Rajczy, M., Padisák, J. & P.-Komáromy, Zs. (1984): Flora in the lamp-areas of the caves near Lillafüred. – Proc. of the International Colloquium on lamp flora, Budapest, 10-13 October, 1984: 27-41.

FLORA IN THE LAMP-AREAS OF THE CAVES NEAR LILLAFÜRED

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/Hungary/

Lillafüred, a little health-resort at the foot of Mt. Bükk lies in the vicinity of Miskolc, a city in NE-Hungary. There are two show-caves, the cave "Anna-barlang" and the cave "István-barlang" /Fig. 1./. The geology, the history of development and the exploration history of these caves are very different but they vere opened to the public within very similar circumstances, when Lillafüred, as a health-resort was built up. From that time on their history has been almost the same.

1. THE DESCRIPTION OF THE CAVES

1.1. Geological and historical background

The cave "Anna-barlang"

The stream "Szinva" has a 30-40 m high waterfall at Lillafüred as it joins the stream "Garadna". This waterfall has been deposited a huge heap of travertine since the beginning of the pleistocene. During this process lots of cavities, diverse in their dimensions, have been vaulted by the travertine /Fig. 2./. The number of the cavities was increased by the tree-trunks being covered in by the travertine. As such a trunk decayed a new cavity started its beginning. This way numerous separated cavities of various size have been formed in the travertine cone of stream "Szinva".

The exploration of the cavities started in 1833 when a tunnel was drived into the travertine with the aim of tapping the springs abounding in water which rose from the bottom of the travertine heap. Driving the gallery a number of cavities were explored. The cave originated this way /partly from the cavities of nature, partly from the artificial gallery/ was opened to the public. Unfortunately it was frequented only for a short periode of time. The almost completely forgotten cavern was investigated and described by Kadić in 1912 /Kadić

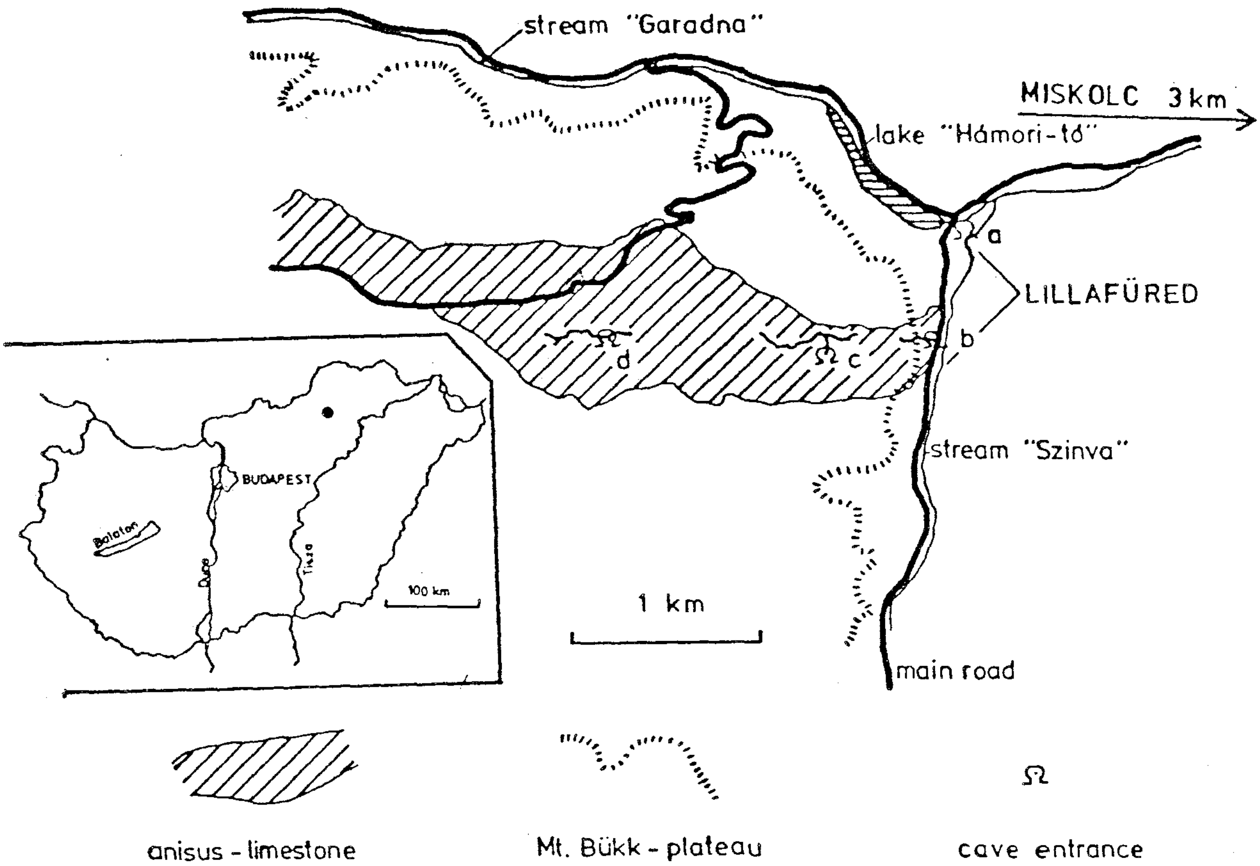

Fig. 1. The vicinity of Lillafüred and the eastern part of the plateau of Mt. Bükk /after Juhász 1977/.
/cave entrances: a/ "Anna-barlang", b/ "István-barlang", c/ "István-lápai-barlang", d/ "Létrás-tetői-barlang"/

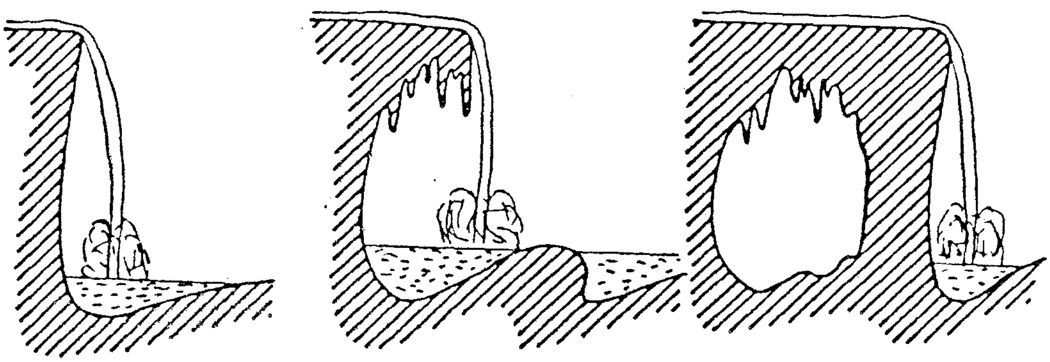

Fig. 2. Syngenetic cave formation in travertine

1921/. In 1928, when Lillafüred was built up, the caverns were excavated, new galleries were driven and new cavities were explored. Later an electric lighting system was installed and th the cave was opened to the public. The actual length of the touristic part of the cave is cca. 200 m /Lénárt 1982/.

The cave "István-barlang"

In the Mt. Bükk a relatively narrow strip of middle triassic /anisusian/ limestone extends from the elevation called "Létrás-tető" as far as the valley of the stream "Szinva" /Fig. 1./. The cave, being a member /the spring-cave/ of the cave-system developed in this limestone-belt, was formed by the erosion of an underground stream. At present it has no permanent stream, only a deep siphon with variable level of stagnant water. Floods are rare, recently in 1958 and in 1974 was such high water that the cave was inundated and the water flew out of the entrance. The cave was discovered in 1913 through its natural vertical entrance and it became known in its present length in 1928. Then a horizontal gallery was driven from the road of the valley "Szinva", the caves was fitted up for the touristic purpuses and an electric lighting system was installed. It was opened to the public in 1931. The actual length of the illuminated part of the cave is cca. 250 m /Fig. 3./.

Both caves were opened until 1944. After the 2nd World War the damages were repaired only in 1953. That year the caves were opened only temporarily, then an overall renovation took place and in 1955 they were opened again finally. The route, i.e. the illuminated area became shorter in both caves after this renovation. Since that time the lighting system was renovated in the early seventies.

1.2. History of the flora in lamp-areas

In 1962 green plants were collected in both caves first. At that time no ferns were living in the caves, not even a prothallium was found. The first collector, S. Borbély sent moss-samples to Á. Boros, the well-known hungarian bryologist. As

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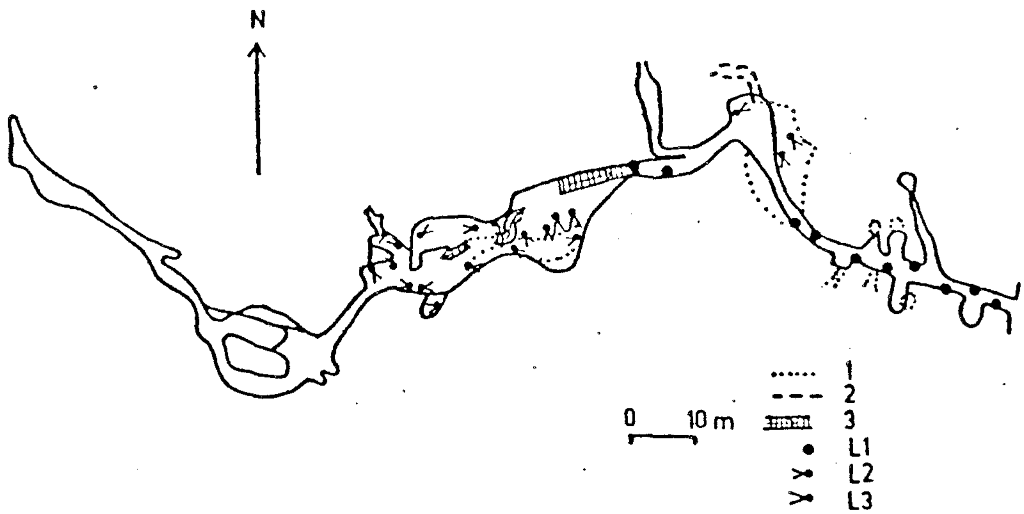

Fig. 3. The map of the cave "István-barlang" /after Lénárt 1984/. /1 - upper level, 2 - lower level, 3 - steps with the direction of the slope;

Lamps: L1 - low power incandescent lamp in lamp brackets similar to those in "Anna-barlang", L2 - reflectors with high power incandescent lamps, L3 - reflectors with iodine-lamps/

Borbély wrote in his letter "the mosses sent are proliferating in the caves ... it can be laid down as a fact that even before the 2nd World War there were mosses around the lamps" /Borbély in lit. ad Boros, 10.02.1962. in hungarian/. Two months after Cs. Dékány gathered mosses in both caves and sent the samples to Boros as well. He identified 6 moss species from the two caves altogether /Boros 1964/. Two years later K. Verseghy collected mosses in the caves. Her material was identified by L. Vajda and contained 14 species altogether /Verseghy 1965/. Verseghy mentioned that unicellular blue-green and green algae were found living around the lamps as well. No fern was found in the caves, but the material contained fern prothallia from the cave "István-barlang". Later on L. Vajda collected mosses in the cave "Anna-barlang" in 1969 and then L. Lénárt in both caves in 1982. This latest gathering contained 4 fern species in the cave "István-barlang".

The management of the caves tried to fight against the process. In the cave "István-barlang" there were two occasions when all the green covers /except those from the ceiling/ were removed by means of brushing and water. First time they used tap water /in 1977/ but second time /in 1980/ the water of the stream "Szinva" was pumped into the cave /L. Lénárt, pers. com./.

1.3. Ecological factors

"Anna-barlang"

It is an important fact that the ecological diversity of the lamp-areas is very low in this cave. The climate is very constant as it usually in caves, seeping waters are rare, the rock is almost homogenous. Dripstone decorations are rare, but there are several spots of clay. More than 80 % of the illuminated surfaces are air-dry calc-tuff formations. The air humidity /97-100 %/ serves as the only water supply for the plants. The draught of air is very slow.

"István-barlang"

The diversity of the ecological factors in this cave is much higher than that in the other cave. The climate of the outer halls is not very constant, because they are not so far from the entrance. Seeping and dropping waters are frequent, the illuminated surfaces might be limestone, dripstone, travertine and clay as well. There are two entrances, the draught can be relatively fast sometimes. On rare occasions the lower parts of the cave are inundated with water. The climate of both caves was studied by Szabó /1963/.

2. METHODS

Green plants were collected from both caves in April, 1984. We took samples at very lamp from each green cover. Algological samples were taken under sterile conditions by scraping the plants into tubes filled with inorganic fluid medium. The samples were then cultivated in the laboratory and two months later the species were identified under microscope. Moss samples were gathered from the spots which seemed to be different by the thorough examination and they were identified in the laboratory. Ferns and fern prothallia were registered in the note book.

As far as we know this is the first study when such a complete sampling took place in order to make clear the distribution patterns inside the cave. The qualitative data taken this way were analysed by means of cluster analysis. Further details regarding the methods are given in P.-Komáromy et al. /1985/.

Pressed for space only the flora of the cave "Anna-barlang" will be discussed here in detail. However, some fragments from the data concerning the other cave will be discussed as well.

3. THE RECENT FLORA IN LAMP-AREAS OF THE CAVE "ANNA-BARLANG"

3.1. The lighting system

The cave is illuminated by incandescent lamps. The power of the lamps was originalley 100 W, but few years ago they were replaced by 60 W lamps. Recently a further reducation of light was carried out: from the beginning of 1984 there are 40 W lamps lighting in the cave. The too large candle-power lamps were very favourable for the plants. Moreover the lamp brackets were favourable as well, because the surface next to the lamp is lighted with the possible highest candle-power /Fig. 4./. The morphology of the cave, i.e. the narrow, low galleries has the same effect. The lamps are mounted on the ceiling or on the walls 2-3 m high above the ground.

3.2. Results

Recently the cave is in a catastrophic state. There are extended green coatings around each lamp. Though the number of algal species is greater than that of the mosses, the quantity of the mosses is far larger. The composition of the

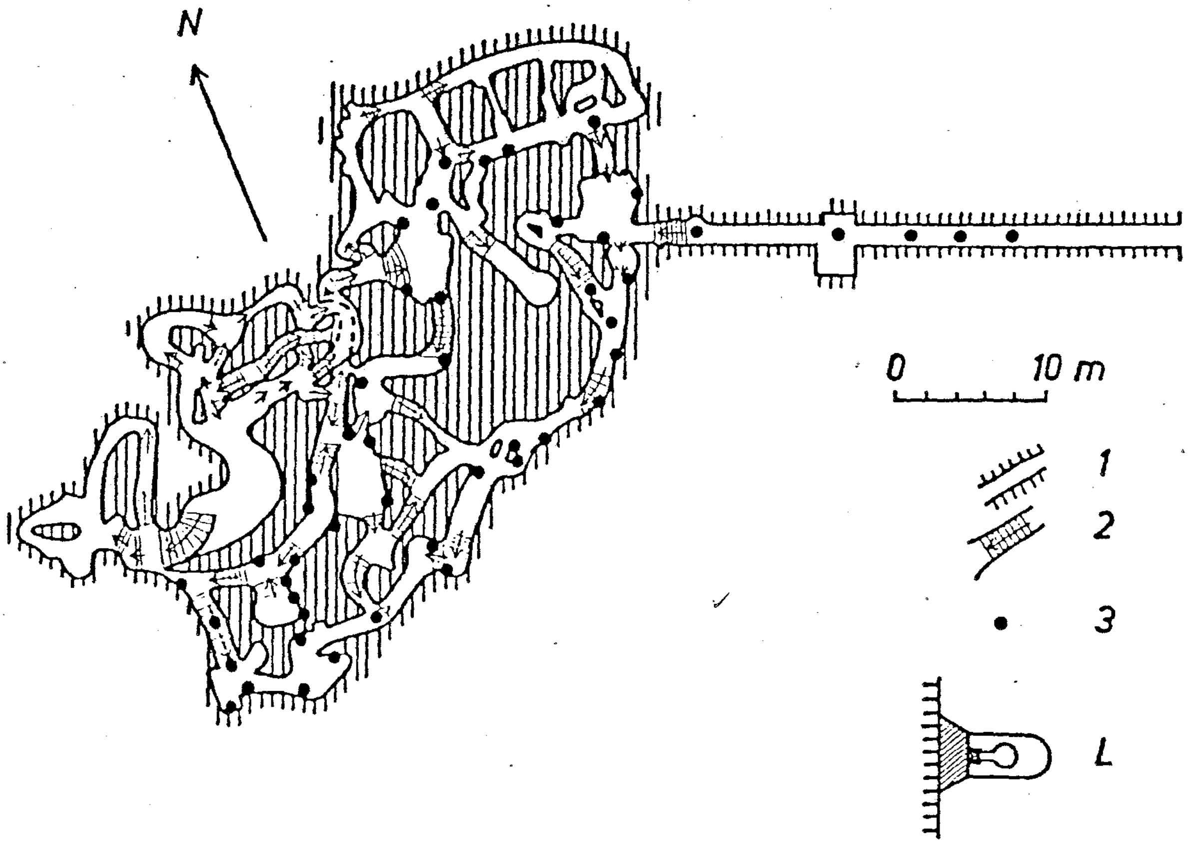

Fig. 4. The map of the cave "Anna-barlang" /after Lénárt 1982/. /1 - the outline of the cave at ground level 2 - steps with the direction of the slope, 3 - lamp L - the lamp bracket/

flora and the frequency relations are given in Tab. 1. The distribution patterns of the species do not form any group. No topographical or ecological factor seems to exist forming such groups /as e.g. "the species being frequent near the entrance", or "the species being frequent in the places where seeping waters occur", e.t.c./. The result of the cluster analysis /Fig. 5./ shows that the very similar sampling sites /lamp-areas/, i.e. the members of a cluster are sometimes near to each other, sometimes far away; dry and wet sampling sites might be united in one cluster /P.-Komáromy et al. 1985./.

Tab. 1.

The composition of the flora in lamp-areas of the cave "Anna-barlang" and the frequency relations

	Frequency /No. of samples/	Species number
Algae /42 species/	common /29-34/	2
	very frequent /19-21/	2
	frequent /8-12/	6
	rare /3-6/	10
	very rare /1-2/	22
Mosses /10 species/	common /31/	1
	frequent /7-8/	2
	rare /3/	1
	very rare /1/	6
Ferns /1? species/		
sporophyte	very rare /1/	1
prothallium	rare /6/	?

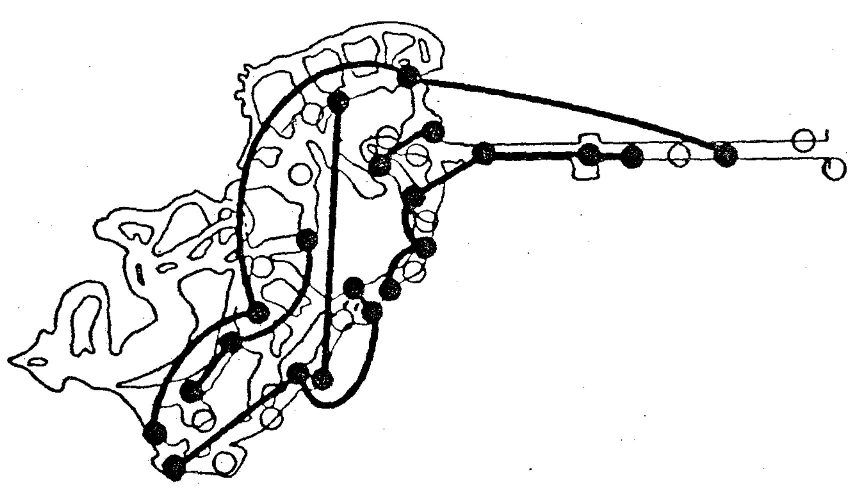

Fig. 5. The clusters of the sampling sites in the cave "Anna-barlang" formed at the similarity level 0.5 /after P.-Komáromy et al. 1985./.

3.3. Discussion

The green coatings in the cave developed first before the 2nd World War. Though we know this, we have no information on the extension of these living covers. We think they were not too wide-spread as there is no trace of it in any publication of this cave. During the 8 years long dark period a destruction took place most probably and the remains of the covers were more or less decomposed. A few years after the installation of the renovated lighting system there were extended green coatings in 5 places, but the majority of the lamp-areas were not green yet. In the beginning of the 80's a rapid expansion of the green plants took place resulting an almost continuous green carpet on the walls. This process is closely interlinked with the prosperity of the cave-tourism in this cave from 1977 on /Lénárt 1982/ without question.

The development of these green covers is depended essentially on the light /intensity and the time of illumination/. Undoubtedly the water relations are also very important, but in the case of this cave they have almost no effect. The next effect on the developing of this flora must be the infection probability, because the cave is allways much more poor in propagating cells than its surroundings.
What are the effects introducing propagating cells into the caves?

A/ the stream swallowed by the sinkholes;
B/ seeping or dropping waters having penetrated the rock above the cave;
C/ the draught directing into the cave;
D/ the animals living in the cave or visiting the cave;
E/ the people visiting the cave /paying tourists, cavers, scientists, workers/;

The A/ effect must be neglected in this case as the cave has no stream. The B/ effect should result a distribution in the cave characterized by the high species diversity near the wet places and a decreasing diversity in the more distant places. The C/ effect should result a distribution characterized by the high species diversity near the entrance and a low diversity in the innermost parts of the cave. Our results do not prove neither B/ nor C/ effect. D/ and E/ effects results a scattered distribution in the cave. Where should be the highest diversity if the man is the introducing effect? Essentially the probability of the infection is equal, but a slightly higher probability was to be found in the tight places /the visitors must tuch the walls/, in the places where the sights are numerous and in the places where people work. Our results proved that in this cave the main introducing and distributing factor was the man.

A similar conclusion was got in an experiment carried out in the cave "Pál-völgyi-barlang" /Padisák et al. 1985/.

4. SOME DATA FROM THE CAVE "ISTVÁN-BARLANG"

The present situation is more catastrophic in this cave as in the previous one. The green carpets are more extended, the species number and diversity are higher. A lot of space should be needed to discuss it in details, therefore we show only one interesting phenomenon.

In the greatest hall of the cave there is a large travertine formation, a giant "frozen waterfall" /cca 30 m high and 30 m wide/. Recently more than 80 % of its surface is green. The species composition of this carpet /apart from the lowermost part of it/ is very sparse: a few alga species in small quantity and only one moss species in huge numbers! This homogenous carpet was resulted by the removal of the original separated small green spots. The plants were removed from the surface by means of brushes, then the water pumped on to the surface spread the propagating cells on the whole surface. Another effect of this water /stream water from outside/ was to spread a typical plantonic alga species over the surface living in this cover.

5. SUMMARY

Analysing the flora of the lamp-areas in the Lillafüred caves it revealed that the introducing effects /and mainly the people visiting the caves/ are the most important in the velocity of the development of the green covers around the electric lights, when the light and water conditions are given. Alteration of the water relations /e.g. to make the surface dry in any way/ is not useful in general /dripstone formation stops, dry stalactites are less decorative, etc./. This way the reduction of light, then the reduction of the introducing probability are the main stages in the fight against the "green invasion" in the illuminated caves. This invasion needs much more time to form in a cave where the illuminated surfaces are far from the visitors.

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A LILLAFÜREDI BARLANGOK LÁMPAFLÓRÁJA
/Összefoglalás/

A Miskolc városhoz /ÉK-Magyarország/ tartozó Lillafüreden két idegenforgalmi célokra kiépitett barlang található /Anna- és István-barlang/. Mindkét barlangot már a II. Világháború előtt ellátták villanyvilágitással és a lámpák fénykörében már akkor megjelentek a zöld növények. Az ötvenes években újra megnyiló barlangokban 1962-től kezdve gyüjtöttek mohákat a lámpaflórából. A növényesedés a hetvenes évek végétől vált katasztrófális méretüvé. Jelenleg a két barlangban minden lámpa rendelkezik kisebb-nagyobb kiterjedésü lámpaflórával.

Mindkét barlangban igyekeztünk teljesen begyüjteni a barlangi lámpaflórát: minden lámpánál végeztünk gyüjtést, figyelmünk az ott megtalálható valamennyi zöld növényre kiterjedt. Helyszüke miatt részletesen csak az Anna-barlanggal foglalkozunk itt. Választásunk két okból esett erre a barlangra: ez a barlang kisebb, lámpaflórája szegényesebb, ezért részletesebben tárgyalható; ez a barlang a környezeti tényezők szempontjából nagyon homogén, ezért az általános törvényszerüségek tanulmányozása egyszerűbb.

Az Anna-barlangban 42 alga taxont, 10 mohafajt és 1 páfrányfajt sikerült kimutatnunk. Ezenkivül több lámpa körül élnek páfrány-előtelepek, melyek faji hovatartozása nem dönthető el. Az egyes fajok barlangon belüli elterjedését és az egyes lámpák flórájának összetételét vizsgálva arra a következtetésre jutottunk, hogy ebben a barlangban a zöld növények szaporítósejtjeinek behurcolója és elterjesztője az ember. Megfelelő intézkedéssel ez a fertőzési veszély csökkenthető lenne, igy a lámpaflóra megjelenése és elterjedése a barlangban sokkal több időt venne igénybe.

Az emberi hatás fontosságára utal az István-barlangban végzett felelőtlen lámpaflóra-irtások növénytanilag kimutatható eredménye: a lesikálás utáni lemosással sikerült az Óriás-vizesés /egy hatalmas cseppkőlefolyás/ teljes felületét egyenletesen befertőzni, igy a felületet jelenleg egy mohafaj tömegvegetációja boritja.

Ábra- és táblázatszövegek.

1. ábra. Lillafüred környéke és a Bükk-fennsik keleti része /Juhász 1977. nyomán/.
/barlangbejáratok:

2. ábra. Szingenetikus barlangkeletkezés mészfutában

3. ábra. Az István-barlang térképe /Lénárt 1984. nyomán/
/1 - felső szint, 2 - alsó szint, 3 - lépcsők a lejtés irányával;
Lámpák: L1 - járatlámpa, L2 - reflektor izzólámpával, L3 - reflektor halogénlámpával/

4. ábra. Az Anna-barlang térképe /Lénárt 1982. nyomán/
/1 - a barlang körvonala talajszinten, 2 - lépcsők a lejtés irányával, 3 - lámpa, L - lámpatest/

5. ábra. Az Anna-barlang gyüjtőhelyeinek csoportosulása 0,5-es hasonlósági szinten

1. táblázat

A lámpaflóra összetétele és a gyakorisági viszonyok az Anna-barlangban

	Gyakoriság /minták száma/	Fajszám
Algák /42 faj/	közönséges	
	nagyon gyakori	
	gyakori	
	ritka	
	igen ritka	
Mohák /10 faj/	közönséges	
	gyakori	
	ritka	
	igen ritka	
Harasztok /1? faj/		
sporofiton	igen ritka	
előtelep	ritka	

DIE LAMPENFLORA DER HÖHLEN VON LILLAFÜRED

/Zusammenfassung/

In zu der Stadt Miskolc /Nordostungarn/ gehörenden Lillafüred sind zwei Schauhöhlen zu finden /Anna-barlang und István-barlang/. Beide Höhlen wurden schon vor dem zweiten Weltkrieg mit elektrischer Beleuchtung versehen und schon damals erschien ein grüner Pflanzenwuchs im Lichtkreis der Lampen. Diese Höhlen wurden in der fünfziger Jahren wieder beleuchtet und seit 1962 sammelte man Moose aus der Lampenflora. Diese Flora hat seit Ende der siebziger Jahre eine katastrophale Verbreitung erreicht. Heute haben alle Lampen in den beiden Höhlen eine kleinere oder grössere Lampenflora.

Wir versuchten die Lampenflora in den beiden Höhlen vollkommen einzusammeln: wir sammelten bei jeder Lampe und nahmen auf die sämtlichen dort befindlichen grünen Pflanzen Bedacht.

Wegen Raummangel können wir uns hier nur mit der Anna-barlang eingehend beschäftigen. Unsere Wahl fiel auf diese Höhle aus zwei Gründen: diese Höhle ist kleiner, ihre Lampenflora ist ärmer und deshalb detaillierter zu beschreiben; die Höhle ist vom Geschichtpunkt der Umgebungsfaktoren aus sehr homogen und deshalb ist das Studium der allgemeinen Gesetzmässigkeiten einfacher.

In der Anna-barlang konnten wir 42 Algentaxone, 10 Moosarten und eine Farnart nachweisen. Ausserdem leben in der Umgebung mehrerer Lampen Farnprothallien, deren Arten wir nicht bestimmen konnten. Nach der Untersuchung der Verbreitung der einzelnen Arten innerhalb der Höhle und der Untersuchung der Zusammensetzung der Flora der einzelnen Lampen kamen wir zu der Folgerung, dass die Fortpflanzungszellen der grünen Pflanzen durch die Menschen in die Höhlen eingeschleppt und verbreitet werden. Diese Austeckungsgefahr wäre durch entsprechenden Massnahmen zu vermindern, so würde das Erscheinen und die Verbreitung der Lampenflora in der Höhle viel länger dauern.

Auf die Bedeutung des menschlichen Einflusses deutet das botanisch nachweisbare Ergebnis der unverantwortlichen Vernichtung der Lampenflora in der István-barlang: mit der Abscheuerung und Abwaschung des "Riesenwasserfalles" /eine mächtige Sinterwand/ wurde die ganze Oberfläche gleichmässig infiziert und so ist die Sinterwand jetzt mit der Massenvegetation einer Moosart bedeckt.