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STATUS SURVEY OF THE CAVE SCORPION *Chaerilus chubluk* IN A VOLCANIC CAVE, KRONG NO DISTRICT, DAK NONG PROVINCE

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Abstract. Status survey of the cave scorpion, *Chaerilus chubluk* Lourenço, Tran & Pham, 2020 was carried out in a volcanic cave**,** in Krong No district, Dak Nong province in 2022 and 2023. A total of 43 individuals were recorded, among which 25 individuals in 2022 and 18 individuals in 2023. This species is only known from Co cave which is now strongly threatened by human impact. Based on the current area of occupancy (AOO) and the extent of occurrence (EOO) of *C. chubluk*, associated with its recent regression in both AOO and number of individuals, this species is tentatively classified as critically endangered by IUCN. The research results are presented for the first time, as scientific data for the conservation of this scorpion and integrated into the IUCN database.

Keywords: *Chaerilus chubluk*, conservation status, IUCN criteria, volcanic cave.

1. Introduction

The most critical threat to scorpion species is the destruction of their natural habitat. Habitat loss and habitat destruction have a strong influence on scorpion distribution patterns since many species have quite specific habitat requirements and well-defined distribution patterns. Many natural areas, previously suitable for scorpions, are currently destroyed. Many specific habitats within these natural regions are rapidly destroyed

due to logging, agriculture, construction development, and increment of tourism. Natural habitats of all kinds are destroyed at an alarming rate [1]. Many scorpion species are literally losing their 'homes' and they could rapidly vanish.

Caves represent unique habitats inhabited by specialized, endemic scorpion species. Howarth (1983) [2] suggested that invertebrates including scorpions found in caves were quite particular in morphology and showed high endemic levels. The separation of cave ecosystems from external environments, with differences in light regime and moisture, can lead to the speciation of cave forms which can become adapted to the particular cave environments. Presently in Vietnam, some caves are exploited for tourism development and consequently, many cave scorpion species are threatened by human impact. These will become extinct unless conservation actions are implemented. The development of tourism has not only destroyed the natural structure of caves but also affected the fauna living in the caves. The cave scorpions include the world's most threatened species, and the cave ecosystems are isolated from outside habitats. In northern Vietnam, two cave scorpion species (*Euscorpiops cavernicola* and *Vietbocap thieduongensis*) are threatened by various factors. According to the known data on their distribution and habitat status, the two species should be ranked as globally Endangered or Vulnerable [3], [4].

The new species *Chaerilus chubluk* Lourenço, Tran & Pham, 2020 (Scorpiones: Chaerilidae) was described based on a pre-adult individual. *Chaerilus chubluk* was recorded in Co cave, a volcanic cave that belongs to the Krong No Volcanic cave system, Krong No district, Dak Nong province. It represents the first scorpion to be found in a volcanic cave in Vietnam probably not having true troglobitic elements and shows at least a much less degree of adaptation to caves than other scorpions from Vietnam such as those of the genus *Vietbocap* Lourenço & Pham, 2010, which show a total adaptation to cave life [5]. In fact, the habitat of this scorpion species is probably getting narrowed due to human impact as long as its conservation status remains unassessed.

This paper is presented for the first time on the current status of the volcanic cave scorpion based on IUCN criteria and on the available data obtained on the species in order to make recommendations to the local and national authorities for consideration.

2. Content

2.1. Material and methods

Co cave, where *Chaerilus chubluk* was found, is located 7452 m northwest of Chu B'Luk volcano and is considered the last cave of the C cave system to the northwest of this volcano. The Co cave outlet is located about 70 m south of the Dray Sap Landscape Special Use Forest. The topography of the Co cave area is quite flat, slightly rough (highly floating) in the upper part of the cave forming a thunderstorm-ledge running in the sub-latitude, coinciding with the development of Co cave. The entrance of the cave has an altitude equivalent to the current topographic surface of the area; it is small in size and hidden under a tree so it is difficult to be detected. Basalt pits, dark gray,

blocky structures distributed on the surface of this area are in most cases discrete blocks and boulders often pierced by the root system, which increases the level of cracking, especially around the area of the main cave. Movements in this area should be done with attention. The cave length is 575.5 m and the depth is around 14.9 m. Co cave entrance is only a narrow and rugged niche, about 2 m wide, of which the highest portion is only about 0.7 m - 0.8 m. Consequently, the access to the cave is rather difficult.

The lava cave system of the Chu B'Luk volcano was formed from basalt lava flow with high temperature (1000 - 12000 °C) and low viscosity produced during the Chu B'Luk eruptions which occurred about 700,000 to 200,000 years ago, Therefore, these events belong to the Middle Pleistocene (Q12), and Xuan Loc Formation (12Q12 xl). The results of the K/Ar absolute isotopic age analysis of fresh basalt samples collected on the ceiling of C6.1 cave and C2 cave walls have 689,000 years and 668,000 years, respectively. Thus, the age of Co Cave formation is expected to be of equal value [6].

This survey is composed of two major components: a demographic study and the habitat conditions. The demographic study targeted a specific population. Demographics are the quantifiable statistics of a given population to characterize such a population at a specific point in time. Demographics can be viewed as an essential information source about the population of a region. Demographic data include population size (number of individuals) and age structure (adults, juveniles). Ultraviolet light was used to scan every site within a 5 meters distance in the cave for one hour. The cuticle of scorpions fluoresces to a bright green under UV light making individuals easy to detect in a relatively non-invasive way [7]. Scorpions were collected using forceps, then photographed, marked with an individual dot number using non-toxic paint, and returned to the capture place.

The second component of the survey is habitat condition throughout all the sites in the cave. The survey results lead to an assessment of the habitats: disturbed or undisturbed habitats, invasion by exotic species, light regime, rubbish, noise, and so on. All these results should lead to an estimation of the population reduction of the target species.

In addition, other surveys were carried out in other caves in the area to ascertain the total surface of occupancy. The survey was conducted in two periods with a duration of 10 days each. To assess the conservation status of each species, IUCN criteria will be used together with data obtained during the survey period to produce recommendations to the local and national authorities [8].

The survey was carried out during August for two consecutive years, 2022 and 2023.

2.2. Results and discussion

Of the total of 25 individuals recorded in 2022, 8 were adults and 17 were juveniles. Some of the adults and juveniles recorded in 2022 were not found again during the 2023 survey (Table 1).

This species is known from only Co cave which is strongly disturbed by tourism development. The inside environment of the cave is polluted by visitors' activities, such

as eating, drinking, and smoking. This results in a large amount of rubbish throughout the cave's space. The rubbish includes plastic bottles, fruit juice cartons, beer and soft-drink cans, footwear, clothing, fruit peels, egg-shells, and peanut shells. These food wastes have the potential to attract pest species into the caves, artificially altering community structures and greatly impacting the natural species diversity in the cave systems. The constant light has a detrimental effect on the invertebrate populations in the caves. It also creates a fantasy world that is a potential source of the excitement (exhibited as noise) felt by visitors in the cave. This noise will be of great disturbance to the invertebrate populations within the cave systems. Due to the undefined nature of the pathways in a cave, the floor of each cave has been badly trampled with any suitable habitat and destroyed.

Table 1. Data on the abundance of Chaerilus chubluk recorded in 2022 and 2023

Types and a total of individuals	**Individuals recorded**	
	In 2022	***In 2023***
Adults	8	5
Juveniles	17	13
Total number of individuals	25	18

The five criteria used by IUCN assessments are (a) reduction in population size; (b) small geographic range; (c) small population size and decline; (d) very small or restricted population; and (e) quantitative analysis of extinction risk (International Union for Conservation of Nature 2001). An overview of the IUCN criteria and its applicability to *Chaerilus chubluk* can be seen in Table 2. Criteria (b), (c), and (d) are applicable while (a) and (e) are data deficient due to the lack of additional observations. Criteria (d) meet the category of Endangered but criteria (b) and (c) are at the highest level of threat, thus receiving priority over the former.

Table 2. Overview of the IUCN Red List criteria, and its applicability in the present study. (AOO-Area of Occupancy; EOO-Extent of Occurrence; n-mature individuals)

Criterion	**Critically endangered**	**Endangered**	**Vulnerable**	**Applicability**	**Justification /decision**
A. Population reduction (over 10 years or three generations)	(≥ 90% and causes are reversible, understood and ceased) or ≥80%	(≥70% and causes are reversible, understood and ceased) or ≥ 50%	(≥50% and causes are reversible, understood and ceased) or ≥30%	No	Insufficient data
B. Geographic range	(EOO <100 km^2 or AOO <10 km^2) and two of (a) fragmentation	(EOO <5000 km^2 or AOO <500 km^2) and two of (a) fragmentation	(EOO <100 km^2 or AOO <10 km^2) and two of: (a) fragmentation	Yes	Critically endangered

	and/or a single location; (b) continuing decline; (c) extreme fluctuations	and/or locations ≤5; (b) continuing decline; (c) extreme fluctuations	and/or locations ≤10; (b) continuing decline; (c) extreme fluctuations		
C. Small population size and decline	n < 250 and (reduction ≥25% over 3 years or one generation or (reduction and (larger subpopulation ≤ 50 or ≥90% individuals in a single subpopulation or extreme fluctuations)))	n < 2500 and (reduction ≥20% over 5 years or two generations or (reduction AND (larger subpopulation ≤250 OR ≥95% individuals in a single subpopulation or extreme fluctuations)))	n < 10,000 and (reduction ≥10% over 10 years or three generations or (reduction and (larger subpopulation ≤1000 or 100% individuals in a single subpopulation or extreme fluctuations)))	Yes	Critically Endangered
D. Very small or restricted population	n < 50	n < 250	n < 1000 or AOO < 20 km^2 or locations	Yes	Endangered
E. Quantitative analysis of extinction risk	≥ 50% over 10 years or three generations	≥ 20% over 20 years or five generations	≥ 10% over 100 years	No	Insufficient data

The criteria and their applicability to IUCN assessments of *Chaerilus chubluk* are exposed in detail in Table 2. Some comments on each one of them are as follows:

- To use criterion (A), a good estimate of the relative temporal change in species abundance is needed. However, it is usually difficult to determine the total abundance of a particular species of invertebrate. In the present study, population size was inferred using a methodology that involved high sampling effort over the entire area. However, as no similar sampling of the species was made before this study, comparable data is not available and this criterion should not be applicable to the risk assessment of *Chaerilus chubluk*;

- Criterion (B) can be analyzed in both terms of the Extent of Occurrence (EOO) and Area of Occupancy (AOO). Because this species is known from only one cave, its known range is about 0.035 square kilometers, so EOO and AOO fit the category of

Critically Endangered (EOO < 100 km^2, AOO < 10 km^2). The cave as an isolated habitat from others and species known from only one cave provided evidence about fragmentation and single location. Adding to the fact that the habitat is threatened by uncontrolled and increasing tourism practices, the quality of this habitat is continuing to decline (requirement B2(B)(iii)), so the category of Critically Endangered is the one best suited for criterion (B);

- Criterion (C) fits the category of Critically Endangered due to the abundance only recorded 43 individuals with 25 individuals for 2022 and 18 individuals for 2023, and subpopulation ≤ 50;

- The abundance estimation mentioned for the criterion (C) is above the threshold value for the category of Critically Endangered in the criterion (D) with n < 50;

- Criterion (E) demands a large amount of data, which is not available so far.

From the applicable criteria, (B), (C), and (D) the authors have classified *Chaerilus chubluk* as Critically Endangered.

3. Conclusions

The first scorpion to be found in a volcanic cave in Vietnam, *Chaerilus chubluk*, has a habitat that is probably getting narrowed due to human impact as long as its conservation status remains unassessed. This study has classified *Chaerilus chubluk* as Critically Endangered. Based on the present data, this classification should be integrated into the IUCN database.

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