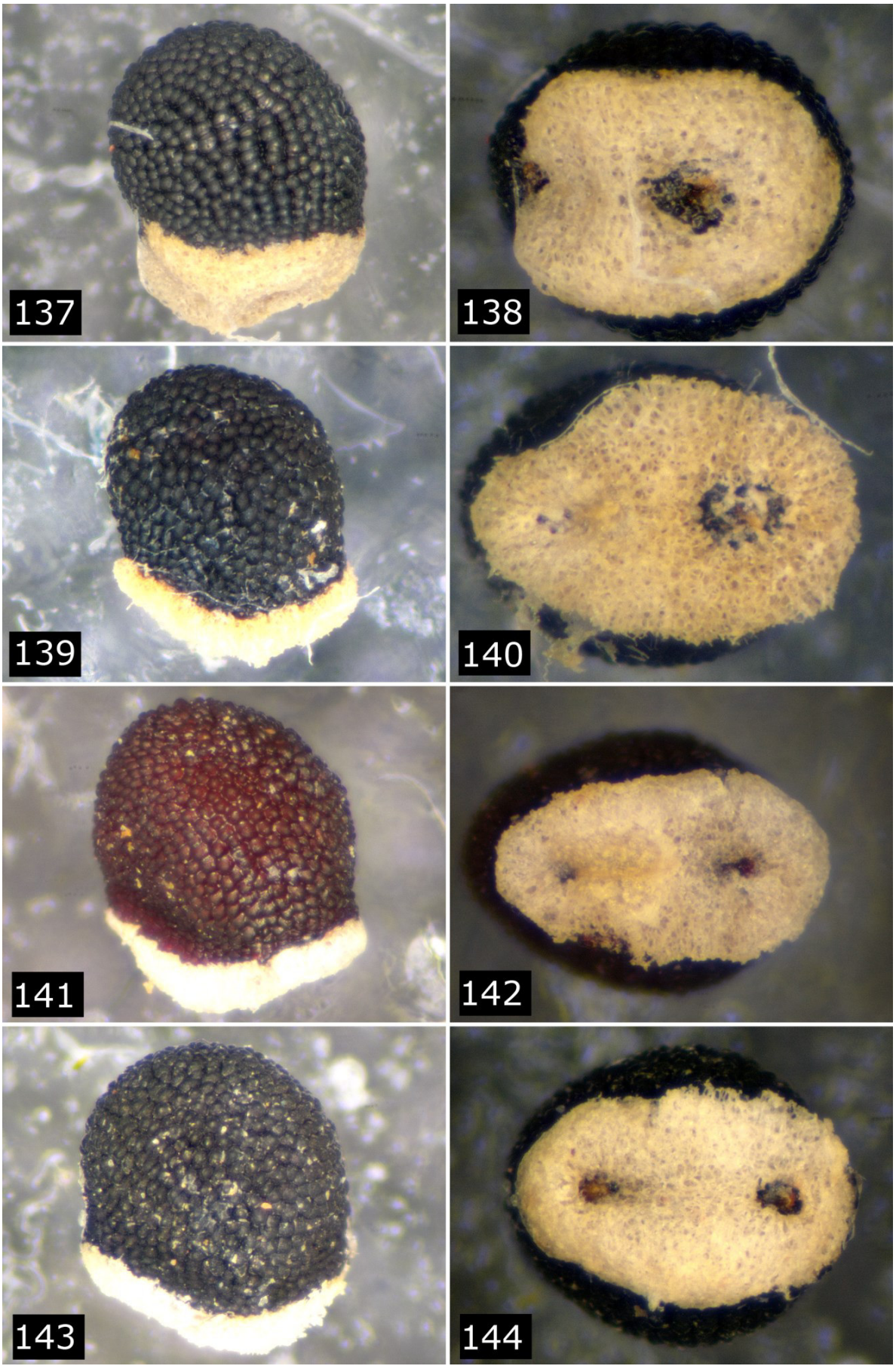


Figs 129–136. *Gymnocalycium schmidianum* subsp. *asperum*. Catamarca, N of Fiambalá, 5–8 km W of Palo Blanco, 2200 m. MM 1144, MM 1145, MM 1300, Tom 09-527, Tom 09-528, Tom 09-684. Photo M. Meregalli, A. Funetta, T. Kulhánek.

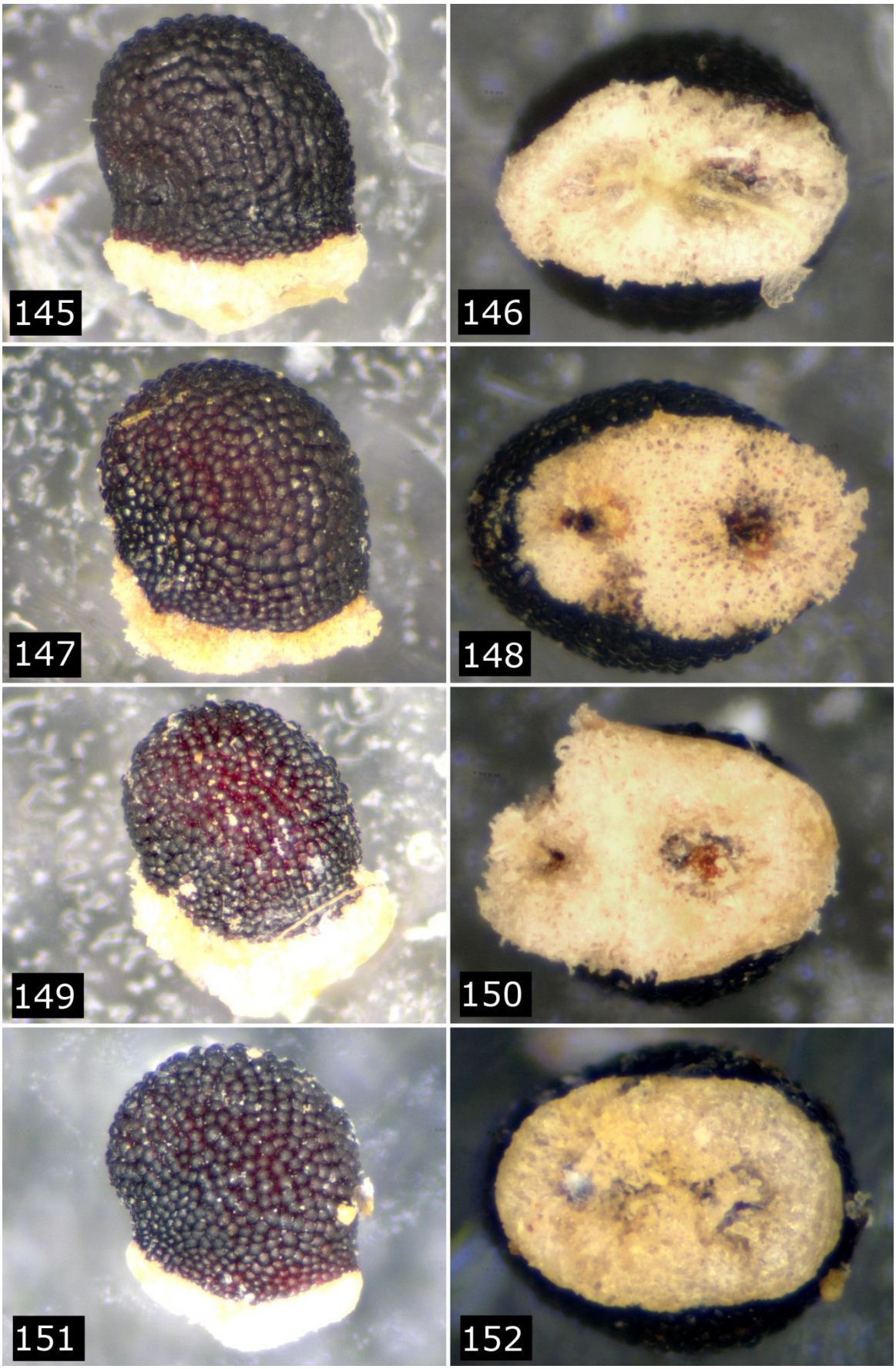
The seedlings show some minor differences, particularly in the colour of the body, between the Palo Blanco and the crossing to Antofagasta populations (Figs 177–178), but this may also depend on the characters of the mother plant from which the seeds were harvested; shape and spination are identical.

Discussion.
The presence of the two clearly differentiated subspecies of *G. schmidianum* in the hills north of Fiambalá is surprising, particularly considering the proximity between Mesada de los Zárate and Antinaco (Figs 180, 181). If an east-west gene flow (between Palo Blanco and Taton, for example) appears unlikely, the same cannot be claimed in the case of the north-south disjunction between the plants growing at Antinaco and those from Mesada de los Zárate. No physical geographical gap separates nowadays the two localities, but they are respectively at south and west of an almost 4000 meter high massif, that may have had importance in the colonization of this area in the past. Indeed the two forms are clearly distinct, even though some introgression probably exists (and intermediate populations may be present in the hills between the two localities). Populations showing intermediate traits at the point of contact between two subspecies are implicit in the concept of subspecies, even though, when this occurs, it poses questions about the patterns of differentiation. The differentiation of *G. schmidianum* subsp. *asperum* from the ancestral form common to the two subspecies must have occurred by allopatry, possibly triggered by adaptation to different environmental pressures. Indeed, at Antinaco the plants grow in dry Monte vegetation, on migmatitic gneiss and granite, a habitat drier but not particularly dissimilar from the habitats of the typical *G. schmidianum* subsp. *schmidianum* around Tinogasta. At Mesada de los Zárate the habitat appears to be less dry, with a Jarillal formation richer in species, and the substrate is finer and looser, composed of stones and sand deposits. The plants grow at higher altitude at Mesada, but the highest altitude reached near Antinaco is not known, thus this parameter cannot be evaluated. Another aspect that should be considered is that palaeoclimatic events, and the corresponding palaeobotanical changes in these regions, may have determined isolation of populations that evolved independently, followed by more recent re-colonization. The last glacial period surely had strong impact on the South American vegetation (Clapperton 1995), and it could be speculated that the two subspecies came into contact near Antinaco only quite recently, in the post-glacial period, after expansion from the south, along the western slopes of the Sierra the Fiambalá, of *G. schmidianum* subsp. *schmidianum*. More researches are required to achieve a better knowledge of the patterns of differentiation of these species, also aiming at recognizing reciprocal relationships among *G. schmidianum* and *G. spegazzinii*, *G. catamarcense* - *G. pugionacanthum* and the other species of the subgenus *Scabrosemineum*.

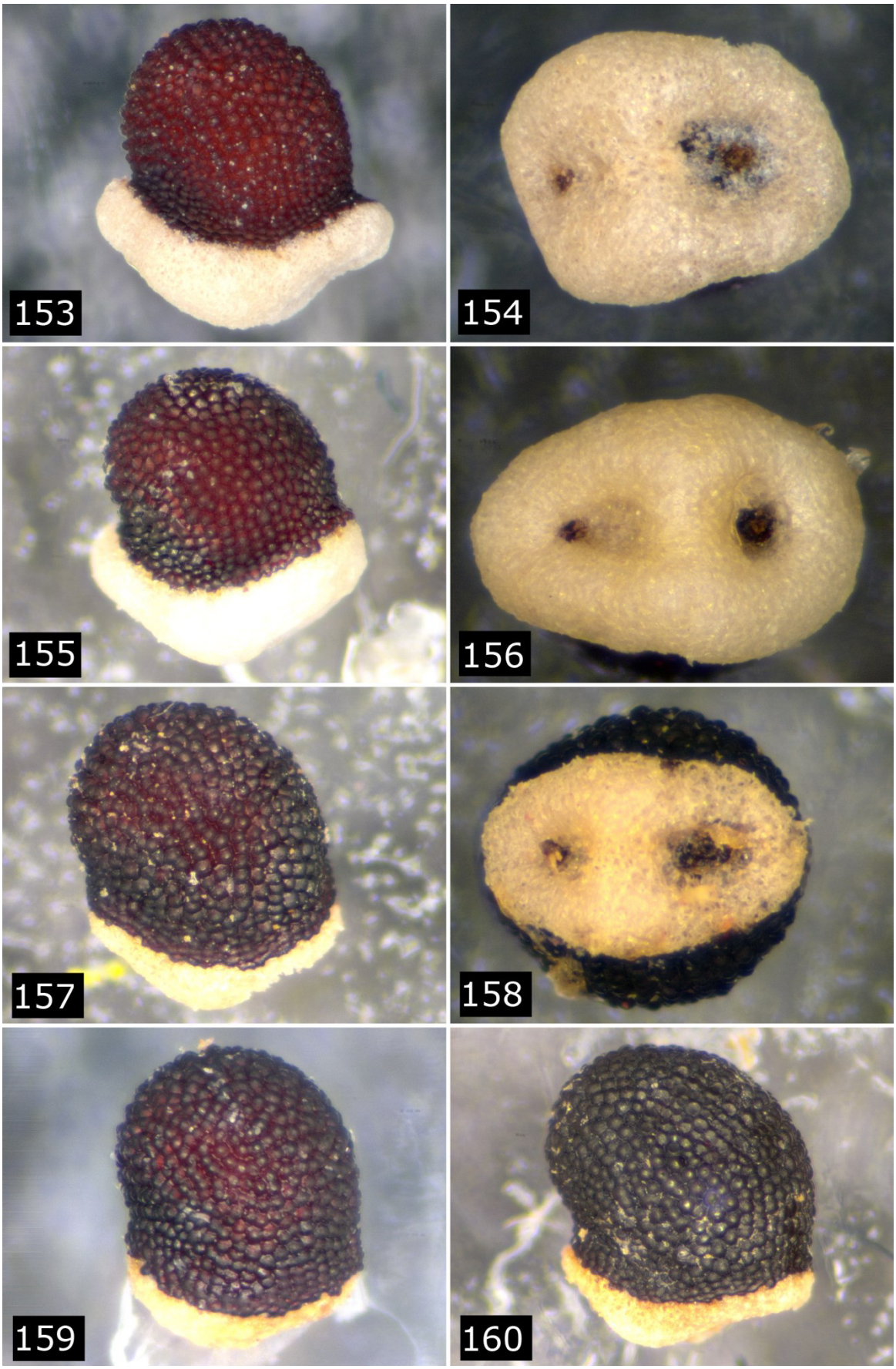
Acknowledgements. We spent fantastic days in the field with Ludwig Bercht in 2012; in 2010 and 2011 M. Meregalli visited most of the localities with Andrea Funetta, whereas T. Kulhánek explored the habitats in 2009 with Jaroslav Procházka and Rodomír Řepka. We wish to thank Ludwig Bercht for his very useful suggestions to complete the paper and Franz Strigl, who kindly provided us with a copy of his original trip diaries. We are indebted to our friend Graham Charles for revising the English language.



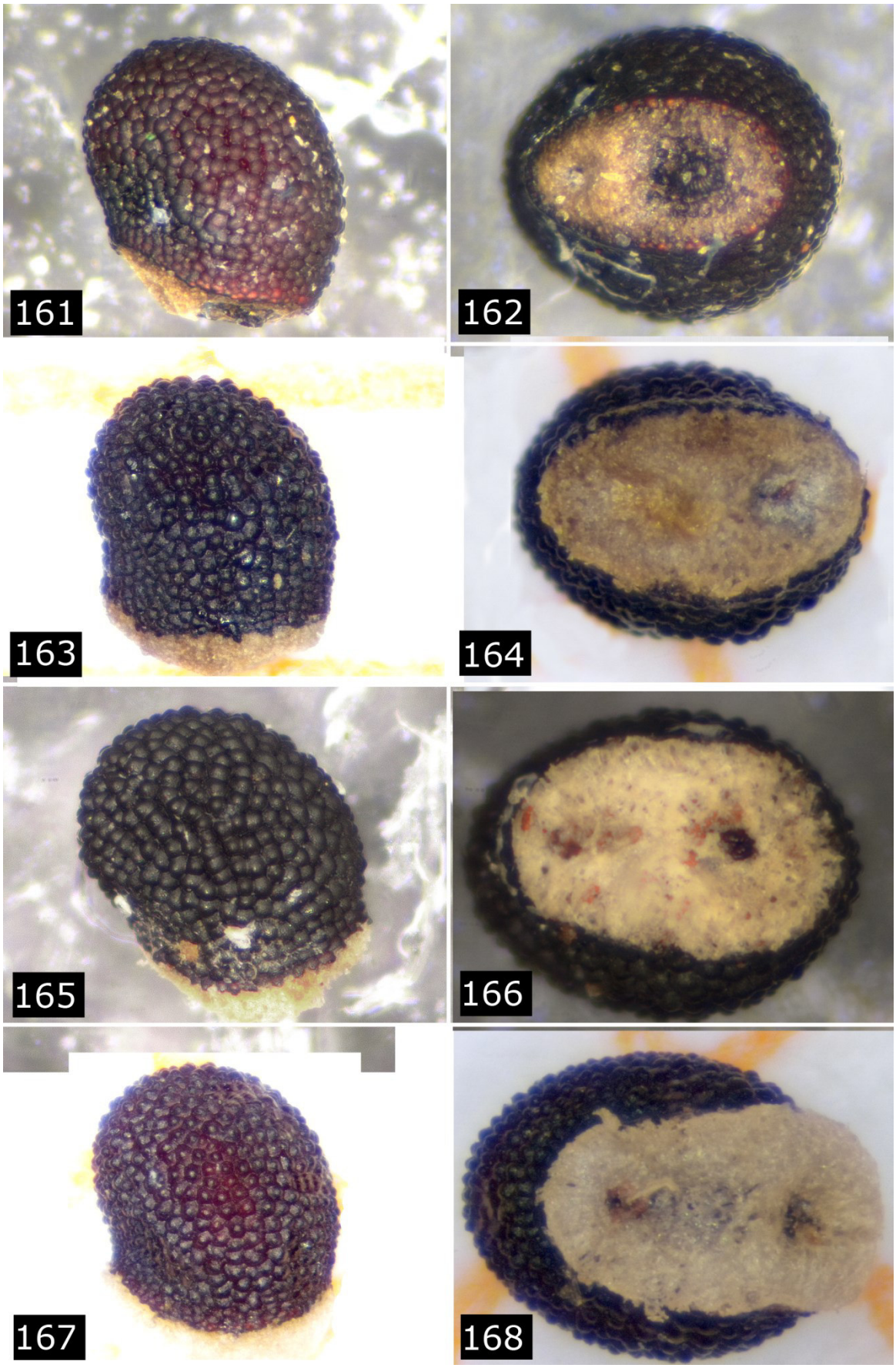
Seeds of *Gymnocalycium schmidianum*. Figs 137–138: STO 60. Figs 139–140: MM 1150. Figs 141–142: MM 1502. Figs 143–144: Tom 12-682.



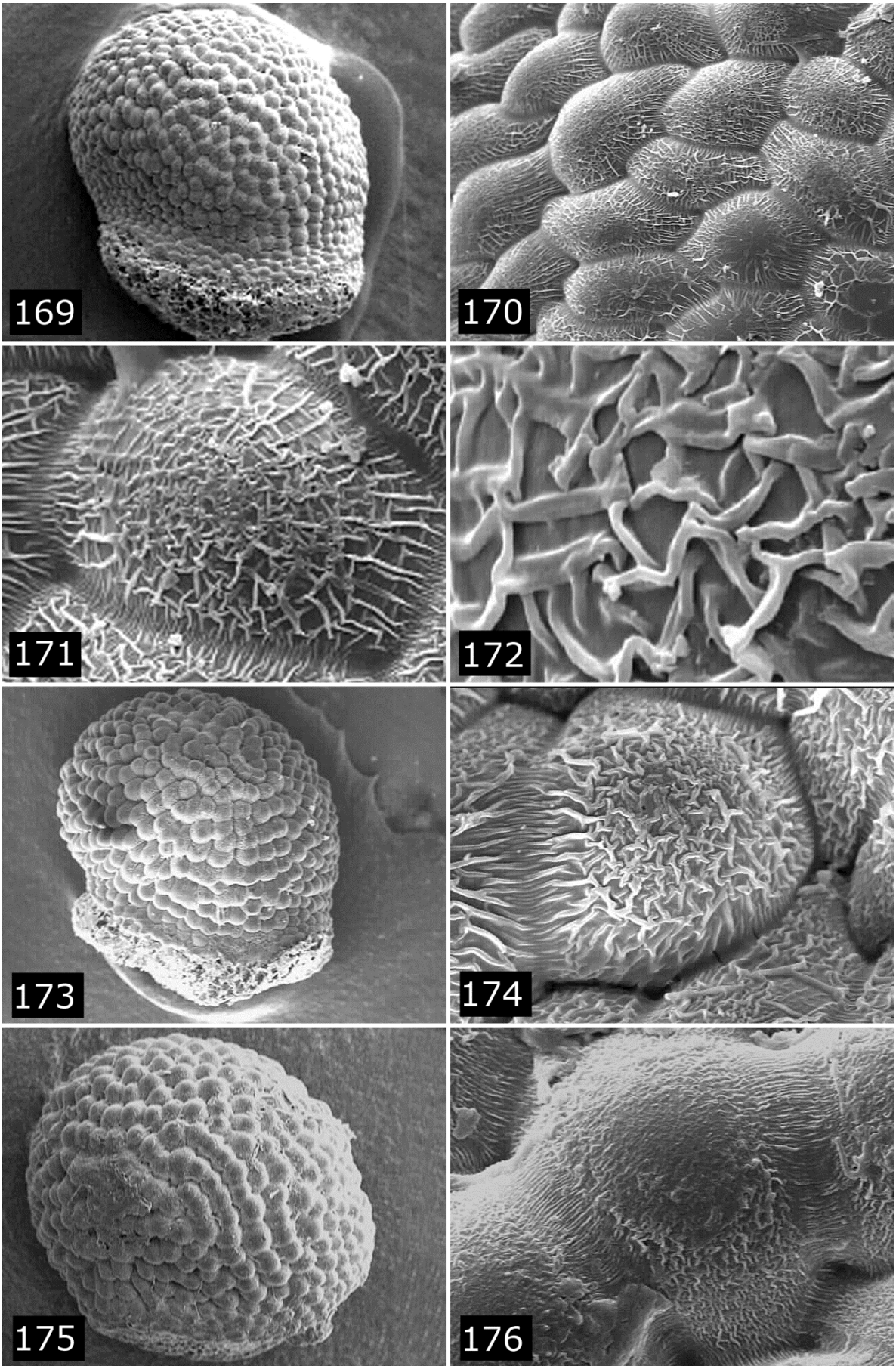
Seeds of *Gymnocalycium schmidianum*. Figs 145–146: Tom 12-690. Figs 147–148: Tom 12-691. Figs 149–150: Tom 12-692. Figs 151–152: Tom 12-693.



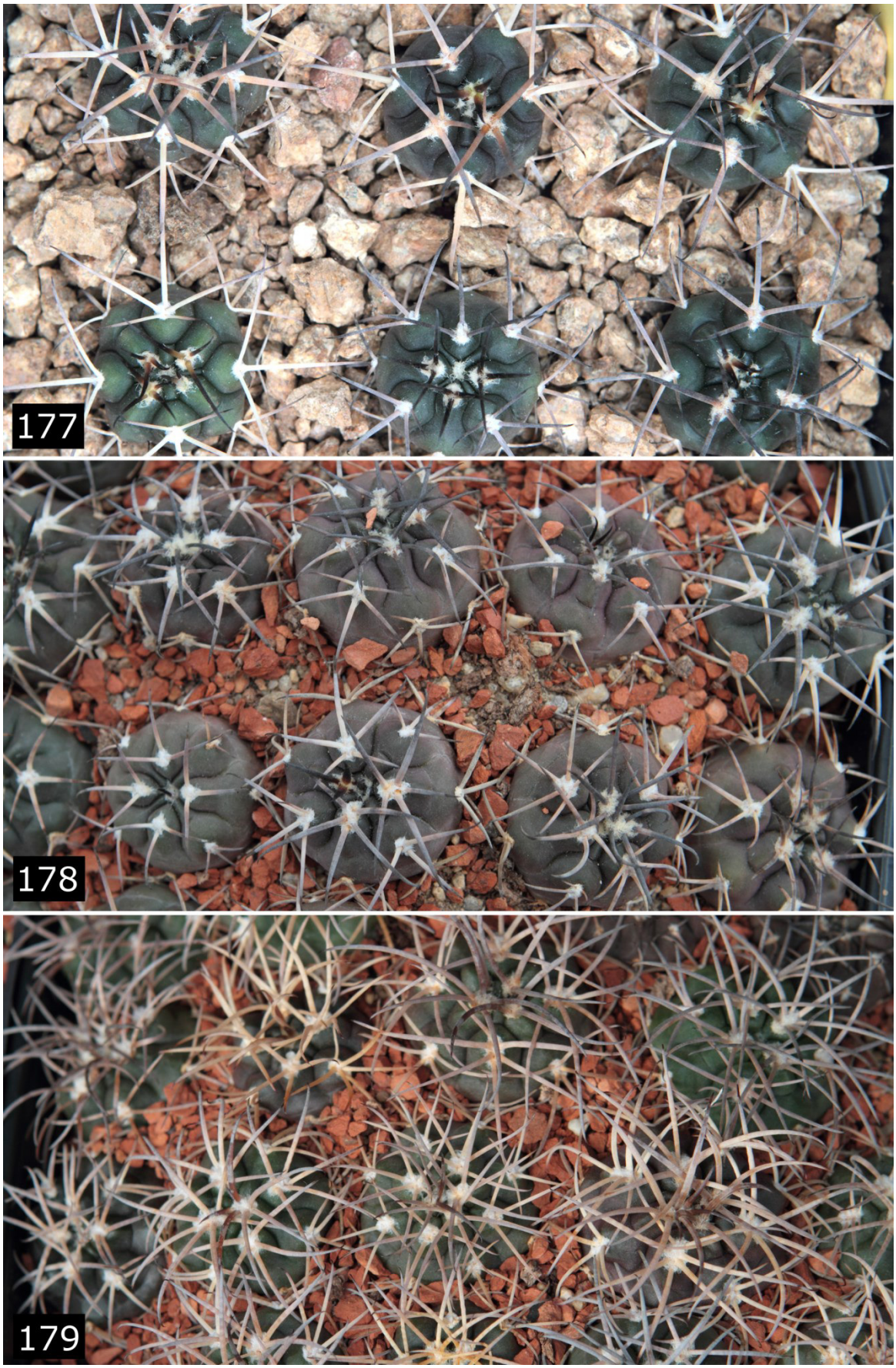
Seeds of *Gymnocalycium schmidianum* subsp. *asperum*. Figs 153–154: MM 1297. Figs 155–156: Tom 12-687. Figs 157–158: Tom 12-684. Fig. 159: MM 1295. Seed of *G. schmidianum* subsp. *schmidianum*. Fig. 160: MM 1294.



Seeds of *Gymnocalycium.* Figs. 161–162: *G. spegazzinii*, MM 1132. Figs 163–164: *G. spegazzinii*, MM 1315. Figs 165–166: *G. catamarcense,* MM 1138. Figs 167–168: *G. pugionacanthum*, Tom 12-707.



Seeds at SEM. Figs 169–172: *Gymnocalycium schmidianum* STO 87/60. Figs 173–174: *G. catamarcense*, N of Hualfin. Figs 175–176: *G. spegazzinii*, Cafayate.



Seedlings of *Gymnocalycium*. Fig. 177: *G. schmidianum* subsp. *asperum* Tom 09-529. Fig. 178: *G. schmidianum* subsp. *asperum* Tom 09-527. Fig. 179: *G. schmidianum* subsp. *schmidianum* VS 793.

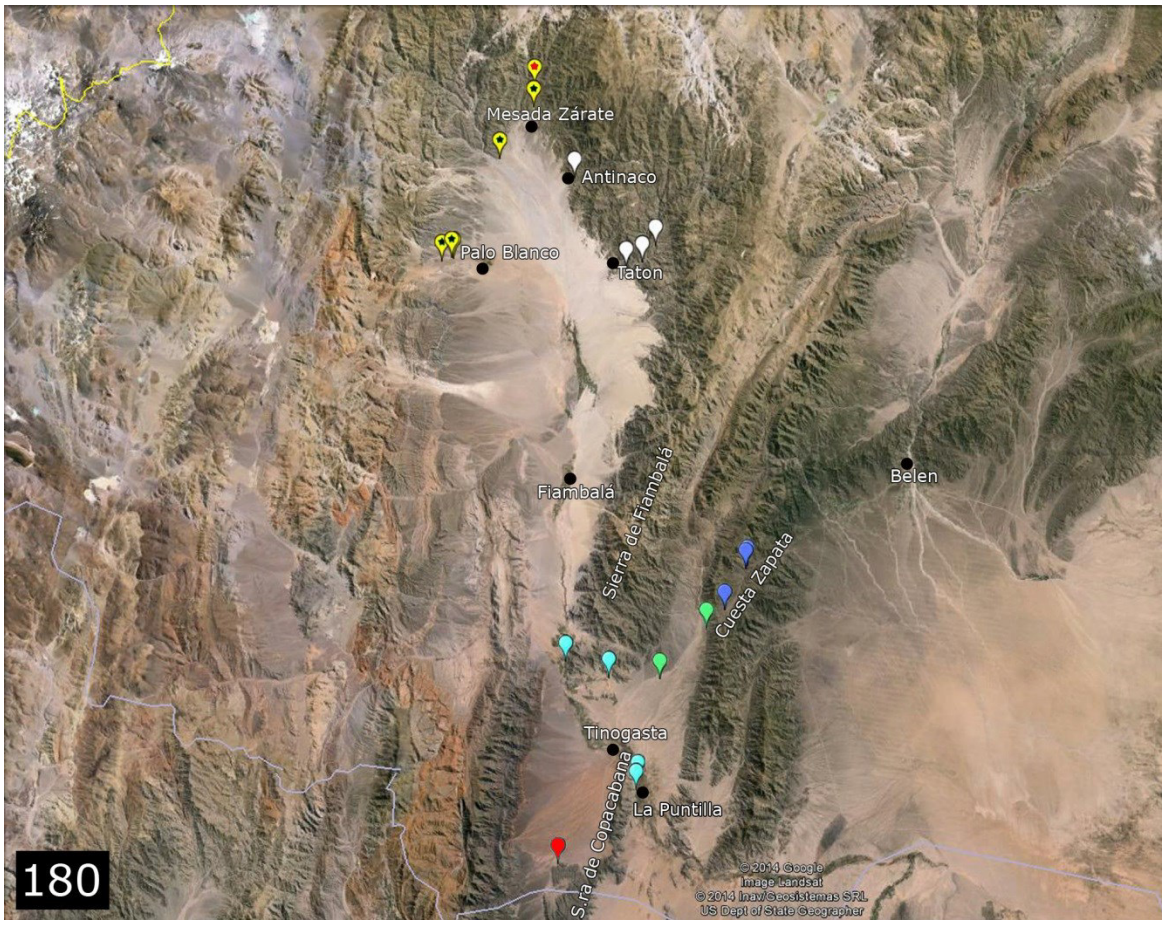


Fig. 180. Distribution of *Gymnocalycium schmidianum*. **Red mark**: *G. schmidianum schmidianum*; type locality; **light blue marks**: populations morphologically similar to the type form; **green marks**: populations from the alluvial plain north of Tinogasta and the base of the Cuesta de Zapata; **purple marks**: populations from the Cuesta de Zapata; **white marks**: populations from Taton and Antinaco; **yellow marks with red star**: *G. schmidianum* subsp. *asperum*, type locality; **yellow marks with black star**: other populations of *G. schmidianum* subsp. *asperum.* Map from Google Earth.

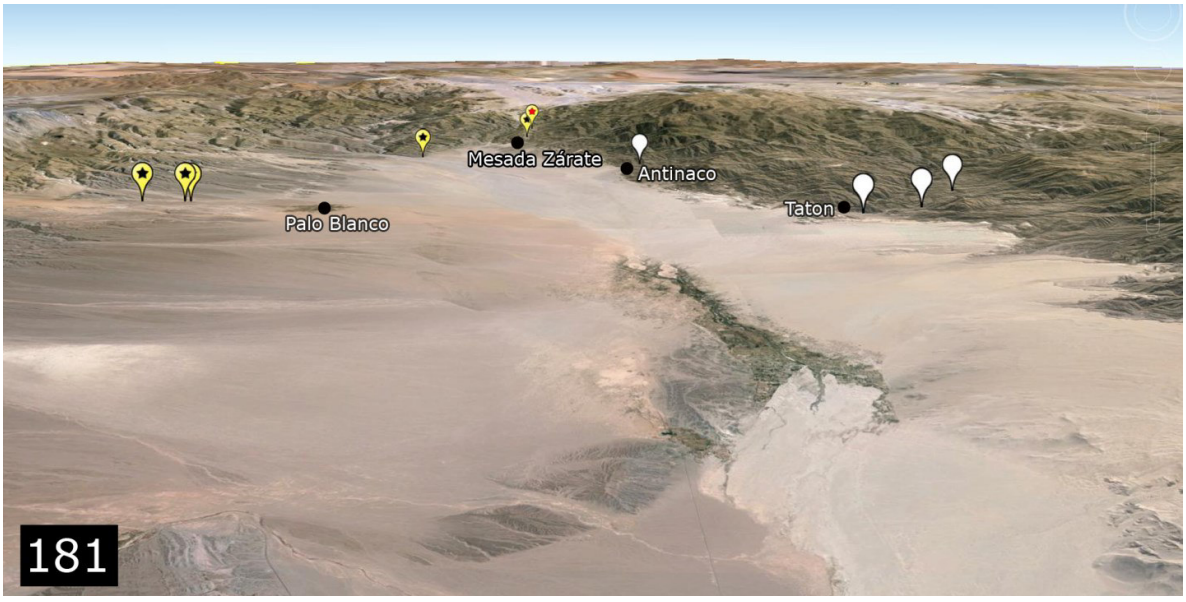


Fig 181. The valley of Fiambalá, 3-D view at 10,000 m altitude. Marks for the populations of *Gymnocalycium* as in Fig. 180. Map from Google Earth.

Cited fieldnumbers.

LB 1307, LB 4498, MM 1502, Tom 12-682. Argentina, Catamarca, S of Tinogasta, Ruta 60, 3 km N Copacabana, 1155 m

LB 1309. Argentina, Catamarca, Ruta 3, 26 km S of Tinogasta.

LB 4507, MM 1300, Tom 12-684. Argentina, Catamarca, N of Fiambalá, 5 km W of Palo Blanco, 2218 m

LB 4509, MM 1295 Tom 12-685. Argentina, Catamarca, N of Fiambalá, 19 km N of Palo Blanco, crossing to Antofagasta de Sierra, 2055 m

LB 4514, MM 1297, Tom 12-687. Argentina, Catamarca, N of Fiambalá, 5.5 km N of Mesada de Zárate, 2642 m

LB 4517, MM 1299, Tom 12-689. Argentina, Catamarca, N of Fiambalá, Antinaco, 1950 m

LB 4520, MM 1505, Tom 12-690. Argentina, Catamarca, Ruta 3, 12 km N of Tinogasta, 1345 m

LB 4522, MM 1506, Tom 12-691. Argentina, Catamarca, 25 km NE of Tinogasta, Ruta 3, W slopes of Cuesta de Zapata, 1608 m

LB 4523, Tom 12-692. Argentina, Catamarca, 30 km NE of Tinogasta, Ruta 3, W slopes of Cuesta de Zapata, 1840 m

LB 4524, MM 1143, Tom 12-693. Argentina, Catamarca, E slopes of Cuesta de Zapata, 28 km W of Ruta 40, 1775 m

LB 4525, MM 1142, Tom 12-694. Argentina, Catamarca, Cuesta del Tambillo, 18 km W of Ruta 40, 1715 m

LB 4527, MM 1507, Tom 12-695. Argentina, Catamarca, Cuesta del Tambillo, 15 km W of Ruta 40, 1580 m

LB 4528, MM 1140, Tom 12-696. Argentina, Catamarca, Cuesta del Tambillo, 13 km W of Ruta 40, 1490 m (*G. catamarcense*)

MM 1132. Argentina, Salta, 12 km E of Ruta 40 dir. Hualinchay, 1986 m (*G. spegazzinii*)

MM 1138. Argentina, Belen, Camino Bande, 1250 m (*G. catamarcense*)

MM 1144. Argentina, Catamarca, N of Fiambalá, 6 km W of Palo Blanco, 2205 m

MM 1145. Argentina, Catamarca, N of Fiambalá, 8.5 km W of Palo Blanco, 2200 m

MM 1146. Argentina, Catamarca, N of Fiambalá, 2 km E of Taton dir. Rio Grande, m 1905

MM 1150. Argentina, Catamarca, Ruta 3, about 20 km S of Tinogasta, 1440 m

MM 1291. Argentina, Catamarca, N of Tinogasta, S. José, 1240 m

MM 1293. Argentina, Catamarca, N of Fiambalá, 8 km E of Taton dir. Rio Grande, 2020 m

MM 1294. Argentina, Catamarca, N of Fiambalá, 11 km E of Taton dir. Rio Grande, 2445 m

MM 1296, Tom 12-686. Argentina, Catamarca, N of Fiambalá, 1.5 km N of Mesada de Zárate, 2380 m

MM 1301. Argentina, Catamarca, S of Tinogasta, S of La Puntilla, m 1145

MM 1315. Argentina, Salta, Colomé, 2220 m (*G. spegazzinii*)

STO 87/60. Argentina, S of Tinogasta.

Tom 09-527. Argentina, Catamarca, N of Fiambalá, 5.5 km W of Palo Blanco - Plaza, 2186 m

Tom 09-528. Argentina, Catamarca, N of Fiambalá, 7.8 km W of Palo Blanco - Plaza, 2307 m

Tom 09-529. Argentina, Catamarca, N of Fiambalá, 5.4 km N of Punta del Agua, 2050 m

Tom 12-707. Argentina, Catamarca, Ruta 46, 30 km E of Belen, Cuesta de Belen, 1040 m (*G. pugionacanthum*).

VS 793. Argentina, Catamarca, N of Tinogasta, El Puesto, 1345 m

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