

Population, flocking behaviour and habitat selection of the Grey Crowned Crane *Balearica regulorum* at Lake Ol' Bolossat basin, Kenya

Wanyoike Wamiti, Nathan Gichuki, Dorcus A. Sigana, Peter Njoroge, Günter Nowald and David Fox

Summary

Lake Ol' Bolossat is an inland wetland located in Nyandarua County, Kenya that provides critical year-round habitat for the Globally Endangered Grey Crowned Crane *Balearica regulorum gibbericeps*. This study aimed at establishing the population size and density of cranes in the basin, ratio of young to adults (as a measure of productivity), and habitat selection and use during the breeding and non-breeding seasons. Using complete ground counts, five censuses were conducted between 2017 and 2020 with between 521 and 1115 cranes recorded, and we estimate the local population size to be 250–350 individuals. Population density ranged from 0.99–2.18 cranes/km² during the breeding and non-breeding seasons respectively. From all 219 observations made during the study period, the mean flock size was 28.21 with a maximum flock size of 332 and a modal flock size of 2–25 individuals. The average proportion of young cranes across all counts was 11.65% indicating a population which is breeding successfully. Although cranes occupied both wetlands and terrestrial habitats in almost equal proportions across the year cumulatively, the difference in choice of habitat between the breeding and the non-breeding seasons was significant ($\chi^2=489$, $df=1$, $p=0.0001$), whereby more cranes (mostly paired individuals) were observed in marshes during breeding months. Wheat fields were the most often used of terrestrial habitats among fields of different crop types sampled. Holding 14% and 5% of Kenya's and the global population of Grey Crowned Cranes, respectively, Lake Ol' Bolossat is undoubtedly an important site for this species' conservation and survival.

Keywords: Lake Ol' Bolossat, *Balearica regulorum gibbericeps*, habitat selection, population size, flock characteristics

Introduction

The family Gruidae comprises 15 extant species found in all regions of the world except Antarctica, and only marginally in the Neotropics (Archibald & Meine 1996). The Gruidae have been cited as the most threatened of all bird families in the world (Meine & Archibald 1996), with four species listed as Least Concern, seven as Vulnerable, three as Endangered and one as Critically Endangered (BirdLife International

2020b). The Grey Crowned Crane is the only species present in Lake Ol' Bolossat basin where this study was conducted.

Grey Crowned Cranes occupy mixed wetland-grassland habitats throughout eastern and southern Africa (Walkinshaw 1964). The subspecies *gibbericeps* has been reported as abundant in Kenya, Uganda and Tanzania (Meine & Archibald 1996), with Kenya hosting the largest population (Morrison 2015, BirdLife International 2020). They also occupy agricultural land such as cultivated crop fields (maize, oats, wheat, barley etc.), fallow land and irrigated fields. Morrison (2015) has described this species as an icon of Africa's wetlands and grasslands, thus it is an excellent indicator species of the health of these ecosystems. Its global population has been reported as declining over the years. This was estimated at over 100 000 individuals in 1985 (Urban 1988), 50 000–64 000 individuals in 2004 (Beilfuss *et al.* 2007), and 26 500–33 500 in 2014 (Morrison 2015). As a result, it is listed as Endangered on the IUCN Red List of Threatened Species (BirdLife International 2020c).

The Kenyan population too has been declining. From 1980 to 1999, estimates ranged from 20 000 to 35 000 (Urban *et al.* 1989, Gichuki 1993, Daut 1994), but from 2015 to 2020, numbers reported were much lower at 8 000 to 12 500 (Morrison 2015, Wamiti *et al.* 2020). These estimates point to a continuously declining population, conforming to an average loss of 735 cranes per year over a period of 34 years (1985–2019). Although there is a recent national population estimate (Wamiti *et al.* 2020), detailed information from regional strongholds is lacking, including Lake Ol' Bolossat, where the second largest count (1115 individuals) of the species in Kenya has been recorded.

Prior to 2019, Kenya had not conducted a countrywide census to establish its Grey Crowned Crane population. According to Wamiti *et al.* (2020), there had only been two previous attempts, both of which were limited in their coverage. Reporting by the African Waterfowl Census (e.g., Nasirwa *et al.* 2018, Madindou *et al.* 2019), has indicated Lake Ol' Bolossat to be one of the few sites nationally, and sometimes the only site, continuously supporting a high number of cranes.

In Kenya, Lewis & Pomeroy (1989) describe the Grey Crowned Crane as occurring mostly over 500 m above sea level and in areas with over 500 mm of rainfall. Known breeding sites include areas of western Kenya and the Lake Victoria basin, Baringo and Kericho, Narok, Naivasha, and east of the Rift Valley especially around Mt. Kenya and the Aberdares, as well as the Nairobi and Amboseli regions (Brown & Britton 1980). In the study population, the longer (nine months) breeding season usually runs between June and February (when cranes build nests, incubate and rear chicks), while the shorter (three months) non-breeding season lasts between March and May. This classification of seasons is, however, not fixed. It varies from year to year, and is based on a normal local weather pattern on which the cranes' life cycle is in turn dependent. The objective of our study was to describe the characteristics of the Lake Ol' Bolossat population in terms of the size, density, habitat selection and use, age structure as an indicator of breeding productivity (proportion of young/juveniles, immature and sub-adults) as well as its conservation status for management purposes.

Materials and methods

Description of the study area

Lake Ol' Bolossat (0°09' S, 36°26' E) lies at an altitude of 2330 m in the northern reach-

es of Nyandarua County, Kenya (Fig. 1). The lake itself covers an area of 43.3 km² (Krhoda 1992). The lake basin is bounded to the east by the steep Satima escarpment rising up to 2530m and from the base of which approximately ten springs feed Lake Ol' Bolossat. On the gently sloping western margins, formed by the Dundori ridge (2850m), three rivers drain into the lake at the northwestern end. Water leaves the basin via the Ewaso Narok River that starts at the picturesque 75 m high Nyahururu falls at the north end of the lake. An internal drainage basin, the lake is characteristic of Rift Valley lakes in having a shallow maximum depth of 4 m (Thenya *et al.* 2011), a narrow width of 0.16–3.4 km, and a linear stretch of approximately 30 km. Internationally, the lake is recognized as an Important Bird and Biodiversity Area (Wamiti *et al.* 2009) thus qualifying as a Key Biodiversity Area, and it is also recognized as a site in danger by BirdLife International (2020a). Nationally, the Kenya government has declared an area of 147 km² around and including the lake as a Protected Wetland Area through Legal Notice No. 179 of 4 July 2018 (Kenya Law 2018).

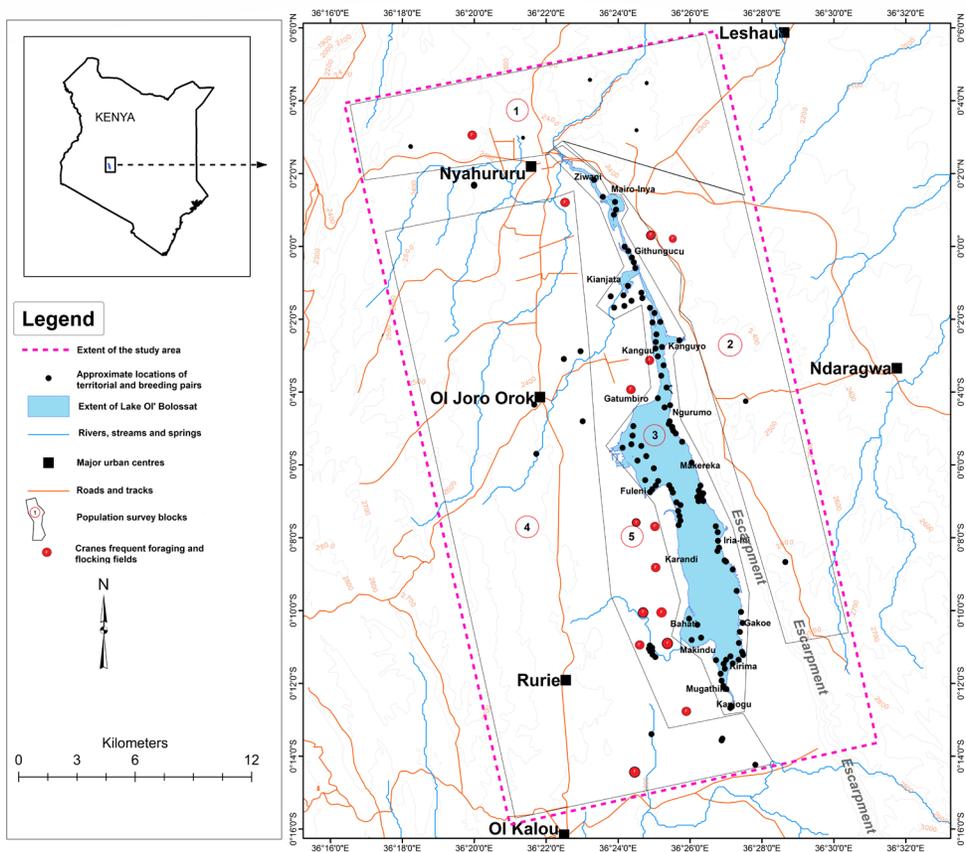


Figure 1. Location of Lake Ol' Bolossat showing the extent of the study area (survey boundary), approximate locations of territorial pairs, major flocking sites and census units (1=Shamanei-Leshau, 2=Ndaragwa-Shamata, 3=shoreline & riparian land, 4=Nyahururu-Ol' Kalou highway, 5=foraging fields).

The lake's 43.3 km² is comprised of approximately 20 km² of permanent marshes, the remainder being open water. It is surrounded by an extensive (though heavily encroached and overgrazed), wet-dry riparian grassland ecosystem that borders cultivated fields and human settlements. The marshes are dominated by *Cyperus* spp., *Schoenoplectus corymbosus* (Cyperaceae), *Typha* spp. (Typhaceae), and may be interspersed by Swamp Cut Grass *Leersia hexandra* (Poaceae), *Persicaria* spp. (Polygonaceae), *Lythrum rotundifolium* (Lythraceae), Mosquito Fern *Azolla* spp. (Azollaceae) and Kariba Weed *Salvinia molesta* (Salviniaceae). The cultivated crop fields included wheat, oats, barley, peas, potatoes, beans, and fallow fields, whereas the grasslands were either native pasture or playing fields. Fallow agricultural fields were dominated by Ruby Grass (*Rhynchelytrum repens*) and species of the genus *Eragrostis*. The rest of the lake basin is dominated by cultivated fields, natural and plantation forests, rivers, marshes, swamps, man-made water reservoirs, infrastructure (roads, an airstrip, a railway, power transmission lines, etc.), homesteads and urban areas. For greater detail on the conservation threats faced by cranes in Kenya and the Lake Ol' Bolossat, see Wamiti *et al.* (2020).

Data collection

Data were collected for a period of 32 months from December 2017 to July 2020 during which we conducted five censuses: February 2018, October 2018, January 2019, March 2019 and March 2020. Although bird surveys can be undertaken at any time (Pomeroy *et al.* 2018), counting cranes was conducted at approximately the same time, between October and March, for consistency. In most years, this period coincides with the peak of the breeding season in October–January when most breeding pairs have chicks. It is also the time when harvesting and field preparations for crops (maize, wheat, barley, and oats) takes place thus attracting cranes that seek spilled grains. Meanwhile, February and March coincide with the dry season when cranes are known to form flocks, facilitating counting. This time period therefore offers the best opportunities to obtain a minimum population estimate comprised of resident individuals, new recruits (juveniles) and immigrants.

The study area was determined by observing a resident flock of cranes (with some marked individuals) moving between their roosting sites within the lake's marshes and foraging fields nearby. This area was divided into five census units of variable sizes (Fig. 1) and we employed the same approach and team leaders in each count to reduce observer bias in the data collection. Parts within the 646-km² study block covered by unsuitable habitats (e.g., forested habitats, major roads, and urban centres) were excluded in determination of the population density, following Gichuki (1993). When these areas (approximately 120 km²) were excluded, the area of remaining suitable habitat for cranes amounted to 526 km².

A complete (true) count over a sample census was chosen since it does not require correcting for detection bias and is recommended for rare species that have a limited, selective choice of foraging fields (Gregory *et al.* 2004). A ground count, reported as the simplest and most common form of counting waterbirds (Wetlands International 2010), was adopted. Ground was covered using a vehicle, motorcycle and on foot (along the lake shoreline). Other researchers have, however, used aerial counts (e.g., Nsengimana *et al.* 2019) and transect-based distance sampling (e.g., Amulike *et al.* 2020) as alternative methods. The entire study area was covered in two days. Day one encompassed the shoreline and the riparian land, and the foraging fields (units

3 and 5; Fig. 1), both holding the majority of the population and accounted for 83% of all the observations. The 80km long shoreline was split into six sections and each assigned to two teams. Two teams started counting at the same point and walked a transect line along the shoreline in opposite directions to meet another team to conclude. Other units (1, 2 and 4) were counted on day two, mostly targeting breeding and territorial pairs that nest and forage in the lake's satellite wetlands. Except for unit 4 that had a site where cranes flocked, units 1 and 2 supported pairs and/or families that rarely wandered far from their sites. Presence of colour-marked individuals in flocks helped reduce chances of double counting. Counting took place simultaneously over a four-hour period (08:00–12:00) which also helped reduce the chances of double counting.

For each sighting of cranes, the following data were recorded: date, time, number of young and adults, habitat type, estimated field area (ha), and coordinates. Exact counts were made of small flocks (<30 cranes) while medium-sized (31–100 cranes) and larger (>100 cranes) flocks were estimated using a tally counter. Where flocks were tight (i.e., individuals close to each other, frequently mixing), counting was attempted 3 to 4 times and the highest count was used. Two broad age categories of cranes were identifiable in the field (juveniles and adults), and were used in calculating young/adult ratios. Data were divided into breeding and non-breeding seasons.

Results

Standard population measurements

For each of the five complete ground counts conducted, the total number of cranes recorded was: 650 (February 2018), 521 (October 2018), 894 (January 2019), 1115 (March 2019) and 622 (March 2020; mean 760.4, S.E. 107.8, S.D. 240.9). Population size differed significantly across the five censuses ($t_4 = 7.056$, $p = 0.002$). Population densities (cranes/km²) for each census were: 1.24 (February 2018), 0.99 (October 2018), 1.69 (January 2019), 2.12 (March 2019) and 1.18 (March 2020), with a mean density of 1.44 cranes/km².

The mean proportion of young cranes across all five counts expressed as a percentage of the total number of cranes was $11.65\% \pm 1.140$. There was a higher ratio of young recorded in the non-breeding season ($12.87\% \pm 1.434$) compared to the breeding season ($9.49\% \pm 1.583$) although this difference was non-significant (Welch F test in the case of unequal variances: $F = 2.503$, $df = 209.4$, $p = 0.1152$). This ratio was however significant between the small (12.95%), medium (8.68%) and large (6.45%) sizes of flocks (Welch F test in the case of unequal variances: $F = 5.007$, $df = 51.81$, $p = 0.0103$).

The mean group size was 28.21 cranes/group ($n = 219$, s.e. 3.24, s.d. 47.97, median = 4, mode = 2, range = 1–332) while the modal group size were flocks with 2–25 individuals ($n = 151$, Fig. 2). Half of these smaller flocks (i.e., 2–25 crane groups) were, however, observed as pairs ($n = 76$). There were a total of 13 flocks with over 100 cranes, 11 of them occurring during the non-breeding season, while the other two were observed during the June breeding season (due to the presence of a c. 80 cranes resident flock). There were only four sightings of single individuals, likely partners of incubating pairs.

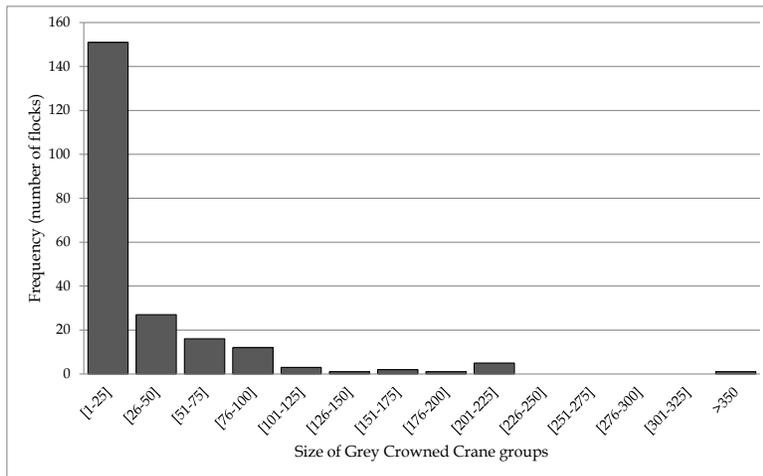


Figure 2. Frequency distribution of Grey Crowned Crane groups observed at Lake O' Bolossat basin.

Habitat selection

Cranes were found to utilize both dry/terrestrial and wet habitat substrates for 46% and 54% of observation time respectively. Comparing habitat use between the breeding and the non-breeding seasons, more cranes were observed in wet substrates (wetlands) during the breeding season than during the non-breeding season ($\chi^2=489.28$, $df=1$, $p=0.0001$). Across all counts, most (35.6%) of the cranes observed were territorial pairs occupying primarily the lake's marshes, followed by wheat fields (29.2%; Table 1). Eight of the 13 largest flocks (i.e., those with over 100 cranes) were recorded in the wheat fields. Cultivated crop fields had the highest diversity of dry substrates (terrestrial habitats) comprising of cereal (barley, maize, wheat, and oats) and other crops (peas, beans and potatoes; Table 1). The size of fields preferred by cranes for foraging ranged from 0.5–130 ha. However, there was only a weak relationship between size of foraging fields and size of crane flocks (Spearman Rank Correlation $r_{108}=0.0011$, $p=0.9909$).

Table 1. Spatial distribution of Grey Crowned Cranes in different habitats and details of observations made during the study period.

Habitat types	No. cranes	No. observations	Mean group size	Proportion (%) of total observations
Cultivated crops fields				
Wheat	3494	64	54.59	29.2
Barley	632	3	210.67	1.4
Fallow	591	9	10.11	4.1
Maize	377	6	62.83	2.7
Oats	253	5	50.60	2.3
Other crops	72	4	18.00	1.8
Grasslands	209	9	23.22	4.1
Wetlands (marshes)				
Lake's edge	741	78	9.50	35.6
Streams/springs	252	19	13.26	8.7
Reservoirs	58	22	2.64	10.1
Total	6179	219		100.0

Discussion and conclusion

Standard population measurements

The Grey Crowned Crane population in the Lake Ol' Bolossat basin has both resident birds and immigrants as shown by the fluctuating number of individuals across the five counts we conducted. We conservatively estimate that the basin has a resident population of between 250 and 350 cranes, based firstly on the findings of Wamiti *et al.* (2020) who established a total of 103 territorial pairs in the lake. We add to this our own observations of 30 additional territorial cranes in satellite wetlands, and an additional resident flock of approximately 80 individuals. This crane population reached a maximum of 1115 cranes during the non-breeding season. Our results show that the Lake Ol' Bolossat basin is a key site for the species given that it holds 14.3% of Kenya's estimated population, and should therefore be monitored annually in both the breeding and non-breeding seasons.

The population density reported in this study of 0.99–2.12 cranes/km² compares favourably with Kisii's 1.14 cranes/km² (Burke 1965), 1 crane/km² in Uganda (Pomeroy 1980), 1.57–2.89 cranes/km² in the Kitale area (Gichuki 1993) and Ngorongoro Crater's 2.4 cranes/km² during the wet season (Amulike *et al.* 2020). Crane density was observed to vary between the breeding and non-breeding seasons resulting from the arrival and departure of immigrant birds from other areas, although we couldn't determine whence they originated. However, food, nest-sites and rainfall are important factors that are reported as key in influencing this crane's variable local and seasonal movements (del Hoyo *et al.* 1996).

Even though our juvenile data included both fledged and unfledged cranes (as these weren't separated during data collection), our findings of a young/adult ratio of 11.63% is consistent with studies showing a ratio of 10–15% elsewhere, and is indicative of a healthy population (Archibald & Meine 1996). This is especially encouraging given that immediately prior to our study, only a single chick fledged during the entire 2015/2016 breeding season for unknown reasons (Muigai 2016). The improvement in breeding success that we observed may be attributable to the ongoing conservation efforts by Cranes Conservation Volunteers in the study area who have worked to reduce threats such as collection of eggs, removal of chicks, trapping of adults, and minimized livestock disturbances at the nesting sites.

Gichuki & Gichuki (1991) reported a flock size of 2–130 birds at Lake Ol' Bolossat with a mean flock size of 15.4 birds/flock compared to this study's flock sizes of 2–332 individuals and a mean of 28.1 birds/flock. This is perhaps because of our extended period of study (32 months) running over both breeding and non-breeding seasons compared with their five-month study between August and December (breeding season). Large flocks may be more vulnerable to threats such as increased risk of disease and parasite transmission, and at sites where cranes are exposed to conflict with farmers there are high risks of poisoning and trapping because of the crop damage that cranes may cause.

Habitat selection and use

Habitat selection is often related to seasonal changes in foraging ecology (Nowald *et al.* 2018), and as expected, cranes observed in this study occupied a variety of different habitats in different seasons. Small fields (mostly ≤ 0.5 ha) that looked potentially suitable for cranes but were surrounded by wire fencing or hedges were largely avoided. This is probably because cranes prefer open fields with a good view

of approaching danger such as humans and feral dogs. Cranes were observed to favour more open adjacent areas, even if these small fields contained preferred forage. Hence, security is perhaps more important than food in choice of a foraging site. The choice of a foraging field also appeared to be affected by factors such as proximity to human disturbance, a crop's stage and type, and the size/area of the field.

Compared to the steeply sloping and intensively farmed eastern side of the lake with limited open habitats, the gently sloping western side had higher crane concentrations due to presence of large farms that allow mechanized farming, especially in the wheat farms. Cranes roosted on trees, in marshes and shallow water at the lake edge, in small to medium-sized flocks, pairs or family groups. The lake has three main roosting sites in the south and central sections, and a fourth in a nearby man-made reservoir, Robert's dam. Identification of roosting sites is important because cranes are especially concentrated at these, and therefore especially vulnerable to disturbance. Roosts are important in dictating habits of cranes such as local dispersion and use of foraging habitats (Allan 1996). Furthermore, knowledge of roosting sites may offer important future opportunities for censusing cranes with multiple simultaneous counts.

Cranes that foraged in grasslands and fallow fields often occurred together with livestock. Pairs with chicks were also seen pecking on dry and fresh cattle dung, perhaps looking for insects such as larvae and adult dung beetles. As food availability became scarce, cranes left the fields but would return immediately after they were burned or ploughed, to take advantage of unburned waste grains or sowed seeds that might be exposed.

Ring recoveries

During the period of this study, two adult cranes bearing colour rings were observed (G. Muigai, pers. comm.; 2 March 2019). We confirmed that these birds were ringed at Lake Ol' Bolossat between July 1988 and March 1989, at the age of one month old (Gichuki & Gichuki pers. comm.). These individuals present new information on longevity in a wild Grey Crowned Crane, with the age of 32 years being 12 years older than the previous record of 20 years old (Allan 1996).

Acknowledgements

This study's fieldwork was funded by the African Bird Club (through a Conservation Award) and Leiden Conservation Foundation (African Cranes Grant) through the International Crane Foundation/Endangered Wildlife Trust Partnership. We also benefited from activities of two CEPF grants to Cranes Conservation Volunteers and East Africa Wild Life Society. Kenya Wildlife Service, to whom we are sincerely thankful, granted research authority. We are also grateful to the National Museums of Kenya and the University of Nairobi, whence this research was conducted. Field equipment support was realized from Idea Wild (Denver, CO, USA) and the Nature and Biodiversity Conservation Union (NABU, BirdLife Germany). We appreciate data collection support from members of Cranes Conservation Volunteers (George Ndung'u, Rhoda Wangeci, Charles Gichuki and Hillary Wanjohi) and the Nyahururu Bird Club (Peter Karani and David Warui). We cannot forget the cordial reception we enjoyed from the local community around the lake and within the entire study area. We also thank D. Pomeroy and J. Bradley for helpful comments.

References

- ALLAN, D.G. 1996. A review of the biology and conservation of Cranes, p 13–29 in Beilfuss, R.D., Tarboton, W.R. & Gichuki, N.N. (eds) *Proceedings of the African Crane and Wetland Training Workshop*. Baraboo: International Crane Foundation.

- AMULIKE, B.B., FULLER, T.K., HOULIHAN, P.W. & GRIFFIN, C.R. 2020. Seasonal variation in Grey Crowned Crane (*Balearica regulorum*) abundance in the Ngorongoro Crater, Tanzania. *African Journal of Ecology* (April): 1-7. <https://doi.org/10.1111/aje.12738>
- ARCHIBALD, G.W. & MEINE, C.D. 1996. Family Gruidae (Cranes), p 60-89 in del Hoyo, J., Elliott, A. & Sagatal, J. (eds) *Handbook of the Birds of the World*. Vol 3. Barcelona: Lynx Edicions.
- ARCHIBALD, G.W., SHIGETA, Y., MATSUMOTO, K. & MOMOSE, K. 1981. Crane research around the world, p 1-12 in Lewis, J.C. & Masatomi H. (eds) *Proceedings of the International crane symposium at Sapporo, Japan in 1980 and papers from the World Working Group on Cranes*. Baraboo: International Crane Foundation.
- BEILFUSS, R.D., DODMAN, T. & URBAN, E.K. 2009. The status of cranes in Africa in 2005. *Ostrich* 78(2): 175184. <https://doi.org/10.2989/OSTRICH.2007.78.2.11.91>
- BIRDLIFE INTERNATIONAL. 2020a. Important Bird Areas factsheet: Lake Ol' Bolossat. Downloaded from <http://www.birdlife.org> on 15/10/2020.
- BIRDLIFE INTERNATIONAL. 2020b. IUCN Red List for Birds: Cranes. Downloaded from <http://www.birdlife.org> on 15/10/2020.
- BIRDLIFE INTERNATIONAL. 2020c. Species factsheet: *Balearica regulorum*. Downloaded from <http://www.birdlife.org> on 24/09/2020.
- BROWN, L.H. & BRITTON, P.L. 1980. *The Breeding seasons of East African Birds*. Nairobi: East Africa Natural History Society.
- BURKE, V.E.M. 1965. A count of Crowned Cranes (*Balearica regulorum* Bennet) in Kisii district, Kenya. *Journal of East African Natural History* 25(3): 162-163.
- DAUT, E.F. 1994. *Trapping Crowned Cranes (Balearica regulorum) using Alpha-Chloralose at Saiwa Swamp National Park, Kenya*. Ithaca, NY, USA.
- DEL HOYO, J., ELLIOTT, A., & SARGATAL, J. (EDS). 1996. *Handbook of the Birds of the World*. Vol. 3. Barcelona: Lynx Edicions.
- GICHUKI, N.N. 1993. Factors affecting the reproductive success of the Grey Crowned Crane. Unpublished PhD Dissertation. University of Cambridge.
- GICHUKI, N.N. & GICHUKI, C.M. 1991. Relationship between habitat selection and flock characteristics in foraging Grey Crowned Cranes *Balearica regulorum* in Kenya p 357-361 in Harris, J. (ed) *Proceedings 1987 International Crane Workshop, 1-10 May 1987, Qiqihar, Heilongjiang Province, People's Republic of China*. Baraboo: International Crane Foundation.
- GREGORY, R.D., GIBBONS, D.W. & DONALD, P.F. 2004. Bird census and survey techniques p 17-55 in Sutherland, W.J., Newton, I. & Green, R. (eds) *Bird Ecology and Conservation: A Handbook of Techniques*. New York: Oxford University Press.
- HARRIS, J. & MIRANDE, C. 2013. A global overview of cranes: status, threats and conservation priorities. *Chinese Birds* 4(3): 189-209. <https://doi.org/10.5122/cbirds.2013.0025>
- KENYA LAW. 2018. Declaration of Protected Area: Lake Ol' Bolossat. Downloaded from http://kenyalaw.org/kl/fileadmin/pdfdownloads/LegalNotices/2018/LN179_2018.pdf on 22/10/2020.
- KRHODA, G.O. 1992. The hydrology and functions of wetlands, p 13-22 in Crafter, S.A., Njuguna, S.G. & Howard, G.W. (eds) *Wetlands of Kenya: Proceedings of the KWWG seminar on wetlands of Kenya, NMK, Nairobi, Kenya, 3-5 July 1991*. Gland: IUCN.
- LEWIS, A. & POMEROY, D. 1989. *A Bird Atlas of Kenya*. Rotterdam: A.A. Balkema.
- MADINDOU, I., GICHOHI, E., BETT, A., N'GWENO, F., CHESIRE, D., IKIME, T., & GACHERU, P. 2019. *Waterbird Count Results in the Rift Valley and Central Kenya for July-August 2019*. Centre for Biodiversity Research Reports: Ornithology. National Museums of Kenya: Nairobi.
- MEINE, C.D. & ARCHIBALD, G.W. (EDS) 1996. *The Cranes: Status Survey and Conservation Action Plan*. Gland: IUCN.

- MORRISON, K. 2015. *International Single Species Action Plan for the Conservation of the Grey Crowned-crane* (AEWA Technical Report No. 59). Bonn: Germany.
- MUIGAI, G. 2016. Grey Crowned Crane monitoring report at Ol' Bolossat, Nyahururu: Nyahururu Bird Club.
- NASIRWA, O., MUNGAI, P., NG'WENO, F., KIRAO, L., CHESIRE, D., IKIME, T., & BARASA, F. 2018. *January 2018 Waterbird Count Results in the Rift Valley, Nairobi, Central, Coast, Amboseli and Yala Swamp*. Nairobi: National Museums of Kenya.
- NOWALD, G., FANKE, J., & HANSBAUER, M.M. 2018. Linking crane life history and feeding ecology with natural habitats and agricultural lands, p 18–34 in Austin, J.E., Morrison, K.L. & Harris, J.T. (eds.) *Cranes and Agriculture: A guide to sharing the landscape*. Baraboo: International Crane Foundation.
- NSENGIMANA, O., BECKER, M., RUHAGAZI, D., & FERUS, J. 2019. Minimum population size and distribution of Grey Crowned Cranes *Balearica regulorum* in Rwanda : an aerial and ground survey, 6525. <https://doi.org/10.2989/00306525.2018.1540445>
- POMEROY, D. 1980. Aspects of the ecology of Crowned Cranes *Balearica regulorum* in Uganda. *Scopus* 4: 29–35.
- POMEROY, D.E. 1980. Growth and plumage change of the Crowned Crane *Balearica regulorum*. *Bulletin of the British Ornithologists' Club* 100(4): 219–223.
- POMEROY, D., PLATZ, E., PLATZ, K., LACK, P. & GOTTSCHALK, T.K. 2018. The problems of recording bird numbers in the breeding season as pairs. *Ornithological Science* 17(1): 69–78.
- THENYA, T., KITEME, B.P., OUKO, C.A., KAHU, N., NJUGUNA, E., KARANJA, F., OJWANG', D. & WAMBUGU, G. 2011. *Assessment of Ecological Status and Socio-economic Dynamics of Upper Ewaso Ng'iro Basin Wetlands*. Centre for Training and Integrated Research for ASAL Development. Nanyuki: CETRAD.
- URBAN, E.K., FRY, C.H. & KEITH, S. 1986. *The birds of Africa*. Vol. 2. London: Academic Press.
- WALKINSHAW, L.H. 1964. The African Crowned Cranes. *The Wilson Bulletin* 76(4): 355–377.
- WAMITI, W., GICHUKI, N., SIGANA, D., NJOROGE, P., MORRISON, K., NDUNG'U, G., & RUBALCABA, J. 2020. Water depth , vegetation height, and offshore distance are critical factors in nest-site selection for Grey Crowned Crane at Lake Ol' Bolossat. *Authorea*, 1–14. Downloaded from <https://www.authorea.com/users/317648-wanyoike-wamiti> on 11/10/2020.
- WAMITI, W., MALAKI, P.A. & MWANGI, A.W. 2009. Birds of Conservation Concern Upgrades Lake Ol' Bolossat Status to Kenya's 61st Important Bird Area in Harebottle, D.M., Craig, A.J.F.K., Anderson, M.D., Rakotomanana, H. & Muchai, M. (eds) *12th Pan-African Ornithological Congress, Cape Town, South Africa, 7–12 September 2008*. Animal Demographic Unit: University of Cape Town.
- WAMITI, W., MWANGI, J., FOX, D., BAKARI, N., SCHRÖDER, W., NOWALD, G., WALTER, B., NDUNG'U, G., BII, E., WANJALA, M., NEKESA, V. & KIMANI, D. 2020. Kenya's first countrywide census of Grey Crowned Crane: February–March 2019. *Bulletin of the African Bird Club* 27(2): 210–218.
- WETLANDS INTERNATIONAL. 2010. Guidance on waterbird monitoring methodology: Field Protocol for waterbird counting. *Wetlands International* (March): 1–15.

Wanyoike Wamiti*

Zoology Department, National Museums of Kenya, Museum Hill/Kipande Rd, P.O. Box 40658-00100, Nairobi, Kenya & School of Biological Sciences, University of Nairobi, P.O. Box 30197-00100, Nairobi, Kenya. Email: wamiti@gmail.com; ORCID No. 0000-0001-7300-2101

Nathan Gichuki

School of Biological Sciences, University of Nairobi, P.O. Box 30197-00100, Nairobi, Kenya

Dorcus A. Sigana

School of Biological Sciences, University of Nairobi, P.O. Box 30197-00100, Nairobi, Kenya

Peter Njoroge

Zoology Department, National Museums of Kenya, Museum Hill/Kipande Rd, P.O. Box 40658-00100, Nairobi, Kenya

Günter Nowald

Crane Conservation Germany/NABU Crane Centre, Lindenstrasse 27, D-18445 Gross Mohrdorf, Germany

David Fox

African Conservation Foundation, 175A Victoria Road, London N22 7XH, United Kingdom & African Bird Club, c/o BirdLife International, The David Attenborough Building, Pembroke Street, Cambridge CB2 3QZ, UK

Scopus 41(1): 13-23, January 2021

Received 7 November 2020