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CAVE MONITORING PRIORITIES IN CENTRAL AMERICA AND THE CARIBBEAN

PREDNOSTI MONITORINGA V JAMAH SREDNJE AMERIKE IN KARIBOV

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Michael Day & Susan Koenig: Prednosti monitoringa v jamah Srednje Amerike in Karibov

Kras pokriva okrog 300.000 km^2 (50 %) ozemlja Srednje Amerike in Karibov. Jam je verjetno več desettisoč. V celotni Srednji Ameriki in Karibih je monitoring v jamah zelo redek in agencije za urejanje in varstvo okolja ga nizko cenijo. Izjeme se pojavljajo le v nekaterih zaščitenih področjih in v redkih turističnih jamah. Z mnenjem, da je monitoring res potreben, se v splošnem ne strinjajo. Poleg tega je monitoring omejen zaradi nezadostnega financiranja in opreme in zaradi pomanjkanja ustrezno usposobljenega osebja. Vendar je monitoring v jamah nedvomno potreben, kajti jamsko okolje je izrazito občutljivo in kraška pokrajina doživlja naraščajoč pritisk zaradi razvoja. V tej zvezi je nujna inventarizacija in program monitoringa vsaj v bolj pomembnih jamah. Tak monitoring se lahko usmeri na fizično okolje, zgodovinske ali predzgodovinske ostanke, favno, izkoriščanje surovin, kakovost vode in turistični obisk. Enako pomembno je izvajanje monitoringa na kraškem površju, kajti degradacija površja se nujno odraža tudi v slabšanju podzemeljskega okolja.
Ključne besede: jame, monitoring, Srednja Amerika, Karibi.

Abstract UDC: 551.44.001.5(728/729)

Michael Day & Susan Koenig: Cave monitoring priorities in Central America and the Caribbean

Karstlands cover about 300,000 km^2 (50%) of the land area of Central America and the Caribbean. The number of caves is probably tens of thousands. Cave monitoring is uncommon throughout Central America and the Caribbean, and is generally accorded a low priority by agencies responsible for environmental management and conservation. Exceptions occur only in some protected areas and in a few commercial caves. Fundamentally, it is not recognized generally that there is a need to monitor caves. Beyond that, monitoring is limited severely by paucity of funding, equipment and qualified personnel. Cave monitoring clearly is warranted, however, because cave environments are inherently fragile and because the karstlands are under increasing developmental pressures. In these contexts, selected inventorying and monitoring programs seem advisable in at least some of the more significant caves. Such monitoring programs might focus on physical environments, historic and prehistoric remains, faunal populations, resource extraction, water quality and human visitation. Equally importantly, surface karst environments need to be monitored too, because degradation at the surface will almost inevitably be mirrored by deterioration in underground conditions.
Key words: caves, monitoring, Central America, the Caribbean.

INTRODUCTION

Central America and the Caribbean jointly constitute one of the World's premier karst areas, with karstlands covering a total of about 300,000 km^2, or approximately 35% of the land area (Day, 1978, 1993; Kueny, 1999; Kueny & Day, 1998 and in press). Of the approximately 160,000 km^2 of karst in Central America (not including the bulk of Mexico), over 75% is in the Yucatán Peninsula, with other significant areas in Guatemala, Belize and Honduras. Ninety percent of the Caribbean's 130,000 km^2 of karst is in the Greater Antilles, particularly Cuba, Hispaniola, Jamaica and Puerto Rico, with smaller areas in the Bahamas, the Lesser Antilles, Trinidad and the Netherlands Antilles.

The carbonate rocks are highly variable, and range from Holocene to Jurassic in age (0-200 m years BP). Their dissolution has produced a wide range of karst landscapes, including dry valley networks, dolines (sinkholes), polygonal karst depressions (cockpits), residual hills (cones and towers), and extensive cave systems. The regional karstlands have been influenced markedly by tectonic, eustatic and climatic changes Gardner, 1987), and human impact on them has been considerable (Day, 1993). Approximately 16% of the total regional karst area has been afforded protected area status, although nationally the proportions are highly variable, with karst conservation in general being most pronounced in Belize, Honduras, the Yucatán, Cuba and the Dominican Republic (Day, 1996; Kueny, 1999; Kueny & Day, 1998 and in press).

Karst cave systems, many of them large and extensive, characterize the regional karstlands (Middleton & Waltham, 1986). Regionally, the precise number of caves is, of course, unknown, but it is probably tens of thousands, many of which have not been surveyed or recorded. In many countries and karst areas there have not been exhaustive inventories of the cave systems, with some notable exceptions, such as that for Jamaica by Fincham (1997) and for Belize by Veni (1996).

Significant Central American cave areas include the Yucatán Peninsula, with its extensive water-filled conduit systems and cenotes. There are also extensive river cave systems in Guatemala and Belize, including the Chiquibul River System (Miller, 2000).

Caves elsewhere in Central America are numerous, although less well known. In the Caribbean there are extensive cave systems in the Greater Antilles, particularly in Cuba, Jamaica and Puerto Rico. Caves in Hispaniola are less well known, and there are also numerous, although less dramatic cave systems on the smaller islands.

CONSERVATION AND PROTECTION OF KARST AND CAVES

Conservation of karst and caves in the Caribbean and Central America is a subject of considerable contemporary concern (Day, 1993; Kueny, 1999; Kueny & Day, 1998 and in press). In 1997 the International Union for the Conservation of Nature and Natural Resources (IUCN) World Commission on Protected Areas (WCPA) recognized karst landscapes as significant areas in need of protection (Watson et al, 1997), and in the same year, the Caribbean Conservation Association identified "protected areas" as one of its principal education and research themes (Medina, 1997). Watson et al (1997) identify numerous rationales for protecting karst landscapes, including the following: as habitats for endangered species; because of rare minerals and/or unique landscapes;

as important historic and prehistoric cultural sites; as significant areas for scientific study; as religious and spiritual areas; as areas of specialized agriculture and industry; as important to the understanding and maintenance of regional hydrology; and as recreational and tourism areas with associated economic and aesthetic value. A valuable regional corollary, focusing on East Asia, is provided by Vermuelen & Whitten (1999).

Human impacts upon the karstlands of Central America and the Caribbean have been long term and severe except in the most isolated and rugged areas and where population densities are lowest (Day, 1993, 1996). Of greatest impact have been forest clearance, species introduction, agriculture, utilization of water resources, urbanization and industrial activities, including mining and quarrying. Human impact began prior to European contact, when native populations may have been as great as 100 million in Central America and six to eight million in the Caribbean (Watts, 1987).

In general, efforts to conserve and protect karstlands in the region have been uncoordinated and of limited scope. A modest 14% of the Caribbean's karst landscape, about 18000 km^2, has been conserved within 121 protected areas, with 90% of that in the Greater Antilles (Kueny, 1999; Kueny & Day, 1998). In Central America just over 18% of the karst is afforded protection in 47 protected areas totaling nearly 28000 km^2, with most of this by area in the Yucatán and the highest national percentage in Belize (Day, 1996; Kueny, 1999; Kueny & Day, in press). Most of these karst areas are so recognized not for their intrinsic value as karst landscapes but for their significance in other, not unrelated contexts, such as their biological diversity, hydrological significance, archaeological interest and recreational value. Even so, real protection is not guaranteed, and many protected karst areas are subject to forest clearance, agricultural incursion, water contamination, and the looting of archaeological materials. Management and policing are of variable effectiveness, and in some areas are non-existent, with some of the largest and most significant reserves being the most vulnerable (Kueny, 1999). The situation is also highly volatile, with reserves being created and disestablished on a regular basis.

Regional conservation of caves is equally fragmentary, with significant differences in scope and accomplishment between individual countries. Ideally, caves would be conserved within the context of broad regional karstland conservation, following the recommendations of the IUCN World Commission on Protected Areas (Watson et al., 1997), but this is rarely the case. Broadly, cave conservation regionally encompasses several overlapping categories of interest:

1. Caves may be conserved because they fall within protected karst areas.
2. They may be conserved because they are specifically designated as sites of anthropological or archaeological importance.
3. They may be conserved because they are sites of cultural or historical importance.
4. They may be conserved as sites of biological or other scientific significance.
5. They may be conserved as commercial entities.
6. They may be conserved for other economic, personal or government purposes.

Few Caribbean or Central American caves are managed as part of an integrated conservation strategy, except where they are located within protected areas. Even in this situation, environmentally sound cave management may be subordinated to other concerns, such as maintenance of surface biotic communities. Management of commercially operated caves is usually geared towards provision of visitor comforts and safety, rather than towards environmental protection. Only in Puerto Rico is there specific national legislation designed to protect caves, although that is poorly enforced.

Many Cuban caves are regarded as culturally and historically significant, particularly as a consequence of their military role during the 1959 socialist revolution, and "…the science, exploration, and conservation of caves are taken very seriously in Cuba, with a central institute and caving groups in every region." (Middleton & Waltham, 1986, 61).

President Fidel Castro has considerable personal experience of caves and during the revolution he gained an appreciation "...for this fragile environment, emphasizing the protection and conservation of caves" (Schenck et al, 1999, 300). Speleological groups have played a prominent role in recent Cuban history (Jimenez, 1987). Cuban vcaves also have considerable archaeological significance.

Cave conservation in Hispaniola is largely as a consequence of other efforts. For example, del Este National Park, in the Dominican Republic, contains "…several cave systems of anthropological importance" (IUCN, 1982, 190-191). Cave conservation in Jamaica is similarly disorganized, with only a handful of caves afforded any meaningful protection. The commercially operated Green Grotto, on the north coast, is the only cave to have undergone an environmental impact study. Windsor Great Cave, in Trelawny Parrish, while exploited for guano and tourism for the past seventy years, is starting to receive some conservation because the former owner donated the land title to WWF-UK with stringent terms of reference, and because of the presence of the nearby Windsor Research Centre. Maintenance of a visitor log is required under the terms of reference, but this is poorly maintained owing to a lack of proper signage. An integrated conservation strategy for Jamaica's Cockpit Country, with specific reference to cave communities, is being developed under the Nature Conservancy's Parks-in-Peril programme (Chenoweth et al, 2001).

In Puerto Rico, the Rio Camuy Caverns State Park, near Aricibo, is one example of a small but well-protected karst area (Vale, 1999), as is Ensueno Cave, a privately-operated cave with a well-integrated management plan (Gurnee, 1987). Puerto Rico has a specific, if poorly enforced Cave, Cavern and Sinkhole Protection Law (Law 111 of 1985). In 1999, in response to efforts by the Ciudadanos del Karso and the Fundacion de Investigaciones del Karso Puertorriqueno, Law 292 was created for the Protection of the Karst Physiography of Puerto Rico. These are, in some senses, isolated examples, and the northwest karst belt of Puerto Rico has been listed as one of the Karst Waters Institute's 10 most endangered karst ecosystems (Tronvig & Belson, 1999).

Barbados has a Caves Authority, established in 1977 and amalgamated in 1982 into the National Conservation Commission. Harrison's Cave is one of the few caves in the eastern Caribbean that has been studied intensively and for which there is a conservation strategy (Gurnee, 1978, 1994; Hobbs, 1994). Another exception is Fountain Cavern, in Anguilla (Gurnee, 1989). In the Bahamas, important submerged island flank cave systems are incorporated within protected areas, including Lucayan National Park on Grand Bahama (Middleton & Waltham, 1986). In Trinidad several caves are conserved as the habitat of the Oilbrid or Guacharo (Steatornis caripensis).

In Belize all caves are potential archaeological sites and, as such, fall under the jurisdiction of the Department of Archaeology, with permits being required for entry. Specific caves are protected within national parks and similar reserves. For example, three significant caves - St. Herman's, Petroglyph and Mountain Cow - are within the Blue Hole National Park (Day, 1996). Similarly, the Chiquibul National Park contains portions of the Chiquibul Cave System (Miller 1996). In neighboring Guatemala the Cuevas de San Miguel are conserved within a wildlife refuge, and in Honduras the Talgua Cave (Cave of the Glowing Skulls) is located within the Sierra de Agalta National Park, and the Cuevas de Taulabe are incorporated within a national monument (Kueny, 1999). In Costa Rica Caverna Nicoa, which contains indigenous pre-Columbian artifacts, is conserved within the Barra Honda National Park.

CONTEMPORARY CAVE MONITORING

Cave monitoring is uncommon throughout Central America and the Caribbean, and it is generally accorded a low priority by individuals and agencies responsible for environmental management and conservation, even though it has the potential to be a valuable indicator of overall environmental health. Fundamentally, it is not generally recognized that there is really a need to monitor caves and, beyond that, potential monitoring is limited severely by paucity of funding, equipment and qualified personnel.

Exceptions occur in some protected areas and in a few commercial caves, but these are generally the result of individual initiatives, dispersed in space and time, rather than facets of long-term, holistic studies. Such monitoring as does occur is generally haphazard and restricted to the assessment of specific individual parameters, in most cases the status of faunal populations.

There have been numerous, although disparate studies of bats, birds, fish, insects and other faunas in Central American and Caribbean caves. Most of these studies have focused on taxonomic description and delineation of species' ranges. Unfortunately, few have continued over extensive time periods, and thus they do not provide much help in assessing population changes over time. Notable examples include the studies by Hobbs, Reddell and others in Central America (Hobbs, 1993; Reddel, 1981; Reddell and Veni, 1996). Ongoing studies of faunal populations have been instituted in selected caves, but these are the exceptions. For example, there is ongoing monitoring of the bat populations in Windsor Great Cave, in Trelawny Parrish, Jamaica, by the Windsor Research Centre and affiliated researchers. Another example is ongoing research into the ecology of caves in Trinidad (Darlington, 1993). For an exhaustive review of cave ecology see Wilkens et al (2000).

Likewise, there have been numerous regional geomorphological and related cave studies which could be potentially valuable as the bases for monitoring projects, for example because they have evaluated water quality, sediment loads, and/or cave meteorology, but few of these studies have a lengthy history, again with a few exceptions, notably in Cuba (e.g. Batista & Rodriguez, 1986).

In Belize the Department of Archaeology's jurisdiction permits at least some form of monitoring of visitor numbers in certain caves. For example, the Blue Hole National Park, including St. Herman's Cave, receives about 6000 visitors annually. Che Chem Ha, in the Cayo District of western Belize, is a privately owned and operated cave, but the owners are required by the Department of Archaeology to maintain a visitors log and to lock the cave entrance when no visitors are present.

CAVE MONITORING PRIORITIES

Cave monitoring is best regarded as but one aspect of overall karstland management, with its primary objective being to assess the degree of success in the maintenance or establishment of a sustainable and acceptable karst environment. Thus it is a means to an end, not solely an end in itself. Monitoring is necessary to assess the success of management plans and objectives, perhaps most succinctly expressed for karstlands as “Management… to maintain natural flows and cycles of air and water through the landscape in balance with prevailing climatic and biotic regimes.” (Watson et al, 1997, 18).

Despite the lack of previous recognition and the logistical limitations mentioned above, cave monitoring clearly is warranted, however, because cave environments are inherently fragile and because the caves themselves and the karstlands in general are under increasing developmental pressures. Specific reasons to embark upon cave monitoring projects, or to expand existing endeavours, include the following:

1. The caves are sensitive indicators of overall environmental health.
2. They are integral to regional hydrology and water supply.
3. They contain significant and specialized biotic communities.
4. They contain significant abiotic resources.
5. They are potentially important recreational sites.
6. They may contain valuable anthropological, archaeological and/or historical evidence.
7. They may be important in other scientific contexts.

Manifestly, the highest cave monitoring priority is to audit the overall health of cave environments. In this context, critical indicators are variables such as air quality, water quality, other abiotic factors, such as sedimentation rates, rates of speleothem growth, and the vitality of floral and faunal populations.

Environmental health in caves must also be seen within the bigger picture of the overall health of the associated surface karstlands. Degradation in cave environments is in many cases the consequence of changing surface conditions, and there is a dynamic relationship between the two. Caves do not exist in a vacuum, and in this context it is necessary to develop parallel inventorying and monitoring of surface karst conditions and resources, including such parameters as surface air and water quality, the health of floral and faunal surface communities, rates of erosion and sediment transport, human population changes, and associated indices such as the extent of urbanization or industrialization.

A fundamental aspect of such monitoring is to conduct inventories of existing conditions, so as to create a baseline reference against which to measure either negative or positive changes. This is a critical first step in the monitoring process, and one that will enable the identification of specific resources requiring conservation.

Another reason to monitor and conserve caves is to protect their integrity as natural laboratories for scientific research. The importance of caves as repositories of evidence of paleoenvironments, for example, is well documented (e.g. Gillieson, 1996), and such crucial records can be compromised or destroyed as a result of human induced changes in cave environments. Even so, cave environments have some resiliency, and in this context even a disturbed cave is preferable to total destruction, as may result, for example, from uncontrolled quarrying.

Much the same holds true for the archaeological and historical significance of caves. Regionally, caves have been used by people for a wide variety of purposes and for extended periods of time (Gillieson, 1996; Kempe, 1988). Pre-European inhabitants of Central America, such as the Maya, for example, used caves as shelters, for water supply, and for ceremonial and/or religious purposes (Veni, 1990; McNatt, 1996). Careful inventory of such cave archaeological sites and environments has been limited, but should be a precursor to any cave monitoring, management or development project.

Water quality is a parameter that has major ramifications for cave and karst ecosystems because it influences speleological processes themselves, as well as impacting biota and affecting potential water supplies for human use. For this reason, monitoring of cave water quality, particularly for contaminants should have a high priority. Instrumentation for such monitoring is, however, relatively expensive by local standards unless underwritten by scientific or commercial funding agencies.

There have been virtually no studies of air quality variation through time in Caribbean and Central American caves, although air quality deterioration, particularly involving increased levels of carbon dioxide and increased temperatures, has been documented particularly in commercial caves elsewhere and may have significant implications for caves faunas and cave artifacts, including cave art (Gillieson, 1996). As for water quality, monitoring of these changes is relatively straightforward but is constrained locally by cost.

Other cave resources that merit monitoring include those of current or potential economic significance. For example, the excavation from caves of bat guano has been historically significant throughout the region, primarily for use as fertilizer. In selected locations cave guano is still highly sought after by local farmers and entrepreneurs, and monitoring projects are warranted locally to assess the extent of depletion and rates of contemporary accumulation. Similarly, cave formations (speleothems) may be removed for sale or decoration by insensitive or unwitting people, and such harmful activities merit continuing attention, investigation and, if necessary, intervention.

Concomitant with guano extraction is the need to monitor the reduction and prevent any possible local extermination of bat colonies or individual species within colonies. Loss of bat populations, particularly on karst-dominated islands where they represent the most abundant native mammalian biomass, will have significant ecological and economic effects as bats serve as pollinators, seed dispersers, and consumers of insects, many of which are pests to humans and to agricultural crops.

Monitoring of cave faunas has received an understandable and probably justified preponderance of effort. This is because faunal populations are relatively conspicuous candidates for monitoring, and it may also reflect a more general concern for conservation of wildlife. Nevertheless, changes in cave faunas are potentially important indicators of broader environmental changes, and monitoring of cave animal populations clearly is warranted. As Gillieson (1996, 203) has noted, "Cave biota…are…severely disadvantaged by quite minor disturbances. Thus they have low resilience in the face of a change to the cave ecosystem. The spectrum of impacts on caves have serious consequences for their biology and ecology, and adequately conserving cave biota is a major challenge for protected area management." In Central America and the Caribbean inventorying of cave biota is yet at a preliminary stage, with short scientific studies serving only to hint at the true diversity of regional cave life.

Auditing of visitor numbers is needed in many instances and should be a high priority, especially where caves are operated commercially or are heavily visited by local residents and/or foreign visitors, including cavers. At present reliable figures are available for very few caves in the region. In most cases there is simply no record maintained. Even for commercial operations the available numbers are unreliable, for example because commercial operations have incentives to under-declare visitor numbers and income in order to reduce tax liability.

Visitor impacts need to be assessed likewise, particularly in the light of the well-documented effects of large numbers of visitors on cave systems elsewhere in the World (e.g. Huppert et al., 1993; Gillieson, 1996). Regionally one obvious impact of visitors is the refuse deposited in caves, along with the ubiquitous graffiti. Elsewhere it has been shown that the introduction of foreign substances into caves can have profound impacts on cave ecosystems (Gillieson, 1996).

Cave monitoring priorities need to be established so as to provide a meaningful overall assessment of cave and karst environmental health. Clearly it is not feasible to institute monitoring programs in large numbers of caves, particularly those in remote areas and to which access is limited. Likewise, it is not easy to justify more than a limited number of monitoring programs in caves that are not subject to disturbance. Perhaps the most pragmatic approach is to institute concerted, integrated monitoring programs in well- known caves whose significance in various contexts is already widely recognized and acknowledged, where evidence of environmental degradation is already present, and where there is concern for the caves' integrity and welfare.

CONCLUSION

Cave monitoring is poorly developed in Central America and the Caribbean, and is hampered by a general lack of awareness of its importance and utility. Other impediments include limited funding, the absence of requisite equipment, and the scarcity of qualified personnel. Given the regional significance of the caves in a wide variety of contexts, cave monitoring programs clearly are warranted, and should be integrated so as to provide as holistic an assessment of karst ecosystem health as is possible. Monitoring might best be instituted in some of the better known, more heavily visited caves whose scientific and other significance are already recognized and whose conservation thus perhaps engenders the most ready support.

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PREDNOSTI MONITORINGA V JAMAH SREDNJE AMERIKE IN KARIBOV

Povzetek

Kras pokriva okrog 300.000 km^2 ali okoli 50 % ozemlja Srednje Amerike in Karibov. Natančno število jam v teh kraških predelih je neznano, verjetno jih je več desettisoč, od katerih jih je mnogo neraziskanih oziroma niso zabeležene. V celotni Srednji Ameriki in Karibih je monitoring v jamah zelo redek in agencije za urejanje in varstvo okolja ga nizko cenijo. Izjeme se pojavljajo le v nekaterih zaščitenih področjih in v redkih turističnih jamah, toda tudi v teh primerih je monitoring bolj slučajen in obsega le elemente, ki se zde posebej zanimivi, običajno so to populacije jamskega živalstva. Z mnenjem, da je monitoring res potreben, se v splošnem ne strinjajo. Poleg tega je monitoring omejen zaradi nezadostnih denarnih sredstev, zaradi pomanjkanja opreme in ustrezno usposobljenega osebja. Vendar je monitoring v jamah nedvomno potreben, kajti jamsko okolje je izrazito občutljivo in kraška pokrajina doživlja naraščajoč pritisk zaradi razvoja. Jame so namreč zelo pomembni potenciali za preučevanje nekdanjega okolja in za paleontološka preučevanja; so vključene v regionalno oskrbo s pitno vodo; v njih so pomembne populacije podzemeljskega živalstva; v njih so pomembne ekonomske surovine, kot npr. netopirski guano; to so mesta posebnega antropološkega in zgodovinskega pomena; in vedno pomembnejše postajajo

kot turistične točke. V tej zvezi sta nujni izbrana inventarizacija in program monitoringa vsaj v bolj pomembnih jamah. Taki programi monitoringa so lahko usmerjeni na fizično okolje, zgodovinske ali predzgodovinske ostanke, jamsko favno, izkoriščanje surovin, kakovost vode in turistični obisk. Enako pomembno je opravljanje monitoringa na kraškem površju, kajti degradacija površja se nujno odraža tudi v slabšanju in uničevanju podzemeljskega okolja.