Bioclimatic of mycosis among wild and endemic animals captive-bred at Tsimbazaza Park in the Madagascar

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Abstract: The Madagascar is renowned as a country with a high endemism Fauna. The island is among the hotspot biodiversity countries. In fact, some infectious diseases are harmful for its wild endemic animals but related information is lacking. This study is carried out to overcome at this deficit. The method of records’ research is used to estimate the incidence of the mycosis among these animals which were captive-bred at the Tsimbazaza Park. Then, a bioclimatic study is done to appreciate the influence of climate on the development of fungal pathogens and its impact on animals. During the period of observations from year 2011 to April 2018, three types of mycosis (ringworm, aspergillosis and candidiasis) are affected twelve animals: three of them are healed and the rest died mostly by sudden death. Aspergillosis was common than the others type of infections. All classes of animals (mammals, aves, reptiles) are concerned with eleven endemic species listed on the red list of International Union for Conservation of Nature (IUCN). Females were more vulnerable than males. The optimum of diseases are located in 2016 and 2017, recorded among the global warmest years. These conditions was favorable both for generating discomfort within the living organisms and for fungus development. Infections were more significant at the two periods of off season in the Madagascar. These outcomes will help in improving the management of the conservation program by taking into account climate-pathological risks. They may be used too, as eco epidemiology indicators on prevention of the mycosis infections in the Madagascar.

Keywords: Bioclimatic, eco epidemiology, hotspot biodiversity, mycosis, Madagascar, wild endemic animals.

1. Introduction
The Madagascar’s isolation over than millions of years is an ideal condition for the development of a highest endemic biodiversity. The International Conservation has recorded among the Malagasy Fauna: i) 101 endemic primate species and subspecies, (ii) five endemic bird families which represent 51% of the diversity, iii) 370 reptile species with 90% endemic, not found nowhere else (Conservation international, 2017). In 2016, the UNEP-WCMC has classified the island among the hotspot biodiversity countries (MEEF, 2016). In fact, infectious diseases such mycosis are harmful for these wild endemic animals while related information is lacking. This retrospective research aims to fill this gap by estimate the incidence of the mycosis infections among these animals captive-bred at Tsimbazaza Botanic and Zoology Park (PBZT). Then, a bioclimatic study is carried out to appreciate the relationship between climate conditions within discomfort of living organisms and the development of fungal infections. The outcomes of the study will help mainly to improve the conservation program and to prevent mycosis diseases in the Madagascar.

2. Site and Methods
2.1 Site
The PBZT is positioned at 1261m altitude in the capital of the Madagascar. It is set in the sub humid climate stage attenuated by fogs in the dry season (Cornet A., 1974). The Park is assigned for the conservation of endemic species exposed to extinction in their natural local. It participates in the implementation of the national strategies and policies on climate change and biodiversity (MeSupRes, 2015).

2.2 Methods
Investigation of the zoo stored data
A research method using zoo records is done (Holly Farmer and al., 2013). The investigation concerned the archives information which are stored from year 2011 to April 2018 at the Zoo. They are related to: i) scientific name, ii) sex, iii) clinical data,
including details of symptoms, treatment given, iv) year of the infection, v) finality of disease: healed or death with the date, vi) the results of post-mortem examination: organs or tissues lesions after dissection observations and laboratory investigations\(^2\) to specify the kind of mycosis.

**Bioclimatic study**

Climate data (temperature and rainfall) from national meteorology office is used to appreciate the relationship of climate on the fungus development and the discomfort of the living organisms. Humidity Index (HI) which measured the effects of combined heat and humidity on the body stress is used to class discomfort of living organisms according its value (Demoulin P., 1998):

- 20 <HI <29: Feeling of well-being
- 30 <HI <34: Feeling more or less uncomfortable
- 35 <HI <39: Sensation of large discomfort. Care or may extend to general feeling of discomfort.
- 40 <HI <45: Danger.

### 3. Results and Discussion

#### 3.1 Mycosis, species and their IUCN status

Three kinds of fungal infections are identified to distress wild endemic animals. These are: ringworm, candidiasis and aspergillosis. Twelve (12) species in all classes of animals (reptiles, aves, primate and non-primate mammals) are affected by mycosis. Only one species, *Chrysolopus pictus* (*Chrysolopus p.*), was not an endemic animal; ten (10) of them are endemic species listed in the International Union for Conservation of Nature's red list (IUCN, 2011). The classes on the red list are following:

- **Class in “danger of extinction” (EN):** three species (03): *Anas bernieri* (*Anas b.*), *Circus macrosceles* (*Circus m.*), and *Lemur catta* (*Lemur c.*)(Tab.1).

<table>
<thead>
<tr>
<th>Photo 1 PBZT</th>
<th>Class: Aves</th>
<th>Ordre: Ansériformes</th>
<th>Family: Anatidae, Species: <em>Anas b.</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Photo 2 PBZT</td>
<td>Class: Aves</td>
<td>Order: Falconiformes</td>
<td>Family: Accipitrídeae, Species: <em>Circus m.</em></td>
</tr>
<tr>
<td>Photo 3 PBZT</td>
<td>Class: Primates</td>
<td>Order: Lemuriformes, Family: Lemuridae, Species: <em>Lemur c.</em></td>
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</tbody>
</table>

**Table 1: Animals in class of danger of extinction (IUCN)**

- **Class in «Vulnerable» (VU):** four species (04): *Eulemur rubriventer* (*Eulemur r.*), *Cryptoprocta ferox* (*Cryptoprocta f.*), *Falcula palliata* (*Falcula p.*), *Uratelornis chimaera* (*Uratelornis c.*)(Tab. 2).

<table>
<thead>
<tr>
<th>Photo 4 PBZT</th>
<th>Class: Primates</th>
<th>Order: Lemuriformes, Family: Lemuridae, Species: <em>Eulemur r.</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Photo 5 PBZT</td>
<td>Class: Aves, Order: Passeriformes, Family: Vangidae, Species: <em>Falcula p.</em></td>
<td></td>
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<tr>
<td>Photo 6 PBZT</td>
<td>Class: Aves, Order: Coraciiformes, Family: Brachyptéricalidea, Species: <em>Uratelornis c.</em></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2: Animals in class of Vulnerable (IUCN)**

\(^2\) Laboratoire National de Diagnostic Vétérinaire (LNDV) and Laboratoire de l’Institut Pasteur de Madagascar (IPM)

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• **Class in “Newar Threatened”** (NT): One species: *Lophobis cristata* (*Lophobis c.*) (number=2) (Tab.3).

Table 3: Animal in class of Newar Threatened (IUCN)

- **Class in “Least Concern”** (LC): two species (02): *Crocodile niloticus madagascariensis* (*Crocodile n. m.*) and *Anas platyrhynchos* (*Anas p.*) (Tab. 4).

Table 4: Animal in class of Newar Threatened (IUCN)

If the ringworm is observed for one animal and the candidiasis disease for two, in opposite, aspergillosis was common among nine animals. Three (03) animals are recovered after treatment: *Eulemur r.* from a ringworm disease and *Lophobis c.* and *Chrysolopus p.* from a light aspergillosis. Nine (09) others was dead with five (05) sudden death.

### 3.2 Animals by sex and years of disease

The Figure1 reports the dispatching of animals by sex within the study years.

For the year 2018, two animals (02) were affected: *Anas b.* and *Anas p.* Otherwise, two species are concerned by candidiasis: *Lemur c.* (year 2011) and *Crocodylus n. m.* (year 2014).

Females were more vulnerable to fungal infections with 9/12 proportion without direct relation with the breeding season.

**3.3 Post mortem lesions**

The following photos are shown some post mortem lesions due to deep aspergillosis and candidiasis with laboratories confirmations.

- Lesions due to aspergillosis

**Photos 10 PBZT:** Aspergillosis for *Cryptoprocta f.* The clinical symptoms were: Skin diseases at the beginning and after a few days of healing, relapse with weakness, dyspnea and slimming

![Photo 10 PBZT](image)

Elevation of infected sternum, bronchial bifurcation become umbilicated with granulomas in the lungs

Granulomas on the tissues of the heart

**Photos 11 PBZT:** Aspergillosis for *Anas b.* No clinical signs following but sudden death

![Photo 11 PBZT](image)

**Photo 12 PBZT:** Candidiasis for *Crocodylus n. m.* The clinical symptoms were deep abatement followed by sudden death

![Photo 12 PBZT](image)

Hemorrhagic lung associated with pulmonary edema

**Photos 13 PBZT:** Candidiasis for *Lemur c.* The clinical symptoms were: depilation and chronic inflammatory skin lesions followed by degeneration

![Photo 13 PBZT](image)
3.4 Mycosis infections and climate data

Warm temperatures with abundant rainfall are a favorable climate for the reproduction of fungal. Diseases are prevailing during the months of the two periods of off-season in the Madagascar: i) first off-season: between February to the end of April or the beginning of May and ii) second off-season: from September to beginning of October (Fig. 2).

Figure 2: Distribution of mycosis during the study period

<table>
<thead>
<tr>
<th>Year</th>
<th>Months</th>
<th>J</th>
<th>F</th>
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<th>A</th>
<th>M</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
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<td>2011</td>
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</table>

The death on July of *Lemur c.* is an exception because it is due to a long illness.

The common characteristics of the climate (temperature, rainfall) for each months of the study period, compared to the reference period 1961/1990 in the Madagascar were: i) minima temperatures higher than the average temperature, ii) an overall increase of maxima temperatures except for July 2014, and iii) rainfall with turbulences. These situations confirmed the effectiveness of climate ‘study change in 2008. In fact, it is projected that the changing would be expressed mainly in rise of the extreme temperatures (minima and maxima) and a disorder in the rainfall (DGM, 2008).

In addition, the results are reliable with the observations of the global warming about the warmer year’s records from 1880 to 2017, for the years 2016, 2017 and 2014 (Global Temperature Anomalies, 2018) (Tab. 5).

Table 5: Comparison of average-differences of the temperatures at the national and global levels on the warmer years

<table>
<thead>
<tr>
<th>Years</th>
<th>National average-deviation</th>
<th>Global average-deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>+1.36°C</td>
<td>+1.25°C</td>
</tr>
<tr>
<td>2017</td>
<td>+1.07°C</td>
<td>+1.13°C</td>
</tr>
<tr>
<td>2014</td>
<td>+ 0.83°C</td>
<td>+0.88°C</td>
</tr>
</tbody>
</table>

According the Global Climate Risk Index 2015, the Madagascar is ranked as the 8th most country affected by climate change with vulnerability risk (DGDFPE/MFB, 2016).

The measure of Humidity Index (IH) has confirmed the relationship between the discomforts of the living organism within the development of the fungi pathogens (Tab. 6).
The mycosis disease in well-being class (HI= 26 or 28) requires others considerations as habitat, food or captivity than only climate stress.

Global warming had significant impacts both on plants (Andriamalalanirina F., 2018) and on animals in the Madagascar.

4. CONCLUSIONS
Three kinds of mycosis (ringworm, aspergillosis, candidiasis) are affected all the classes of wild endemics animals captive-bred in the Tsimbazaza Park. Aspergillosis was the common fungal infections. Most species were on the IUCN red List. Females were more vulnerable than males mostly during the two periods of offseason in the Madagascar. Moreover, the maxima of the fungal infections are corresponded with the global hottest years. Climate stress had an impact both on animal's body discomfort and on the development of fungal pathogens.

The outcomes will help to improve the management of the conservation program by taking into account the climate-pathological risks. They may be used too as eco-epidemiology indicators on prevention of mycosis in the Madagascar.

REFERENCES


Table 6: Degree of discomfort measured by Humidity Index (IH) for each species at month corresponding on healed or death

<table>
<thead>
<tr>
<th>IH value</th>
<th>Class of discomfort</th>
<th>Species Healed (H) or death (D)</th>
<th>Date</th>
<th>Type of mycosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>Well-being</td>
<td>Falculea p. (D)</td>
<td>May 2016</td>
<td>Aspergillosis</td>
</tr>
<tr>
<td>28</td>
<td></td>
<td>Circus m. (D)</td>
<td>September 2016</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td></td>
<td>Lemur c. (D)</td>
<td>July 2011</td>
<td></td>
</tr>
<tr>
<td>30 à 31</td>
<td>More or less uncomfortable</td>
<td>Crocodylus n. m. (D)</td>
<td>September 2014</td>
<td>Aspergillosis</td>
</tr>
<tr>
<td>34</td>
<td></td>
<td>Anas b. (D)</td>
<td>April 2018</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td></td>
<td>Eulemur r. (H)</td>
<td>April 2016</td>
<td>Ringworm</td>
</tr>
<tr>
<td>35 à 36</td>
<td>Large discomfort extend to general feeling of discomfort.</td>
<td>Cryptoprocta f. (D)</td>
<td>October 2017</td>
<td>Aspergillosis</td>
</tr>
<tr>
<td>37 à 38</td>
<td>Large discomfort, Care</td>
<td>Uratelornis c. (D)</td>
<td>March 2016</td>
<td></td>
</tr>
<tr>
<td>37 à 38</td>
<td>Large discomfort, Danger</td>
<td>Anas p. (D)</td>
<td>February 2018</td>
<td>Candidiasis</td>
</tr>
<tr>
<td>39 à 40</td>
<td>Large discomfort extend to general feeling of discomfort</td>
<td>Chrysolopus p. (H)</td>
<td>February 2017</td>
<td>Aspergillosis</td>
</tr>
<tr>
<td>39 à 40</td>
<td></td>
<td>Lophobis c. (n=2) (H)</td>
<td>February 2017</td>
<td></td>
</tr>
<tr>
<td>39 à 40</td>
<td></td>
<td>Cryptoprocta f. (D)</td>
<td>October 2017</td>
<td></td>
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</tbody>
</table>


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