# A most peculiar cactus: *Puna clavarioides*

Roberto Kiesling

When Pfeiffer published the first description of *Opuntia clavarioides* in 1837, he could hardly have imagined that his quilled pen would eventually be replaced by a ballpoint, that carriages would no longer be powered by horses, or that cactus collectors would send color photographs via computers! But, since 1837, few cactus lovers have learned more about the plant than Pfeiffer did. Its morphological peculiarities and biology have remained obscure, and people have very often discussed whether or not the cultivated "finger form" is a natural form of growth. Only a few photos of the flowers have been published, which perhaps means that it is not free-flowering under cultivation.

*Opuntia clavarioides* was described from plants collected by John Gillies at Mendoza, most probably at the Paramillos de Uspallata, on the way from Mendoza to Uspallata through Villavicencio. The route still exists, but it is a rough one, used only by tourists and for access to a few mines. Today the main route to Uspallata and Chile takes a different way, along the Río Mendoza. Pfeiffer's publication mentions "Chile," but this is a mistake—possibly Gillies mistakenly cited "Chile" instead of "en route to Chile." Most plausibly, this can be interpreted as an indication of the absence of definite borders at the time of collection, the transitional period from Spanish domination to organization as an independent country later named Argentina.

Gillies, a Scottish physician of the British naval force on leave because of tuberculosis, chose for his recuperation not some Mediterranean country, as was common, but rather Mendoza, in order to have an opportunity to collect unknown plants in this unexplored part of the New World. During the years he lived at Mendoza (1821–1828), he became a friend of General San Martín, who organized the army for the liberation of Chile and Peru from the Spaniards. San Martín is the principal figure in Argentinean history, not only for his clever military actions, using psychology more than arms (though at the time the word psychology was not yet created). Moved by ideals of freedom and independence, he lacked personal interest in power or riches. Gillies, San Martín, and other friends were active in founding public libraries, a couple of schools for boys, and another for girls (in those days this was very advanced and produced some violent reactions, including the killing of a pharmacist who collaborated with Gillies), and other beneficial actions for Mendoza. Gillies's salary from the British army was in great part spent to obtain books for the libraries. There are a couple of bibliographic references to his life (Barr, 1972; Dawe, 1988).

Coming back to *Opuntia clavarioides*, the plant grows at approximately 2300–3000 meters (7000–9000 feet) above sea level, under a very severe climate. The scarce summer rains fall irregularly with an average of 100 to 300 mm (4 to 12 inches) per year (some of the precipitation arrives as snow in winter). Most of the days are clear and sunny. The great insolation heats the air and produces strong winds nearly every afternoon, when the air ascends, moving up the mountain slopes. The soil surface is hot during the day, easily reaching 30°C (86°F) or more at noon, but temperatures diminish with the usual late afternoon winds. Nights are cool, several degrees below freezing in winter, and not more than 10°C (50°F) in summer. (The average minimal temperature is –7.3°C and the average maximal is 18.6°C (65°F and 18°F, respectively; climatic data from Ambrosetti et al., 1986.)

The known distribution of this species is in the valleys of Valle de Uspallata, Valle de Calingasta, and Valle de Iglesia, which run north of Mendoza and all along San Juan, between the true Cordillera de los Andes and, to the east, a parallel mountain of ancient geological origin referred to as the Precordillera. In fact, the three valleys form a line and can be considered as a single large valley between the above-mentioned mountains. (Each valley has a different drainage: Río Mendoza, Río San Juan and Río Jáchal.) Paramillos de Uspallata, the locality where Gilles very likely collected *Opuntia clavarioides*, was revisited in 1937 by A. Ruiz Leal, a botanist from Mendoza.

Some colonies of this plant are incredibly dense and abundant. The vegetation—if you can call it vegetation—is nearly that of a desert, consisting of some separate shrubs (creosote bush is predominant), many of them spiny, some annuals with a predominance of grasses, and very wide spaces between the plants. Excellent studies of the vegetation have been published by Ambrosetti et al. (1986) and Roig et al. (1998), with more details about climate, soil composition, plant communities, etc.

The soil appears to be composed of irregular pebbles 1 to 5 cm in diameter (less than half an inch to 2 inches), but this is an illusion: the pebbles on the surface have no soil between them, as the wind has blown the fine particles away. This is called desert pavement and consists only of a carpet of pebbles. Under the carpet we find the real soil—mixtures of very thin soil (clay) plus a thicker material (sand), plus pebbles and stones. There are not many large stones on the surface because the extreme temperatures produce daily expansion and contraction; in consequence, the larger stones shatter.

But what are the consequences for our lovely, small, and fragile plant? It must resist the wind, extremely hot and cold temperatures, nearly permanent dryness, and even some weeks every year of wet soil, which turns hot during the day and cool at night; near the soil surface, water from the snow turns to ice every night.

What are the biological, chemical and physical survival mechanisms possessed by this plant? And what are the mechanisms that allow it to use these factors as advantages for survival? We do not know—we only observe facts and describe them. The following interpretations are partial and tentative.

## The roots

When describing a plant, the first organ normally mentioned is the root, because this is the first part appearing from the seed. In the present case it is also justified, considering the importance of the roots to the total volume of the plants. The roots are a large handful—robust tubers, like sweet potatoes, more or less rounded above and pointed below. Externally they have a brown "skin" similar to that of potatoes, separating more or less easily, and we suppose it helps reduce the friction of the tuber with the soil. We need to consider the soil's contraction and dilatation from temperature and also that the amount of water changes throughout the day and year. Water turns to ice every night during some six months of the year, producing strong pressures and permanent changes in moisture.

From the tuber, some thin roots grow downward, as is normal; but some grow upwards! Botanical texts teach us that roots are geotropic, which means that they must go down, but to be sure, these roots never read a botany book. By going upwards, the tips of these rebellious roots

**Figure 1.** The habitat of *Puna clavarioides* at Paramillos de Uspallata.

can absorb extremely minimal rains, as well as drizzle. We have observed that many other cacti also have these ignorant, upwardly mobile, roots (actually subterranean stems).

## The neck

From the upper part of the tuber is a "neck" connecting the root with the stems. So now we have the next question—what is this neck?

First, it's better that we answer: how did it arise? This species, like many others, has contractile roots. This means that with a scarcity of water, when the plants are dehydrated, the root volume is reduced, but as the root is fixed firmly at the lower extremity, it is the top that moves downwards. When the roots absorb water once again, the volume increases, but their general form reduces the possibility of growing upwards, because it is easier—and natural—to grow downward, penetrating deeper into the soil thanks to the pointed apex. Over the years, the tuber positions itself deeper and deeper into the soil. Looking at the approximately heart-shaped form of the tuber, we can easily understand how this happens.

And the other question: why does it happen? We know that the differences in temperature are not as extreme at a depth of 10 centimeters (4 inches) as they are at the surface, and they are even more uniform at 20 centimeters (8 inches), which is about the depth of the larger tubers. In cultivation we rarely think of the environmental conditions of soil, frequently submitting the poor roots to hot temperatures when confining them in small pots.

But we started to describe the "neck": it is more or less cylindrical, shaped like a short, half-used pencil; these necks have a length of up to 7 centimeters (3 inches) or more, and a diameter of about 1–1.5 cm (1/3–3/4 inches). Covered by a kind of skin or bark composed of irregular overlapping plates that also prevent friction with the soil, the neck suffers more friction than the tuber; its contractions and expansions are more pronounced. Also we can see some old dry segments of aerial stems attached to the sides.

The last question: what actually is the neck? It is a speciaized underground stem, with apical and lateral growing points from which the aerial stems are produced yearly.

## The stems

We must also make mention of the stems. Surely no one grows plants for their marvelous and beautiful roots; we better appreciate stems and flowers, except for carrots and potatoes, ingestion being the sincerest form of flattery.

The stems—the aerial ones, not the underground "necks"—are sparse (from 1 to 5, rarely to 10, but rarely more in habitat), conical, pointing downwards. Only the flat top is at the soil level, surrounded by soil and pebbles. Actually, the upper disk is not completely flat; it has a more or less flat center, but the border is more elevated, as that of a dish. The borders grow actively, while the center areoles rest.

In cultivation, low light-levels and perhaps an excess of fertilizer and water (especially if the plant is grafted) produce abnormal finger-like growths along the border of the flat part, but this sort of growth *never* occurs in nature. Under cultivation, an entire branch can adopt a cylindrical form for the same reasons. In my interpretation, this thin cylindrical growth is an adaptation existing also in the field: during spring, the new stems start to grow underground, from the neck, as a thin cylinder, which, coming to the surface, receives light, expands laterally, and forms a cone. An excellent, well-illustrated article about this species in habitat, emphasizing the stems, was published by Guilmer & Thomas (2000).

The stems are annual, after each summer becoming reduced in size. They dry up and withdraw into the soil, remaining attached to the neck, breaking off later. During the resting period, the plant disappears from the surface due to the contraction of the underground portions. The aerial stem can break off from the neck, apparently because of the contraction there, and blow away. Due to its form, the aerial stem cannot re-penetrate the soil. Some of these detached stems do root and produce new individuals, but

**Figure 2.** The terrain at the same locality.

**Figure 3.** Tuber, "collar", stem and flower.

many surely die (we have found a few stems separate from the tubers in spring and beginning to root).

At the apex, areoles are very dense and contiguous; on the sides, they are 1 to 2 mm apart. When the stems dry out, the spines appear denser, resulting in a white covering that reflects light. When the stem is hydrated, the apex color is brown, and its size is normally from ½ to 3 cm diameter (a quarter to one and a half inches). Exceptional stems can measure more, but in those cases they are not perfectly round, having an undulate border.

Can you imagine searching for a whitish or brownish disk, dull, small as a coin, in the middle of thousands of small whitish, black and brown pebbles of the same size? Even if one knows the exact location, it is necessary to spend some time, patience, and attentiveness to find them. Frequent goat droppings further confuse the search!

Spines are small, white or translucent, hard to see with the naked eye, and adpressed to the stem surface. After looking at them carefully with a lens, they can be said to have an arrangement resembling the teeth of a comb. This arrangement is called "pectinate" (pecten means comb in Latin), although the order is not so evident as in *Sulcorebutia*, for instance. Examining and dissecting the areoles under high magnification, we note with surprise that there are no glochids!

As glochids—as defined in all cactus books—are present in the entire subfamily Opuntioideae, we suspected that the areoles, like the roots, have also some degree of ignorance, but soon we arrived at a different conclusion: this species had dramatic changes during its evolution from a "common opuntia" to its present condition. The plants are so reduced that they have more root than stem (an extreme adaptation to very severe conditions), with annual growths to catch solar energy and to produce flowers for perpetuation but abandoned after their useful time, just as mega-companies cut their subsidiaries when they no longer produce a profit. It is a matter of survival!

We conclude that the plants reduced the volume of spines to the minimum, and glochids to zero, because—they simply do not need them. The stems are very well camouflaged, and large animals like rabbits, rats, or guanacos pay hardly any attention to them. The small white spines are useful for reflecting sunlight and perhaps for absorbing dew, but they are obviously not a defense against herbivores.

## Flowers

The buds are borne on the sides of the aerial stems. The receptacle is dark-brown to near violet and bears several scales as in *Rebutia* flowers. Yes!—as in *Rebutia* or some other genus of Cactoideae, not as in the normal opuntioids, which have areoles on the receptacle. In the opuntioids, these areoles resemble those of the stem but are slightly simplified in being smaller and in having fewer and smaller spines.

But in *O. clavarioides* the areoles of the receptacle are extremely simplified, reduced to the scale axils and bearing neither glochids nor spines, only some hairs and bristles. Flowers open during summer, about December to February in the southern hemisphere. The diameter when open is from 3 to 4 cm (1¼ to 1½ inches). The stamens are sensitive, as in all the opuntioids I've observed: if the stamens are touched, they slowly curve toward the style, and, after some 15 to 30 minutes, return to their original position (this only happens during the active stage, i.e., during periods of warmth). The color of the flower is mostly yellow; sometimes lemon-yellow, or darker brown-yellow, or with a slight brownish tinge, or even—although more rarely—completely pink or red.

## The fruit

Some time after the flower has been fertilized, the tepals, stamens, and style fall away, leaving the immature fruit with the classic umbilicus of the Opuntioideae. At least this gives us some indication of its relationship! The fruit is obconical, dark, dull blackish-violet, about 1.5–2 cm long (one half to ¾ of an inch), attached to the side of the stem. The walls are thin and soon dry when mature. The seeds inside are notable for the prominences on their exterior, resembling bunions on a toe. The fruit does not open by itself, i.e., it is not dehiscent. It falls from the plant and is opened mechanically by abrasion from pebbles and wind or by other external factors. There is an interesting paper by Ruiz Leal (1944) with observations on the germination and development of the seedlings.

The seeds, fortunately, have an external cover (called an aril or funicular envelope), demonstrating that the species is correctly placed in the subfamily Opuntioideae. The aril in this case is soft, and the external tissue has parallel, hair-like cells. Stüppy (2002) published a study of the anatomy of Opuntioid seeds, including our species (under the name *Maihueniopsis clavarioides*).

## Taxonomic and nomenclatural considerations

After all this explanation, let me give some short considerations about the placement of this plant in historic and modern cactus systematics.

The species was originally known as *Opuntia clavarioides*, so named by Pfeiffer in 1837. This name was undisputed for nearly a century, but then Knuth (in Backeberg & Knuth, 1936) changed it to *Cylindropuntia clavarioides* (Pfeiffer) Knuth. This placement was influenced by the abnormal finger-like growths produced in cultivation. Some years later, in 1942, Backeberg changed it again, this time to *Austrocylindropuntia clavarioides*.

An Argentinean botanist, Alberto Castellanos, redescribed the species under the name *Opuntia ruiz-lealii* in 1943, apparently not realizing that his species was identical to the earlier-described *O. clavarioides*. Castellanos was surely misled by published descriptions and illustrations of abnormal cultivated plants and also by the mistaken notion that the species came from Chile. In 1959 Backeberg, although noting that both names corresponded to the same species, drew attention to the differences between

**Figure 4.** A flowering plant in habitat.

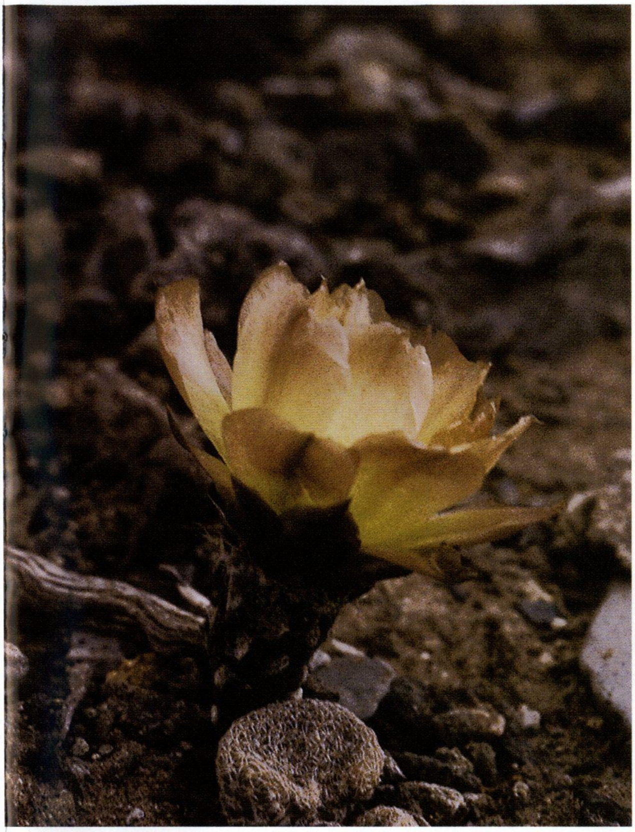

**Figure 5.** A close-up of the flower.

European cultivated plants and Castellanos' illustration of field plants by making the combination *Austrocylindropuntia clavarioides* var. *ruiz-lealii*—without justification in my opinion.

Previously, in 1953, Castellanos had defended the new name he created for *Opuntia clavarioides*, arguing that Pfeiffer's description was based on abnormal plants (he mentions an article of the nomenclatural rules that is now no longer in the Code). On the other hand, Pfeiffer's description describes only conical stems, not the finger-shaped forms that Castellanos imagined to have been described by Pfeiffer. (Castellanos evidently lacked the original description, because he thanks a colleague for information about it.)

In 1982, Kiesling considered this species, together with *Opuntia subterranea* Fries (also known as *Tephrocactus subterraneus*), to be sufficiently distinct from all known genera to justify a separate genus, which he published as *Puna*. In 1997 Ferguson & Kiesling published and added another species to this genus, *P. bonnieae.* The IOS Consensus (Hunt & Taylor, 1990) placed *Puna* as one of the many synonyms of *Opuntia*, using the wider concept of this genus. Preparing his monumental book *The cactus family*, which appeared in 2000, Ted Anderson (in 1999) made yet another change: he recombined the species as *Maihueniopsis clavarioides*, without any explanation, only mentioning that several new combinations were based on unpublished molecular studies of Rob Wallace (Wallace and Dick published their work later, in 2002).

Recently more people—both scientists and amateurs—have become interested in the subfamily Opuntioideae. Most of them consider *Opuntia* in the wide sense to be heterogeneous (an omnibus, or polyphyletic, genus), and consequently recognize other genera as well (*Maihueniopsis*, *Austrocylindropuntia*, *Cumulopuntia*, *Cylindropuntia*, *Grusonia*, *Tacinga*, *Consolea*). The above-mentioned paper of Stüppy (2002), and the one on molecular systematics of Opuntioideae by Wallace and Dicky (2002), support most of these segregations.

As to *Puna*, some people accept it and others do not, as is usual in such cases! I believe that the very distinct morphological features (scales but not areoles on the receptacle, indehiscent fruits, the structure of the aril, the pectinate spines, the highly adapted roots and neck), plus such environmental reactions as geophytism and deciduous or desiccated aerial stems, are enough to maintain *Puna* as a separate genus.

This article was intended to describe some of the many peculiarities of this small and strangely wonderful cactus, as well as to explain why I still uphold the genus *Puna* for *Puna clavarioides* and the other two species, *P. subterranea* and *P. bonnieae*, which share several of the same peculiarities. The latter two have also had several name changes; *P. bonnieae*, for instance, has already been changed from *Puna* to *Opuntia* to *Maihueniopsis* and to *Tephrocactus*!

## Cultivation

The following opinions are based on the plant's native climate, but each of us needs to cultivate it according to our own growing conditions: light, temperature (minimal, average, and maximal), and, very important—the temperature variation between day and night during both summer and winter. Your own experience or the experiences of other growers in your area must also be considered.

I believe that higher latitudes (central or northern USA or central Europe) can be a better environment for this species, not only because those areas have longer days in spring and summer but because more hours of light compensate for the sun's lower intensity. Also, these areas have lower and more variable

**Figure 6.** A fruiting plant at Paramillos de Uspallata.

**Figure 7.** *Puna clavarioides* with two fruits. All photos by the author.

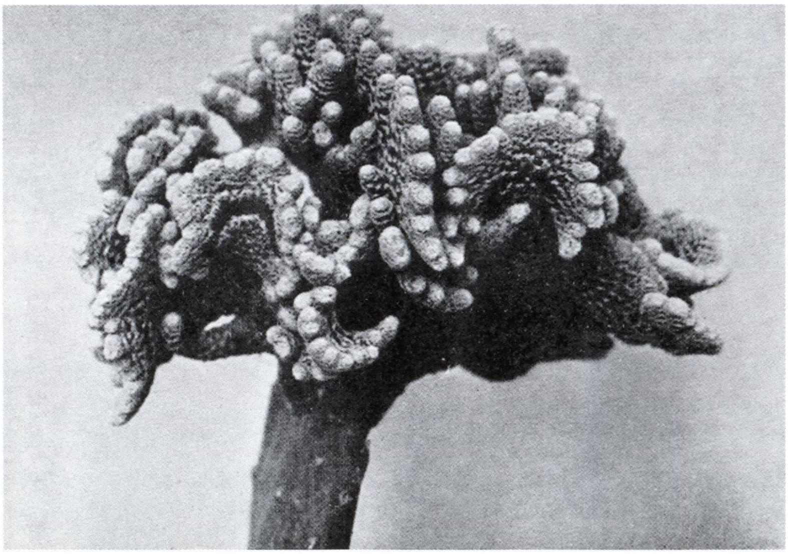

**Figure 8.** *Opuntia clavarioides*, crested.

temperatures. On the other hand, plants growing in hot places, as in the southern USA (California, Arizona, Texas) or the Mediterranean countries, may have some difficulties, basically due to the heat. In fact the plants are easy to keep alive; the difficulty lies in fostering a natural and active growth in order to produce the exquisite flowers.

Traditionally, *P. clavarioides* was grafted on *Opuntia* (*O. ficus-indica*), but the segments can easily be rooted, producing tubers in a couple of years. By grafting or by using too rich a soil, the finger-shaped (or even crested) forms result, but with some care this can be avoided in order to have a more natural appearance. Light deficiency also helps to produce abnormal growth. Remember that in nature the old segments fall off and die, so you should not worry if some parts of your plant also languish or die after a couple of years.

**Soil:** As for many cacti, the soil must be very well-drained, which means it should incorporate a good quantity of pebbles, allowing excess water to drain out of the pot. For the rest of the soil, use a normal cactus mixture with a low nitrogen content.

**Watering:** Please remember that winter is a resting time for this plant, a time when not much water evaporates. If you have several plants, one can try sporadic winter watering, but if you have a very few, do not take the risk. Wet soil in winter can produce a proliferation of fungi that can rot the tuber. In any case, we are not sure if water at this time is really useful for the plant.

**Light:** Choose a place with as much luminosity as possible, both in intensity and in duration. Sun radiation is very high in habitats at those elevations (up to 9000 ft), where the air is dry and thin all the year round. You can hardly provide too much intensity of radiation in cultivation, but perhaps longer radiation can compensate. You could move to a more appropriate clime, or—less expensive and more considerate of your non-chlorophyllous loved ones—add artificial light. Additional light for some 2–4 hours each day can be very useful for many of your plants. One additional comment: in the field, the plants are not exposed to full sun all day long; as they grow on slopes; part of the morning or afternoon has only indirect light. Also, the scattered shrubs produce shade, helping to reduce the intense radiation.

**Temperature:** We mentioned that the roots (mainly the tuber) stay cool at their natural depth. The air and soil-surface temperatures are also cool during the year, except during very sunny hours. Therefore we have the difficult problem of providing much sunlight but with relatively low temperatures. Use a layer of 5–10 cm (2–4 inches) of sand on your benches and submerge the pots in it; this helps to control the soil temperature. You can also add a little water to the sand each day; which because of capillary action will be absorbed by the roots in small quantities, just as would occur in the field. Evaporation will help to keep the pot temperature some degrees lower in summer. Plants situated near the greenhouse ceiling have more temperature variation, but the roots become too hot during the day and the plants do not flourish.

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## The new editor

After some ten years as Editor of the *Cactus & Succulent Journal* and Managing Editor of *Haseltonia*, Myron Kimnach is retiring this summer. His replacement will be D. Russell Wagner of Berkeley, California.

On the professional side, Russell received a B. S. in Chemistry from the University of Georgia and his doctorate in Physical Chemisty from the University of California, Berkeley, in 2001. Recently he has been working in electronics and its application to astrophysics. His other strong interest is in succulent plants, including seed-raising and propagation. He has an extensive library on succulents and is now Editor of the San Francisco Succulent and Cactus Society Newsletter. Currently he is on a botanical field-trip in South Africa.

Until July 1, all manuscripts and photos should continue to be sent to Myron Kimnach (see information on the inside of the front cover). After that date, all material must be mailed or emailed to Russell Wagner, P. O. Box 14965, Berkeley CA 94712. His email is wagner@lmi.net and his phone is (510) 234 4235.