



Ethnozoological Knowledge and Local Perceptions about the Reintroduction of the North African Ostrich (*Struthio camelus camelus* Linnaeus, 1858) in the Koutous, Niger

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Authors' contributions

This work was carried out in collaboration among all authors. Author MIM the lead author of the article, developed the research protocol, collected field data and wrote the manuscript. Author AH gave methodological advice for carrying out this work and revised the manuscript. Author MKAH participated in the analyses of the manuscript. Authors MP and AM contributed in supervising the work and revised the final version of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The North African Ostrich (*Struthio camelus camelus*), also known as the red-necked ostrich, disappeared from Niger 15 years ago but preliminary work completed in 2011 has shown that the species has not vanished from the collective memory in the Koutous. Using a Participatory Action Research (PAR) approach, this study combines the results of questionnaire surveys and local market monitoring conducted between October 2017 and January 2020, in order to document the

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ethnozoological knowledge of the communities living in the surroundings of the ostrich breeding centre of Kellé (Zinder). It fits within the wider framework of the species reintroduction program. A total of 120 people were interviewed individually to evaluate their knowledge about the species and their opinion about its possible return in the Koutous. The results emphasized that the ostriches were mainly sources of food (meat or eggs) and traditional medicines (topical pain killers), and to a lesser extent, of ornament objects. Additionally, wildlife products trade still occurs in three of the four weekly markets monitored and one stallholder still had an ostrich bone to sell. Entailing either animal hunting or disturbance, these uses could represent limiting factors to the re-establishment of wild populations. No mention was made of cultural, natural or religious heritage or source of incomes, suggesting the value was limited to subsistence. However, with eight usable products listed, the value of a single animal is relatively high since it can fulfil various demands.

Most of the interviewees had limited knowledge about the species' ecology but they anticipated a lack of suitable habitat. No other cause than lack of water (low rainfall, climate change, desertification...), habitat encroachment by human activities (urbanisation and agriculture) and hunting was thought to have caused the extinction. Habitat restoration was indeed the most-cited prerequisite for successful restoration of wild populations; however the need to ensure the animals' security (fences, patrols, regulations, anti-poaching campaigns...) was also put forward. The confidence rate in the reintroduction initiatives was mitigated: none of the people interviewed was confident it would be a success in the current context but 56.66% of them were optimistic if preliminary requirements are met. The interpretation of the answers to the open-ended questions suggests underlying risks of illegal hunting and human-wildlife conflict but the request for public awareness campaigns and regulations gives hope for the return of free-ranging North-African ostriches in the future.

This study provides key baseline data about the local communities' perception of ostrich conservation and key elements in a Participatory Rural Appraisals (PRA) approach (also known as "Méthode Active de Recherche et Planification Participative" - MARP) in any conservation project. In particular, this work will contribute to the development of feasibility plan for future North African ostrich reintroduction in the Koutous.

Keywords: *Struthio camelus camelus*, uses, perception, reintroduction, Koutous, Niger, Participatory Action Research (PRA).

1. INTRODUCTION

The human-wildlife interactions underlie the hunter-gatherer cultures and are vital for the subsistence of many communities worldwide [1,2]. Whilst the exploitation and consumption of wild animals vary with the natural conditions, resources availability and food preferences in each country, the bushmeat remains the main, if not the only source of protein for thousands of people in Africa [3,4]. The volumes actually consumed are difficult to evaluate, but the practice yields important socio-economic benefits for the studied populations [5,6,7]. Consequently, socio-cultural issues play an important role in the sustainability of non-timber forest products (NTFP) and cannot be overlooked when planning the reintroduction of a game species [8]. Where the evidence bases are weak, perception surveys can be useful to test policy assumptions and in some circumstances, this could be an effective tool to deconstruct under-evidenced stereotypes [9].

The North African ostrich (*Struthio camelus camelus*), also known as the "red-necked ostrich", is a wild subspecies of ostrich that was once widespread throughout Sahelo-Saharan Africa [10] and was widely used for its nutritional, therapeutic and other traditional virtues [11]. A combination of anthropogenic and natural pressures is thought to have led to its extinction in Niger in early 2000 [12]. As a consequence, a national strategy established since 2009 aims to the return of this giant flightless bird [13,14].

To our knowledge, there is no background information on how it was perceived when it was still populating the Niger steppes and consequently, the cultural, economic and social values of this animal have never been evaluated, though their understanding is crucial for wildlife restoration [15,16,17,18]. The ethnozoology is an emerging discipline focusing on the variety of past and present interactions between human cultures and the regional fauna [19].

The last wild ostrich died 15 years ago [12], but even if there are few witnesses of this time of coexistence, this ecological knowledge was passed down through generations as oral folklore. Our study aims to assess and characterize the ethnozoological knowledge of the ostrich in the Koutous (Niger) so that it can be valued for conservation purposes [20]. A combination of interviews and surveys produces information about: (a) knowledge (e.g. levels of ecological awareness and understanding); (b) experiences (e.g. in regards to possible conflicts); (c) beliefs and values (e.g. beliefs of therapeutic value and levels of tolerance of resource spoliation); (d) attitudes and opinions (e.g. views of wildlife restoration); and (e) expectations (e.g. fears and hopes) [9].

2. MATERIALS AND METHODS

2.1 Study Sites and Local Communities

The investigations were carried out in October 2017, June-July 2018 and January 2020 in four localities of the Koutous, an area of Sahelian steppes in the department of Gouré (Zinder, Niger) where annual plants dominate (Fig. 1). There is a great Sahelian human diversity in the Koutous since small-scale agriculture tribes such as the Dagrás (sub-group of Hausa) and the Mangas inhabiting the sandstone plateau-land are surrounded by pastoral ethnic groups including Tuaregs, Toubbous and Peuls [21,22].

The perception surveys have been done in four localities randomly selected within a 50 km perimeter of the Kellé ostrich captive breeding site (N14°16'10,5" E10°5'5,92"): Damou Kaoudi (N14°13'41.7" E10°02'51.0"), Foudé (N14°10'22,1" E10°6'14.8") and Kellé (N14°16'13.4" E10°38'56.4") are in the municipality of Kellé, while Tchaou (N14°02'40.9" E10°03'55.3") is in the municipality of Gouré. Total inhabitants in these villages are 3,932 inhabitants, ranging from 398 to 1799 people [23] who speak either Kanouri, Dagrás or Manga languages. They are administered by both mayors and traditional leaders whose legitimacy is accepted by communities and government [24].

A preliminary perception survey was conducted during 17 days in June 2011 on 270 people aged over 40 living in Kellé village: these in-depth interviews aimed at exploring the relationship between people and ostriches when they used to share the same environment. A door-to-door

approach was initially selected, but rapidly people came and present themselves to talk about the time when ostriches were free-ranging. It came out that most of people older than 55 years have seen wild ostriches. This animal is also part of several tales [25,26] and therefore persists in the local culture. In summary, the preliminary results describe the ostriches as shy but possibly aggressive animals that do not pose problem to crops but could steal millet in women's harvest basket: keeping them away may require the intervention of the men.

2.2 Collection of Data

Building on the exploratory data, a quantitative research survey was designed to evaluate the current perception about ostrich within the communities living in the area targeted for reintroduction. In October 2017 and June-July 2018, 10% of the total population of the four study sites, i.e. 120 adults, have been interviewed face-to-face using a structured open-ended questionnaire, regardless of their gender, age, ethnicity or social background. In each of the four villages, 30 adults randomly selected were asked to express (1) their factual knowledge about the possible uses of the ostrich and the plant species that the ostriches would feed on, and (2) their opinion about ostrich' reintroduction and conservation. As perception is the subjective process of acquiring, interpreting, and organizing sensory information [27,28], it is difficult to obtain unbiased answers to questions that may have negative social, economic and cultural repercussions. Therefore, the questionnaire was designed to collect and interpret perception data with three questions taking different angles resulting of the following assumptions:

- 1) "Causes of extinction" is an expression of past activities in which the interviewee was not involved;
- 2) "Success of reintroduction" makes the interviewee feel exposed to possible judgement by the investigator;
- 3) "Requirements for success" is a more open expression of the interviewee's critical views and reflects their understanding of the project.

The level of abstention can either indicate ignorance or reticence [29,30]. Crossing the results obtained through the three questions provides an opportunity to precise the perception reducing the semantic biases.

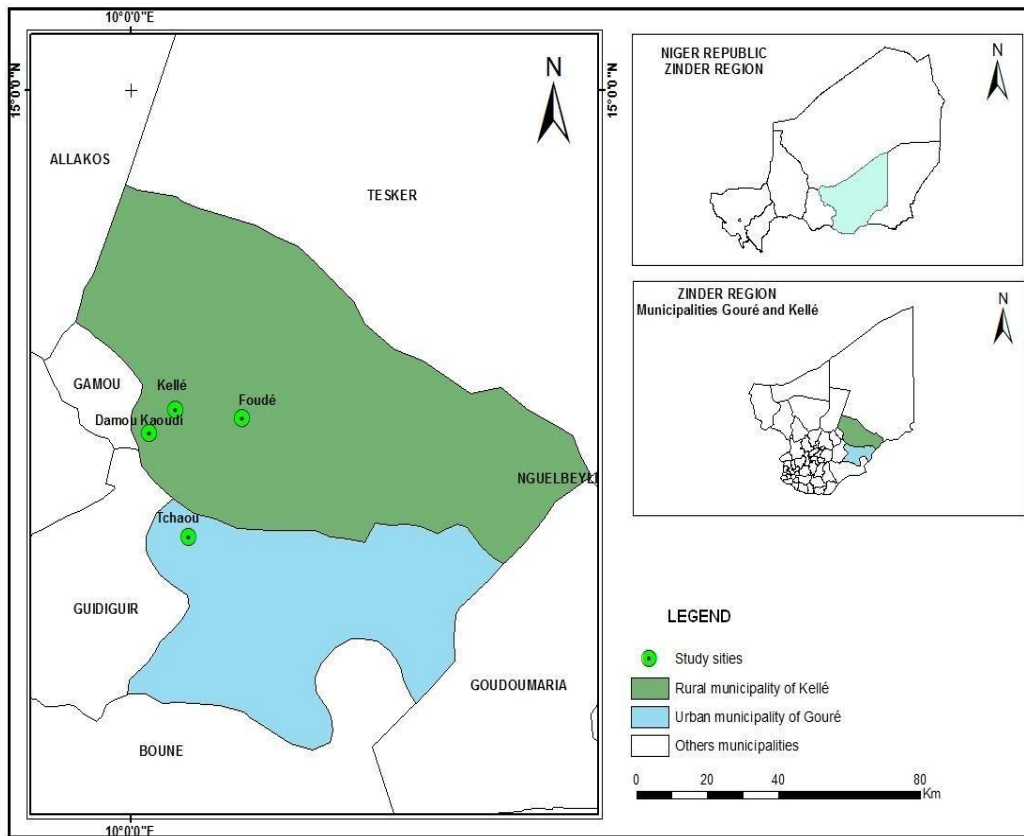


Fig. 1. Location of study sites

Additionally, in order to estimate the local demand for wildlife products, a 4-week observation survey was conducted in January 2020 in each of the four nearest weekly markets to Kellé, namely Damou Kaoudi, Foudé, Tchaou and Kazoé. During each visit, the market was visited systematically to count the number of stalls selling wild animal products and classify them by category (food, pharmacopoeia, ornament). When ostrich products were identified, the sellers were asked to answer to a semi-structured interview which was conducted to understand the market demand and the supply chain of this trade.

2.3 Data Analysis and Processing

The entries frequencies (FE) were presented in diagrams or histograms in Microsoft® Excel:

$$FE = \sum n/N$$

Where n is the number of references to an entry (category of use, cause of extinction, palatable plants...) and N the number of informants.

The Use Value (UV) was calculated for each use-category employing the following formula [31] to evaluate the ostrich products importance:

$$UV = \sum U/N$$

Where U is the number of uses mentioned by each informant and N the number of informants.

In order to detect possible dependencies between the variables, the survey results were presented in the form of a contingency table in Microsoft® Excel. Thus, the possible uses of ostrich products were presented by age categories of the interviewees (18-29, 30-49 or 50-84 years-old) and gender. A principal component analysis (PCA) was performed on each of these tables [32] in order to describe the correlations between the variables.

3. RESULTS

3.1 Profiles of Respondents

All 120 people interviewed were Niger citizens living in the survey area. The sex-ratio of the

interviewees was nearly balanced, with 51 men (42.5%) and 69 women (57.5%), and about the half of them were young adults (53.3% younger than age 30) while 19.2% were older than age 50 (Table 1).

90% of them were farmers, breeders or storekeepers with low level of literacy, whereas the remaining 10% were educated people either in activity or retired.

3.2 Factual Knowledge

3.2.1 Ostrich products use

The useable ostrich products disclosed by the 120 interviewees comprise three

categories (Fig. 2): Food (100%), pharmacopoeia (85.83%) and ornament (43.33%). In particular, eight products were listed: egg (content), meat, fat, faeces, bones, bone marrow, egg shell and feathers (Fig. 3). The highest frequencies of entries were for egg, meat and fat (100%), droppings (75%) and egg shell (74.16%); bones and bone marrow were mentioned in 25% of the answers.

The principal component analysis (Fig. 4) showed that the age categories influence knowledge of ostrich by-products and the first two axes accounted for 90% of the total variance. Elderly people listed a wider variety of possible uses while the meat and eggs were listed in all age categories. The feathers, egg shell and

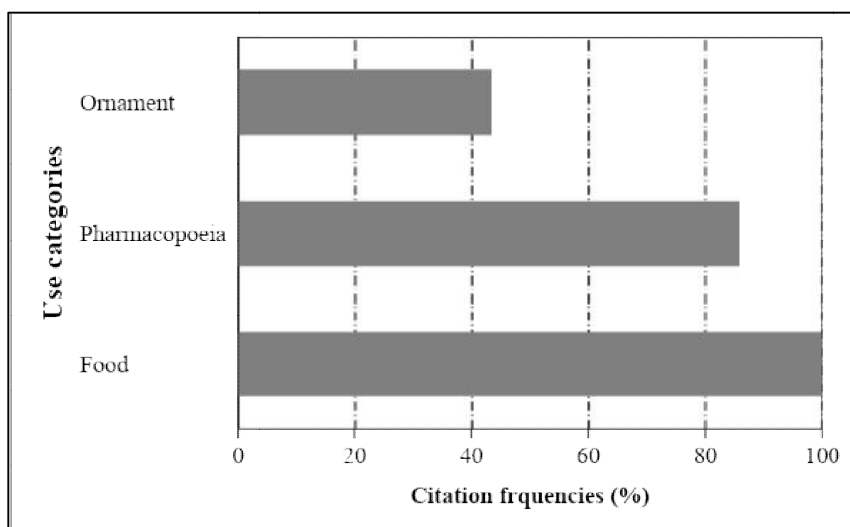


Fig. 2. Entries frequencies for each category of ostrich' useable products listed by the interviewees (N=120)

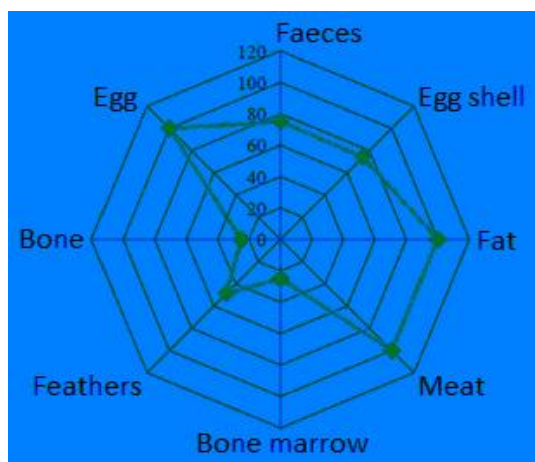


Fig. 3. Radar diagram showing the use value (%) of ostrich parts/organs

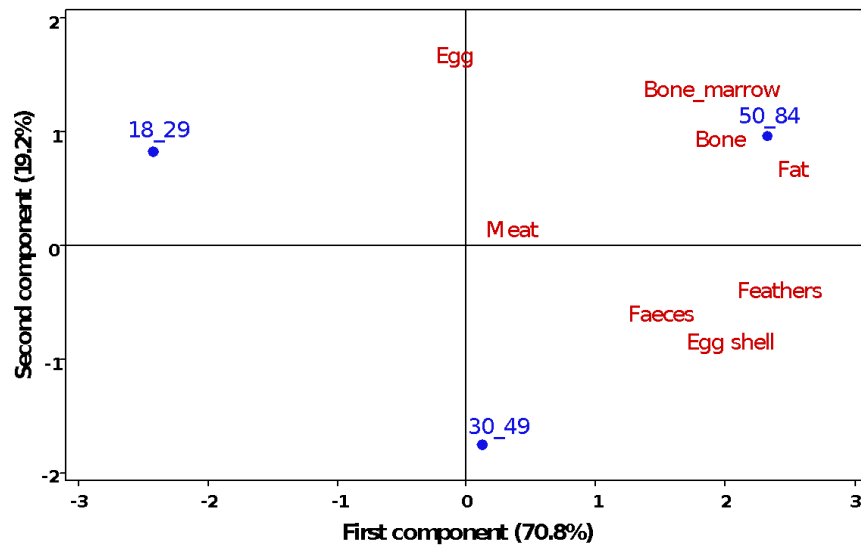


Fig. 4. Principal Component Analysis of knowledge of ostrich by-products and the age categories of the people interviewed (N=120)

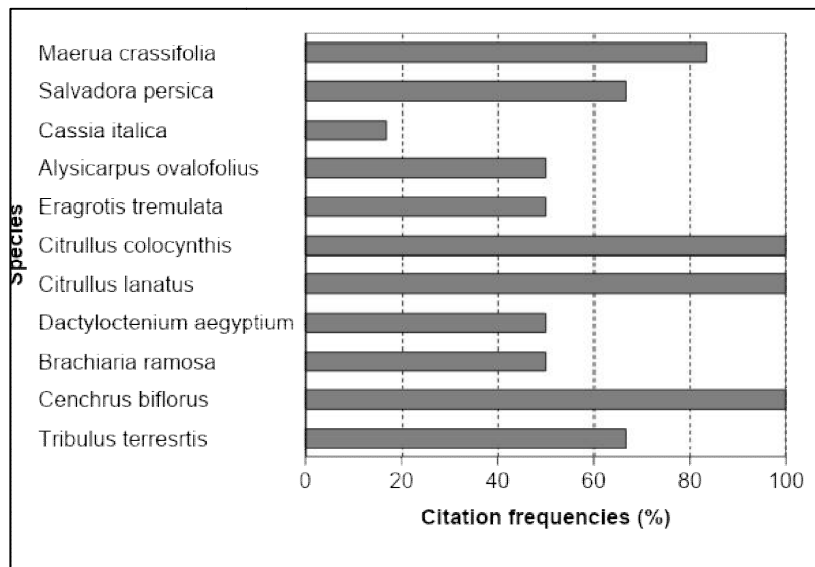


Fig. 5. Frequency of entries for each palatable plant species mentioned by the 31 interviewees in the Koutous (Niger)

faeces were identified by respondents in the older age-classes (30-49 and 50-84), but the bone-marrow, bone and fat were only identified as useable products from ostrich by the 50-84 age class.

About 85.83% of the interviewed people recognized medicinal properties to the ostrich by-products and listed a total of eight diseases and symptoms that could be treated by traditional

drugs made of fat, bone marrow, bones, egg shell or faeces (Table 2). Therapeutic indication appears to be mainly as topical pain killer for rheumatism, ophthalmic disorders, muscle pain, fracture, snakebite, weakness and baldness.

3.2.2 Trade of by-products

Ten wildlife product stallholders were observed in three of the four weekly markets monitored: none

was seen at Damou during the four visits, and the four observed at Foudé and Tchaou were seen only once during the four visits (Table 3). In the Monday's market of Kazoé, three to six stallholders were identified and came on a regular basis.

Only one 75-year-man had ostrich by-products, in particular an old tarsal bone from Tesker (Niger), of which genuineness has not been

confirmed. This man explained he is doing wildlife business since 1984 and during that time, wild ostriches used to be abundant in the country.

A semi-structured interview was conducted with each of the stallholders and it appears the youngest persons were very curious once the investigator expressed her interest in ostrich by-products.

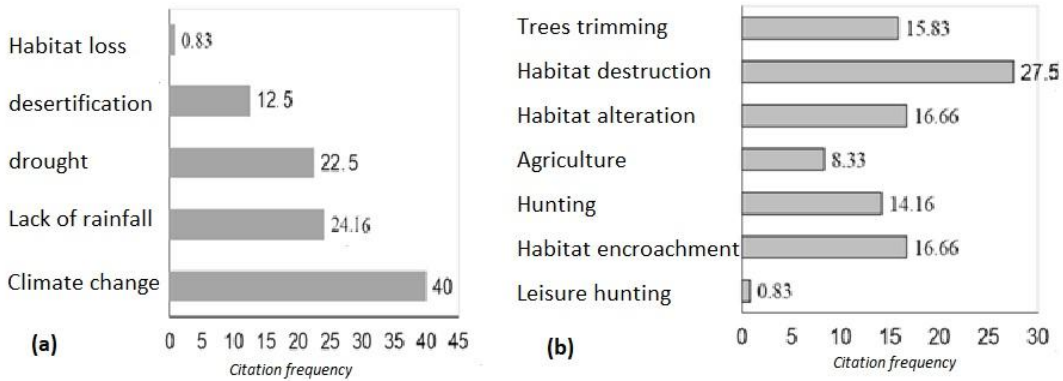


Fig. 6. Answers provided about the natural (a) and anthropocentric (b) causes of wild ostrich loss in the Koutous (Niger) by 120 local people interviewed individually in 2018

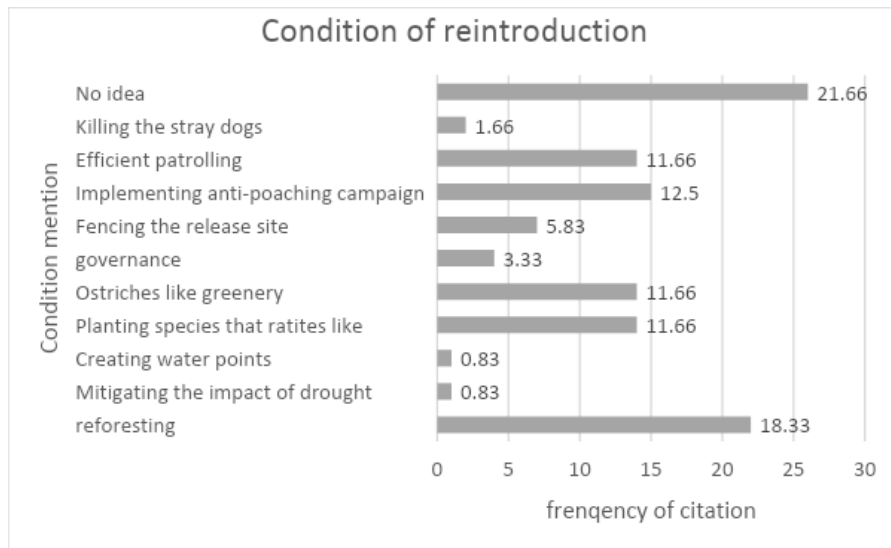


Fig. 7. Frequencies of the requirements for successful reintroduction based on 120 open-ended individual interviews

Table 1. Gender and age classes of the 120 interviewees

	18-29 years-old	30-49 years-old	50-84 years-old	Total
Men	28	13	10	51 (57.5%)
Women	36	20	13	69 (42.5%)
Total	64 (53.3%)	33 (27.5%)	23 (19.2%)	120

Table 2. Traditional therapeutic uses for ostrich products in the Koutous (Niger)

Diseases	Product used	Medical use
Rheumatism	Fat	Massage with fat
Ophthalmic disorders	Egg shell	Eye drops of a filtrated solution made with eggshell powder
Otitis	Faeces	Ear drops of a filtrated solution made with faeces in water
Fracture	Fat and bone marrow	Topical ointment made of a mixture of fat and bone marrow
Muscle pain	Bone	Topical ointment made of bone ash mixed with oil
Snakebite	Fat and bone marrow	Topical ointment made of a mixture of fat and bone marrow
Baldness	Faeces	Incinerated faeces mixed with any ointment to be applied to the scalp
Weakness	Bone and bone marrow	Bone ash mixed with other lotions for massage

Table 3. Number of sellers of wildlife products registered by market and by visit (N = 4)

Markets	Week 1	Week 2	Week 3	Week 4	Total number of stallholders
Tchaou (Thursday)	0	0	0	2	2
Foudé (Sunday)	1	0	1	0	2
Kazoé (Monday)	3	6	3	4	6
Damou (Saturday)	0	0	0	0	0

Table 4. Wildlife products stallholders encountered in the weekly markets of Tchaou, Foudé and Kazoé monitored – age and by-products in sale

Stallholder	Locality	Age (years-old)	Products
1	Tchaou	75	Ostrich bone (tarsus)
2	Tchaou	40	Other animals
3	Foudé	38	Other animals
4	Foudé	37	Other animals
5	Kazoé	60	Other animals
6	Kazoé	35	Other animals
7	Kazoé	42	Other animals
8	Kazoé	40	Other animals
9	Kazoé	45	Other animals
10	Kazoé	37	Other animals

3.2.3 Knowledge of the suitable diet composition for ostrich

31 persons (25.8%) were able to answer the question about the plant species eaten by the ostriches; 74.2% were not able to answer. A total of 11 plant species were listed by the interviewees as being palatable by the ostrich (Fig. 5): nine are herbaceous species and two woody species (*Maerua crassifolia* Forssk. and *Salvadora persica* L.). *Citrullus colocynthis* L., *Citrullus lanatus* Thunb. and *Cenchrus biflorus*

Roxb. Were unanimously cited while *Cassia italica* Mill. is the species with the lowest citation frequency (16.66%).

3.3 Perception about ostrich conservation initiatives

The three last questions of the open-ended questionnaire invited the interviewees to share their opinion about (1) the “causes of extinction”, (2) the “success of reintroduction” and (3) the “requirements for success”. Crossing the results

obtained through the three questions provides an opportunity to precise the perception reducing the semantic biases.

3.3.1 Indicated causes of ostrich local extinction

All interviewees (N=120) have accepted to share their opinion on (1) what natural causes and (2) human activities have led to the ostrich local extinction.

Five natural causes were mentioned (Fig. 6a): Climate change (40%), lack of rainfall (24.16%), environmental drought (22.5%), desertification (12.5%) and loss of habitat (0.83%).

The anthropogenic causes of wild ostrich loss have been described in various and sometimes overlapping ways (Fig. 6b). In particular, the indirect impacts on habitat have been articulated by: habitat alteration (27.5%), habitat destruction (16.66%), habitat encroachment (16.66%), improper trees trimming (15.83%) or agricultural expansion (8.33 %). They total 85% of the answers. Hunting represents 14.16% of the answer and one person (0.83%) even specified the opportunistic recreational hunting activities.

3.3.2 Opinion about ostrich reintroduction

Amongst the 120 persons interviewed, 56.66% (n=68) were optimistic about the success of a possible reintroduction of the ostrich in Kellé area but only if some solutions are implemented to support the restored population. 60.29% of the respondents were of the opinion that public awareness and good wildlife governance are a needed prerequisite; 22.05% pointed out the need of habitat restoration while 17.64% believe that it would work if some water points are created.

43.33% of interviewees (n=52/120) did not believe that a reintroduction project would work, including nine (17.30%) who did not want to explain their answer. The other 43 interviewees (82.70%) advocated the priority for anthropization (n=34) and a change of era (n=9).

3.3.3 Requirements for successful reintroduction

When asked what the requirements for a successful reintroduction are, the response rate is 78.34% and ten entries have been recorded (Fig. 7).

Most of the suggested requirements can be categorised in the “release site management” group which includes reforestation (18.33%), mitigating the impact of drought (0.83%), creating water points (0.83%) or planting species that raptorial birds prefer (11.66%). An ambiguous answer was the fact that ostriches like greenery (11.66%).

Other answers imply “ensuring the animals’ security”: fencing the release site (5.83%), implementing anti-poaching campaign (12.5%) or efficient patrolling (11.66%) or killing the stray dogs (1.66%).

A last category, representing the “governance” comprises and involvement of customary and governmental authorities (3.33%).

4. DISCUSSION

The assessment of the local community perception was made in order to contribute to the feasibility plan for ostrich reintroduction.

The results of this study provide a baseline understanding of what the population in Koutous knows about the ostrich’s ecology and value, 15 years after the last wild individual died. It also represents an unprecedented evaluation of their perception about wildlife conservation issues and ostrich reintroduction in their habitat.

Preliminary observations suggested that people older than 55 years-old could have seen wild ostriches in their environment: these represent nearly 20% of the survey participants. Most of people encountered (90%) rely on small-scale agriculture or local selling. The factual knowledge about the species appears closely related to the local activities as all interviewees describe this wild bird as a non-specific grazer and a source of food and traditional treatments (mainly pain killers). Less than a half of them mentioned its ornamental value. Its potential benefits to generate indirect revenues or fame through vision tourism has not been mentioned by anyone; neither has been indicated any value as cultural, religious or natural heritage. The financial income was not listed neither even if wildlife products trade still exists in local markets.

Indeed, three of the four weekly markets monitored counted one to six stallholders with wildlife products, and one 75-year-old man still had ostrich bones to sell, despite the absence of local source of supply. This bone was said to

date back to the times when ostriches were still in the wild, but whilst its genuineness had not been proven, its presence on the stalls reflects a value of rarity and authenticity. On the other hand, if it has not been purchased for so long, one could put forward that there is not much demand for this pharmacopeia ingredient.

Additionally, the results suggested that young people have limited knowledge of the uses of the ostrich, particularly regarding medicinal use.

All people interviewed thought the ostriches were a source of meat what raises the concern of a possibly high use value in the future and a threat to the species if it becomes again a sought after "bush meat". It confirms the preliminary survey results where hunters' relatives narrated the past consumption of smoked ostrich meat and told the high nutritional value of ostrich eggs [25]. The consumption of ostrich meat is accepted in the religious and socio-cultural context of Niger, however, in a retrospective study on meat consumption, the beef dominates in the Sahelian zone (Gambia, Senegal, Niger, Mali, Mauritania, Nigeria, Chad), unlike the forest regions (Cameroon, Benin, Guinea, Ivory Coast, Ghana) where the meat intake is more diversified in favour of poultry and wild game meat [33,34].

A list of eight products and by-products of the species has been compiled from the responses obtained: the use value of a single individual is potentially high because it meets several market demands. Some of these products, such as bones, eggshells or feathers, have a long shelf life, as does have fat after transformation. These products are amongst the most cited in ethnozoological studies related to wild game [35,36,37]. Even if the commercial value is not formally acknowledged by the interviewees, the entry frequency can be considered as an indicator of threat and the survey methodology therefore appears to be an effective way of assessing the risk of poaching or animal disturbance.

The bushmeat and eggs market could have a dramatic impact on the re-establishment of the ostrich in its habitat by directly impacting the population growth rate [38,39,40]. The collection of ostrich products (faeces, feathers, broken eggshells...) can also have an indirect impact because of the induced disturbance, but also because of the risk of injury for the collectors, which would ultimately generate a situation of human-wildlife conflict.

The question about the plants eaten by the ostriches indicates if the communities perceive a competition with free-ranging herbivores more than to really evaluate their factual knowledge about the species ecology. Only 31 persons were able to list the plants species constituting the diet and those were amongst the elderly. Even if their answers matches the known ostrich diet [16], they are also mainly Poaceae, Fabaceae and wild watermelons that dominate in the local pasture [14]: It is likely that the people interviewed made an inventory of all the local palatable species they knew. 75% of the persons interviewed could not answer and they formulate it either by "not having seen", "not having been told" or "better asking to the ostrich breeding centre staff". Consequently, whereas the results haven't directly emphasized any existing reluctance to share habitat with ostriches, they suggest the targeted population for reintroduction is inexperienced in their ecology. Some former reintroduction projects, e.g. giraffes in Niger [41] or hippos in Burkina Faso [42], have shown that fears of competition for pastures or damage to plantations can be generated in novice social groups before any harm actually happened.

The three opinion questions aimed to evaluate what the local communities think about wildlife conservation initiatives: The assessment approach has included questions with different semantic features in order to identify some of the processes that may affect individual behaviours and attitudes [27,28] and particular attention was paid to the non-responses as indicators of sensitive topic [29,30].

Whereas all people gave their opinion about the historical causes of local extinction and future reintroduction, only 78% were comfortable with the question on the management requirements for successful ostrich population's reestablishment.

A perception of lack of habitat to support both people and wildlife shows through the three last questions of the open-ended questionnaire: 68% of interviewees expressed that human activities expansion caused the loss of the species. Additionally, no other natural cause than drought and climate change has been expressed (e.g. epidemic, predators, competition with other animals...): it reflects a distancing from the problem-solving process as those elements seem to be out of their control. This hypothesis is supported by the comments about reintroduction: even if 57% gave a positive answer, they all

stressed the need of habitat restoration (40%) or implementation of good awareness and governance (60%) as a preliminary condition to success. None thought that reintroduction would work in the current context, but their optimistic answer gives evidence they wanted to seem supportive. Amongst the 40% who told a reintroduction will fail, most of them openly said the human needs and welfare are a priority and a third of those refused to explain their view.

When asked what would be needed for the species' recovery, the habitat restoration was again the most cited prerequisite (43%) but the rate of non-response was also high (22%). The need to protect the ostriches from being killed was expressed by 35% of the people interviewed: in particular, 19% said that the animals should be protected from poachers and predators while 16% advocated a responsibility of authorities and managers to implement good regulations and awareness campaigns. Interestingly, amongst the ways people formulate their answers, nearly 12% said that "ostriches likes green pasture" and about additional 6% recommend the release site to be fenced: this suggests they either think the risks of resources shortage or illegal hunting are too high, but it could also be interpreted as a fear a spoliation of their crops or pastures for livestock, underlying possible human-wildlife.

In particular, the methodology applied in this study fits the requirements of a Participatory Action Research (PAR), and the results are baseline data that will benefit to a Participatory Rural Appraisals (PRA) approach also known as MARP – "Méthode Active de Recherche et Planification Participative" recommended for the protected area management [43,44].

In order to investigate the communities' perception and involvement for a wildlife conservation project such as the ostrich reintroduction, it appears instrumental to engage in collective reflection and joint decision through a cyclical process of exploration, knowledge construction, and action at different moments throughout the research process [45,46].

5. CONCLUSION

This study demonstrates the ostrich is still present in the local culture and its past importance as natural resource for people is still alive. However, very little is known about the ecology, and a lack of understanding the

conservation initiatives is implied. Some underlying risks of poaching or conflicts for land use were inferred.

Whilst no major threat to the reintroduced animals has been identified, a significant proportion of the people interviewed openly said there is no place anymore for the ostriches in their environment. On the other hand, the call for awareness campaigns is a positive point to consider in a reintroduction feasibility plan.

A pronounced interest for the potential use value has been noticed during the semi-structured interviews but not quantified in the context of this study. Therefore, participative approaches must be evaluated and finding ways to generate alternative benefits to the local population seems to be crucial to ensure the future of free-ranging ostriches.

The absence of pressure for the last decades must be considered favourable to successful reintroduction in the Koutous and an opportunity of building alliances between researchers, managers and participants in the planning, implementation, and dissemination of the project process. These results represent key baseline data for future periodic monitoring of local perception and a tool for the sustainable management of Sahelian ecosystems.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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