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Diversity and abundance of amphibian species in the Guguftu highland and Chefa wetland, Amhara Regional State, Ethiopia

Abeje Kassie Teme*, Mengistu Wale Mollaleign, Asersie Mekonnen Aregie

Wild Animals Case Team, Animal Biodiversity Directorate, Ethiopian Biodiversity Institute, Addis Ababa 30726, Ethiopia

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ABSTRACT

Objective: To describe the population status, abundance and diversity of amphibians found in Guguftu highland and Chefa wetland.
Methods: The present study dealed with amphibian diversity at Guguftu highland and Chefa wetland during the period of August 2015 to September 2015. Transect line and visual encounter survey methods were used in careful visual estimation and amphibians were recorded in all possible habitats of the study area.
Results: The total of 251 individuals of amphibians within 12 species grouped into 5 families were recorded in the Guguftu highland and Chefa wetland. Chefa wetland had the highest species abundance as well as richness with a total of 231 individuals falling in 11 species.
Conclusions: This study reveals that the Chefa wetland is rich in amphibian diversity and supports many more species. Further studies are needed on molecular basis, population structure, habitat use by amphibians for better understanding and also imposing several conservation strategies in Chefa wetland.

1. Introduction

About 7 528 amphibian species are known worldwide with varying density (Figure 1), of which Anura, Caudata, and Gymnophiona account for 88%, 9% and 3%, respectively[1]. Since 1985, the total number of recognized species has increased by over 60%[1]. However, more than 150 become extinct[2]. This shows extinction rate for amphibians is greater[3,4] and their decline may cause other species to become threatened[5,6]. The lack of accurate information on amphibian distributions, particularly for tropical regions where diversity and declines are concentrated[2], is often a roadblock for effective ecosystem restoration, conservation and management.

Reptiles and amphibians are among the most poorly studied vertebrate taxa globally[7]. Despite a recent surge in amphibian studies[8,9], including several expeditions to the undulating highlands[10], there is knowledge gaps on the Ethiopian amphibian. Therefore, information about the species is needed to encourage habitat protection and restoration[11].

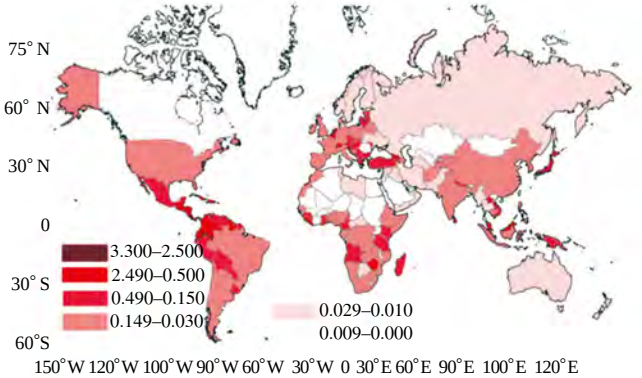

Figure 1. The density and distribution of amphibian species of the world.
Map prepared by Tiwari, Gross, Vredenburg and van der Meijden. Data were expressed as total number of species/land area of country in km^2.

One-third of the world's amphibian species are threatened

*Corresponding author: Abeje Kassie Teme, Wild animals Case Team, Animal Biodiversity Directorate, Ethiopian Biodiversity Institute, Addis Ababa 30726, Ethiopia.
Tel: +251 913205773
E-mail: kassieabeje@gmail.com
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nowadays[12]. Different hypotheses are thought for amphibian declines[13]. Habitat loss and fragmentation are the greatest threats[13,14]. Pollution affects about 19% of amphibian species, which is higher than those recorded for birds or mammals[13]. The permeability of amphibian' skin makes them susceptible to chemical contaminants[14]. Infectious diseases are listed among the major threats to global loss of amphibian diversity[14,15]. The chytrid fungus has caused the decline of at least 200 species of frogs[16].

Amphibians are facing extinctions worldwide as a result of numerous factors. Habitat alteration has long been implicated in the loss of biodiversity[17]. International Union for Conservation of Nature has identified 41% of amphibians at risk of extinction[18].

Some factors are shared with other endangered species of the world and are part of biodiversity crisis such as habitat destruction, alteration and fragmentation[19] and introduced species[20]. This enables us to understand the ecological mechanisms underlying declines[13]. These more complex and elusive mechanisms include climate change[21], increased ultraviolet radiation like UVB rays and chemical contaminants[22]. The underlying mechanisms behind these factors are complex and they may be working synergistically with habitat destruction and introduced species, to maximize declines[23].

In the northeastern and Horn region of Africa, Ethiopia is the most favorable place for amphibian diversity and endemicity, an area associated with cooler and moist habitats in the highlands, as compared with generally warm and dry surrounding areas (Sudan, Northern Kenya, Somalia and Djibouti)[9].

A rich and varied number of animal and plant species occur in Ethiopia, many of which are endemic[10]. Seventy-three species of amphibians are recorded, out of which a remarkable 30 species (over 41% of the total) are endemic (European Bioinformatics Institute, 2014, unpublished document).

Except a taxonomic study on amphibians by Largen[24], there is limitation of clear understanding and knowledge about conservation status, molecular studies and biology of different species of Ethiopian amphibians[9]. This is the same true for Chefa wetland and Guguftu highland. Therefore, this study is needed to know the abundance and diversity of amphibians in the study area.

2. Materials and methods

2.1. Study area

The study was conducted at Chefa wetland and Guguftu highland (Figure 2), Amhara Regional State between the months of August 2015 and September 2015. Chefa wetland is the main wetland of Ethiopia found near to Kermesse Town (a town in Oromia zone of Amhara Regional State). This wetland is the home of many species of animals including amphibians. The Chefa wetland is about 82 000 ha[25]. Borkena River, the major feeder of the Chefa wetland, is heavily silted during periods of rain[25]. About 300 000 cattle rely on the wetland[26]. Guguftu is a small Afroalpine patch located in the east of the main massif of the South Wollo Afroalpine habitats. It is located near the main road Dessie to Mekane-Selam at average elevation of 3 700 m asl. The dominant plant is red-hot poker, *Lobelia* sp., Gincher grass and Chefra plant.

Three study sites (inlet of the river, hot spring, marsh) were systematically sampled for amphibians in Chefa wetland and two study sites from Guguftu highland (bottom of the mountain and peak of the mountain).

2.2. Sampling techniques

2.2.1. Transect method

The transect method was used as described by Heyer *et al*.[27]. Three persons who worked for 4 h per search day (early morning and night) (12 man-hours) made three visits to each site. The sites were sampled in a random rotational sequence in order to minimize bias. Sampling was carried out during the rainy season. In addition, several opportunistic records were made.

The parameters noted during observation include name of the species, village name and habitat in which the species was found. The species were identified by field guide[28]. Careful counting was carried out to avoid double counting.

Voucher specimens were collected and fixed with 41% formaldehyde and preserved using ethanol either purposely for making a reference collection to be deposited at the Ethiopian Biodiversity Institute, or for identification.

2.2.2. Visual encounter survey

Visual encounter survey was employed to count and observe the presence of amphibians at the study area, with both day and night transects conducted to understand the ecology of the species found. Diurnal transects were conducted between 6 a.m. and 8 a.m. and night transects between 6 p.m. and 8 p.m.

2.3. Data analysis

2.3.1. Amphibian abundance and diversity

Amphibian abundance was expressed in terms of numbers of individuals observed. Descriptive statistics was used to show the diversity of amphibians in different sampling sites. Species diversity indices were computed for amphibian species recorded in each sampling site. For comparison, both Shannon-Weaver index (H') and the inverse of Simpson index (D) were computed.

Shannon-Weaver index, $H' = -\sum Pi \ln Pi$

where Pi is the proportional abundance of the i^{th} species

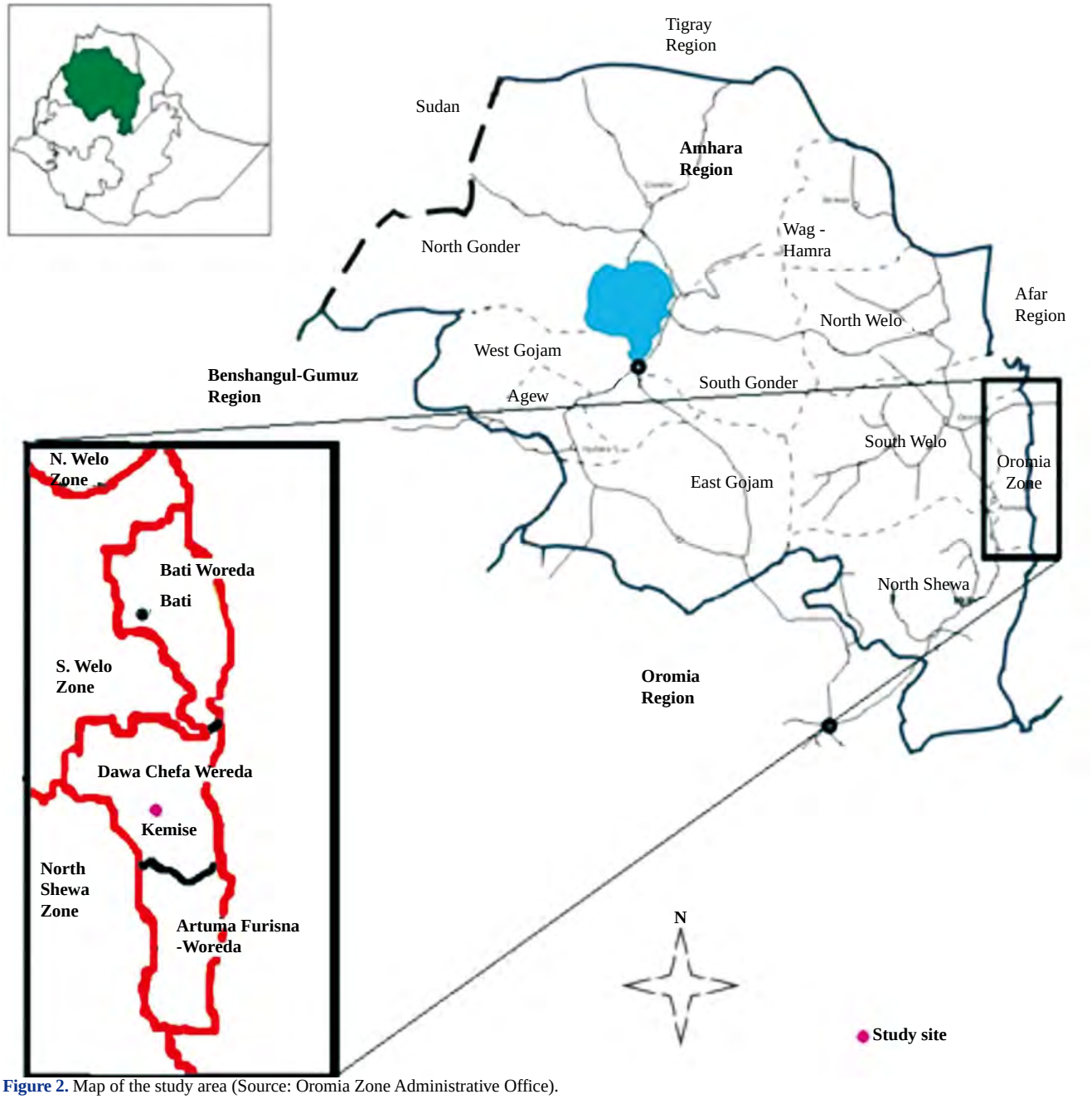

Figure 2. Map of the study area (Source: Oromia Zone Administrative Office).

Pi = ni/N, i = 1, 2, 3…S

where ni is abundance of the i^{th} species, N is total number of individuals, and S is species richness, total species in community.

Shannon diversity index is one of the heterogeneity or information theory indices[29]. H' assumes that individuals are randomly sampled from an infinitely large population and that all species are represented in the sample. H' is maximum (Hmax) when all S species are represented by the same number of individuals (even distribution)[30]. It is possible to calculate a separate additional measure of evenness. This is given by the ratio of observed diversity to maximum diversity. It is termed Shannon's evenness index (E).

E = H'/Hmax

where Hmax is lnS, H' is Shannon's diversity index, and lnS is the natural logarithm of species richness.

Simpson's index measures the probability that any two individuals drawn at random from an infinitely large community belong to different species.

Simpson's index is given by the equation: D = 1/C

where $C = \sum Pi^2$.

3. Results

A total of 251 individuals of amphibians were observed in the Guguftu highland and Chefa wetland. A total of 12 species belonging to 5 families were recorded with photographic evidences (Figures 3 and 4). Among the 5 families recorded, the highest number of species belonged to the family Ptychadenidae (5 species) and family Bufonidae followed by Ptychadenidae (4 species).

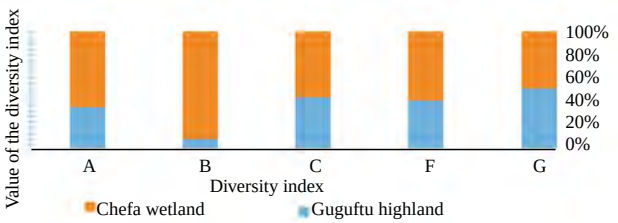

Figure 3. The diversity of amphibians (anura) in the Guguftu highland and Chefa wetland.

A: Species richness; B: Number of individuals; C: Shannon-Weaver index, H'; F: Simpson' sindex, D; G: Shannon evenness index, E.

Chefa wetland had the highest species abundance (Figure 5) as well as richness with a total of 231 individuals falling in 11 species (Figure 3). Six species (20 individuals) were recorded from the Guguftu highland (Figure 3). *Leptopelis yaldeni* (*L. yaldeni*) was found only in the Guguftu highland and it was not found in the Chefa wetland. *Amietophrynus gutturalis* was the most abundant species in the Chefa wetland that accounts for 92 individuals. *Ptychadena cooperi* and *P. tellinii* were the least abundant that accounts for 6 individuals each in the Chefa wetland. Among the total species recorded from the Guguftu highland, *L. yaldeni* was the most abundant that were recorded 10 individuals and *Tomopterna* spp. was the least that were recorded only one individual (Figure 5).

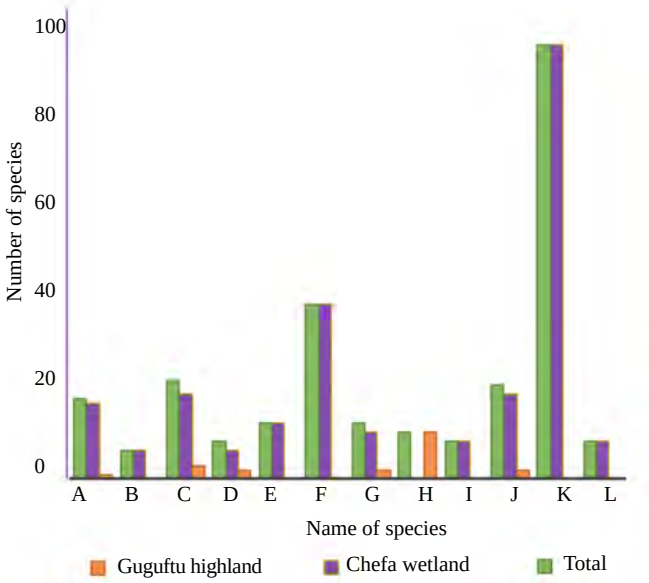

Figure 5. The abundance of amphibians (anura) in the Guguftu highland and Chefa wetland.

A: *Tomopterna* spp.; B: *P. tellinii*; C: *Ptychadena mascareniensis*; D: *Ptychadena cooperi*; E: *Ptychadena anchietae*; F: *Phrynobatrachus natalensis*; G: *Phrynobatrachus acridoides*; H: *L. yaldeni*; I: *Amietophrynus xeros*; J: *Amietophrynus regularis*; K: *Amietophrynus gutturalis*; L: *Amietophrynus garmani.*

Figure 4. Some of the amphibians recorded in the study area.

P. tellinii: *Ptychadena tellinii*.

By comparing amphibian species diversity across the two amphibian communities, the results showed that Chefa wetland had the highest species diversity (H' = 1.89, D = 4.76) (Figure 3). The Guguftu highland had the least diversity (H' = 1.47, D = 3.28).

4. Discussion

Many habitat types may occur within an area, amphibians may utilize only a few of these and different habitats showed a specific pattern in their species composition[31]. The number of individuals that represent each species in community may differ from place to place depending on the amount and distribution of rainfall, available habitats and human interference as the structure and diversity of an amphibian community is determined by the availability of food, moisture and micro habitat[32]. The habitat of study areas was vastly cultivated with paddy fields. These kinds of ecosystems well attracted to amphibian species may be used for various purposes such as food (insects) and home grounds *etc*. Amphibians are important to agriculturalists. They play a key role in ecosystem functioning and act as predator, mainly as consumers of insect pest[33]. In the present study, we identified a variety of amphibian species utilizing two different habitats, namely, the Chefa wetland and Guguftu highland.

Chefa wetland had the highest species diversity (H' = 1.89, D = 4.76) compared to Guguftu highland (H' = 1.47, D = 3.28). This is may be due to the Chefa wetland that had rivers which feed water especially during wet season and the ecosystem is wet throughout the year. Secondly, in the Guguftu highland, there is dense human population and the amphibian habitat is fragmented.

The highlands of Ethiopia are the main repositories of moist forests and wetlands in Ethiopia, which are known to be home for, among others, a diverse and unique amphibian fauna. In general, mountain ranges in tropical regions are seen to be important because they harbor much diversity at species, lineage and allelic levels[34]. Mountain ranges remain ideal places for the survival of lineages through climatic changes, and hence for genome divergence[34]. The Ethiopian montane has the highest rank of percentage of endemic genera and species of amphibians within biogeographic provinces of the intertropical montane region in Africa[9]. In line with this, in the current study, we found endemic amphibian in the Guguftu highland that is *L. yaldeni* which was intended to be restricted in Gojjam highland[9]. Therefore, the Ethiopian highlands require high priority research on amphibian systematics for focused conservation. Timely action is needed when one considers the value of amphibians as indicators of habitat change, and the current scale of human interference in these habitats.

In the present study, authors have made on amphibian diversity in the Guguftu highland and Chefa wetland, thus adding to the distributional range of species. In this paper, authors presented that study areas are well potential habitats to determine amphibian diversity. Furthermore, molecular based studies are needed to identify and document amphibian species from different locations of Chefa wetland to better understanding of their distributional ranges.

Conflict of interest statement

We declare that we have no conflict of interest.

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