The Present Situation of Speleology in Japan[1),2)]

Masuzo UÉNO[3)]

(With One Plate and Ten Text-figures)

1. A Brief History

Thirty-eight years ago, when I was a post-graduate in zoology at Kyôto Imperial University, I was working on freshwater biology, and in particular on the taxonomy and ecology of Cladocera and other freshwater Crustacea. Naturally, I came to be interested in subterranean species and this led me to go to caves to collect them. I began with an exploration of the aquatic fauna of Akiyoshi-dô (or the Akiyoshi Cave) in 1927, and was successful in collecting three species of Crustacea, one of which was registered as a new species of the isopod genus *Caecidotea* (it belongs to the genus *Asellus* at present). It was probably the first scientific survey of cave aquatic fauna in Japan, though two years before F. SILVESTRI investigated the terrestrial fauna

1) This is an enlarged and revised form of my lecture originally delivered before the meeting of the National Speleological Society, under the presidency of Mr. Russell H. GURNEE, which was held on September 4, 1962, at Closter, New Jersey (U. S. A.). Paragraph 4 and a bibliography at the end of this article have been newly prepared.

2) For the preparation of the present manuscript, I am much indebted to Dr. Shun-Ichi UÉNO, Department of Zoology, National Science Museum, Tôkyô, for his effective assistance in furnishing me with much useful material. My cordial thanks are also due to Mr. Tadashi KURAMOTO, of the Akiyoshi-dai Science Museum (Mr. Isao KAWASAKI, Director), who was kind enough to afford me every facility, when I visited Akiyoshi-dô in January 1965, and to Yoshiyasu KANETSUNA who kindly supplied me with his unpublished data on diatoms of Akiyoshi-dô. I am also grateful to Mr. Hirosi YAMAUTI for providing me with the figure of Ryûô-dô.

3) Kônan Women's College; formerly Kyôto University.

of the same cave. For my cave studies, I gained a great deal of information from A. S. PACKARD's *The Cave Fauna of North America* (published in 1888). At that time no other scientific cave investigations had been made in Japan; only a few well-known caves, such as Akiyoshi-dô, were visited by tourists with curiosity. In 1935, when my text-book on freshwater biology was published in the Japanese language, I reviewed the progress of researches on subterranean fauna, in referring to the work on animal life of subterranean waters by Hermann SPANDL and Pierre A. CHAPPUIS (both books similarly entitled *Die Tierwelt der unterirdischen Gewässer*), as well as to René JEANNEL's *Faune cavernicole de la France*. After that time, however, no speleological activities had become flourishing in Japan. My interest in research work then turned to limnological investigations of lakes, including both plankton and benthic animals, as well as physical and chemical properties of lake waters.

After the War, our knowledge of the fauna of Japanese caves increased rapidly, thanks largely to the works by J. ISHIKAWA, H. TORII, R. YOSII, Shun-Ichi UÉNO and some others, particularly to considerable research by Professor YOSII and the last-named. Besides these biospeological studies, we owe much to the fundamental work by Mr. Hirosi YAMAUTI, Assiatant Professor at Ehime University, Matsuyama in Shikoku. Having overcome many initial difficulties in exploration, he has brought a great many caves to light and has prepared a large number of maps of these caves. A number of Japanese biologists and other scientists who were interested in speleological work, ardently wished to organize a society for the purpose of promoting research activities on caves and subterranean waters. Then, in 1954, the Spelaeological Society of Japan was founded and I was appointed its president. At present, there are in Japan four speleological organizations, of which two are nation-wide in their scale and the other two local. One of the former is the just-mentioned Society,

though it is yet a small group. Another was organized in 1961 for the purpose of cave explorations, called the Japanese Association for Caving, under the leadership of Mr. YAMAUTI. These two organizations have made several co-operative attempt to investigate Japanese caves and have made many contributions to the knowledge of Japanese speleology.

In October 1959, when the Akiyoshi-dai Science Museum was founded by the town of Shûhô-chô, Japan had a speleological museum for the first time. It is located on the Akiyoshi-dai, the karst topography of which is the most beautiful limestone landscape in Japan and from which we can go down by lift into Akiyoshi-dô. Since then the Museum has contributed much to the advancement of speleological knowledge of the Akiyoshi area. In 1961, the Museum established an underground laboratory for the purpose of making physiological and ecological observations and experiments on cave animals *in situ*. The laboratory is set up in a small cave called Kômori-ana,[4] about 200 meters long, near the entrance to Akiyoshi-dô. It consists of three rooms equipped with water supply and electric lights.

Investigations of animal and neolithic human remains have made a good start in some caves just in recent years.

2. The Number, Dimension and the Distribution of Japanese Caves

There are known to be in Japan some 700 caves, more than 500 of which have been scientifically investigated. The majority of them are small or very small and only a few of them are of moderate size. There are no huge caves like the Mammoth Cave in Kentucky. About 500 are limestone caves and pot-holes, 20 lava caves located around volcanoes, and another 20 are developed in the rock formations other than limestone, such as a few small caves formed in the fissures of sedimentary rock at the foot of Mt. Arafuné, Nagano prefecture. Maps are prepared for about 70 limestone caves.

4) ana means cave alike dô.

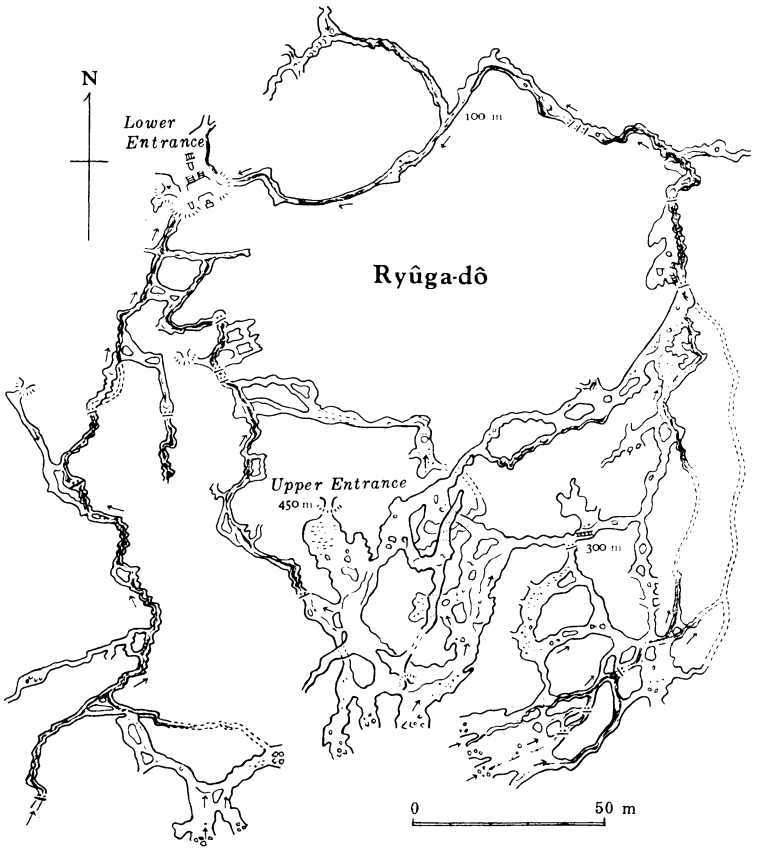

Fig. 1. Plan of Ryûga-dô, northeast of the city of Kôchi in Shikoku.
(Adapted from a map prepared by Mr. H. YAMAUTI)

The largest limestone cave in Japan is Akka-dô in the northern part of the Kitakami mountain range in the Tôhoku district, measuring a little more than 8 kilometers in total length. Following Akka-dô in dimension, both Akiyoshi-dô in the Akiyoshi area in the western part of Honshû and Ryûga-dô near the Pacific coast of Shikoku attain a total length of about 2 kilometers respectively. Akiyoshi-dô opens at the southern edge of the Akiyoshi-dai, which is a conspicuous karst pene-

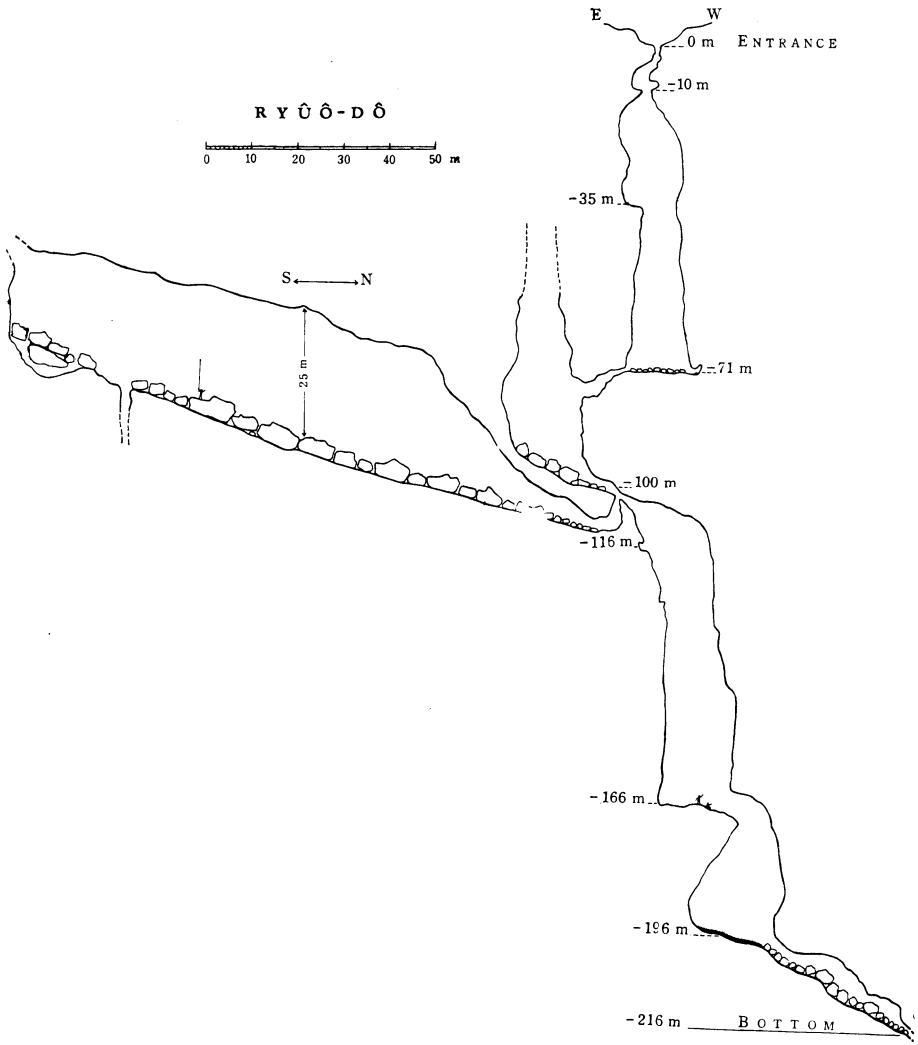

Fig. 2. Vertical section of Ryûô-dô in Shikoku. (Courtesy of Mr. H. YAMAUTI; the figure has been prepared by Mr. T. OKAMOTO in 1964)

plane of 130 km^2 in area and 200–400 meters above sea level. This plateau has numerous (circa 10,000) swallow-holes (Doline) on its surface, and has some 130 caves and pot-holes, as well as complicated systems of underground streams. The hitherto known deepest pot-hole was Ryûgo-no-Coiffait-ana located on the Akiyoshi-dai. It is a shaft of 95 meters in its vertical depth. It was named in honour of a Frenchman Dr. H. COIFFAIT, who had been a visiting speleologist in Japan in 1957 and co-operated with us in exploring caves in western Honshû and in Shikoku. In the early summer of 1964, however, YAMAUTI's students explored a pot-hole called Ryûô-dô, which exceeds considerably the above-mentioned one in depth. They were successful in going down 216 meters to the bottom of that shaft from the upper entrance. It is located at Ôno-ga-hara in the northwestern boundaries of Kôchi and Ehime prefectures in Shikoku.

Limestone caves are scarce in Hokkaidô and in the districts along the coast of the Sea of Japan, while they are numerous in the districts along the Pacific and in the southwestern parts of Japan. A great number of caves are distributed in Shikoku south of its central mountain range, as well as in the Akiyoshi limestone area. In the former district, there are known to be more than 70 caves, of which 60 were investigated. Among them, Ryûga-dô near the city of Kôchi is the most conspicuous in its complexity of passages with a great many cascades and pot-holes in the underground streams, and also in the richness of its fauna. I have already mentioned the Akiyoshi area. Lava caves are well developed at the foot of Mt. Fuji (the Fuji volcano), and are also found in western Honshû and western Kyûshû.

Some 40 caves are commercialized for tourists. Stalactites and stalagmites attractive to visitors are particularly beautiful in Akka-dô in the Tôhôku district as well as in Fûren-dô near Usuki in Kyûshû. Rimstone pools are wonderfully developed in Akiyoshi-dô.

3. The Fauna of Caves and Subterranean Waters

It is worth mentioning that Japanese caves are mostly small in scale; nevertheless they have a rich and noticeable fauna. It is characterized by the predominance of animals of primitive types as well as by the endemicity of true cave-dwellers (troglobionts[5]). Actually all the troglobiontic species of animals hitherto found in Japanese caves are endemic to the Islands, and at the same time the majority of them have been regarded as representing old phylogenetic lines of respective groups. It is impossible to draw a sharp line between true aquatic cave animals and true dwellers of subterranean waters in the planes where there are no caves. This difficulty is an obstacle to the zoogeographic presentation of the cave aquatic fauna as opposed to cave terrestrial fauna.

It is a noticeable fact that vertebrate cave dwellers are quite absent in Japanese caves, with an exception of a marine gobioid fish *Luciogobius albus* REGAN. This white fish smaller than 100 mm. in body length with degenerated eyes has been found in a cave and a few wells near the sea coast in western Japan. Arthropods are the most important components of the Japanese cave fauna, as in European and American

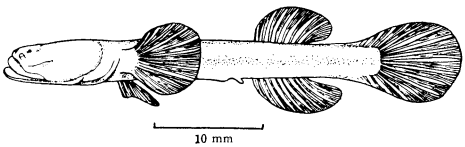

Fig. 3. *Luciogobius albus* REGAN, found in a cave on the tiny island, Daikonjima, in Shimane prefecture. (After TOMIYAMA, 1936)

5) Some American speleozoologists have used a term *troglobite* for a true cave-dweller, but I am employing here the term *troglobiont* (suffix biont denoting a living being) for it, in line with German research workers. In an English summary of his recent article "Naissance de la biospéologie" (*Internat. J. Speleol., 1* (1964), 153-161), C. MOTAS has applied troglobites to a French term troglobies (SCHINER, RACOVITZA). In his *Tiergeographie auf ökologischer Grundlage* (1924), Richard HESSE, however, classified cave animals in using the terms eucavale (*Troglobien*), tychocavale (Troglophilen) and xenocavale (Trogloxenen). See also paragraph 4.

caves. Some groups of animals belonging to this phylum have been studied fairly well. They are: trechine beetles, springtails, pseudoscorpions, water-mites, millipedes, gammarids, cyclopoid and harpacticoid copepods, bathynellids and others. Ostracods and spiders have not been sufficiently studied. Earthworms and flatworms have received little attention. Archiannelids are found in a few caves, but their descriptions are not yet published.

YOSII's laborious studies of springtails (Collembola) for many years showed that there occurred in Japanese caves more than 100 species of this group, among which he determined a large number of troglobionts. Some of them, such as the genus *Sinella*, are of especial zoogeographic interest. In this genus are known eleven species, six belonging to the subgenus *Sinella* and the remaining five to the subgenus *Coecobrya*. YOSII has pointed out that the American troglobiontic species of this genus have developed from *S.* (s. str.) *curviseta* BROOK, while the Japanese representatives have been derived from *S.* (s. str.) *höfti* SCHAEFFER. Taxonomy and zoogeography of cave-dwelling trechine beetles (Harpalidae) have been S. UÉNO's chief work, on which he spent so much time since 1951 in exploring caves throughout the four main islands of Japan, as far as the Ryûkyû Islands and Taiwan. He described more than 60 species of troglobiontic trechids found in Japanese caves. His results enabled him to draw the conclusion that the speciation of that group of beetles in respective caves is remarkable. This is best illustrated by his results obtained in Shikoku. Of the 94 caves and pot-holes explored by himself, 25 have 20 troglobiontic species belonging to four different genera. The genera (and subgenera) change successively with the geographic distribution of caves from west to east in the following way: *Rakantrechus* (*Yamautidius*), *Rakantrechus* (s. str.), *Ishikawatrechus* (s. str.), *Ishikawatrechus* (*Nipponotrechus*), *Ryugadous* (*Yuadorgus*), *Ryugadous* (s. str.) and *Awatrechus*.

Besides these, a troglophilous species of *Trechiama* occurs as a relict in a cave at a high altitude in eastern Shikoku. Troglobionts are

extremely scarce in aquatic beetles on the earth. In southwestern Japan, however, there occur six species of blind dytiscids and phreatodytids, the latter of which is particularly interesting as they represent an ancient stock of adephagous beetles and fill a gap between terrestrial and aquatic forms.

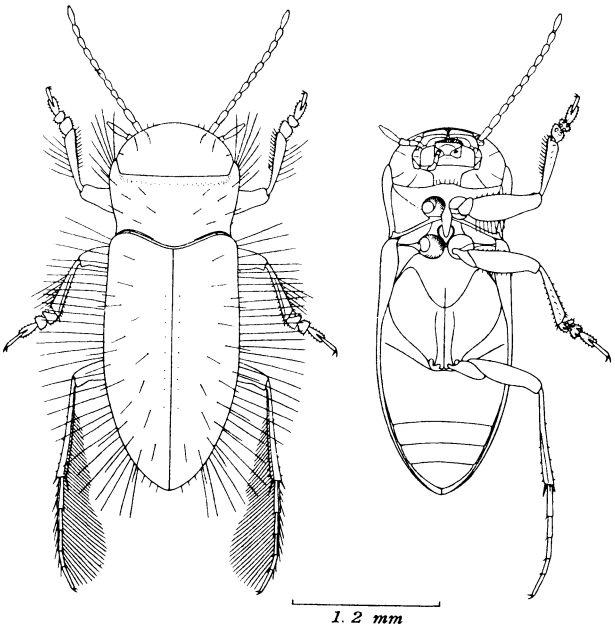

Fig. 4. *Morimotoa phreatica* S. UÉNO, ♂, a blind aquatic beetle taken in the subterranean water at Himeji. (After Shun-Ichi UÉNO, 1957)

YAGINUMA has described more than twenty species of cavernicolous spiders. The majority of them are those found everywhere outside caves; at least four or five troglobiontic species are known, such as *Leptoneta akiyoshiensis* OI, *Nesticus akiyoshiensis* (UYEMURA), *Cybaeus okafujii* YAGINUMA and *C. kuramotoi* YAGINUMA. Water-mites (Hydracarina) were studied by IMAMURA in recent years. He described a

great many new species found in subterranean waters and in caves. Among the cave water-mites, *Mideopsis ryugaensis* IMAMURA is found only in Ryûga-dô and the other three species are endemic to Akiyoshi-dô. I shall mention them in paragraph 4.

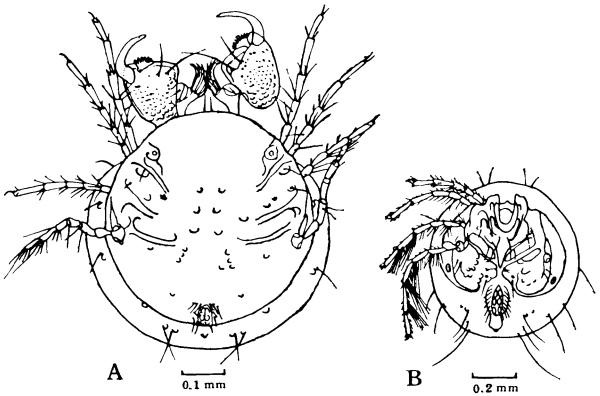

Fig. 5. Two troglobiontic water-mites. A—*Uchidastygacarus palmifer* IMAMURA, ♂, ventral view. B—*Mideopsis ryugaensis* IMAMURA, ♂, ventral view. (After IMAMURA, 1957, 1959)

It was an exciting happening when a minute Crustacea of a primitive type was found by Y. MORIMOTO and Y. MIURA in the subterranean water in the city of Himeji. None of this group, Syncarida-Bathynellacea, had ever been known in the regions outside Europe with the exception of the Malay peninsula. I and MORIMOTO have been successful in describing fifteen Japanese species belonging to three genera, *Bathynella*, *Parabathynella* and a new genus *Allobathynella* established by MORIMOTO and MIURA. All the species are troglobionts, some of which have peculiar features, such as keels in *Parabathynella carinata* M. UÉNO and the large size exceeding 2 mm. in *P. gigantea* MORIMOTO. Later I discussed the phylogenetic relation between the four genera known in the world, including *Thermobathynella* which is not distributed in Japan.

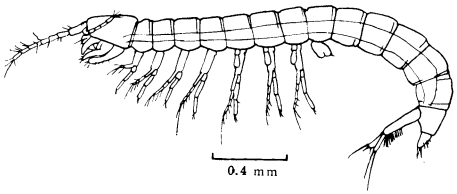

Fig. 6. *Parabathynella gigantea* MORIMOTO, ♂, lateral view; taken in a driven well at the town of Dainan-chô south of the city of Ôita in Kyûshû. (After MORIMOTO, 1963)

ITÔ has recorded more than twenty subterranean species of the cyclopoid Copepoda, most of which are those found in surface waters. Among them, *Speocyclops yezoensis* ITÔ is a most noticeable species. Harpacticoid Copepoda are MIURA's chief work, in which he has described more than ten subterranean species. In his recent monograph on aquatic Isopoda, MATSUMOTO gives a number of subterranean species.

More than ten species of troglobiontic molluscs have been described. Both species of the Hydrobiidae, *Akiyoshia uenoi* KURODA & HABE as well as *Bythinella* (*Moria*) *akiyoshiensis* KURODA & HABE dwell in slowly flowing underground streams. The other troglobiontic snail *Cavernacmella kuzuuensis* (SUZUKI) is semi-aquatic. Cavernicolous flatworms (Turbellaria) are little known. Two trogloxenous triclads, *Dugesia japonica* ICHIKAWA & KAWAKATSU (it has long been identified with *D. gonocephala*) and *Phagocata vivida* (IJIMA & KABURAKI) are recorded.

ARNDT[6] obtained accurate statistics of the species of living animals found in caves and subterranean waters in Germany; but his method of computation cannot be used in Japan at present. However, the numbers of Japanese cave animals will further increase considerably. Our knowledge is still inadequate for certain zoogeographic

6) ARNDT, Walther. Die Anzahl der bisher in Deutschland (Altreich) in Höhlen und im Grundwasser lebend angetroffenen Tierarten. *Mitt. Höhlen- und Karstforschung*, 1940, 58-65.

problems relating to cave animals. For instance, HOLDHAUS[7] has pointed out that in Europe the northern limit of the distribution range of true cave animals other than beetles agrees to that of blind true cave beetles. It is not certain whether such a phenomenon will be seen in Japan too. It will further be noted that there seem to exist certain relationships between the Japanese and North American cave faunas. The faunal connection is particularly interesting in that the mode of dispersal is markedly different according to animal groups. Certain groups occur only in the southeastern part of the United States and in the Japanese Islands, while the others are spread over the northwestern areas of North America and the northeastern corner of the Far East, including Japan. The former pattern is well represented by trechine beetles of the *Trechoblemus* complex, and the latter by notopterans (Grylloblattoidea) of the archaic orthopteran group. Such relations are exhibited also by the springtail group *Sinella* (the *Sinella-Coecobrya* complex), chthoniid pseudoscorpions, and so on. This problem must be solved by the close co-operation of Japanese and American speleobiologists. I expect and hope for a close contact between them for the promotion of speleology.

4. Cave Animal Communities

No complete knowledge of animal communities has yet been obtained for Japanese caves. From cave surveys we still know little about how their cave animal communities are organized. The difficulties of such surveys lie chiefly in the actual labour involved in collecting in the dark, and determining the species of animals captured. The Spelaeological Society of Japan and the Japanese Association for Caving have made several co-operative surveys of a number of caves, among which Akiyoshi-dô and Ryûga-dô have become best known with regard to the animals living there. I shall therefore take the former cave which is

7) HOLDHAUS, K. Die europäische Höhlenfauna in ihren Beziehungen zur Eiszeit. *Zoogeographica* (Jena), *1* (1932), 1-53.

most familiar to me, as an example to give an outline of a cave animal community in Japan.

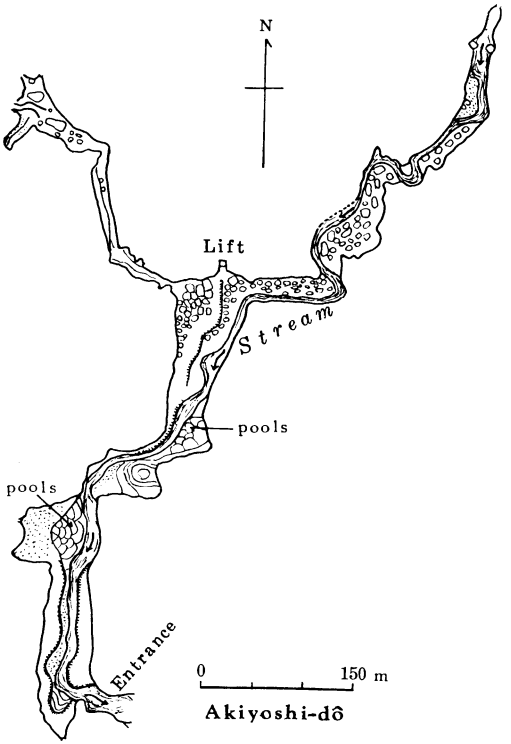

Fig. 7. Plan of Akiyoshi-dô. (Adapted from M. ÔTA, 1963)

The animal community in a cave differs greatly in its structure from any one of the epigeal communities. Every component of the former is either dwelling sporadically everywhere in an ecologically favorable situation or aggregated in particular places, viz. damp and still microhabitats. I refer here to all the animals in a heterogenous assemblage in the cave under consideration as the community. Besides true cave-dwellers, troglobionts (*vide ante*, footnote 5), which could not live outside a cave, there are usually recognized two more ecological

groups of cavernicoles, viz. troglophiles and trogloxenes. The determination of these two groups is not always easy. Both cave animal groups are as similar or the same as outside species. Troglophiles are, however, those whose populations have become capable of surviving their entire life cycle within the caves, while trogloxenes are found only frequently in caves. Beyond these we often meet with accidentals which happened to be in caves.

I shall begin with the abiotic environment of Akiyoshi-dô. The atmospheric temperatures in the depths of the cave are nearly constant throughout the year, ranging from 12°–16°C. in January to 17°–18°C. in the middle of July. The annual amplitude is about 4°C. The area at a certain distance from the entrance receives the influence of the atmosphere outside the cave in winter. Although it has become markedly dry in recent years, it is always still wet because of an underground stream running throughout the cave after emerging in the deepest part. The annual amplitude of relative humidity is extremely small (90–95%). The temperatures of underground waters do not exceed 18°C. in summer and are higher than 13°C. even in winter. The water of both stream and pools is weakly alkaline, their pH values showing 8.0–8.2. Owing to large calcium contents (52–70 ppm), the total hardness of water gives large values (140–190 ppm).

The terrestrial community of Akiyoshi-dô is composed of more than thirty-five species of animals, the majority of which are regarded as troglophiles or trogloxenes and have a lesser ecological significance. Insects and spiders are the richest in the number of species, consisting of at least ten of the former group and twelve of the latter. *Trechiama* (s. str.) *pluto* S. UÉNO is a representative troglobiontic beetle[8] and is the largest (7 mm. in body length) among the cave trechids. A camel cricket *Tachycines horazumi* FURUKAWA, which is a common troglobiont in the caves of southwestern Japan, is an important member, together

8) It was also obtained at the bottom of two pot-holes, Ryûgo-no-Coiffait-ana and Fûsen-ana on the Akiyoshi-dai; in the former it was found together with another troglobiont, *Rakantrechus* (*Uozumitrechus*) *etoi* S. UÉNO.

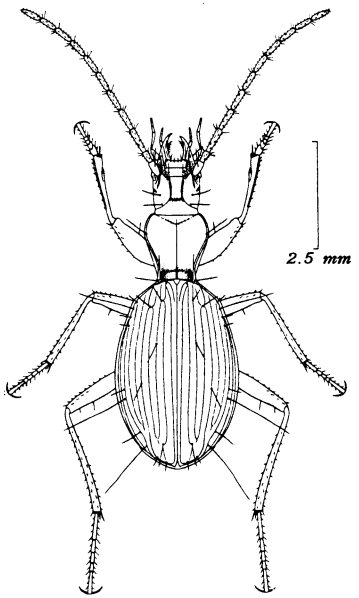

Fig. 8. *Trechiama* (s. str.) *pluto* S. UÉNO, ♂, taken in Nakao-dô in the Akiyoshi area.
(After Shun-Ichi UÉNO, 1958)

with two troglophiles *Diestrammena japonica* BLATCHLEY and *D. apicalis* BRUNNER, in the community because of the greater numbers of its individuals. Among the twelve species of spiders, six have become well adapted to cave life, but there are only two troglobionts, *Nesticus akiyoshiensis* (UYEMURA) and *Cybaeus okafujii* YAGINUMA; the remaining four are troglophiles. Millipedes (Chilopoda and Diplopoda), the former four and the latter six species, are also the important components of the community, though there are no troglobionts. Among the chilopods, three troglophiles *Epanerchodus etoi* MIYOSI, *Sklerobrotopus ikedai* TAKAKUWA and *Oxidus gracilis* (KOCH) are the common dwellers in this cave. A minute amphibious snail, *Cavernacmella kuzuuensis* (SUZUKI), which is 2 mm. high and belonging to the Assimineidae, is a representative troglobiontic gastropod found on the wet walls and rocks. Of more than five species of springtails, *Sinella* (*Coecobrya*) *akiyoshiana* YOSII is a typical troglobiont (*vide ante*, paragraph 3).

There are found in this cave five species of bats,[9] all of which belong to the insectivorous group of the Chiroptera. They are trogloxenes which return to the outside of the cave periodically for feeding on insects, and yet they are of ecological significance since their

9) *Minipterus schreibersi fluginosus* HODGSON, *Myotis merodactylus* TEMMINCK, *Myotis nattereri bombinus* THOMAS, *Rhinolephus cornutus cornutus* TEMMINCK and *R. ferrumequinum nippon* TEMMINCK.

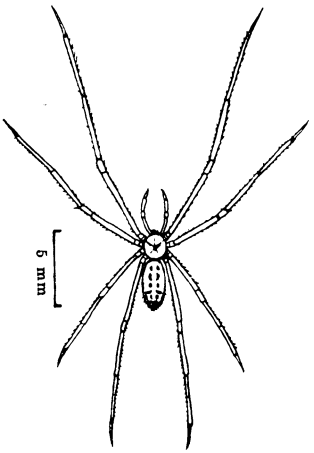

Fig. 9. *Nesticus akiyoshiensis* (UYEMURA), a troglobiontic spider found in Akiyoshi-dô. (After T. YAGINUMA, 1960; by permission of Hoikusha Publishing Co., Ltd., Ósaka)

faeces (guano)[10] form an important source of food for cave animals. There are small accumulations of bats' dung falling onto the floor beneath the resting or wintering site of the colonies, which have decreased rapidly in number in recent years. No adequate information has yet been obtained regarding the bats of Akiyoshi-dô——the size of their colonies, their seasonal abundance and habits, and what are the principal species forming heaps of excreta. I look forward to Mr. KURAMOTO's careful work now in progress dealing with these matters.

In recent years we met occasionally with two species of rats, *Rattus rattus rattus* (LINNAEUS) and *Rattus norvegicus norvegicus* PALLAS, wandering into the cave. They are accidentals which join the community temporarily with the coming of visitors. Regarding the food relation in the terrestrial community I will deal with that later on.

The aquatic community is composed chiefly of several species of Crustacea. *Pseudocrangonyx shikokunis* AKATSUKA & KOMAI, which is widely distributed in the subterranean waters of central and western Japan, is the only troglobiontic Amphipoda inhabiting the shallow rimstone pools. Four surface water species of the cyclopoid Copepoda, *Macrocyclops albidus* (JURINE), *Eucyclops serrulatus* (FISCHER), *Paracyclops fimbriatus* (FISCHER) and *Mesocyclops* (s. str.) *leuckarti* CLAUS survive also in those pools as troglophiles or trogloxenes. There was once found a population of a cladoceran *Ceriodaphnia*

10) *vide*: HUTCHINSON, G. E. Survey of contemporary knowledge of biogeochemistry. 3. The biogeochemistry of vertebrate excretion. *Bull. American Mus. Nat. Hist.*, New York, *96* (1950), 1-554. (Cave guano, pp. 381-461).

quadrangula (O. F. MÜLLER). Water-mites are also the main components of the community; they are *Axonopsis* (*Hexaxonopsis*) *miurai* IMAMURA, *Uchidastygacarus akiyoshiensis* IMAMURA and *Soldanellonyx akiyoshiensis* IMAMURA, all of which are troglobionts and the latter two are endemic to Akiyoshi-dô. A minute snail *Akiyoshia uenoi* established by KURODA and HABE as a new genus and a new species is a striking troglobiont inhabiting pools and slowly flowing part of the stream. Among the other aquatic invertebrates, *Dugesia japonica* ICHIKAWA & KAWAKATSU is the only triclad turbellarian as a troglophile or trogloxene. It is worth mentioning that an archiannelid was obtained in the underground stream near the entrance of the cave. The food relation in the aquatic community is not known.

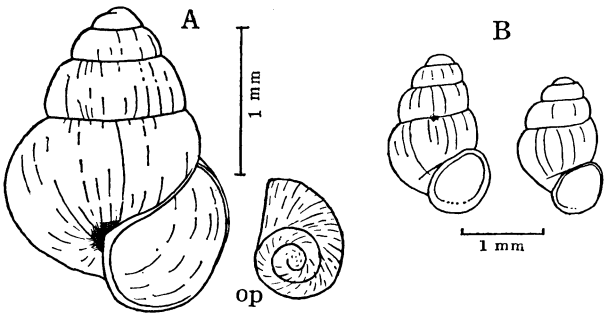

Fig. 10. Two cave-dwelling snails. A—*Cavernacmella kuzuuensis* (SUZUKI), shell and operculum (op). (Adapted from T. HABE, 1941). B—*Akiyoshia uenoi* KURODA & HABE, two forms of shells. (Adapted from T. KURODA & T. HABE, 1954)

During the past forty years since electric lights were installed in the cave in 1925 for visitors, the natural cave environment has gradually changed. Within the limits of artificial lights, chlorophyll-containing plants which found a chance to invade the cave have become capable of growing successfully. The recent improvement in the light led some species of ferns and mosses to quicken their growth in the

lighted area. There are at present five species of ferns and nine species of mosses,[11] as well as two species of mushrooms, though the former two groups cannot fully grow up to a spore-forming stage. The principal species of ferns are *Pteris multifida* POIR. and *Cyrtomium fortunei* J. SM. Recently Mr. KANETSUNA has found on the wet rock near an artificial light eight kinds of diatoms, of which *Navicula contenta* was the principal species. This diatom is derived very likely from the stream flowing out from the cave, because it makes up the flora there together with the other eighteen species of the same group. *Cocconeis placentula* var. *lineata*, which is the most abundant among them, was incapable of entering the cave, whereas *Navicula contenta* was successful in finding a new habitat under artificial light.

Some animals constituting the community have become herbivors in their food habit and feed on these green plants. As is usual in most caves, the primary sources of food for animals in Akiyoshi-dô are organic debris transported into the cave by water and other agencies, or introduced by man; as well as bats' excreta. As a result of the growing of primary producers such as ferns, mosses or algae, the food chain in this cave, which had begun with the organic materials mentioned above, has partly changed to chlorophyll-containing plants in the first instance. Having enumerated twenty-two species of cave animals which had been attracted to lights, KURAMOTO[12] has suggested that certain troglobionts of ecological significance in the community, such as *Cavernacmella kuzuuensis* and *Sinella akiyoshiana*, seem to have

11) IWATSUKI, K. and S. UÉNO, The green plants growing in Akiyoshi-dô Cave, southwestern Japan. *Mem. Coll. Sci. Univ. Kyoto*, ser. B, *26* (1959), 315-322; HINO, I., Plants growing in Shûhôbô Cave. *Bull, Akiyoshi-dai Sci. Mus.*, no. 2 (1963), 26-35 (in Japanese, with English summary); HINO, I., Bryophytes found inside and outside the Shûhôdô Cave. *Bull. Akiyoshi-dai Sci. Mus.*, no. 3 (1964), 49-56 (in Japanese, with English summary).
Shûhô-dô is a synonym for Akiyoshi-dô.

12) KURAMOTO, T., Animals attracted to the artificial lights in Akiyoshi-dô Cave. *Bull. Akiyoshi-dai Sci. Mus.*, no. 2 (1963), 36-48. (In Japanese, with English summary).

changed their food habits to dependence upon green plants. Regarding the nutritive relation, Akiyoshi-dô has now changed from a monotrophic cave[13] of only allochthonous nutrition supply to an amphitrophic cave,[13] where foods are derived from both allochthonous and autochthonous origin. We have no knowledge of cave bacteria and fungi which may play an important role in the food chain. Microbiological studies will be necessary not only in Akiyoshi-dô, but also in many other caves in Japan.

Such a development that has occurred near lights offers an interesting ecological and physiological subjects to be studied. It is, however, not always desirable to permit the existence of such conditions, which will be unavoidable with the rapid increase of visitors to the cave. For the conservation of Akiyoshi-dô, I think it will be necessary to eliminate such plants as much as possible in order to keep the natural conditions inside the cave, leaving certain typical lighted places for continuous ecological observations.

13) DUDICH, E., Die Klassifikation der Höhlen auf biologische Grundlage. *Mitt. Höhlen- und Karstforsch.*, Heft 3 (1933), 35-43.

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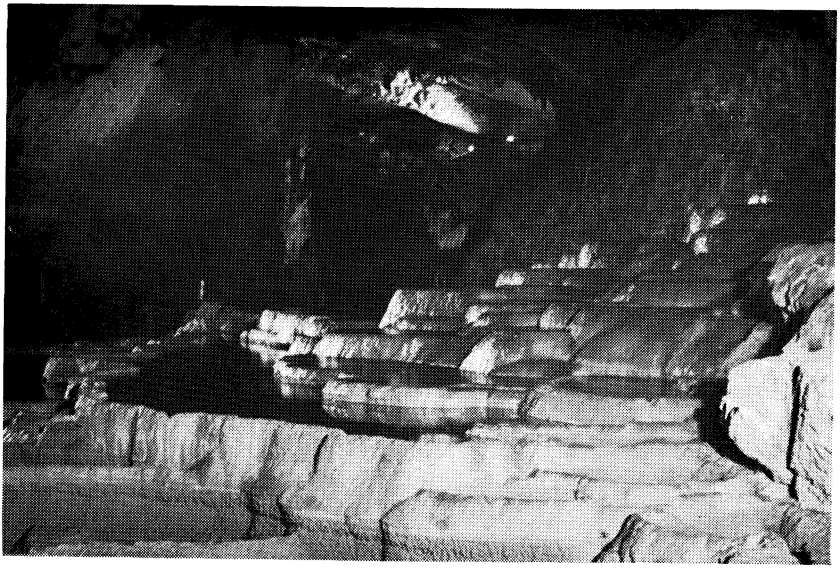
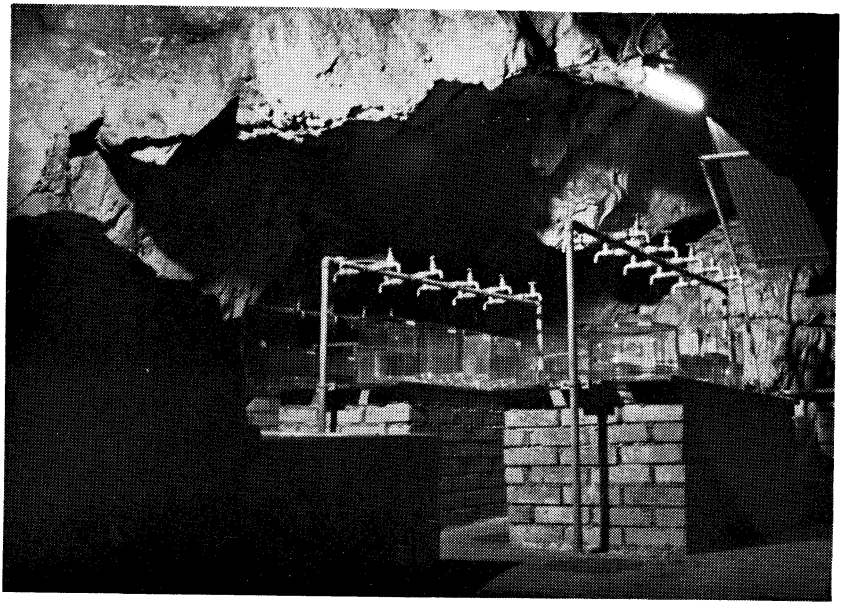


1. "Hyakumai-zara", a group of rimstone pools in Akiyoshi-dô. (Courtesy of Mr. T. KURAMOTO)



2. The Kômori-ana Underground Laboratory attached to the Akiyoshi-dai Science Museum. (Courtesy of Mr. T. KURAMOTO)