

## The Dolomite Caves of Sierras Bayas, Southeastern Buenos Aires, Argentina

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### Abstract

By far, limestone, gypsum, basalt and clastics caves are well documented in Argentina but dolomite caves have not been clearly mentioned in the speleological literature of this country yet. The Sierras Bayas site is close to the Olavarría town in Buenos Aires, Argentina. Three depositional sequences of Precambrian age compose the Sierras Bayas epiclastic Group. In particular the lowermost shows two sedimentary facies assemblages: a sequence of quartz - arkosic sandstones and shales and other composed of stromatolitic, calcite cemented dolostones and shales; stromatolites indicating an age of 800 – 900 Ma. These rocks are presently exposed along quarries whose operations led to the discovery of well-developed caves and galleries, the focus of this work.

Four isolated caves have been topographed but, in fact, it is proposed here that they form part of a unique system composed of partially or totally communicated conduits. Up to now 83,27 m were mapped with a maximum difference in elevation of almost 7 meters. During the last decades they have been intentionally filled up with rocks and debris, probably by local miners, causing the isolating of several passages and moreover, the total burying of many of them. In spite of this a descriptive work has been held in some cavities with very significant results.

Explored cavities are subhorizontal and small: the largest of all totals 45,37 m in length with a difference in elevation of 6 meters. Concretions such as stalactites, curtains and stalagmites are barely developed and are few in numbers, they are composed of aragonite and calcite but dolomite was also found. On the contrary, other types of depositional features are dominant and comprise thick calcite/aragonite crust, botroidal like accumulations, etc. Numerous dissolutional speleothems were found including ceiling pockets of different sizes and shapes, some scallops, notches, niches and a pothole. The natural sediment fill consists mostly of medium to fine debris and collapsed breccia.

It is proposed here that these are semiactive caves, this assumption is based upon the sporadic water flow observed in some conduits of the Matilde Catriel and Mallegni cavities. Finally, it is proposed that they are polygenetic caves. Matilde Catriel displays tubular passages, has an elliptical cross section and large scallops indicating a phreatic origin although presently it is evolving under vadose conditions. La Nueva and Santa Lucia, both at shallower depths, show steep entrances, smaller dissolutional features and water trickling confirming the slow evolution in an epiphreatic environment.

### Geological Setting

The Sierras Bayas Group is located in Buenos Aires province, Argentina and belongs to the Sierras Septentrionales range (Figure 1). This geological province extends with northwest direction along 300 km exhibiting an igneous-metamorphic basement of 2000 Ma and the oldest unmetamorphosed precambrian sedimentary deposits of the country. The highest point of the range is 500 meters above sea level. The structure corresponds to fault bounded and tilted blocks and a gentle folded strata. Three depositional units composed this Group, the oldest is named Villa Mónica Formation (55 m) which shows two facies assemblages. The lower one is quartz-arkosic and comprises shallow marine siliclastics: conglomerates, arkosic sandstones and laminated shales and the upper one corresponds to shelf stromatolitic dolostones and shales (~35m). The Rb/Sr data for these levels indicate an age of 800/900 Ma (POIRÉ, 1993) which coincides with the age suggested by the stromatolitic assemblage found in this research. The following two depositional sequences are Cerro Largo Formation and Loma Negra Formation. The first represents a shallowing trend with chert breccia at the base that passes to fine stratified shales (glaucinitic), fine grained, cross-stratified sandstones, arenites and finally claystones. The second comprises red and black micritic limestones interpreted as an environment of carbonate ramp, shelves and lagoon (POIRÉ, 1993).

In particular, the Villa Mónica Formation, the focus of this work, hosts the caves analyzed here. It represents a gradual marine transgression with the development of littoral sub-environments as it is pointed out by the presence of shales and very fine sandstones with trace fossils at the top. A climate change to tropical conditions led to the evolution of a carbonate sequence and well-developed columnar and stratified stromatolites. These organisms built important domic biostromes of originally magnesium calcite but presently they constitute dolostones due to diagenesis. Periodic sub-aerial exposures occurred later and iron rich shales were deposited over this sequence. Carbonates were also subjected to karst processes with the development of caves, karstic terraces and collapse dolines (BARRIO et al., 1991).

Locally, the strata are folded in a plunging syncline with an east-northeast axe. Caves are located in the northern end of the fold where dips are no higher than 20°. A system extensional and transtensional faults constitute the main structural framework of the site. Normal faults are axially oriented and related with release during folding and are considered the main controlling factor of the dissolution. Apart from them there are numerous strike slip ones with a gently sinistral displacement that secondarily contributes to that processes.

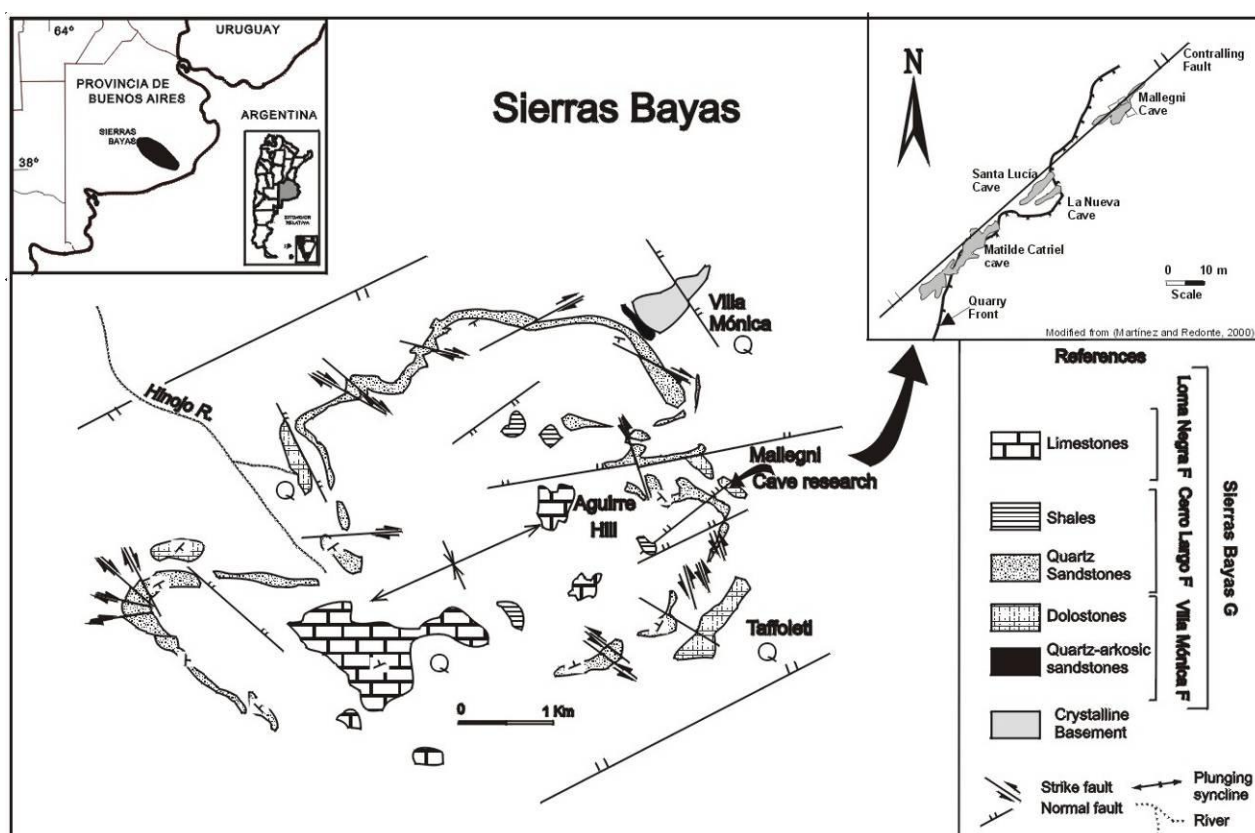


Figure 1: Geological map of Sierras Bayas outcrops and quarries (Q) distribution. Plan view of the studied caves.

## Speleological Setting

The mining activities of the Mallegni quarry have unburied a series of caves in the dolostones of the Villa Mónica Formation. The cavities resulted from karst phenomena developed during the Quaternary times although a series of dissolutional features found in bedding planes suggest that similar processes could have occurred during the lower Paleozoic (BARRIO et al., 1991; BARREDO, 1997).

Identified as Mallegni, Matilde Catriel, Santa Lucia and La Nueva, they are located between 250-270 m above sea level. Climate is template to moderately warm and humid with a mean rainfall of 850 mm per year. Temperatures range from 15°C to 30°C during summer and from 5° to 15 °C in winter with a mean annual of 14.1°C.

Caves explored are aligned parallels to the bedding dip and are clearly controlled by the normal axial faults and cracks. They also follow the geological contact between the dolostones and the cuspidal impermeable shales of the lowest facies (Figure 1). The detailed topography carried on up to now indicates a partial

horizontal development of only 83,27 m with a maximum difference in elevation of only 7 meters (MARTÍNEZ AND REDONTE, 2000).

The explored cavities are almost dry, water trickles and drops in some joints and concretions but no permanent currents were observed. Internal temperature shows a mean of 17 °C and moisture reaches nearly 95 % in some passages. Matilde Catriel (253 m.a.s.l.), the largest and most important of all, is subhorizontal and totals 45,37 m in length with a partial difference in elevation of 6 meters (Figure 2a). The entrance consists of two vertical pits of more than 2 m deep; these holes are part of the numerous pits developed along joint and fault planes that were exposed during rock blowout. Its main gallery shows a rather lenticular profile with elliptical smaller conduits (Figure 2b) and minor meandering passages.

Speleothems correspond to barely developed stalactites, very few incipient stalagmites and curtains, thick botroidal like accumulations, coatings, petrified cascades and remnants of gourds. Dissolution by imbibition of carbonates formed a dolomitic powder (mostly silty) with isolated quartz grains that covers great part of walls, building a weathering crust.

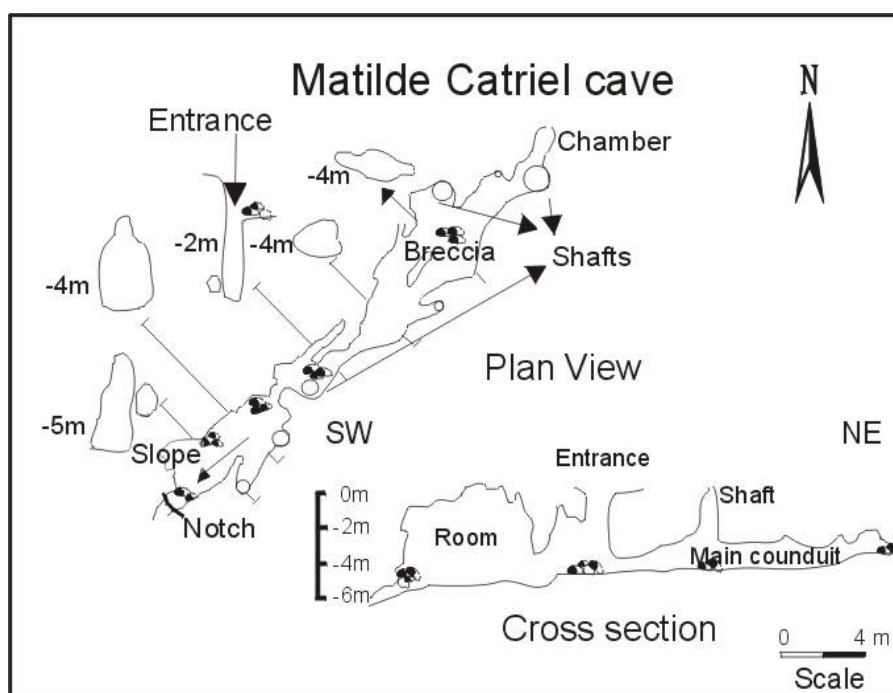


Figure 2a: Plan view and extended profile of the Matilde Catriel cave (modified from MARTÍNEZ AND REDONTE, 2000).

Manganese oxides appear as films or as dendrites on these surfaces together with iron oxides.

All these depositional features are composed of acicular and massive aragonite, rhombohedral, calcite, and scarce yellowish dolomite (Figure 3). Externally, they are mostly white with slight yellowish, dark brownish to reddish tones. These latter are also associated with iron oxide rich clay deposits (*terra rosa*). Calcite is also present as aggregates of white translucent crystals, ranging from 1 to no more than 3 mm in length, as needles and also as pseudohelictites (these latter over calcite crusts). Dolomite was detected in thin section conforming rhombododecahedral and curved crystals, some of them with an aragonite core. Aragonite presents frequent calcite replacements.

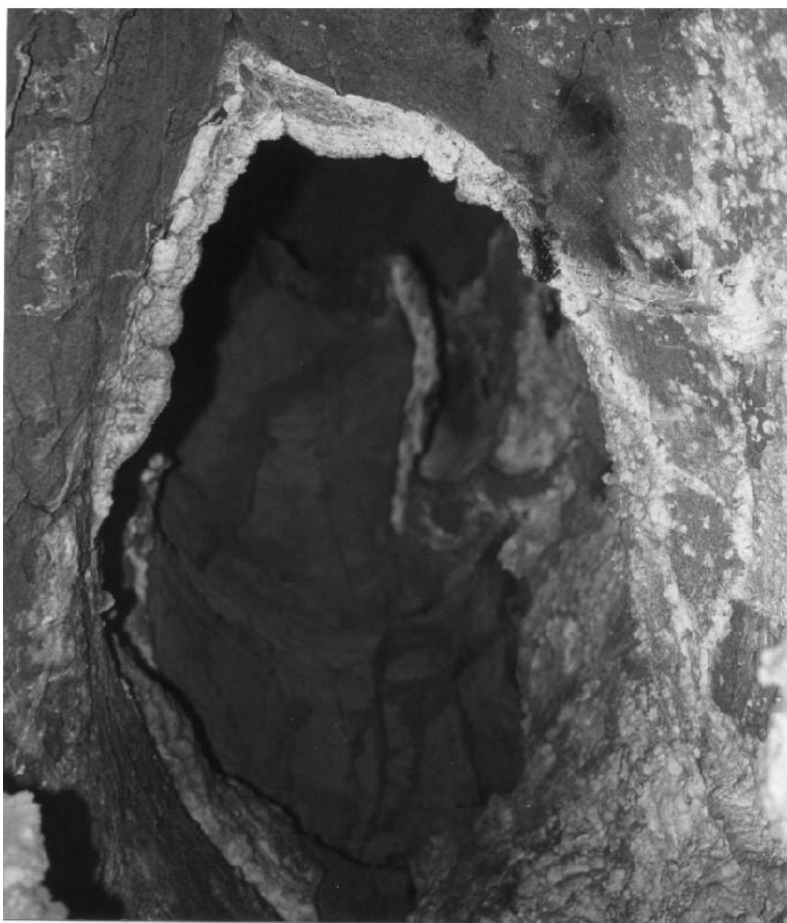
The dissolutional speleothems are numerous and well preserved. Ceiling pockets are of different sizes and shapes, but mostly are independent, simple, semi-circular in cross section and always associated with a fissure (Figure 4). They are large, up to 90 cm in diameter, the bottom is rounded and the axe almost vertical. Few composite pockets were detected: they form groups up to three in number, laterally connected and no larger than 10 cm. Only one independent pocket in levels occurs in this cave, it is 30 cm wide, and shows two smaller and inner cups that reaches 15 cm. As in the first case, it is associated with a fissure.

Horse-shoes shaped wall niches (up to 50 cm) are more frequent in the southern portion of the gallery.

Scallops were found in some walls but they are bad preserved, it seems more likely that they form part of a network of niches cut into the surface of the dolomite. In spite of this it could be possible to differentiate, in



few of them, the deeper portion from the shallow one. Among them tiny and angular pendants exist. Finally, semi-circular, sometimes flute like notches occur longitudinally over the walls and ceiling.



*Figure 2b: Secondary conduit with elliptical profile. See also the aragonite deposit coating it almost entirely.*

The floor is covered by sediments however some pits and a pothole (?) could be unburied. It is semi-spherical and slightly elongated indicating the outflow side, the axe vertical. The maximum diameter of the opening measured is 8 cm, the bottom rounded and smaller, depth is 3,5 cm. It is common to find aggregates of calcite crystals with sparitic cement protruding out of the fissures and building a reticulate framework. Dendrites and red iron oxides layer the walls.



*Figure 3: Aragonite coatings with calcite replacements (whitish tones). Note water films over the wall.*

Floor deposits (*allochthonous and auochthonous*) consist of medium to fine debris and blocks up to 0,70 cm long. The first includes soil clay (loess derived) minerals, quartz grains/pebbles. The second, clay undetermined minerals, quartz, dolomite and lithoclasts (up to pebbles). Collapsed breccias comprise fan shaped piles of angular blocks and clasts related with minor faults and joints. Seldom boulders are piled up as a consequence of roof downfall.

Short-lived channeled flows with a classical anastomosing morphology transport part of these materials. Coarser grains show a subangular to subrounded surface with few of them imbricated. Fines deposits are mostly massive but certain parallel to wavy laminae can be identified. Some passages have been intentionally filled up with loam, rocks and other foreign materials so further details were not available.

The other cavities are less developed. Mallegni is 19 m in length, Santa Lucia only 11,9 m and La Nueva, 7 m. They present steep entrances (nearly 50°) but a gently south dipping floor of no more than 2°. Depositional and erosional features are basically the same but by far less developed. Gravity processes are more significant than those of the main cavity presumably by the human impact.

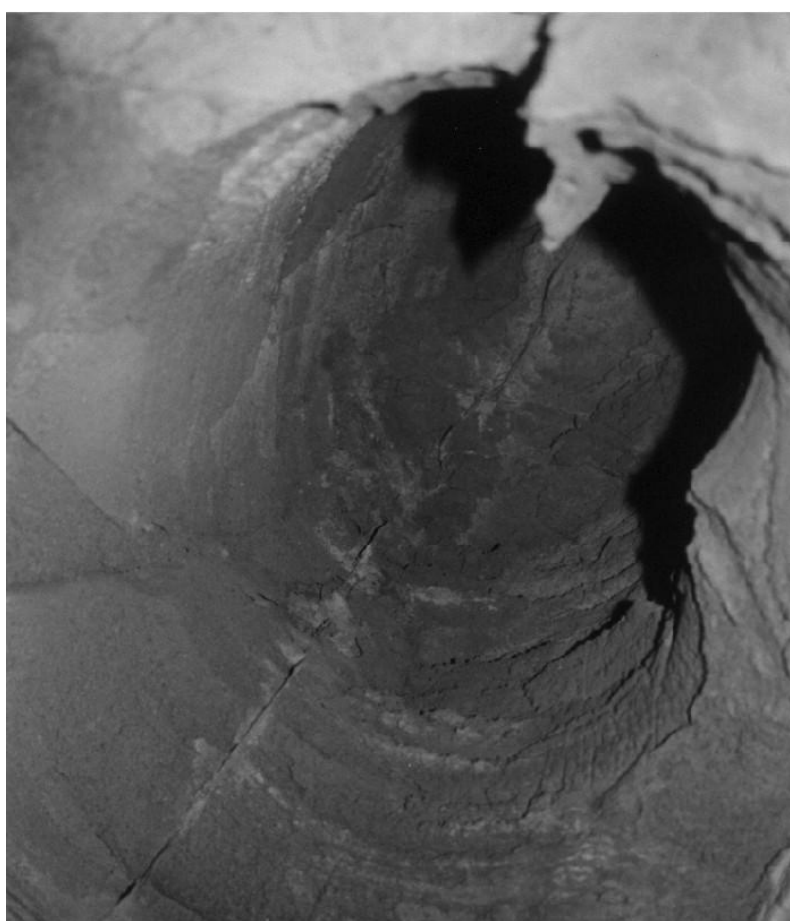


Figure 4: Ceiling Pocket: simple and semi-circular. Note the clear association with a fissure.

## Proposed Model

If it is true that up to now cavities explored are few and apparently isolated they form part of a larger system. Evidences gathered during field works and the inhabitants' testimony permit to certify this hypothesis and even more, to suggest that caves are partially or totally communicated.

Matilde Catriel was deliberately filled with foreign materials thus some western secondary conduits and possibly important branches are now hidden.

In fact, the southern portion is completely obliterated, the gallery should follow as it is suggested by the presence of a well developed notch which emerges from the floor. To reinforce this latter, recent labors met a hole almost 30 m deep, south and close to the this wall, possibly meaning that a down level passage is related to that dissolutional feature. Another key element is that 2 km south a small resurgence was

observed after a rainfall. On the other hand, Santa Lucía is separated from this cave by only 5 m (Figure 1). The ends of both show similar characteristics: a small circular chamber of 2 to 3 m in diameter with barely developed notches and solution cups. La Nueva cave is proposed here to be a lateral and shallower branch of Santa Lucía; Mallegni (263 m.a.s.l.) is located 15 m north clearly following the main structural trend and showing faint current indicators that point out to a mainly west-southwest flow.

Surrounding labors discovered caves that follow the southwest trend, not only in the same hosting rock but in the overlying limestone as well. Some others seem to follow a northeast trend consistent with the syncline plunging. All these unexplored cavities are said to be larger and more complex than the ones described here but these data could not be validated during this work.

Based upon passage morphology, it is proposed here that the “system” is composed of polygenetic caves. The main gallery of Matilde Catriel is almost tubular (Figure 2a), subhorizontal and has a subrounded to sometimes conspicuous elliptical cross section indicating a phreatic origin. The cave relief composed of very well developed ceiling pockets, large scallops produced under slow flows and solution cups in the ceiling, reinforce that assumption. However, at the moment this part of the system is semiactive and is evolving under vadose conditions. Secondary conduits are tubular and subhorizontal too, but few others, located near the entrance (and the entrance itself) are steeper with shafts associated to major fractures; very small scallops were also found. The cave is almost dry although after a rainfall percolation through these pits and through the structural discontinuities increases to such an extent that these vadose conditions become obvious. The pothole found may also suggest that turbulent water moved fast over the floor under such environment. Some bell shaped ceiling pocket might be associated with water trickling down the fissures. Stalactites are growing up and are always wet with stationary drops or are trickling. In some small conduits where moisture reaches 100 % and where there is no dripping, humid walls show solution cups probably resulted from water condensation. Sporadic flooding is also possible as it could be deduced during this research. As a response to a heavy rain, a small spring was observed 2 km south. Percolation increased substantially but a little portion of the Matilde Catriel southern end was temporally flooded. A maximum flooding level line was observed indicating 30 cm in depth, fine debris uniformly covered the floor as a massive deposit. A smooth channel was also incised when flooding ceased and water was insumed towards the southern notch, swash marks were also found. It seems likely that the lowest levels not enough capable to absorb all the water and the presence of underlying impermeable facies gave place to the overflowing of this part of the “system”. A direct consequence of this latter is that water level rise resulting in the partial flooding of the upper passages and thus becoming temporally active. Further conclusions are speculative due to the human impact yet if these assumptions are correct there might be flooded tunnels downwards which again points out to a larger system than that explored here. To sustain such conclusion it is worth mentioning that recent hole measurements indicates that the phreatic level is in between 15 to 20 m deep, less than 8 m from the deepest point of Matilde Catriel.

Concerning the other cavities, Mallegni exhibited a well developed floor channel but no evidences of flooding were observed, all the remaining conduits indicate a vadose evolution. La Nueva and Santa Lucia showed huge amounts of water pouring through the pits, intense dripping and joint associated trickling as for the rain, but no phreatic conduits.

## Concluding Remarks

During the last decades mining activities increased producing a remarkable change in the landscape. Outcrops once laterally continuous are now gone or indented by quarries and open pits. Lots of caves have been discovered and rapidly destroyed. These caves have been discovered long ago and it is said that the last native head (Mapuche) sheltered in one of them at the end of XIX. His wife narrated lots of stories about the “abysm” and so the cave was named Matilde Catriel in her honor. Like this, there are hundred of tales which assure that caves were once “bigger”. Explosions introduced new fractures, produced rock fall downs and even more, some galleries totally crumbled. Likewise, foreign material was intentionally brought in. Concretions were also vandalized: removed or broken and left aside as waists. As a consequence explorations could not progress beyond the quarry boundaries but if the caves discovered in each open pit were joined together this system could reach more than 6 km (Figure 1).

In spite of all this, the detail research held here permitted to arrive to significant conclusions. Apparently isolated caves are part of a unique system, partially or totally connected. Field works suggest a phreatic origin for at least Matilde Catriel cave, being less obvious in the others. The system is semiactive and is being reworked under vadose conditions, concretions grow gradually and only after an intense rain

percolation becomes important. The flooding observed makes it possible to think in lower and deeper conduits still under phreatic conditions.

### Acknowledgments

Thousand of years are needed to achieve the state of this simple beauty, less than a breath to destroyed it. The author wants to thank to those who are helping to preserve this natural environment and to Gustavo Lentijo, Eduardo Tedesco and Aldo Filliponi who assisted the field works.

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