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Original Research Article

Assessment of black crowned crane and wattled crane population and spatiotemporal distribution in Jimma Zone, Southwest Ethiopia

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A B S T R A C T

The black crowned crane (*Balearica pavonina*) and wattled crane *(Bugeranus carunculatus)* are the vulnerable resident birds of Ethiopia. However, little is known about their current status, local distribution, and responses to anthropogenic effects and environmental change. This study assessed the population status, spatiotemporal distribution, and factors affecting a population of the two crane species at 18 wetland sites in Jimma Zone, Southwest Ethiopia. The result shows, wetlands used by the cranes were classified as slope, riverine, depressional, and lake fringe based on topographic positions, landforms and hydrologic conditions. A total of 304 black crowned cranes and 30 wattled cranes were recorded at the wetland sites over the study period. Statistically, the population status of the two crane species were significantly ($P < .01$) varied among the wetland sites in the non-breeding season, whereas this was not true for the breeding season. Spatially the wattled crane population was varied significantly ($P < .01$) among wetland sites throughout the study period (2013 - 2017) when black crowned crane population was varied significantly ($P < .01$) in most years. Likely, variation in the temporal distribution of the black crowned crane population was significant ($P = .001$) for the study period where the distribution of wattled crane was significant for the third and final year. A regression analyses revealed the presence of multiple anthropogenic and environmental variables with significant influence on the crane population, including crane-inhabiting wetland proximity to other wetlands, wetland size, wetland buffer area ownership and use ($P < .01$). Generally, promising numbers of the black crowned crane and wattled crane are found in Jimma Zone. For better conservation impact, there is a need for improved spatial planning and policy support to control crane habitat fragmentation resulting from infrastructure and urban development, wetland drainage, and buffer area mismanagement.

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1. Introduction

Of the six crane species that occur in Africa, the black crowned crane (*Balearica pavonina*) and the wattled crane (*Bugeranus carunculatus*) are resident birds of Ethiopia (Beilfuss, 2004; Beilfuss et al., 2007; Aynalem, 2009; Aynalem et al., 2011; Harris and Mirande, 2013). Both species are known to suffer population declines across their geographic ranges and categorized as vulnerable in the IUCN Red List of threatened species (BirdLife International, 2016a, 2016b). In Ethiopia, the population of wattled crane is estimated below 200 individuals and that of a black crowned crane is unknown (Beilfuss et al., 2007). The report on wattled crane population is produced from surveys conducted on limited number wetlands sites such as Fogera plains, Lake Tana, Finchaa and Chomen swamps, Berga floodplain, Dilu Meki (Tefki), Koffe swamp, Boyo wetland, Bale mountains national park, and another few Important Bird Areas of Ethiopia (EWNHS, 1996; Beilfuss et al., 2007).

The quality and spatiotemporal distribution of crane habitats (e.g., wetlands) differ across the agricultural landscapes of Africa (BirdLife International, 2016a, 2016b). The population sizes of cranes are influenced by habitat-related factors, such as habitat size, quality, and distribution (Newton, 1998). Particularly, habitat specialist birds are affected by habitat fragmentation and distribution (McCann and Benn, 2006). The wattled crane is the most specialized of the African crane species, depending largely on intact wetland and floodplain habitats for its feeding, roosting and nesting (Smith et al., 2016). Yet the black crowned crane depends on wetlands to some extent for its feeding, roosting and nesting (Meine and Archibald, 1996; Aynalem, 2009). In Ethiopia, wetland habitats are considered as wasteland and obstacles to human development because of nuisances and calamities (e.g., Legesse, 2007). Consequently, wetlands are drained and converted into other land uses at a rapid rate (Woldemariam et al., 2018) which in turn affects wetland-dependent birds like the wattled crane (Mekonnen and Aticho, 2011). Except a few wetlands located in remote and sparsely populated areas, most of the wetland habitats are degraded (Aynalem, 2009).

Moreover, several anthropogenic and environmental factors influence the population status and distributions of both black crowned crane and wattled crane. For example, habitat status (degradation, fragmentation, loss), poor hydrological conditions (e.g., drought, flooding), shortage of food resources (e.g., underground tubers, water lilies, various sedge species), and unsuccessful nesting and breeding attempts are affecting the crane population (Johnsgard, 1983). In the meantime, the distribution, population and reproduction success of cranes are affected by human-induced factors like disturbance, conflict with cranes, and habitat modification (Maxson et al., 2008).

In Ethiopia, the spatial and temporal distributions of the black crowned crane and wattled crane are inadequately documented at the national, regional and zonal level. This study hypothesized that large numbers of black crowned crane and wattled crane are distributed throughout wetlands in Jimma Zone, and seriously affected by anthropogenic and environmental factors. A quantitative evidence of spatiotemporal distributions of cranes and factors affect the crane population are required to identify priority areas for habitat and species conservation planning. A systematic investigation to establish facts on the population and spatiotemporal distributions of cranes at the country or regional state levels is not easy; because the large-scale spatiotemporal assessment needs an appropriate logistic arrangement such as helicopter. Therefore, the objective of this study was to assess the population status, spatiotemporal distribution, and factors affect the black crowned crane and wattled crane population at Zonal level- Jimma Zone.

2. Materials and methods

2.1. Study area description

The study area-Jimma Zone is located in the Oromia National Regional State, Southwest Ethiopia (Fig. 1). Jimma town is the capital and administrative center of the Zone and is located at a distance of 350 km away from the capital of Ethiopia- Addis Ababa. The study area is situated between 1689 and 3018 m.a.s.l (meter above sea level) and receives an average rainfall between 1200 and 2400 mm per annum. The maximum and minimum annual temperature of the area is 28.8 and 11.8 ^{O}C, respectively (CSA, 2005).

Jimma Zone has plenty of year-round evergreen wetlands that support biodiversity, livestock, and socioeconomic activities. These wetlands are home for diverse bird species, such as abssinian longclaw, black crowned crane, wattled crane, wattled ibex, rouget's rail among others. The study area contains one of the 69 important bird areas (IBA) of Ethiopia-Koffe wetland.

2.2. Method of data collection

Both preliminary survey and detailed field investigation were conducted to generate information on the black crowned crane (*Balearica pavonina*) and wattled crane (*Bugeranus carunculatus*) population, spatiotemporal distribution, wetlands and

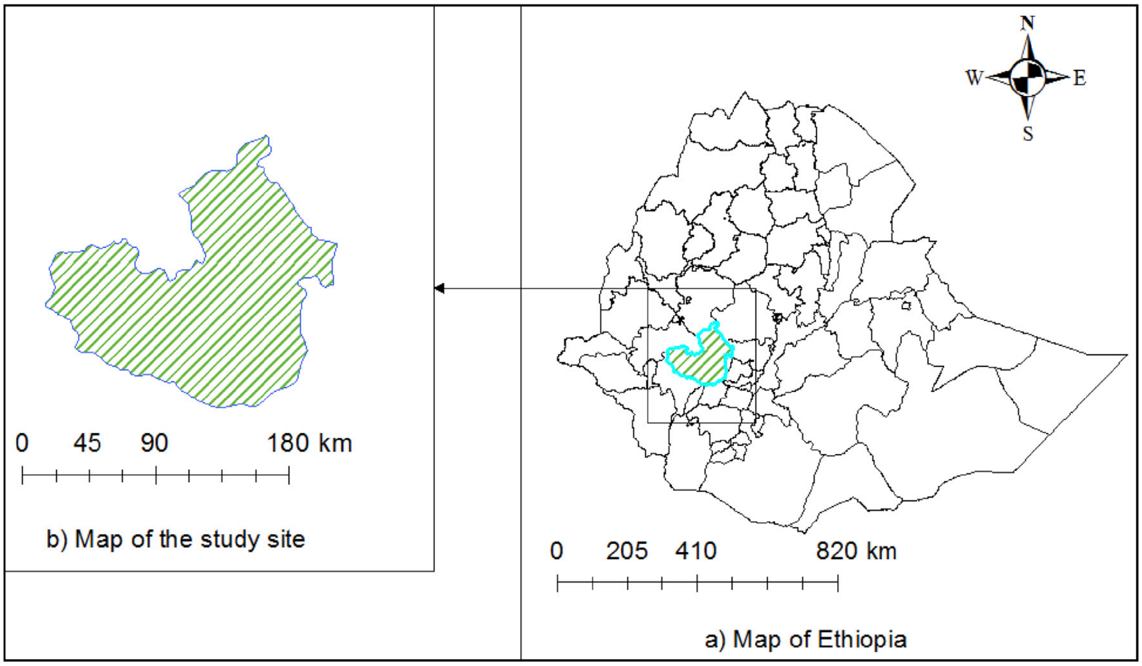

Fig. 1. Geographical location of the study area-Jimma Zone in Ethiopia.

factors affect the crane population in Jimma Zone. During the preliminary survey, field walks and interviews with local communities were made to record the two crane species and to identify potential wetlands used for crane feeding, breeding (nesting), and roosting. Of the 34 potential wetlands identified during the preliminary survey, only 18 wetlands were used by the cranes (Fig. 2); 17 wetlands by black crowned crane and 15 wetlands by wattled crane.

A detailed study of the crane population and factors affect the two crane species was conducted on the 18 wetlands used for feeding, nesting (breeding), or roosting purposes. The 18 wetlands were classified based on landforms, topographic positions, and associated hydrologic conditions following the USA (United State of America) wetland rating procedures (Hruby, 2015). In addition, the wetlands were characterized based on human disturbances such as wetland modification (Battisti et al., 2016) and environmental factors. At each wetland periodic field observations were made to determine the anthropogenic and environmental factors (variables) that affect the crane population. The descriptions and expected effects of these variables on the crane population were presented in Table 1.

At each wetland, a field assistant was hired and trained to conduct the crane counts using the total and point count methods (Jones and Marseden, 1998). A Bushnell binocular was used to count cranes from a distance in the case for large (big) and dense wetlands. Each count took 15–20 min, depending on crane group size. The crane count was conducted in the early morning (06:00–10:00 a.m.) and in the afternoon (03:00–06:30 p.m.) to concede with peak bird activity (Fisher and Hicks, 2006). The cranes were counted simultaneously across the study wetland sites to avoid double counts due to local movement of cranes. Cranes ages were classified as juveniles and adults through observing plumage and social groupings (Downs, 2004).

2.3. Data analysis

The data were entered and cleaned in Excel spreadsheets (Microsoft Corp, Redmond, WA, USA), and the analysis was performed with STATA v.14.0 (Stata Statistical Software: Release 14, College Station, TX, USA: StataCorp LP). Descriptive statistics was used to present the numbers of cranes recorded in each year in the study area. Generalized Linear Mixed Model (GLMM) with Poisson distribution and log link function was used to analyze crane population data (the black crowned crane and wattled crane) collected in the non-breeding and breeding seasons for five years (2013–2017) from the 18 wetland sites. The Poisson distribution was typically used for crane count data and the log link function to ensure positively fitted values. In this model, the numbers of cranes counted in the non-breeding season and breeding season were considered as fixed covariate whereas the 18 sample wetland sites were taken as random effects. Furthermore, the negative binomial model was used to determine the effects of anthropogenic and environmental factors on crane population since the variance of crane count data (crane population) was greater than the mean value (over-dispersed). The negative binomial model is a versatile option to capture over-dispersed data (Agresti, 1996; Hilbe, 2011).

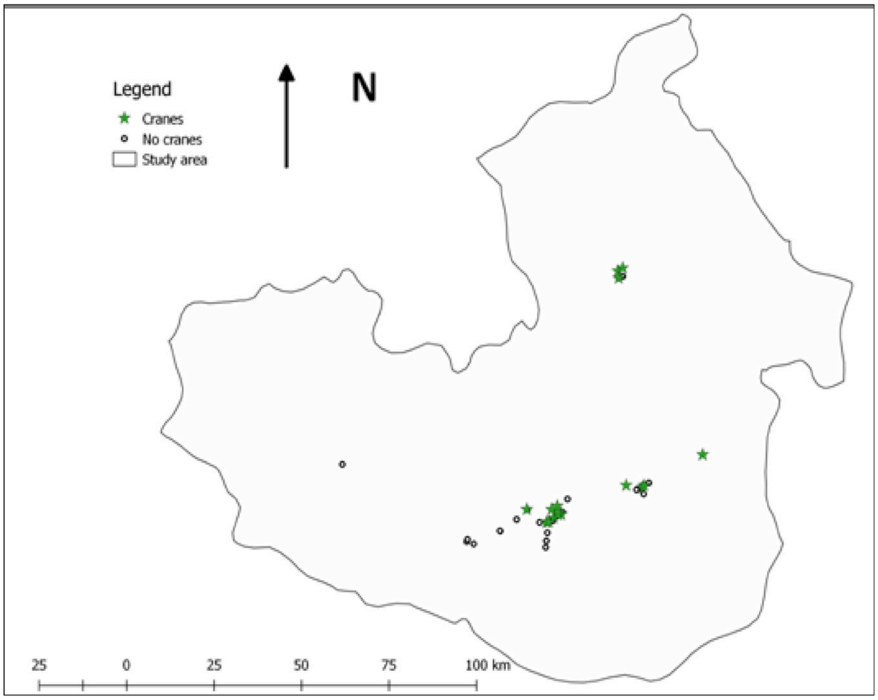

Fig. 2. Occurrence of cranes at wetland sites included in the preliminary survey.

Table 1
Lists, descriptions and expected effects of anthropogenic and environmental factors on the black crowned crane and wattled crane in Jimma Zone, Ethiopia.

Variable list	Variable definition	Expected effect on cranes
1. Environmental		
Flooding	A wetland buffer area is submerged in rainy season: 1) yes, 2) no	−
Wetland proximity	A wetland being used for cranes feeding, roosting and breeding is situated near to (connected with) other wetlands: 1) yes, 2) no	+
Wetland class	A category of wetland based on USA rating procedures: 1) lake fringe, 2) riverine, 3) slope, 4) depressional	±
Wetland size	The size of wetland used by crane for various activities: 1) small, 2) medium	±
Elevation	The average altitude of a wetland used by cranes: in m.a.s.	±
2. Anthropogenic		
Population density	Human population density in the surrounding areas of wetland habitat: 1) densely populated (69 persons/km^2), 2) sparsely populated (31 persons/km^2)	−
Road proximity	A road is present near (<5 km distance) to the wetland: 1) yes, 2) no	−
Proximity to urban	The presence of urban areas are in the vicinity of wetland used by cranes: 1) yes, 2) no	−
Wetland buffer area degradation	The upland areas in the buffer zone adjacent to wetland is affected by soil erosion or degradation:1) yes, 2) no	−
Wetland buffer area ownership	The ownership of the upland areas in the buffer zone adjacent to wetland is: 1) communal, 2) private	±
Wetland buffer area land use	The upland areas in the buffer zone adjacent to wetland is subjected to annual crop cultivation 1) yes; 2) no	−
Wetland grazing	The wetland is used for livestock grazing: 1) throughout year, 2) during dry season	−
Wetland drainage	Peoples drain parts of the wetland for different purposes: 1) yes, 2) no	−
Human-crane conflict	There is conflict between cranes and farmers due to bird crop depredation: 1) yes, 2) no	−

2.4. Spatiotemporal analysis

The centroid (average) latitude and longitude of each wetland was used for the spatial distribution analysis of cranes. The spatial and temporal distributions of the cranes were analyzed using SatScan software version 9.4. The default value of SatSan was used to test the significant difference in crane distribution, and the null hypothesis was rejected at $P > .05$. The pure spatial cluster analysis in SatScan imposes circular windows of varying positions and radius of each of the several possible grid points positioned throughout the study area to detect high crane population. The procedure involves gradual scanning of a data window across space, and noticing the number of observed and expected population inside the window at each wetland location. In this study, the maximum spatial cluster size was set at 50% because it can capture all clustering of the population. For each scanning window of varying position and size, the crane population inside and outside the window was tested by the likelihood ratio test for the null hypothesis that no higher crane population within the window. ArcGIS version software was used to produce maps of the study areas and locate the wetlands.

3. Results and discussions

3.1. Characterization of wetlands used by the cranes

Table 2 presents wetland classes and human induced wetland disturbances. The wetlands used by the cranes in the study area were categorized in four groups; slope, riverine, depressional, and lake fringe wetland based on land forms, topographic positions, and associated hydrologic conditions. In the study area, most of the slope wetlands were converted into cropland, eucalyptus plantation, grassland, and overgrazing. Slope wetland exists where topographic conditions allow ground water to intersect the surface, creating a zone of perennial or near-perennial moisture (Stein at al., 2004). Moreover, in the slope wetland water enters through rainfall, groundwater discharge, interflow, and surface flow when water leaves again by evapotranspiration and discharge through small channels (Hruby, 2015).

The riverine wetlands were found in the floodplains and receive water from Gilgel-Gibe River overbank flooding during rainy season. The wetlands belonging to this class play an important role in crane conservation, providing cranes with a variety of feed resources (e.g., tubers, rhizomes of sedges and water lilies) throughout the year, and serving as roosting site in the non-breeding season. However, in breeding season the overbank flooding from Gilgel-Gibe River and its tributaries often causes damage to nests of the cranes and contributing unsuccessful breeding. Furthermore, overgrazing on aquatic vegetation, expansion of cropland, water abstraction, and domestic and industrial waste disposal were affecting the wetland quality and ecosystems and, hence the cranes. Studies showed that wetland degradation and pollution are major challenges to biodiversity conservation in Jimma area (Mekonnen and Aticho, 2011; Ambelu et al., 2013).

Depressional wetlands accumulate water on a surface throughout the year. A wetland that belongs to this group receives water from rainfall, groundwater discharge, and interflow from adjacent uplands. As compared to other wetlands, the depressional wetlands (e.g., Cheleleki) had a relatively stable vegetation cover throughout the year. Buffer area degradation and expansion of exotic weed species in this wetland class had become a big threat to the wetland habitats and cranes. Lastly, the lake fringe wetland situated along Gilgel-Gibe hydropower reservoir (dam) coastal area was used by a few cranes for feeding and roosting in the non-breeding season.

3.2. Black crowned crane and wattled crane population

Fig. 3 shows the black crowned crane and wattled crane population measured over the study period (2013 - 2017) in Jimma Zone. The total number of individual cranes counted throughout the study period were 304 black crowned cranes (297 adults and 7 juveniles), and 30 wattled cranes (28 adults and 2 juveniles). This signifies the presence of considerable numbers black crowned crane and wattled crane in Jimma Zone- Ethiopia, particularly compared to the national crane population report (EWNHS, 1996; Beilfuss et al., 2007). For the reason that the crane survey made along national biodiversity assessment has overlooked the small crane flocks that exist in the whole of Ethiopia, and underestimated the national crane population. The numbers of the juvenile black crowned crane and wattled crane were little as compared to numbers of individual adult

Table 2
Summary of wetland classes and disturbances identified in this study.

Name of wetland	Wetland class	Human induces disturbances
Asendabo	Lake fringe	Livestock overgrazing
Boye	Riverine	Urban expansion, household sewages, car wash, grazing
Bulbul	Riverine	Buffer overgrazing, cultivation
Buyo-Kachama	Slope	Buffer cultivation, tree plantation, grazing
Cheleleki	Depresional	Weed expansion, overgrazing of buffer area
Denib-Gebena	Slope	Buffer cultivation, livestock overgrazing, drainage
Dimitu	Slope	Livestock overgrazing, cultivation, drainage
Gera-Kacho	Slope	Buffer cultivation, livestock overgrazing, drainage
Gera-Sabit	Slope	Buffer cultivation, drainage, livestock overgrazing
Gonono-1	Riverine	Buffer cultivation, drainage
Gonono-2	Depresional	Buffer cultivation, drainage
Haro-Bore	Riverine	Buffer cultivation, and water abstraction
Haro-Dunga	Riverine	Buffer cultivation, and water abstraction
Jima industrial park (JIP)	Slope	Livestock overgrazing, construction
Ketenibel	Slope	Livestock overgrazing
Koffe	Riverine	Overgrazing, household sewages, car wash, urban
Melika-Faki	Slope	Livestock overgrazing, tree plantation in buffer
Near Gibe river	Slope	Livestock overgrazing

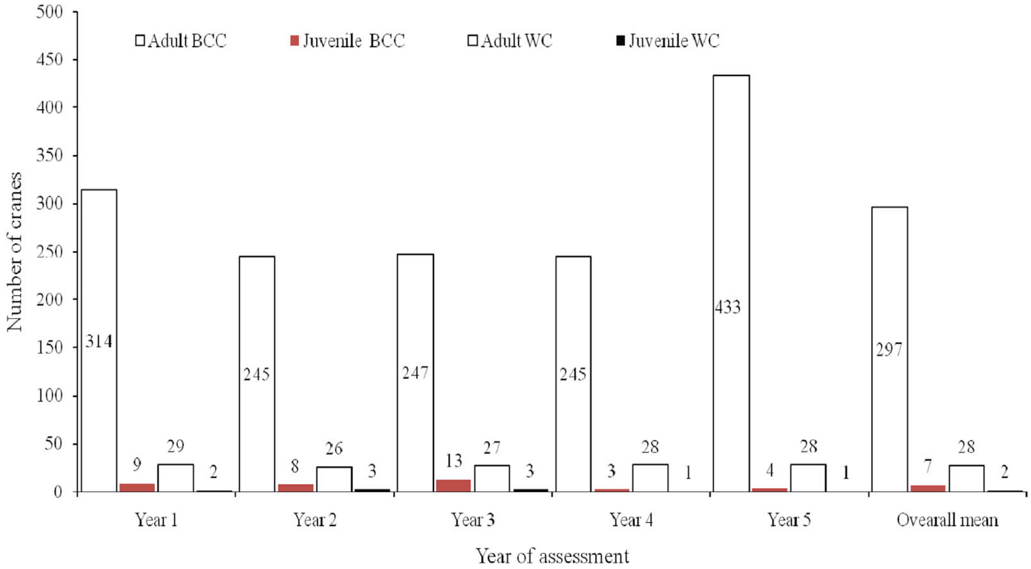

Fig. 3. Summary of black crowned crane and wattled crane population for each study year in Jimma Zone.

Table 3
The generalized linear mixed model, fixed effect coefficient, and model summary for black crowned crane and wattled crane population in the Jimma Zone, Ethiopia.

Model term	Black crowned crane (BCC)						Wattled crane (WC)					
	Estimate	Std. E	t	Sig.	95% CI		Estimate	Std. E	t	Sig.	95% CI	
					L	U					L	U
Intercept	13.090	6.552	1.998	.046	0.214	25.966	.707	.02.0	35.898	.000	.669	.746
Non-breeding season	6.171	1.960	3.149	.001	2.320	10.022	.055	.018	3.081	.002	.020	.091
Breeding season	2.801	1.927	1.453	.127	.912	1.364	.514	.372	1.382	.431	.001	.137
Model fitness		F	9.916				F	9.493				
		Df1	1				Df1	1				
		Df2	466				Df2	352				
		P	.002				P	.002				

L = lower limit; U = upper limit.

cranes, breeding pairs, and potential wetland habitats in the study area. Perhaps, this could be associated with disturbances and breeding habitat deterioration by human activities such as wetland drainage, expansion of agriculture.

The generalized linear mixed models result indicates population status of the two crane species were significantly ($P < .01$) varied among the wetland sites in the non-breeding season, whereas this was not true for the breeding season (Table 3). In the non-breeding season, most of the breeding pairs (territorial birds) and non-breeding flocks of cranes were gathered at relatively bigger wetlands for roosting and feeding, and forms large flock. As a result, the number of cranes at some bigger wetlands has become larger during the non-breeding season, and in the early breeding season the breeding pairs' depart the flock to prepare for reproduction. The departed breeding pairs spend their entire time in their breeding territory-isolate wetland in an agricultural landscape that could provide suitable nesting area and food. When the non-breeding flocks use unoccupied wetlands, grasslands and crop fields (e.g., grain stubble, planted fields) for food and cover during the breeding season. This coincides with other past findings. In the breeding season the floater flocks extensively use grasslands and crop fields for food and cover whereas the breeding pairs spent more time in wetland or breeding territory (Provost et al., 1992; Downs, 2004).

3.3. Spatial and temporal distribution of cranes

Table 4 presents the spatial distribution of black crowned crane and wattled crane in Jimma Zone. The variation in black crowned crane population among wetland sites was statistically significant ($P < .01$) throughout the study period, whereas this was not true in the wattled crane population. Throughout the study period, the black crowned crane population was clustered in different wetland habitats with varying crane population size. For example, in the first two years of study relatively large numbers of the black crowned crane population was clustered (grouping cranes in small distance wetlands

Table 4
A spatial distribution of black crowned crane (BCC) and wattled crane (WC) in the Jimma Zone, Ethiopia.

Years	Cranes	Coordinate (N, E)	Distribution (km)	Wetland (%)	Observed crane (%)	p-value
Year 1	BCC	7.712081, 37.091145	.50	5.55	1.73	0.002
	WC	7.712081, 37.091145	15.81	11.11	10.34	0.98
Year 2	BCC	7.765925, 36.337788	.50	5.55	15.92	<0.001
	WC	7.651605, 36.838683	3.52	27.7	24.14	0.94
Year 3	BCC	8.211027, 37.022379	46.91	16.67	43.70	0.001
	WC	7.659005, 36.874631	5.54	38.89	35.71	0.67
Year 4	BCC	7.644919, 36.816966	50.03	72.22	31.14	<0.001
	WC	7.851782, 37.246254	6.74	11.11	10.34	0.96
Year 5	BCC	7.621003, 36.846924	.50	5.55	1.38	<0.001
	WC	7.791137, 37.246651	.50	5.55	6.90	0.90

Table 5
Temporal distribution for black crowned crane (BCC) and wattled crane (WC) population in Jimma Zone, Ethiopia.

Study year	Crane	Period (initial - Final)	Included population (%)	p-value
Year 1	BCC	December	65.75	0.001
	WC	August	41.42	0.14
Year 2	BCC	December	70.44	0.001
	WC	February	20.45	0.63
Year 3	BCC	December	28.58	0.001
	WC	December	24.16	0.050
Year 4	BCC	January—February	48.81	0.001
	WC	February	56.55	0.35
Year 5	BCC	February	88.42	0.001
	WC	February	66.00	0.001

together) at the riverine wetland; namely Gonono 1 wetland in year 1 and Koffe wetland in year 2. In these two years, about 1.73% and 15.92% of the total black crowned crane populations observed in the study area were clustered in Gonono 1 wetland and Koffe wetland, respectively. Moreover, about 43.70% of the black crowned crane population observed in year 3 was clustered at three wetlands; one riverine (Haro-Dunga) and two slope (Melika-Faki, near the Gibe River) wetland habitats. The observed variation in black crowned crane population cluster was noticed due to seasonal and spatial difference in wetland conditions, buffer area situation, and disturbances. Adverse wetland conditions (related to the degradation extent, flooding, water level, vegetation structure) restrict the cranes foraging behavior and allow cranes to move into another potential wetland. Studies have shown that birds are highly responsive to spatial and temporal variations in food resource quality, quantity, and availability (Aviles, 2003; Zhang et al., 2015). Also, the bird population is changed with habitat modification and disturbance (Browne and Aebischer, 2001). The spatial and temporal availability of aquatic food resources and replenishment of depleted foraging grounds are determined by the hydrological cycle and micro-topographic condition (Bancroft et al., 2002; Russell et al., 2012).

Table 5 presents the temporal distribution of black crowned crane and wattled crane in the study area. Variation in the temporal distribution of the black crowned crane population was statistically significant ($P = .001$) for the study period when the distribution of wattled crane was significant only for the third and final year. The largest number of the black crowned crane population was observed in December for the first three consecutive years, January—February in the fourth year, and February in the fifth year. With regard to wattled crane, the largest population was observed in December during the third study year and February in final year of study. This reveals that wetlands of the study area support relatively large numbers of cranes from December—February, due to gathering of the breeding and non-breeding cranes during the non-breeding period. The temporal variation in crane population may be related to a change in the wetland environment (e.g., water level, human disturbance, and food availability) inducing a shift from breeding to non-breeding season or vice versa. A high level of habitat disturbance reduces both temporal and spatial variability of feed resources, breeding and roosting grounds throughout the breeding or non-breeding seasons (Fernández-Juricic et al., 2003) this affect bird populations and breeding success (Mengesha and Bekele, 2008). Furthermore, the spatial and temporal variation in habitat condition also influences bird reproduction and survival (Sutherland and Parker, 1985) as well as population status (Newton, 1998; Gunnarsson et al., 2005).

3.4. *Impacts of anthropogenic and environmental factors on cranes population*

Table 6 demonstrates the effects of anthropogenic and environmental factors on the black crowned crane and wattled crane population in the Jimma Zone. Among factors influencing crane population proximity to wetlands, flooding, and wetland size had significantly ($P < .01$) positive effect on the black crowned crane population. For example, compared to isolated wetlands, the presence of other wetland habitat to the crane-inhabited wetland increases the numbers of black crowned crane and wattled crane populations respectively 15.036 and 12.847 units, when all other variables being constant.

Table 6
Summary of the negative binomial regression analysis on effects of anthropogenic and environmental factors on black crowned crane and wattled crane population in Jimma Zone, Ethiopia.

Parameter	Black crowned crane			Wattled crane		
	Estimate	Std.E	P-value	Estimate	Std.E	P-value
Intercept	137.336	36.889	.000	90.653	36.889	.014
Flooding	8.219	1.063	.000	.950	1.063	.372
Population density	−35.547	1.696	.000	3.108	1.696	.067
Proximity to road	−0.174	1.564	.912	−3.191	1.564	.041
Proximity to wetlands	15.036	4.131	.000	12.847	4.131	.002
Wetland class	−0.082	1.267	.948	−2.300	1.267	.069
Proximity to urban	10.648	1.190	.000	2.819	1.190	.018
Buffer degradation	17.471	2.154	.000	7.278	2.153	.001
LU in buffer	33.662	5.752	.000	17.614	5.752	.002
Buffer area ownership	14.825	3.160	.000	−7.992	3.159	.011
Wetland grazing	22.056	2.069	.000	−3.935a	2.069	.057
Wetland drainage	−21.687	1.189	.000	−1.430a	1.189	.229
Wetland size	25.842	2.530	.000	7.339a	2.530	.004
Crane-human conflict	−96.297	2.603	.000	−4.032a	2.603	.121
Altitude	−0.099	0.023	.000	-.058a	.023	.013
	LR X^2	282.18		LR X^2	15.483	
Goodness-of-fit	Df	14		Df	15	
	P	.000		P-value	.04	

LR = Likelihood Ratio.

This implies that relatively bigger wetlands and the close proximity of other wetlands allow the movement of cranes over larger areas, which increases the availability of resources for feeding, roosting and breeding. These results correspond to the findings of previous studies. Haig et al. (1998) reported that bird movement among wetlands enhances the survival of young birds and the access to quality nesting and feeding habitats. A single wetland rarely meets the foraging, roosting, nesting and safety needs of birds, which is reflected in low population number and reproduction success (Froneman et al., 2001; Kelly et al., 2008). The proximity of neighboring habitat patches ensures easy movement of aquatic animals among wetlands, enhances food availability, and provide options for birds to use more than one wetland to obtain the necessary resources (Bancroft et al., 1994; Lees and Peres, 2008), ensure habitat configuration and heterogeneity, and enhances population (Paracuellos, 2006).

On the other hands, crane-inhabiting wetland proximity to the road and urban area, livestock grazing, drainage, buffer area cultivation and degradation, and human-crane conflict had significantly ($P < .05$) negative effect on the two crane species population. As compared to undisturbed wetlands where crane-inhabited, a wetland habitat disturbed with urban expansion has contributed for the black crowned crane and wattled crane populations decline with 10.648 and 2.819 units, respectively when all other variables kept constant. Because urban expansion towards wetland habitats, road infrastructure development, and wetland buffer area mismanagement (e.g., degradation, faulty cultivation) aggravate disturbance to the crane, alter the suitable crane habitats, and contributes to crane population decline. Previous studies show, bird population is declined near to infrastructures and increases with distance from infrastructure (Eigenbrod et al., 2009) because infrastructure development alter wetland ecological condition and contributors for wildlife population decline (Fahrig and Rytwinski, 2009; Benítez-López et al., 2010). Also, infrastructure development actions can affect wetland habitat buffer areas that provide several services, for instance, stable feeding and roosting ground for many bird species (Forman, 2003; Barve et al., 2005), goods and services to society, reduces disturbance on core the habitat, and maintains optimum bird population (MacKinnon et al., 1986; Salwasser et al., 1987).

Finally, the presence of human-crane conflict had significantly ($P < .001$) negative effect on black crowned crane population in the study area. Because, farmers chase the cranes during cropping season in order to minimize crop damage caused by the crane. A report from a similar area showed the existence of human-black crowned crane conflict (Gemeda et al., 2016).

4. Conclusion and recommendation

The IUCN declared black crowned crane and wattled crane as vulnerable species due to the rapid population decline throughout their home range countries. Hence, conservation of these species and their habitat has become the global concern to save the species from further loss. The five-year monitoring of the two crane species population indicates the existence of promising numbers of cranes in wetlands of Jimma Zone. A better understanding of the temporal and spatial distribution of cranes helps to indicate the allocation of limited resources for effective conservation actions. The spatial distribution analysis shows the presence of meaningful numbers of both crane species in the third year of a study. This indicates the local movement of cranes into bigger wetlands when there is degradation and disturbance of small wetlands in agricultural landscapes due to extended dry season. As compared to other months, relatively large numbers of cranes are detected from

December to February because during this period the breeding and non-breeding cranes are gathered together at bigger wetlands, which is a convenient time for crane visiting tourists in Jimma area. For better conservation impact, there is a need for improved spatial planning and policy support to control crane habitat fragmentation resulting from infrastructure and urban development, wetland drainage, overgrazing, and buffer area degradations.

Competing interests

There are no competing interests among authors.

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Appendix A. Supplementary data

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