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Gonadosomatic index infers the breeding season of the House Crow *Corvus splendens* in Dar es Salaam, Tanzania

Eligi P. Kimario, Jasson R. John and Harishchandra B. Pratap

Summary

The House Crow *Corvus splendens* is native to the Indian subcontinent but also has a broad invasive range which includes the coast of East Africa. House Crows (HC and HCs throughout this paper) were introduced in Zanzibar in the 1890s from where they later spread to mainland Tanzania. Their negative socioeconomic and ecological impacts have necessitated the instigation of population control programmes using avicides and trapping. Although knowledge on the reproductive biology of HCs, in particular the breeding status, is important for successful control programmes, little is known about it in Dar es Salaam. To establish the HC breeding status, a total of 83 female and 100 male birds were collected from August 2013 to July 2014 from traps operated by the Ministry of Natural Resources and Tourism population control programme. All birds were euthanized, dissected, and sex determined by gonad examination. The gonadosomatic index (GSI) was determined as the ratio of gonad weight upon total body weight. The GSI, which is an index of gonad development relative to the bird's sexual maturation, peaked from October to December suggesting that this period is the main breeding season. The HC population control could be intensified during the onset of gonad development when the demand for resources is high.

Keywords breeding season, gonadosomatic index, House Crow, Dar es Salaam

Introduction

The House Crow *Corvus splendens* is considered to be one of the most intelligent and adaptable birds that exhibit complex social behaviour and is common around human dwellings (Koul & Sahi 2013). It is native to the Indian subcontinent including India, Myanmar, Nepal, Bangladesh and Sri Lanka (Puttoo & Archer 2003; Jackson & Cowburn 2011). House Crows (HCs) were introduced to Zanzibar Island (Tanzania) in 1890s (Finn 1893, Vaughan 1930). The population of HCs grew and spread along the East African coast (Cooper 1996, Jackson & Cowburn 2011). A more recent global assessment of HC spread is provided in Ryall (2016). The HC is considered as an invasive pest especially in its non-native range as it competes with native birds such as Pied Crow *Corvus albus*, Cattle Egret *Bubulcus ibis*, and destroys nests of many local birds. HCs are also known to peck out the eyes of newborn livestock (MNRT 2010). They are shown to be carriers of enteric pathogens including *Salmonella* and *Campylobacter*, and birds infected by Influenza A virus subtype H5N1, which is a human health hazard (Ryall & Meier 2008), have been found in the Far East. The presence of HCs near airports is a potential threat for a bird strike with aeroplanes, especially because of their erratic and unpredictable behaviour when roosting (Ryall & Meier

2008). Based on the ecological and socio-economic negative impacts, they have been subjected to control programmes in many countries including Tanzania, South Africa, Mauritius, Kenya, Yemen, and Singapore by trapping and poisoning using Starlicide DRC#1339 (Puttoo & Archer 2003, Ethekwini Municipality 2007, Ryall & Meier 2008, Suleiman & Taleb 2010). Although knowledge of the breeding cycle is essential for a successful control programme of many invasive species (Dhami 2009), little is known about the HC's breeding season. Understanding the onset of breeding periods allows a control programme to interrupt a pest species' breeding cycle. The development of gonads, quantified using gonadosomatic index (GSI), provides the duration of the breeding season (Williams 1967, Fox 2007). All other breeding behaviours such as pairing, copulation and nesting are triggered by physiological changes in the avian body, the onset of which can be studied by using gonad development indices. This method gives a peak breeding season beyond what is usually observed in the field. The objective of this study was to establish the breeding status of HC in Dar es Salaam using GSI, as an increase in GSI signifies the breeding season for many vertebrates (Williams 1967, Fox 2007).

Materials and methods

The study was conducted in Dar es Salaam city located (6°48′0′S, 39°17′0′E) on the Tanzanian coast. The study sites, with two traps each, were operated by the Wildlife Division of the Ministry of Natural Resources and Tourism and located at both the Tanzania Bureau of Standards (TBS) (Ubungo ward) and Mbezi Kimara (MK) (Mbezi ward), both located in Ubungo municipality, northwest of Dar es Salaam City (Fig. 1). TBS is both a roosting and foraging site while MK is predominantly a foraging area with ample food from slaughterhouse waste; the roosting sites are also in the same vicinity. Traps were baited with leftover foods and meat scraps and supplied with fresh water. Birds were collected from one of the two traps at MK or TBS alternately every week from August 2013 to July 2014 (note that this study was part of a larger ongoing initiative to control House Crows in Tanzania). Birds were removed from the trap before dawn to avoid deterring other crows. They were taken to the laboratory where they were euthanized by chloroform before dissection. The specimens were dissected using a procedure recommended by Friend and Franson (1999). All ethical guidelines of the University of Dar es Salaam were adhered to during the study. To establish sex, gonads were dissected and weighed separately on a digital balance (Mettler AE 100) to four decimal places. The GSI of adult males and females was used to measure sexual maturity in relation to gonad development. The GSI for each month were calculated by dividing the total gonad weight by total body weight (Fox 2007). Kruskal Wallis (K-W) test was used to compare sex specific GSI between months followed by a Mann-Whitney pair wise comparison test. All tests were two-tailed and factors were considered statistically significant at $p < 0.05$.

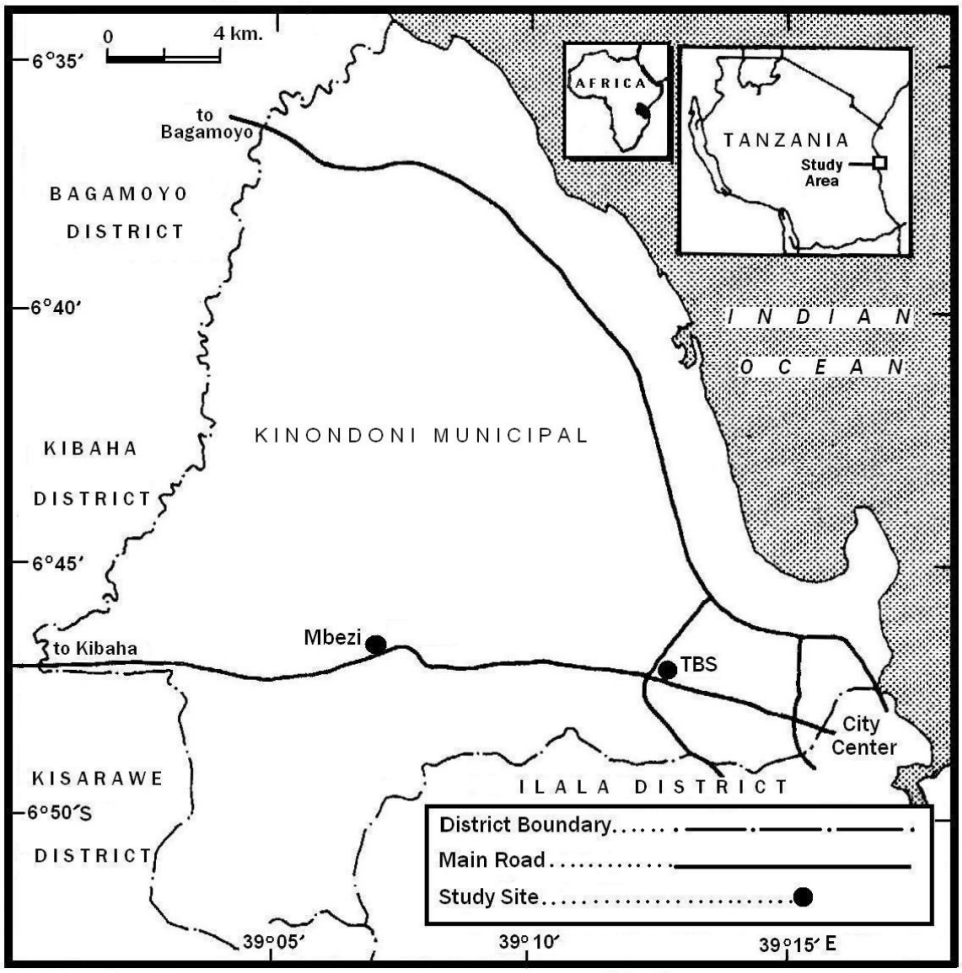

Figure 1. Map of Kinondoni Municipality showing trapping sites at Mbezi Kimara (MK) and Tanzania Bureau of Standards (TBS) in Dar es Salaam.

Results

During the 12 months study period, sex-specific GSI for each month of 83 females and 100 males were calculated. The peak GSI for females was between October 2013 (GSI = 0.235) to December 2013 (GSI = 0.244) while for males it was between October 2013 (GSI = 0.149) to November 2013 (GSI = 0.125) (Fig. 2). These findings of high GSI suggest that the period from October to December is the main breeding period.

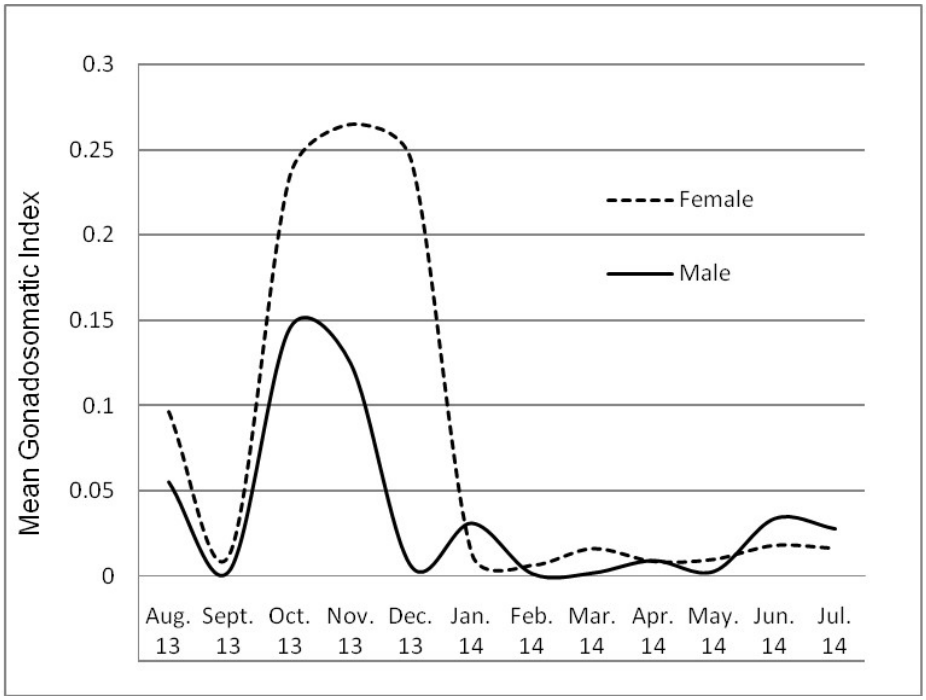

Figure 2. Gonadosomatic index (GSI) for male and female House crows for a one-year cycle from August 2013 to July 2014 in Dar es Salaam.

Over the period of one year, monthly female GSI varied and differed significantly (KW = 42.34, $p < 0.001$). The female mean GSI during the cold dry to short rainy season (June–December) was high (GSI = 0.104), while it was significantly lower (GSI = 0.0083) during the hot dry to long monsoon rainy season (January–May) (Mann-Whitney *U*–test, $U = 247$, $p < 0.001$).

The monthly GSI for males differed significantly during the study period (KW = 29.21, $p = 0.002$). Likewise, the mean GSI for males during the cold dry to short rainy season (June–December) was significantly higher (GSI = 0.057) compared to hot dry to long rainy season (January–May, GSI = 0.009) (Mann-Whitney *U*–test, $U = 579$, $p < 0.001$).

Discussion

Animal breeding status can be followed using indices of reproductive development that are directly correlated with cellular and physiological changes occurring concurrently in gonads (Williams 1967). In fish, for example, an increase in GSI suggests spawning season and thereafter it decreases in spent fish (fish that have already spawned) (Fox 2007). Similarly, in birds, indices of reproductive development increase during the breeding season (Williams 1967). The HC GSI for both, females and males in this study differed significantly between different months indicating that HC has a defined breeding season. The wider window of GSI for females as compared to males can be explained by the fact that upon single insemination the sperm is stored in the oviduct tubes prior to egg laying. Thereafter, reproductive activities such as ovulation and fertilization continue to take place even after several weeks of

copulation or sperm insemination (Birkhead & Møller 1993). Therefore, copulation ceases while females are still fertile and eggs will be fertilized throughout the breeding season creating a time lag, which is reflected in the sex-differentiated GSI.

During the short rainy season, the period from October to December 2013, HCs had significantly higher GSI suggesting the main breeding season. This breeding season inferred from GSI overlaps with that reported in Mombasa (Kenya) where nesting activities peaked in November to December (Ryall 1990, Chongomwa 2011). This is likely because of similar climatic conditions as both Mombasa and Dar es Salaam are located on the East African coast. The HC's breeding season in Eastern Africa, including Dar es Salaam, differs from that of its native range. In its native range breeding mainly occurs from June to September during the dry cool season (Lamba 1963, Ali *et al.* 2007, Awais *et al.* 2015). Dry seasons are favourable for easy availability of nesting materials such as dry sticks, twigs and tree branches, which are common nesting materials (Behrouzi-Rad 2010).

Based on these findings, we recommend that HC population control activities especially poisoning and trapping be intensified during the onset of gonad development (Fig. 2) when the demand for resources, food in particular, is high. Trapping and poisoning during this period will be more effective because many HCs need to feed more when preparing for breeding, thus increasing the risks of being trapped or poisoned. Disruption of HCs' breeding will not only eradicate reproductively active birds, but greatly lower recruitment rates and thus control the total population over time.

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