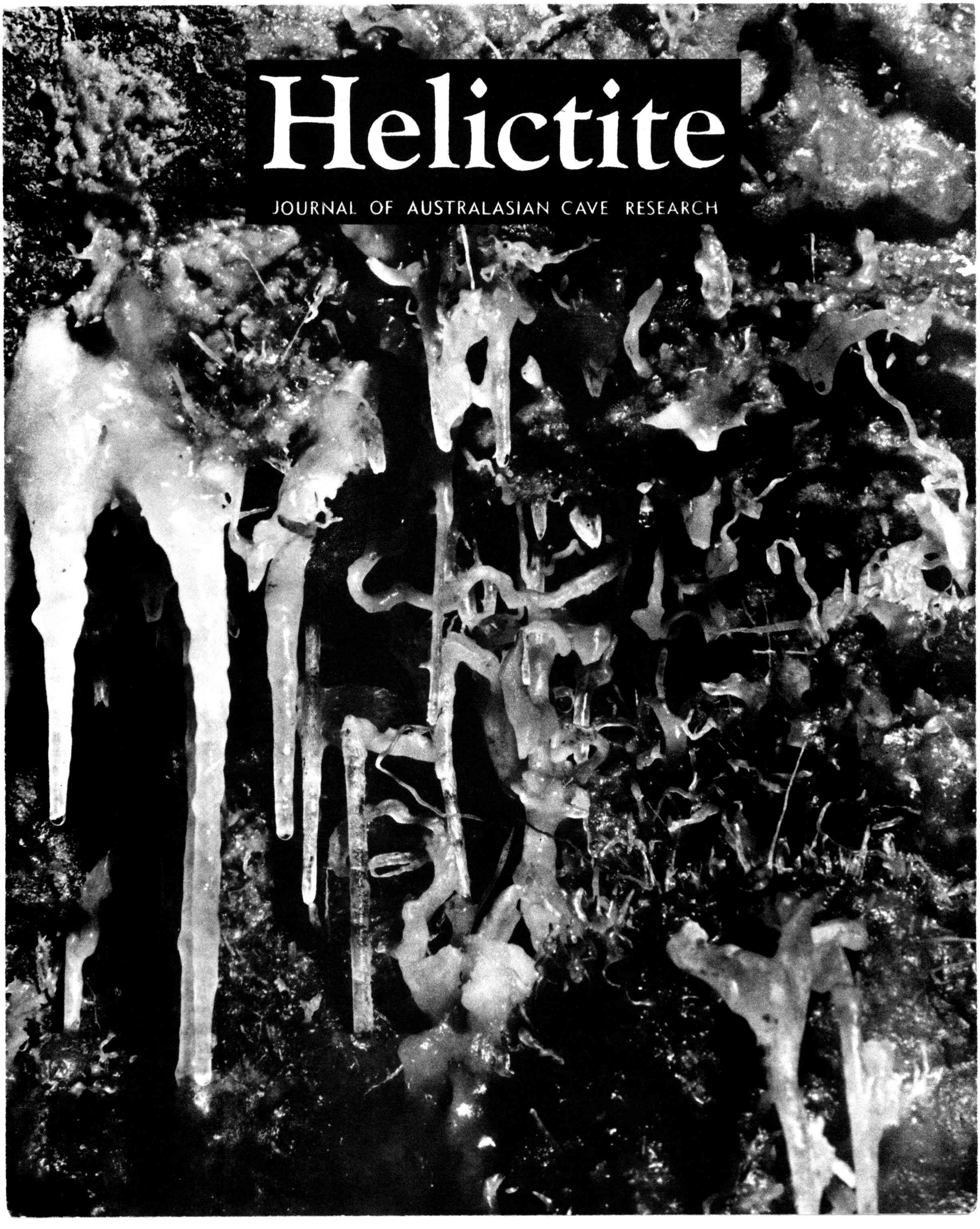
Helictite

JOURNAL OF AUSTRALASIAN CAVE RESEARCH



"H E L I C T I T E"

Journal of Australasian Cave Research

Edited by Edward A. Lane and Aola M. Richards.

VOLUME 1, NUMBER 1. Published Quarterly OCTOBER, 1962

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Subscription £1 per annum, post paid. All correspondence, contributions and subscriptions to "Helictite", Box 183, Post Office, Broadway, Sydney, Australia. "Helictite" is printed and published by E. A. Lane.

INTRODUCING HELICTITE

This is the first issue of a new quarterly publication, "Helictite", and it marks the production of the first periodical in Australia devoted entirely to papers on cave research.

The scope of "Helictite" will be wide, ranging from the scientific study of caves and their contents, to the history of caves and cave areas, and the technical aspects of cave study and exploration. It will also include fringe subjects such as rock paintings and excavation of rock shelters, in view of their great interest in relation to similar art and artifacts found in caves in Europe, Africa, etc.

The territory to be covered incorporates all Australasia in the truest sense - Australia, New Zealand, the near Pacific islands, New Guinea and surrounding areas, Indonesia and Borneo.

"Helictite" is a non-profit publication devoted to providing a reliable news service and collection of speleological papers for those interested in any of its disciplines. For the time being the editors are financing its production. Eventually "Helictite" will become self-supporting through subscriptions, donations, and sales of reprints.

Scientific interest in Australasian caves has increased considerably over the past few years, it was because of this the editors felt it would serve a worthwhile purpose to gather together all relevant papers into a journal of cave science.

We have made a start - now the success of "Helictite" is in the hands of its readers. We need subscribers and we welcome regular contributions in all fields related to speleology in Australasia. Overseas contributions will also be considered.

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FRONT COVER: Group of helictites. Lower level, left branch, Jubilee Cave, Jenolan, N.S.W. Photograph by E. A. Lane.

CAVE ANIMALS AND THEIR ENVIRONMENT

By Aola M. Richards, M.Sc.,Ph.D.

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SUMMARY

Caves can be devided into three distinct regions - the twilight zone, the transitional zone and the troglic zone. The main physical characters of caves - light, air currents, temperature and humidity - are discussed in relation to their effect on cave fauna. Various classifications of cave animals are mentioned, and those of Schiner and Jeannel discussed in detail. The paucity of food in caves, and its effect on the animal population is considered. Mention is made of the loss of secondary sexual characters and seasonal periodicity of breeding among true troglobites. Cave animals have undergone many adaptations to their environment, the most interesting of these being blindness and loss of pigment. Hyperdevelopment of tactile, gustatory, olfactory and auditory organs and general slenderness of body, are correlated with eye degeneration. Several theories on the origin of cave fauna are discussed, and the importance of isolation on the development of cave fauna considered.

INTRODUCTION

Speleology is a very young science, and only took its place as a serious science in the latter part of the nineteenth century, mainly due to the work of E.A. Martel. A generalised interest in caves had arisen in the Middle Ages, but it was not till the discovery of human occupation revealed the customs and habits of a people who had taken refuge there thousands of years ago that an unusual degree of interest was aroused.

Many of the caves with the richest flora and fauna are situated in remote places that are difficult to reach. No cave animals are of economic importance, and none, except the bat, can cause disease in man. Because of this, there has been no incentive to study cave fauna, so that our knowledge of its behaviour, development, life histories, food habits and general ecology is very limited.

The first description of a cave animal was published in 1768. This was of Proteus, the blind salamander, from a cave in Istria, which has since become the most famous of all cave animals. In the nineteenth century, biologists began to show interest in cave life and the many new problems raised by it, but they confined their studies mainly to the field of taxonomy.

The nature of the physical environment of many caves in Europe and North America is fairly well known, as are the general features of the life led in the darkness; but there are numerous ecological and physiological problems which require studying. In 1954, an underground laboratory was set up at Moulis in France, under the direction of the French Centre for Scientific Research, to study the behaviour of cave organisms under natural conditions. Since then, a number of other underground laboratories have been established in Europe, and one is soon to be opened in Kentucky, U.S.A.

Caves vary greatly in size and composition. By far the most important ones to the biologist are formed in limestone. The cretaceous limestone of Southern Europe and the carboniferous limestone of Virginia and Kentucky in North America support a rich and diverse fauna, which is highly specialised in relation to its long isolation underground.

Cave systems form discontinuous units which normally have no direct connection with one another. Usually plant and animal life decrease the further underground one goes. The density of the animal population is approximately inversely proportional to the size of a cave; small caves may contain many animals if conditions are favourable, while large caves have comparatively few animals, most being found around the cave entrance. There is usually a greater variety of animals in older caves.

REGIONS IN CAVES

Caves may be conveniently divided into three distinct regions:

1. The Twilight Zone. Here conditions have changed to some degree from those in the outside world. The light intensity is less, the temperature shows less fluctuation, the relative humidity is higher, and although air currents are present, they are not as marked as on the surface.

2. The Transitional Zone. Here there is usually total darkness, but still a certain degree of fluctuation in temperature and air currents.

3. The Troglic Zone. Conditions here are theoretically completely constant.

METEOROLOGICAL CONDITIONS

Conditions for the existance of cave animals in a subterranean environment and the various modifications that these animals have undergone to meet cave conditions have been the subject of wide-spread study. It has been claimed that one of the principal characters of the subterranean region is the uniformity of the conditions found there, with seasonal and diurnal changes being negligible. However, recent work has shown that the relative humidity, air currents and temperature all fluctuate to a limited extent, which may be sufficient to effect a very sensitive and narrowly adapted animal population. Variations in climatic conditions have been found between caves occurring at the same altitude, and also in various regions within the caves themselves.

1. LIGHT. The absence of light is the only constant character occurring inside a cave. Yet, of all the meteorological factors in caves, it is the one which has least effect on cave animals.

2. AIR CURRENTS. Generally caves are considered to have stable atmospheric conditions where air movements are of negligible importance. This is usually true, but seasonal fluctuations may occur. At certain times of the year air currents may be quite strong, while at others they may be slight. The violence of air movement may vary from place to place in the cave itself, and from cave to cave in the same area. Local variations due to barometric changes are particularly obvious in certain caves on the Nullarbor Plains, South Australia, where large underground air spaces may have very small "blowhole" entrances.

Certain types of caves are known as "wind caves." These have several entrances, and, depending on their physical position in the terrain and the differing altitude of the entrances, the air inside the cave may rise or fall according to the season of the year or outside meteorological conditions. These air currents cause a marked fluctuation of the humidity and temperature inside the cave. Only a very sparce cave fauna can exist under such conditions.

3. TEMPERATURE. It has been stated that animals in caves are stenothermic and hydrophilic. This means that they require conditions of constant temperature and high humidity. The high humidity helps to keep temperatures constant by acting as an insulating blanket. The temperature in caves has generally been considered to be that of the sub-soil in which the cave is situated, with rivers running through them being about half a degree C lower.

Recent work on temperature has shown that it is far from being constant, and that altitude may play an important part in the type of fauna that occurs. Caves at the same altitude, in the same region, may have very different temperatures and yet support the same fauna. In cold climates, caves have been found with temperatures as low as 0°C, yet still supporting cave fauna. The normal cave temperature in the temporate regions lies approximately between 9 and 13°C and a typical cave fauna occurs in these caves. Caves in the tropics may have temperatures up to 26°C and still contain considerable animal populations.

During the course of a year, normal temperature fluctuations of up to 10° can occur inside caves supporting cave fauna, and seasonal variations of 4 or 5° are frequent. Thus stenothermic conditions do not appear to be of major importance in the adaptations of cave animals.

4. RELATIVE HUMIDITY. The most important condition in subterranean ecology is a very high relative humidity. In order to exist, cave-adapted animals require conditions of almost total water saturation of the atmosphere. Atmospheric moisture is maintained at this level in the majority of caves because of the very large surface areas of evaporation present.

The animals become so adapted to these moist conditions that they become thin-skinned. Because of this they suffer water loss very easily, and therefore are unable to survive when removed from caves. This has made study of living cave animals very difficult, and is one of the reasons why scientists in France, and other countries, have set up underground laboratories to study cave animals in their natural environment. Even if taken from a cave for a very short time and then returned, cave animals still die.

A very interesting modification to cave life is found in a number of species of beetles (Coleoptera). These insects have become thin-skinned and have developed long, thin legs, while their abdomens have become distended. Underneath the wings the dorsal surface of the abdomen has become thin and transparent forming a large convex membrane covering a true respiratory chamber. This is used to absorb as much water, or moisture, from the atmosphere as possible because of the rapid water loss through the thin skin. This condition reaches its maximum development in the Bathysciinae, but is also found in some species of Carabidae and Silphidae. If these insects are removed from caves, they are unable to survive the environmental conditions existing in the outside world.

RIVERS AND LAKES

Rivers play an important part in influencing the presence or absence of fauna in caves, in many instances. Two distinctly different types of rivers occur in caves - those originating outside caves, and those formed inside cave systems.

In the first type, the young river is swiftly flowing when it enters the cave, and carries air currents above it through the cave passages and chambers. It may have waterfalls and cascades along its course; it often passes through siphons, and it usually has a gravel or sandy bottom. The walls in the river sections of the cave are frequently worn smooth and scalloped, and there is constant temperature fluctuation. Under such conditions a true cave fauna would be unlikely to exist. The animals found there would be washed in from the epigean world, such as fish, crayfish, eels, and possibly various types of flies and mayflies.

Caves may also contain older rivers which flow more slowly, are less turbulent and more constant in temperature. They usually flow over a clay bed, and have formation on their walls. In such conditions a true cave fauna would be more likely, although representatives from the outside world would still be present.

The other type of river (usually called a "lake" by Australian caving groups) is that formed inside the cave, with no direct connection to the outside world, although the cave system may have. It is formed by water infiltrating through the walls of the cave, oozing down from pendant formations, coming from pool accumulations on the floor, and seeping from clay beds. The water is very clear and of constant temperature, and the river bed if formed of clay. Accumulations of bat guano may be present, thus offering a good food supply. Here a true cave fauna could exist.

CLASSIFICATION OF CAVE ANIMALS

Animals frequenting caves have been classified in several different ways:-

A. SCHINER

One of the simplest and best classifications is that proposed by Schiner in 1852. He grouped cave animals into three different categories according to the degree of their ecological relationship with the subterranean region.

1. Trogloxenes. These are accidental guests in caves and occur normally in the epigean region. They are attracted by the moisture and darkness found in caves, and perhaps by the food. They may like the conditions and stay there, but they may also wander back to the outside world. They usually prefer darkness, so go into caves during the day, and at night return to the outside world to pursue their activities.

2. Troglophiles. These live, feed and reproduce in caves. Although carrying out all their natural functions in a cave, they are still able to return to the dark, humid habitats of the outside world.

3. Troglobites. These are exclusively cave types, and are confined to caves. They are so modified to the conditions there that they are unable to live elsewhere. Troglobites form the true cave fauna.

B. JEANNEL

Another more comprehensive type of classification is that proposed by Jeannel in 1926. He divided caves into two regions - the Light Zone and the Dark Zone. The Light Zone he subdivided into seven different faunistic associations, and the Dark Zone into eight.

1. Fauna of the Light Zone. The climatic conditions here are intermediate between those of the Dark Zone and the exterior. Some degree of light is always present, and there are fluctuations in temperature and humidity. In general, troglobites are never found in this zone. Green plants play an important ecological role, moss, liverworts and vegetable debris, particularly dead leaves, giving shelter to special associations of troglophiles and trogloxenes.

The different types of associations found are:-

a. Parietal - around the cave entrance on walls.
b. Under stones.
c. In soil.
d. Among moss and lichen.
e. Parasitic and scavengers.
f. Troglobites attracted to the Light Zone in their search for food.
g. Aquatic.

2. Fauna of the Dark Zone. This zone forms the most important part of the subterranean region, as it contains the troglobites. It is impossible to explore all the vast network of holes in limestone, and these holes form the niche preferred by most species of troglobites. In this zone different habitats exist from those in the Light Zone. These contain special faunistic associations although many species are common to several of them, and there is much straying from place to place.

a. In and around guano.
b. On stalagmites.
c. Under stones.
d. In vegetable debris.
e. In clay beds.
f. In zones periodically inundated by subterranean waters.
g. Terrestrial crevice animals.
h. Aquatic.

FOOD

The absence of green plants from caves is fundamentally important, as all animals directly or indirectly depend on green plants as their food source. From this it follows that the food of cave animals must come from outside, except where the roots of surface plants may have penetrated the substrata. This food supply is very varied.

A considerable quantity of plant debris is often carried into caves by rivers and streams, or during floods, and fungi are able to grow on this material. Dissolved and colloidal food substances of plant origin are also carried in by water. This organic debris forms a food supply for springtails, millipedes and some beetles, and these insects in turn are preyed on by carnivorous beetles, spiders, opiliones and pseudoscorpions.

In the twilight zone there is constant movement to and from the epigean region as animals, particularly rodents and bats search for food. These wanderers themselves, as well as the bodies of animals accidentally trapped in caves, add to the general food supply.

Bat guano forms an important food source for numerous coprozoic insects and their predators. True guano-eaters, such as some Staphylinid beetles, exhibit no specialisation to cave life, yet the carabid beetles, which prey on them, are highly specialised. The guano supports species of beetles, flies, springtails, Tineid moths, Thysanurans, mites, terrestrial isopods, cockroaches, cave crickets, centipedes and snails.

In general, the food supply is small, and cave life is correspondingly scanty, and made up of small forms.

REPRODUCTION

All troglobites breed in total darkness deep within caves. Here, in the almost uniform conditions of darkness, high humidity and constant temperature, the seasons of the outside world pass unnoticed. Because of this, troglobites no longer show definite seasonal periodicity in their reproductive habits, but are able to breed at all times of the year. Those animals, such as bats, which are directly dependent on the outside world for food, may still show seasonal periodicity.

Animals which breed in caves show no distinguishing secondary sexual characters, which may serve for sex recognition through visual stimulation. Instead they have to rely on the senses of touch and smell, which are highly developed. Among cave crickets, for example, there are certain species in which the male possesses abdominal glands, known as "alluring glands," which produce a sweet-smelling secretion that attracts the female in the darkness.

ADAPTATIONS OF CAVE ANIMALS

Typical cave animals commonly exhibit certain well-marked characters. They are very often blind, or have eyes much reduced in size or efficiency; they are often without pigment, so that the body appears pale or pellucid; they are small, stenothermic and hydrophilic. As if in compensation for loss of sight, organs of tactile sense - in which is included the means of detecting air currents - are often highly developed. These are especially well marked among insects, myriapods and spiders, which may have unusually elongated antennae, up to seven times or more the length of the body, or be covered with long, sensory hairs. Many beetles have tactile hairs scattered over the whole body. Cave crustaceans also have very elongated antennae.

Another peculiarity especially common among insects living on the walls of caves is the development of very long, thin, spindly legs. This is common among beetles, cave crickets, opiliones, spiders and mites. The organs of chemical sense are also very highly developed. Cave animals move with as much certainty as though they could see. Springtails often leap at exactly the right moment to escape from attacking mites.

Recent migrants into caves may be little modified. Some highly-adapted cave animals are often found outside, others never leave their subterranean habitats. Species that live both inside and outside caves may be specially and characteristically modified. The ears of rats and mice that live far within caves are larger than those of the same species outside. The eyes of these rats and mice become sore when the animals are taken outside, though epigean members of the same species live without trouble under the same conditions.

The most startling and the least intelligible of the characteristics of cave animals are their loss of pigment and eyes. The development of elongated antennae and other hypertrophied sensory organs is readily understood, for these are adaptive features of obvious value to the inhabitants of caves. Depigmentation and blindness, however, are of no benefit.

Pigmentation

Although a great many animals found in caves are unpigmented, loss of pigmentation may have been achieved in a number of different ways (e.g. loss of pigment within the lifetime of the individual, or animals born without any pigment).

1. Normally pigmented animals living above the ground may lose some or all their colour if placed for some time in the dark. In 1931, a trout was found in a German cave. It was very pale in colour, having lost all its carotin and most of its melanin. It is thought its occurrence in the cave was accidental, and the loss of pigment had taken place within the lifetime of the fish. In 1955, a six inch long rainbow trout was caught in a cave at Coolamon, N.S.W., in a small lake. It was colourless, and was thought to have been washed in as a fingerling during a flood. It had been observed on several occasions over a period of 12 months before it was caught. On brief exposure to light it immediately began to develop pigment.

2. Some colourless cave animals may develop pigment on exposure to light. Proteus anguinus, the blind salamander, has a colourless skin, with blood-red gills and two black spots on the head which indicate the position of the greatly reduced eyes beneath the skin. When kept in the light, its skin slowly darkens to a deep grey colour, showing that it has not lost the ability to produce pigment, though normally it never does so.

3. Cave beetles have lost their body pigment, but this is not noticeable because the colour of the hard, chitinous exoskeleton is developed separately from that of the body. In epigean beetles pigment is present in the body and the exoskeleton. In cave beetles, however, the body pigment is lost and the flesh is colourless, while the chitin retains its colour.

4. The great majority of troglobites have irrevocably lost the ability to produce any pigment. Most cave crustacea belong here.

There is no doubt that loss of pigment is related to darkness, and with some animals it is possible to demonstrate great variability in colour intensity.

Sense Organs and Reactions

Degeneration of eyes, optic nerves and optic ganglia is widespread among cave animals, and this is associated with the compensatory development of tactile organs. Many cave turbellarians have no expernal eyes. In many snails and cave crustaceans the eyes are reduced. Numerous cave beetles are eyeless. Springtails and mites may be eyed or eyeless. Other caveanimals have apparently normal, functional eyes, and some even have unusually large eyes. The eyes of some species of arthropods vary according to conditions; outside the eyes may be functional, but in caves they are degenerate. It has been suggested that with many cave animals such as springtails and mites, the eyes were already showing signs of reduction while the animals were still living in the outside world. Studies on the eyes of cave fishes and salamanders have shown that eye degeneration began at earlier and earlier stages in embryology until the whole course of development was affected.

Hyperdevelopment of tactile, gustatory, olfactory and auditory organs and general slenderness of body, correlated with eye degeneration is characteristic of cave animals, but also occurs in various epigean species. Some species of silurid fishes, that never occur in caves, commonly have long barbels protruding from the head. These bear gustatory sense organs and receive tactile stimuli. These species do not depend on sight for feeding, and commonly feed at night. Some silurids do occur in caves.

All cave animals are negatively phototropic. Even those which have lost their eyes are still sensitive to light and try to avoid it. Some animals may even die if exposed to strong light.

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Not all taxonomists believe that modified cave forms are entitled to rank as distinct species and genera. Cave beetles of the genus Anopthalmus show a graded series between species without trace of optic lobes or eyes, and those in the epigean genus Trechus. Pigmentation and eyes in cave spiders are variable and may indicate how long the various forms have lived in caves.

There has been much discussion among evolutionists as to how adaptations of cave animals have arisen. Some scientists have held that such characteristics as depigmentation and eye degeneration have been caused by the cumulative effects of environment on successive generations (Eigenmann, 1909). Others have maintained that mutations or other genetic changes, rather than environment, caused evolution toward characteristic cave types because similar changes often occur in the epigean world (Loeb, 1913; Hawes, 1947). Unquestionably animals of particular species may become adjusted to conditions above or below the surface of the earth. This is ecological segregation, and, once an isolated race is established, environment may permit the genetic complex inherent in such animals to form a new species (Pearse, 1934).

ORIGIN OF CAVE FAUNA

There have been a number of theories put forward as to the origin of cave fauna. None of these hypotheses can be accepted or rejected in its entirety. Each theory may account for certain cases, but none can be accepted completely.

1. Banta, 1907. Through an actual organic tendency in certain animals, these were to some extent forced to seek conditions which only exist underground. This compulsion to seek a cave environment existed prior to their migration, thus cave animals have not arisen through accidental isolation but by voluntary migration.

2. Thienemann, 1908. In very remote times there was no proper cave fauna. Following the setting in of external climatic conditions unsuitable to many forms of animal life, these took refuge in caves, and after a long period spent in their new surroundings they became completely dependent on the conditions of life underground and incapable of returning to the outside world.

3. Spencer. Animals came into caves by chance and slowly settled in these surroundings, giving rise to all the cave fauna found today.

4. Pearse, 1938. Epigean animals entered caves for shelter and to take advantage of the high humidity and constant temperature. Many returned to the outside world to search for food. Animals from ground waters

entered caves chiefly for food, which must come directly or indirectly from the world above.

5. Jeannel, 1926. During humid seasons epigean animals might have become adapted for life in caves before entering them.

ISOLATION

Isolation is an important factor in the development of cave fauna as it is very effective in separating small areas. Even though there may be more connections between caves in limestone regions than are apparent, cave systems are isolated and this explains their faunistic peculiarity.

The similarity between cave fauna from widely separated areas is due to the fact that only members of certain groups can adapt themselves to cave conditions. This adaptation produces parallel structure and appearance.

The isolation in caves, and the adaptation to the conditions there, removes many species from the epigean region. Thus in addition to animals with close relatives above ground, cave fauna contains a considerable number of relict species whose epigean ancestors are now extinct. In many areas cave animals are believed to be glacial relicts.

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ABSTRACTS

NEW GENERA OF BEETLES (CARABIDAE) FROM NEW ZEALAND. By E.B. Britton. Ann. Mag. nat. Hist. Ser. 13,4:665-672, November, 1961. Pub.22.5.62.

This paper describes three new genera and species of Carabidae from New Zealand. One genus belongs to the subfamily Harpalinae, and the other two genera to the subfamily Trechinae. These beetles were collected from caves in the Paturau district on the west coast of Nelson, and from a sink-hole on Takaka Hill, Nelson. All show marked adaptation to cave life.

The subfamily Trechinae has already been recorded by Britton from caves in the North Island. In this paper he adds a new species to the genus Duvaliomimus Jeannel, D. orpheus Britton, which is distinguished from other species by greatly reduced eyes, more elongated pronotum and pale colour. The genus Scototrechus Britton is erected for the species S. orchinus Britton, which is closely related to Duvaliomimus. The species Duvaliomimus caecus Britton is now placed in the new genus Neanops Britton.

A new cave-dwelling genus belonging to the subfamily Harpalinae is of particular interest, as so far only one other cavernicolous genus has been recorded, and this is the first record from New Zealand. Britton has named the genus Pholeodytes. P. townsendi Britton shows marked convergence to the "troglobiont" form and is superficially very like the species of Duvaliomimus with reduced eyes. The subfamily Harpalinae, which includes very large numbers of genera and species throughout the world, is surprisingly poorly represented in the New Zealand fauna. So far only seven genera and about twenty-five species are known.

Specimens of P. townsendi and D. orpheus were collected in a dry gypsum passage, and were not associated with moist or dripping surfaces. One specimen of P. townsendi was found dragging along a small cave-weta which had been partly devoured. This demonstrates the carnivorous habits of these beetles and throws some light on their food habits.

NOTES ON AUSTRALIAN CARABIDAE (COL.). - III: A REMARKABLE CAVE-FREQUENTING HARPALINE FROM WESTERN VICTORIA. By B.P. Moore. Ent. mon. Mag.,XCVII (1961):188-190. Date of publication: January 31, 1962.

This paper is the first record of a cavernicolous Carabid beetle from the mainland of Australia. Notospeophonus castaneus Moore frequents caves near Portland in western Victoria, and, at the time of publication was the only known cavernicolous member of the subfamily Harpalinae. N. castaneus is found running about on the damp ground in caves in total darkness at a considerable distance from the entrances. The overall build of the species points to definite adaptation to cave conditions, but the presence of fully developed wings suggests that the species is a recently evolved cavernicole. Details of its life history and food have still to be determined.

OBSERVATIONS ON CAVES, PARTICULARLY THOSE OF SOUTH AUSTRALIA - 1862

By Edward A. Lane

Australian Atomic Energy Commission

Introduction

The historical study of Australian caves and caving areas is fascinating although involving the expenditure of vast amounts of time. Australia's early days are unusually well-documented, but in the case of caves the early history is usually wrapped up in rumour, hearsay, and clouded by lack of written record. Most research work means long hours pouring over old newspaper files, mines reports, land department records, and so on, little of which is catalogued. A small number of exploration journals and scientific studies have extensive material on special cave areas, and of these, the volume by the Rev. Julian Edmund Woods, F.G.S., F.R.S.V., F.P.S., etc., is one of the most interesting. This book gives the ideas and beliefs of 100 years ago concerning the origin, development and bone contents of caves and makes interesting reading in the light of more recent studies of cave origins.

Woods' study, "Geological Observations in South Australia : Principally in the District South-east of Adelaide," was published in 1862 by Longman, Green, Longman, Roberts and Green, London.

In a preface dated November 15, 1861, Rev. Woods points out that the book was written while he was serving as a missionary in a 22,000 square mile district, and "without the benefit of reference, museum, library, or scientific men closer than England." Up to the time of writing, almost no scientific nor geological work had been done in South Australia and much of the area was completely unexplored. The book, also, contained the first detailed description of caves in the southeast of the State.

Father Woods writes about many different types of caves in South Australia, for instance, the "native wells" in the Mt. Gambier/Mt. Shanck area. These are caves, rounded like pipes, and generally leading to water level. Woods points out their likeness to artificial wells. He also writes of sea cliff caves, particularly in the Guichen Bay area, and blow-holes caused by the action of waves on the limestone cliffs. Woods discusses many other types of caves further inland, particularly bone caves.

Origin of Caves

Father Woods discusses cave origins under two sub-heads: 1. Trap rock caves resulting generally from violent igneous action, and 2. Limestone caves resulting from infiltration of some kind. He is mainly concerned with limestone caves which he sub-divides into (a) crevice caves - caves which have arisen from fissures in the rock and are therefore wedge-shaped crevices, widest at the opening, (b) sea-beach caves, caves which face the seashore and are merely holes that have been worn by the dashing of the sea on the face of the cliff, (c) egress caves, or passages to give egress to subterranean streams, (d) ingress caves, or passages caused by water flowing into the holes of rocks and disappearing underground. These caves would have entrance holes in the ground, opening very wide underneath, and having the appearance of water having entered from above, (e) finally a group of caves which he lists by use as "dens of animals."

The Deluge

Father Woods said that most caves known at the time contained bone fragments, generally of extinct animal species, also shells. This was found "to hold good almost universally." At first it was supposed that these remains bore a strong confirmatory testimony to the universality of the Deluge, but, in time, Father Woods writes, this view was abandoned.

"Apart from the fact that bones resulting from the Deluge ought to belong to existing species, because the earth was repeopled with the animals destroyed thereby, two of every species destroyed having been preserved in the ark, it was found that in very few instances were bones found under the same conditions," Father Woods continues.

He adds later in the book: "There was a time when I very tenaciously held an opinion, at one time promulgated by the late lamented Dr. Buckland in his 'Reliquiae Diluvianae' to the effect that the bones in caves were relics of the Deluge. That opinion I (now) hold to be quite untenable. Not only did different causes operate in producing similar phenomena, but also there is overshelming evidence that they were formed at different times. Some, as we have seen, were dens of animals; others, places of human abode or sepulture; others were drains; while some can boast that they entomb animals which have long ceased to exist....The fact found to prevail so extensively, and so confidently appealed to, namely, that all (caves) bore marks of the action of water, is a mere consequence of the course of their existance;- if water did not frequently run in great quantities where they are found, they never would have been there at all. ...What we should never have looked for, namely, the marks of an inundation which only lasted a year many thousand years ago, has not been found. But its very absence might be cited as a corroborative fact....These silent caves, never for ages past enlivened by the busy hum of life, scarcele echoing to the footsteps which expose their hidden beauties, have within themselves a wondrous record of this planet's changes."

Woods sees that a "cavity has, by the small droppings of water, created itself into a palace, and then has stood silent witness to the earth's history, has become a cemetry of a creation swept away in one of its changes."

"Geologists have been accused of requiring too much time," he continues, "for the operation of the mutations they have helped to disclose; but look upon this architecture - this glorious tracery of nature - remembering that it has been formed atom by atom, and line by line; consider how long it must have taken a mere drop of water to take down from above the marvellous columns which adorn this palace of stone, and ask, will years, even counted by hundreds, cover the period it includes."

Cave Origin Theories

Father Woods continues that after the theory of the Deluge was abandoned, some people believed that the bone caves had all been resorts of beasts of prey. This theory, too, was found "not to have universal application." At length, it was realised that the manner in which the bones became accumulated was different in almost every case. "It is worthy to remark....that the osseous caverns are, perhaps, the only instances in science where totally different causes have combined to produce universally similar phenomena."

Referring to Peak Cavern, Derbyshire, for example, Woods writes that the cavern "impresses most beholders with a conviction that the whole was excavated by the running stream."

Fissure caves were more easily understood, he states, if we supposed large rents to have been made in limestone by upheaval, earthquake, or other causes, and these subsequently became connected with caves by the drainage of surface water. Embedding of bones in such caves would be easy to understand.

Bone Caves

Woods considers that the entry of bones into such caves would be mainly by pitfalls, or washed in. The bones could deposit in large masses of clay "laid open", the clay already filling the limestone cavities. Woods believes that these clay fissures would fill eventually with new clay and seal off. He cites examples of caves in Victoria, near Mt. Gambier, of the "pitfall" type.

On the other hand, Woods finds more difficulty in accounting for bones embedded in floors of old river passages in long caves. He asks: Assuming that these caves had been the passages of former streams, would these streams have necessarily carried down bones and filled their former passages with them. Basing his ideas on observations of Greek caves (katavothra) given in the "Annales de Mines," 1833, and quoted by Lyell in his "Principles of Geology," last volume, 1833, Woods discusses periodic river overflow and flooding into caves on higher ground. He explains that bones could be carried into caves in this way. The bones thus carried into caves would also be moved around the cave by flood water and deposited at various levels. In a cave of this type stratification problems would be very confusing.

He suggests that some of the South Australian caves could be similar to the Greek caves discussed by Lyell insomuch as lakes of flood water could form in depressions and overflow into cave systems, carrying bone deposits and earth fill with them. He suggests that areas in South Australia (he names Swede's Flat) might be elevated atolls, the old lagoon area filling with flood water and emptying through "drains" in the middle and overflowing into cavities around the perimeter. He also refers to large swamp areas in the same district which overflowed during wet periods into surrounding caves with entrances higher than the usual levels, or if low-level entrances became blocked.

Woods adds later that of all the debris brought down by streams, the bones of animals were the only things calculated to resist the action of decomposition. "We must consider the bone stalagmite, not as deposited in the manner in which it is found, but as mingled in the first instance with the ordinary debris of a rapid stream passing over the locality which was ordinary dry land, and not the bed of a stream."

He continues that most of the bones in the caves were those of animals drowned by floods and washed into the caves. He says he can show that in the Australian caves the most prominent bones were those of animals which burrowed underground, and therefore the most liable to be drowned in sudden floods. In this case there would be no difficulty in accounting for the osseous deposit in caverns.

Woods also mentions the use of caves as dens for wild animals and gives Kirkdale Cave, Yorkshire (disc. 1821) as a former den for wild beasts. Another cave of this type cited by Woods was in Victoria, near Gisborne, and referred to in a letter read before the Geological Society, London, on June 1, 1859. The letter was from the Government Geologist of Victoria and referred to discoveries in this dry, bone cave of osseous remains of birds and mammals, perfect skulls of dingos, the Tasmanian devil, and "another carnivorous animal."

The various caves north and northwest of Penola (including Naracoorte) impressed Woods by the way the various bones were jumbled up and concreted together without reference to parts. Describing one of the bone caves, he says that the "quantity of small animals it must have taken to form a deep deposit of their bones - perhaps two feet deep, ten feet wide, and of indeterminate length - must have been something prodigious, for they were compressed into the smallest possible space."

Woods describes some of the bones and says that many of them belonged to a previously undescribed rodent-like animal living in abundance near the cave, and not to an extinct species as he first believed. Other bones were similar to those of the native cat, long-nosed bandicoot, native squirrel and Australian possum. He noted that most of the common bones were those of animals which burrowed underground and therefore most liable to be drowned by the sudden advent of water. Bones were generally lime encrustered.

In the case of this cave area, Woods says, the caves had no visible place for either the egress or ingress of water, unless by the roof or through the meandering, thread-like passages at the ends. "A river in the sense of a continued running stream there could not be." Nor, he adds, would the accidental falling of animals through roof holes account for distribution of their bones along the whole length of a passage.

Woods believed that the most likely theory for bone collection and distribution here was that an extensive inundation had occurred driving large numbers of animals into the caves, where they were drowned, and the "restless agitation" of the waters had eventually distributed the bones. He mentions, for example, one group of caves on higher ground. Rising water would force animals up the slope, they would take refuge in the caves, and later the flood water would spill over into the entrances trapping the animals. The inrushing water would also wash the animals deep into the cavities.

Discussing another cave area in the same vacinity, Woods says the bone collections appear to have accumulated from several inundations, with long periods of rest between. He suggests that the initial series of floods formed the caves, and later ones added the bones. He says that the eruption in the past of Mts. Gambier and Shanck, and the volcanoes to the southward, may have caused very heavy torrents of rain and extraordinary floods.

Stalactites

Concerning the formation of stalactites, Woods writes: "It was formerly stated by many eminent chemists that these could not be easily accounted for as water would not dissolve carbonate of lime, or the ordinary limestone. It has, however, been since determined satisfactorily, that water will hold a certain quantity of carbonic acid in solution, and will then dissolve a certain quantity of lime. Water falling on grassy ground derives a quantity of carbonic acid from plants, and this, filtering through and evaporating would leave the lime it had dissolved on the inner side as a little nodule, gradually enlarging by increasing deposition. Wherever the quantity of lime was small and pure, and the evaporation slow, crystallization would take place, which is the case in nearly all the stalactites in these caves."

Underground Drainage

Describing another cave near Mt. Gambier, Father Woods writes that at a depth of about 70ft. was a long passage through which a deep stream flowed. He said it had been followed in a boat, without the passage becoming more narrow or the water more shallow, and "very likely continues till near the coast, where, as before mentioned, there are several natural springs where large quantities of water boil through the limestone."

Woods adds that it had long been a subject of speculation how the water drained from the southern part of this country. The only way of explaining the disappearance of the excess water was to suppose it drained underground. He gives as evidence movement of water in wells and the sound of running water in these southern limestone areas after rain. The cave referred to above was, Woods believed, one of the channels of drainage for the area, its general course lying about southeast. Woods also writes that many of the caves and "wells" in the Mt. Gambier area were among the sole reservoirs of water for the early settlers, before artificial wells were sunk.

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