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NOTES AND FIELD REPORTS

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Local Ecological Knowledge in South Sudan Can Help Conservation and Management of *Cyclanorbis elegans*

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ABSTRACT. – **We present survey data on one of the rarest turtles in the world, the Nubian flapshell turtle, *Cyclanorbis elegans*, on the basis of data coming from structured interviews with Bari fishermen of South Sudan and comparison of these data with those coming from our field studies. Our study documented that local ecological knowledge (LEK) data can be very useful to complement information on the natural history of rare and poorly known species and helpful to their conservation and management. We urge that any protected area focusing on *C. elegans* include a few of their communal nesting areas (as described by LEK) that should be carefully monitored to prevent collection of females or eggs during the reproductive period.**

Standardized or informal interviews with native communities or with selected inhabitants (e.g., hunters, farmers, fishermen) of local villages have been widely used by conservation biologists (Gadgil et al. 1993) in order to obtain information on threatened species at the local scale, thus valuing the local ecological knowledge (LEK) for scientific reasons (e.g., Begazo and Bodmer 1998; Rist et al. 2010). Local ecological knowledge can be very informative also for directing the initial steps of field surveys in logistically difficult contexts such that even the choice of given study areas well suited for scientific investigation may be driven by LEK (e.g., Akani et al. 2013). Therefore, it is generally assumed that LEK can be usefully integrated with complementary scientific knowledge to improve species management. This is especially true for abundant species with which indigenous peoples have frequent interactions (e.g., through harvest).

Chelonians have been subjected to LEK studies in logistically difficult regions, with data coming from interviews being used to complement data coming from field experimental research (e.g., Luiselli et al. 2018). However, no study has to date really explored whether LEK can be useful to direct species conservation and management of isolated or declining species.

In the present study, we used LEK data obtained from fishermen communities in South Sudan (East Africa) for exploring more in detail the ecology and natural history of one of the least known and most threatened turtles on earth, the Nubian flapshell turtle, *Cyclanorbis elegans* (Fig. 1). This species, which is the largest freshwater turtle in Africa and one of the largest in the world, is almost extinct (Baker et al. 2015, 2016; Stanford et al. 2018) but was recently rediscovered in South Sudan (Demaya et al. 2019). We will show in this article that the data obtained from local communities provided not only very useful baseline information on the biology of the target species and on its conservation status assessment and management actions but also by far the most detailed field data available on this species so far.

Methods. — The present study is based on field (both ecological and interview-based) surveys carried out from June 2016 to February 2019. The research team consisted of 4–8 people depending on the site of research, but at least 3 members of the team and 1 local person were always present during surveys. The surveys were made periodically, on average once every week, throughout the study period. The field surveys were conducted at several localities situated along the banks of the White Nile River in South Sudan, with Mongalla and Juba being the main urban centers of the area (Fig. 2).

In each surveyed site and before starting any field ecological research, we interviewed fishermen in local communities. No minors younger than 21 years of age were interviewed, and all interviews were performed by following the standards developed by the British Sociological Association. Each fisherman was fully informed of the scope of our research study and was interviewed independently by means of a standardized questionnaire (Supplemental Material; all supplemental material is available at https://doi.org/10.2744/CCB-1377.1.s1). All interviewers were persons from the local region. The questionnaire consisted of a series of questions relative to the demographic characteristics of the interviewee and on

Figure 1. A live female *Cyclanorbis elegans* captured in Rejaf (South Sudan), January 2019.

his socioeconomic growth indicators as well as a series of questions concerning the turtle species of the area and their apparent phenology (i.e., period of the year in which these turtles are usually captured) and abundance (i.e., number of individuals captured per year at the village scale). We also obtained qualitative information on other aspects of the species' natural history (e.g., diet, number of eggs per female). The reliability of the information provided was determined by examining as much as possible turtle shells or other pieces of evidence in the interviewee's property and by comparisons with the information coming from other fishermen in nearby villages.

On the basis of the results coming from the interviews, we also conducted field surveys by means of random walks (once per week on average but every day in some periods of the field project) in a suite of different freshwater habitat types available to turtles along the White Nile river course, and we also inspected fishermen's catches. Although we were not able to carry out rigorously standardized surveys along the entire river because of logistic and economic constraints, we nevertheless tried to survey as much of the available habitats as possible.

When a turtle was observed, it was identified to species level (Branch 2007), measured for carapace length with a tape, and sexed by examination of secondary sexual characters (cloacal morphology). Shells of dead turtles found in the surveyed villages were deposited in the Biology Laboratory of the University of Juba, whereas photos and videos of living individuals were deposited in the archives of IDECC (Rome) and of the University of Juba data repository. The geographic position of each turtle was recorded by GPS. These geographic coordinates are not provided in the present article for conservation reasons but were made available to the International Union for Conservation of Nature/Species Survival Commission Tortoise and Freshwater Turtle Specialist Group via Anders Rhodin. We also recorded the main habitat features at the sites of capture for all specimens.

Correlation between the number of *C. elegans* shells observed in each village and the latitude of the village was performed using Spearman's rank correlation coefficient (r_s). Correlation between carapace length and width (n = 16) was evaluated by Pearson's correlation coefficient. In the text, means are presented ± 1 SD.

Results and Discussion: Patterns of Variation in Species' Abundance Along a Latitudinal Gradient. — According to local fishermen, *C. elegans* is rare, much rarer than *Trionyx triunguis* or other smaller turtle species. There was a very high consensus among interviewees that the number of individuals caught per year (an index of local population density) appeared to be higher in localities situated south of Juba than north of Juba (Fig. 3). In general, all the interviewed fishermen reported being able to capture an average of 1–4 individuals per year in localities north of Juba up to the wetlands south of Sudd, whereas there were a few oviposition sites where they caught up to 17 gravid females in a single season south of Juba (see below for details). Using the comparative information provided by the various interviewees, there was a clear pattern of a density decrease of *C. elegans* from south to north, whereas exactly the opposite was true for *Cyclanorbis senegalensis* (Fig. 4). On the other hand,

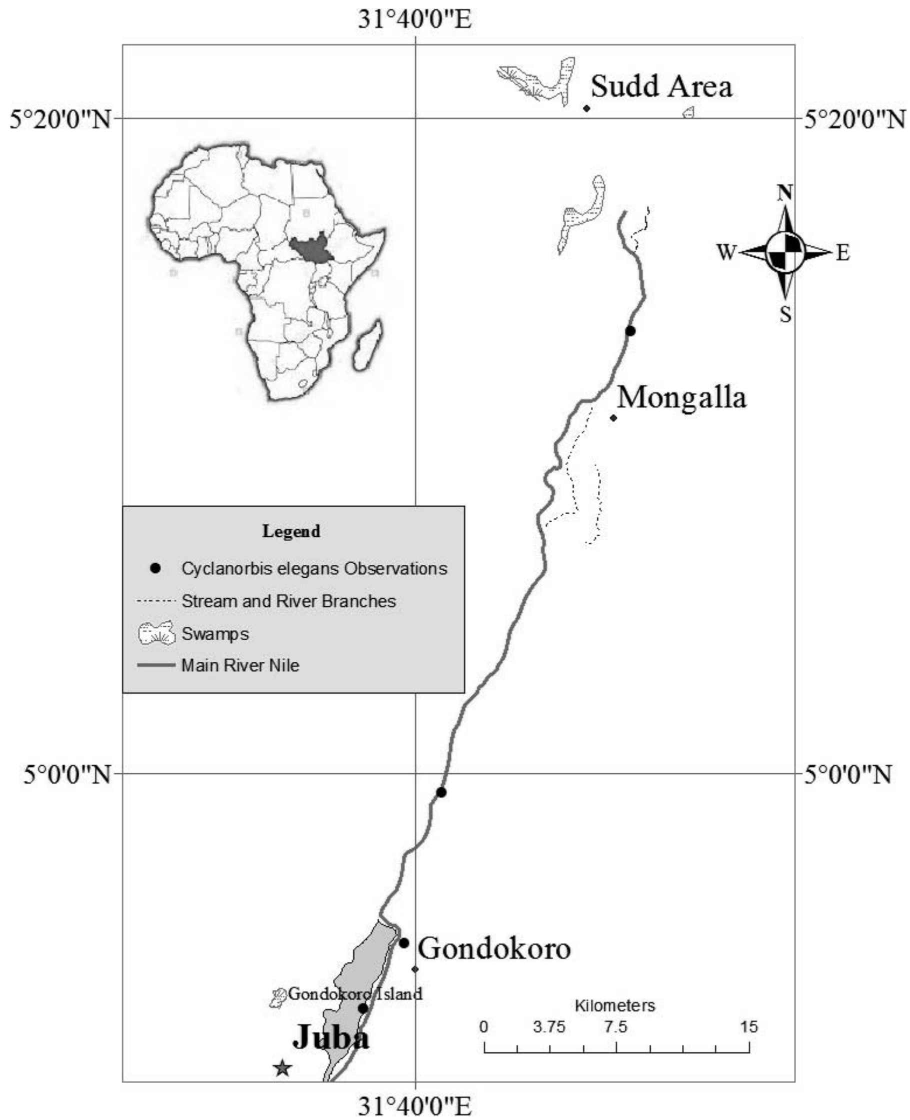

Figure 2. Map of South Sudan, showing the tract of the White Nile river course that was explored during the present research project and the distribution records obtained for *Cyclanorbis elegans*.

the density of *T. triunguis* was reported to not vary remarkably across a longitudinal gradient, as the species was reported to be very common (with well over 100 individuals caught per year at single villages) from the Sudd wetlands to the Ugandan border. This latter was reported to be very common in rain-flooded areas, especially during the rainy season.

In order to get insights into the reliability of these LEK estimates, we counted the number of shells of *C. elegans* that were kept in each village (most villages contained none and a few villages contained multiple shells) and then correlated this number with the latitude of the villages. We observed that there was a significant negative correlation between the number of *C. elegans* shells observed in each village and the relative increasing latitude ($r_s = -0.991$, $n = 16$, $p < 0.0001$), thus confirming the patterns that had been highlighted during the interviews.

Overall, it appears that the 2 *Cyclanorbis* species should show a negative density dependence across a geographic large-scale transect along the White Nile river course, the same as observed in other chelonians that may be in competition for the available resources (e.g., *Kinixys homeana* and *Kinixys erosa* in West Africa; Luiselli et al. 2008). If the negative density dependence of the 2 *Cyclanorbis* is due to interspecific competition, then we can expect that competition strength should be higher between adult *C. senegalensis* and juvenile *C. elegans* given that the adults of the latter species are far larger than adults of the former species. Although further field studies should be planned to analyze experimentally the coexistence dynamics of the 2 *Cyclanorbis* species in sympatric conditions, the evidence coming from LEK clearly suggests that this might be a fertile and promising field for future investigations.

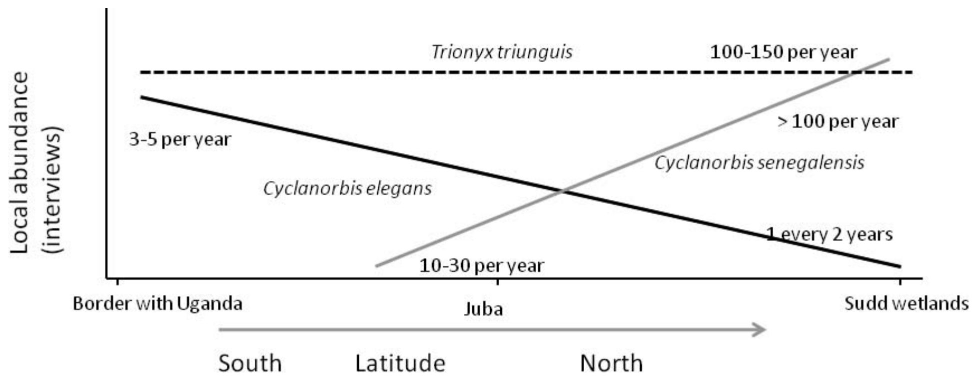

Figure 3. Variation in the local abundance (number of individuals per year per village estimated on the basis of interviews with fishermen) of *Cyclanorbis elegans* in relation to the tract of the White Nile surveyed and in comparison with other sympatric species (patterns based on interviews with local fishermen and on our field data combined).

As stated in previous literature (Baker et al. 2015, 2016; Demaya et al. 2019), *C. elegans* is sought after as food, and our interviews showed that local Bari fishermen consider their meat much better than that of *T. triunguis* or *C. senegalensis*. Interviewees also reported that the Chinese community in Juba also likes eating *C. elegans* and that they always contact Chinese food traders when an individual is captured. An average-sized individual is sold for about USD 150 by local fishermen to Chinese buyers and a big female for up to USD 250 or 300. Thus, the income that comes from selling these turtles is substantial for the poor fishermen communities of the study area, and this makes *C. elegans* an attractive commercial species. However, the fishermen do not specifically target these turtles, as they are the bycatch of traditional fishing activities. We predict that because of Chinese interest in *C. elegans* trade, the local fishermen will intensify harvest pressure on these turtles.

Seasonal Patterns of Occurrence. — All interviewees from all villages agreed that *C. elegans* individuals are captured almost only during the wet season and that nearly all the specimens that they can catch are females carrying eggs. Our field data also confirm this pattern, with a remarkably higher frequency of individuals being found in wet-season months, with the observed frequencies in July, August, and September significantly exceeding the expected ones ($\chi^2_{11} = 26.07$, $p < 0.01$; Fig. 4). Thus, also in this case, our field sightings clearly confirmed the results of interview surveys.

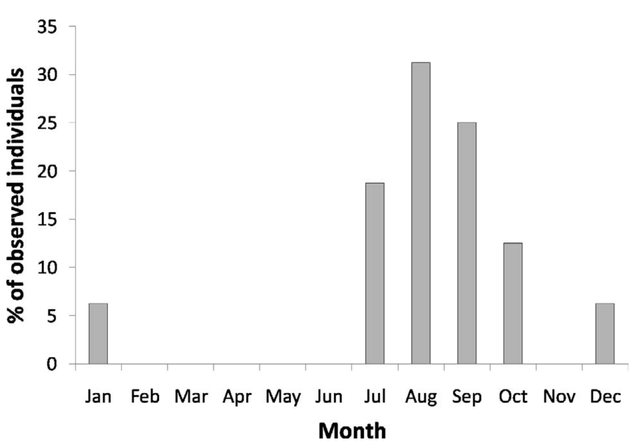

Figure 4. Frequency of individuals (in %) of *Cyclanorbis elegans* observed by month in South Sudan (total $n = 16$). See text for statistical details.

Reproductive Biology. — All interviewees from all villages agreed that gravid female *C. elegans* are found only between July and September, with oviposition events being concentrated in August to early October. Very interestingly, several fishermen agreed that the turtles oviposit year after year in the same sites, usually characterized by sandy banks of tributary rivers (never along the main White Nile river course). They claim that the turtles select quiet places with no large fishes or crocodiles, thus possibly minimizing the risk of predation on the hatchlings. Fishermen also stated that several females may oviposit on the same beach over several years so that it is easy for them to predict when and where the females go to the beach for ovipositing and eventually catch them. For instance, a fisherman told us that he killed 17 females at the same nesting site in July and August 2017. In confirmation of this, he showed us the damaged shells of at least 4 individuals. Although the reported highest number of ovipositing females at a single nesting site was 17, several fishermen reported that each nesting site is used by approximately 3–5 females per year. The occurrence of multiple females ovipositing at single nesting areas, situated outside the main river reaches, seems to be a regular event in this species' reproductive strategy. The width of the nesting beaches that were measured by us ($n = 4$) varied considerably, from about 10 to over 200 m. All the nesting sites occurred along tributary rivers of the White Nile.

Interviewed fishermen agreed that females produce 20–30 (maximum, 38) eggs that they deposit in various clutches in order to minimize risks of predation by Nile monitor lizards (*Varanus niloticus*). Our preliminary data on the eggs counted from wild-caught females and females dissected (by fishermen) agreed fully with the raw counts provided by fishermen during interviews, as we counted

27 oviductal eggs in a female (largest vitellogenic follicle being 5.1 cm in length).

Interestingly, we never observed any hatching or juvenile *C. elegans*, whereas we frequently observed juveniles of sympatric *T. triunguis*. This suggests that *C. elegans* juveniles are either exceptionally elusive or very scarce in the environment. If the latter case is true, this would be another piece of evidence for the highly threatened status of this species in South Sudan.

Morphometrics. — During our field surveys, we recorded carapace measurements of 12 individuals. These measurements do not include the leathery rear margin of the shell, only the bony disk. Carapace length and width were positively correlated ($r = 0.90$, $p < 0.0001$; Fig. 5), with the mean carapace length being 50.8 ± 8.0 cm (range, 34.2–64.0 cm) and the mean carapace width being 46.2 ± 6.6 cm (range, 30.2–53.0 cm). Shell size is much larger if we include the leathery margin in the measurements; for instance, a specimen with bony disk of 34.2 cm had a total shell length of 49.5 cm, and a large individual of 64.0 cm had a total carapace length of 88.5 cm.

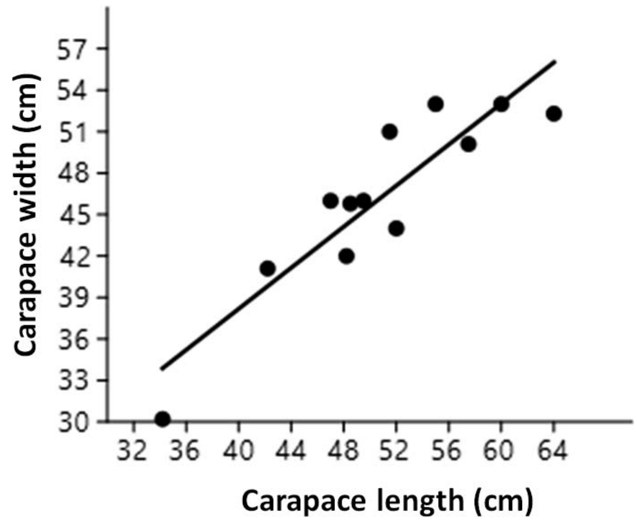

Figure 5. Correlation between carapace length and width in *Cyclanorbis elegans* from South Sudan. See text for statistical details.

Implications of LEK Data for the Conservation and Management of the Nubian Flapshell Turtle. — Our study documented that LEK data, if collected by standardized and independently conducted interviews, can be very useful to complement information on the natural history of rare and poorly known species. In the present case, we have shown that preliminary field data mirror very well the information obtained from interviews, for instance, concerning the seasonal phenology of the species as well as aspects of its reproductive biology. The information concerning the apparent abundance of the species along a latitudinal gradient also seems to be supported by the relative frequency of observation of shells along the same latitudinal gradient, but of course more detailed field data are required before drawing firm conclusions.

Our study also showed that hunting pressure is focused on reproductive females, as the communal nesting areas are easily discovered and generally well known to fishermen and villagers. Several females can be killed at each nesting area in each reproductive season. Eggs can be easily collected the same way, and the clutches of several females can be destroyed at one time. We hypothesize that the general population collapse and extinction of *C. elegans* from most of Africa may have resulted from their predictable oviposition site selection and by the use of communal nesting sites by multiple reproductive females. Indeed, in South Sudan, the human population density is far less than in West Africa, and the freshwater natural habitats are generally in a much better status (L.L., *pers. obs.*). Thus, it may be that *C. elegans* populations declined more quickly in West Africa than in South Sudan because their females were caught in high numbers when ovipositing in communal nesting areas until approaching regional extinction (it is about 20 yrs now that no single free-ranging individual has been found in any West African country despite intense herpetological research in the region). It is urged that any protected area focusing on *C. elegans* include a few of these communal nesting areas that should be carefully monitored to prevent collection of females or eggs, at least during the reproductive period (July–September). In an ongoing project that the authors of this article are carrying out together with the Ministry of the Environment and the Ministry of Wildlife Conservation and Tourism of the Republic of South Sudan, a protected area has been selected for implementation along the White Nile River, with 2 of these communal nesting areas being included in the fully protected zone. Although the creation of a new protected area for *C. elegans* should be an urgent conservation priority, we consider that it is crucial to work jointly with the riverine communities to enlist their collaboration with a conservation program (e.g., via offering monetary incentives for the provision of live specimens for study and release as well as for nests and nest sites although not for excavated eggs).

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LITERATURE CITED

AKANI, G.C., EBERE, N., FRANCO, D., AND LUISELLI, L. 2013. Using local African communities' ecological knowledge to support scientific evidence of snake declines. Herpetozoa 25:133–142.

BAKER, P.J., DIAGNE, T., AND LUISELLI, L. 2015. *Cyclanorbis elegans* (Gray 1869)—Nubian Flapshell Turtle. In: Rhodin, A.G.J., Pritchard, P.C.H., van Dijk, P.P., Saumure, R.A., Buhlmann, K.A., Iverson, J.B., and Mittermeier, R.A. (Eds.). Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonian Research Monographs 5:089.1–089.7. doi:10.3854/crm.5.089.elegans.v1.2015, http://www.iucn-tftsg.org/cbftt.

BAKER, P.J., LUISELLI, L., AND DIAGNE, T. 2016. *Cyclanorbis elegans*. The IUCN Red List of Threatened Species 2016: e.T6004A3086539. http://doi.org/10.2305/IUCN.UK.2016-2.RLTS.T6004A3086539.en

BEGAZO, A.J. AND BODMER, R.E. 1998. Use and conservation of Cracidae (Aves: Galliformes) in the Peruvian Amazon. Oryx 32:301–309.

BRANCH, B. 2007. Tortoises, Terrapins and Turtles of Africa. Cape Town: New Holland Publishers, 128 pp.

DEMAYA, G.S., BENANSIO, J.S., LADO, T.F., DIAGNE, T., DENDI, D., AND LUISELLI, L. 2019. Rediscovery of the Nubian flapshell turtle (*Cyclanorbis elegans*) in South Sudan. Chelonian Conservation and Biology 18:62–67.

GADGIL, M., BERKES, F., AND FOLKE, C. 1993. Indigenous knowledge for biodiversity conservation. Ambio 22:151–156.

LUISELLI, L., ANGELICI, F.M., RUGIERO, L., AKANI, G.C., ENIANG, E.A., PACINI, N., AND POLITANO, E. 2008. Negative density dependence of sympatric hinge-back tortoises (*Kinixys erosa* and *K. homeana*) in West Africa. Acta Herpetologica 3:19–33.

LUISELLI, L., DENDI, D., PACINI, N., AMADI, N., AKANI, G.C., ENIANG, E.A., AND SÉGNIAGBETO, G.H. 2018. Interviews on the status of West African forest tortoises (genus *Kinixys*), including preliminary data on the effect of snail gatherers on their trade. Herpetological Journal 28:171–177.

RIST, J., MILNER-GULLAND, E.J., COWLISHAW, G., AND ROWCLIFFE, M. 2010. Hunter reporting of catch per unit effort as a monitoring tool in a bushmeat-harvesting system. Conservation Biology 24:489–499.

STANFORD, C.B., RHODIN, A.G.J., VAN DIJK, P.P., HORNE, B.D., BLANCK, T., GOODE, E.V., HUDSON, R., MITTERMEIER, R.A., CURRYLOW, A., EISEMBERG, C., FRANKEL, M., GEORGES, A., GIBBONS, P.M., JUVIK, J.O., KUCHLING, G., LUISELLI, L., SHI, H., SINGH, S., AND WALDE, A. (EDS.). 2018. Turtles in Trouble: The World's 25+ Most Endangered Tortoises and Freshwater Turtles—2018. Ojai, CA: IUCN SSC Tortoise and Freshwater Turtle Specialist Group, Turtle Conservancy, Turtle Survival Alliance, Turtle Conservation Fund, Chelonian Research Foundation, Conservation International, Wildlife Conservation Society, and Global Wildlife Conservation.

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