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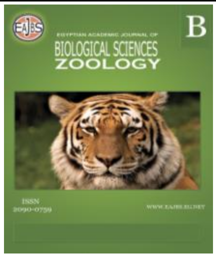

Bird Behaviour during the June 21, 2020 Solar Eclipse in Debre Berhan Town, Central Ethiopia

Sefi Mekonen
Department of Biology, College of Natural and Computational Science, Debre Berhan University, Debre Berhan, Ethiopia. P.O. Box, 445
Email: mekonen.sefi@gmail.com, mekonen.sefi@yahoo.com

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ABSTRACT

Background: A solar eclipse is an occasional natural phenomenon that can alter the physical and biological processes of organisms. On 21 June 2020 a unique opportunity was offered to evaluate how birds change their behaviour during an eclipse. Bird behaviour was categorised using a scan-sampling technique before, during and after the solar eclipse, and at a different time of eclipse day.
Results: Before the eclipse major activity categories were moving (52.45%), foraging (40.20%), and courtship (2.94%) respectively, but there were no roosting/resting observations at this time. These behaviours were much reduced during the eclipse, while roosting accounted for 14.6% of behaviour. When the eclipse began at 06:50, their calling and flying increased, and singing decreased. At maximum eclipse (07:20h), there was a profound decrease in calling, singing, foraging and moving, and courtship; while washing and floating were not observed. After the eclipse, most time was spent foraging (36.3%), followed by moving (flying), with roosting reduced to 2.4%.
Conclusions: Clear and radical behavioural changes were observed when the eclipse was started and maximum. Responses of birds to the environmental factor changes associated with the solar eclipse might be the root cause of observed unusual behavioural change.

INTRODUCTION

A solar eclipse occurs when the moon blocks sunlight from reaching the earth (Sambandan *et al*., 2012; Shanida *et al*., 2016). It affords the rare opportunity to observe the effects of a sudden disturbance to daily solar irradiation patterns upon the physical and biological processes of organisms (Dubrovsky and Tartar, 2008; Como, 2017; Hartstone-Rose *et al*., 2020). Eclipse events are associated with dramatic reduction of incoming global radiation, pronounced changes in surface temperature and humidity and decrease in wind-speed (Anderson *et al*., 1972; Founda *et al*., 2007 and Pasachoff, 2009). Those environmental factor changes affect the behaviour of plants (Deen, and Bruner, 1933), mammals, birds, insects (Zirker, 1995; Jennings *et al*., 1998; Tramer, 2000 and Shanida *et al*., 2016), and planktonic crustacea (Giroud and Balvay, 1999).

In mid-1500, the first recorded observation of an animal responding to a solar eclipse was made by Wheeler *et al*. (1935), noting “birds falling out of the sky and ceasing to sing”.

After this time numerous scientists believes animal behaviour is changed during an eclipse (Gauthreaux, 1980; Waterman, 1989; Alcock, 1990; Drickamer and Vessey, 1991; Littman and Willcox, 1991 and Grier and Burk, 1992). Though occasionally bizarre, modern studies have lent support to the idea that at least some individuals of certain species display altered behaviour during these events (Ritson *et al*., 2019). Solar eclipses offer a unique opportunity to evaluate the relative influence of unexpected darkness on behaviour of animals due to their sudden interference with local light levels and meteorology (Ritson *et al*., 2019 and Hartstone-Rose *et al*., 2020). During this event, unusual behaviour of animals has been recorded such as birds ceasing to call (Hughes *et al*., 2014), birds returning to nocturnal roosts (Wheeler *et al*., 1935 and Jennings *et al*., 1998), nocturnal insects taking flight (Wheeler *et al*., 1935 and Greenbank *et al*., 1980), diurnal fish seeking shelter and nocturnal fishes emerging (Jennings *et al*., 1998), spiders destroying and deconstructing their webs (Uetz *et al*., 1994), bats flying down a ravine (Pandey and Shukla, 1982 and Sanchez *et al*., 1999), and captive animals altering their activity (Kavanau and Rischer,1973; Mukherjhee, 1984; Branch and Gust, 1986 and Gil-Burmann, and Beltrami, 2003). These stereotypically nocturnal behaviours during an eclipse may mimic cues relevant to schedules of daily routines (Nilsson *et al*., 2018).

Studies on animal behaviour during this phenomenon can enhance our understanding of how environmental factors interact to influence animal behaviour (Dubrovsky and Tartar, 2008 and Como, 2017), and provides a valuable contribution to the ecology of the studied animal (Wiantoro *et al*., 2019 and Hartstone-Rose *et al*., 2020). Though occasionally bizarre, modern studies have lent support to the idea that at least some individuals of certain species display altered behaviour during these events (Ritson *et al*., 219). Birds are useful biological resources as indicators of environmental change (Mekonen, 2017), since birds are sensitive to thus changes (Mac-Nally *et al*., 2004; Gregory *et al*., 2005 and Gregory and Strien, 2010). Birds live in an environment that is subject to both regular and irregular fluctuations, and their populations respond to these changes in predictable ways (Mekonen, 2017). The effects of environmental changes like solar eclipse on bird populations are more often influenced by one or more intermediate factors (Amat and Green, 2012 and Mekonen, 2017). The most immediate and direct responses of birds to these changes are behavioural and physiological changes (Temple and Wiens, 1989). Birds are recognizing as good indicators of environmental changes and as useful proxies of a wider change in nature (Lawler *et al*., 2003 and Mekonen, 2017).

Moreover, solar eclipses are always unique since they happen at different locations and times of day, and under different conditions (Founda *et al*., 2007). The solar eclipse of 21 June 2020 was visible over the whole of Ethiopia, with a minimum of 80% of totality in localities furthest from the total eclipse's path. We documented the effects of the eclipse on animals' behaviour at Debre Berhan in central Ethiopia, the first such report from the country.

It is believed that this study was the first systematic study. The present study objective is, therefore, an effort to conduct observations and a field experimental study to document the effects of the solar eclipse on the bird's daily activity. This study presents results on bird behavioural changes before, during and after the solar eclipse that occurred in Ethiopia on June 21, 2020. This paper contributes to a relatively limited knowledge base of bird behaviour during the rare event of a solar eclipse. Additionally, it could inform management practices of birds, by indicating the relative sensitivity of bird species to sudden disturbances in exogenous factors. Recorded data and information from this observation can be utilized to conduct future studies on birds behaviour associated with current continuously environmental changing and would be important to know their ecology and to develop the appropriate conservation management plan (Wiantoro *et al*., 2019). Collectively, this and future research into birds and other animal behaviours during rare phenomena have the potential to expand our understanding of the reactions of a diversity of animals to novel stimuli, and the extent to which response modes and magnitudes vary between taxa exposed to the same stimulus (Hartstone-Rose *et al*., 2020).

MATERIALS AND METHODS

Study Area:

We made observations at Beresa River and Ansas wetland, Debre Berhan Town, North Shewa Zone, Amhara regional state, Ethiopia. The eclipse lasted 2 hours and 27 minutes from 06:50 to 09:17 on Sunday, June 21, 2020, with its maximum of 89.9% solar obscuration at 07:57, 0.924 magnitudes (Table 1). The study area was located in 89.87% coverage of sun/obscuration of the June 21, 2020 annular solar eclipse. Beresa River and Ansas wetland study sites were the best places for carrying out bird observation in addition to the high bird diversity and endemism, and the duration of the eclipse was longer.

Table 1. Circumstances of the June 21, 2020 partial solar eclipse in the Debre Berhan Town, Ethiopia

Time	Event	Azimuthal/ Direction	Altitude
06:50:17am	Partial Eclipse begins	67°	10.0°
07:57:57am	Maximum Eclipse	68°	25.4°
09:17:35am	Partial Eclipse ends	66°	43.6°

Method of Sample and Observation:

Two focal teams with one researcher and supplemented with 3 students each, bird behavioural observations were conducted. All members of a focal team were trained to follow standard observation protocols. Following training, each focal team was assigned one observation site to exhibit, and kept observation of that single enclosure throughout the course of the entire study.

Instantaneous scan sampling technique was applied by observing group of birds and recording what birds did at predetermined time intervals [29 and 41]. Since the data recorded 1:30 (05:20-06:50 a.m.) before, 2:27 (06:50-09:20) during and 1:30 hours (09:20-10:50) after the eclipse was important to note bird species, abundance and behavioural activities (see Appendix 1). Starting 90 minutes before the eclipse, the teams conducted 3-minute auditory surveys (“samples”) estimating the total number of individual bird vocalizations heard (all species combined) every 30 minutes. The observations employed continuous sampling methodologies supplemented by periodic scan sampling at thirty-minute intervals to make sure that data were updated for all members in each group [41 and 42]. At 30 minutes before the eclipse begins to end, we increased the samples to one every 10 minutes and then after the eclipse continue three every 30 minutes. After each scan observers discussed and agreed on behavioural data of the birds observed, i.e., calls (a brief sound of simple acoustic structure- a peep, cheep, squawk, chatter, etc.), songs (a relatively long, often melodious, series of notes usually associated with some aspect of courtship), feeding, courtship, flying, preening, roosting and floating/hovering were transcribed in field notebooks throughout the observation period. Cameras and sound recorders were also used to document the behaviour of birds, providing reference information on species’ activity and identity [43].

Data Analysis:

The behaviours of birds before, during, and after the eclipse was qualitatively compared. All occurrence data were averaged for eclipse situations, and compared descriptively. Behavioural data recorded with instantaneous samplings in the different times of a day were averaged and transformed in percentages to determine expected values for a chi-square test. Two-tailed t-tests assuming unequal variance were then performed to compare behaviours durations on the day of the eclipse to both comparative samples.

RESULTS

Observed Bird Species:

The detected total of 10 species of birds was Three-banded Plover (*Charadrius tricollaris*), Yellow-breasted Apalis (*Apalis flavida*), Bokmakierie (*Telophorus zeylonus*), Southern Masked-Weaver (*Ploceus velatus*), Egyptian Goose (*Alopochen aegyptiaca*), Pied Crow (*Corvus albus*), Speckled Pigeon (*Columba guinea*), Rouget's rail (*Ralbus rougetii*), Wattled Ibis (*Bostrychia carunculata*), and Blue-winged goose (*Cyanochen cyanoptera*). Of the 285 different individual numbers of birds that were formally observed, the abundance of birds before, during and after eclipse were 135 (47.37%), 73 (25.61%) and 77 (27.02%), respectively (Fig. 1). However, the numbers of birds observed were not varied significantly between phases of the day (before the eclipse, during the eclipse and after (post) eclipse) ($t = 5.886$, $df = 2$, $P = 0.28$).

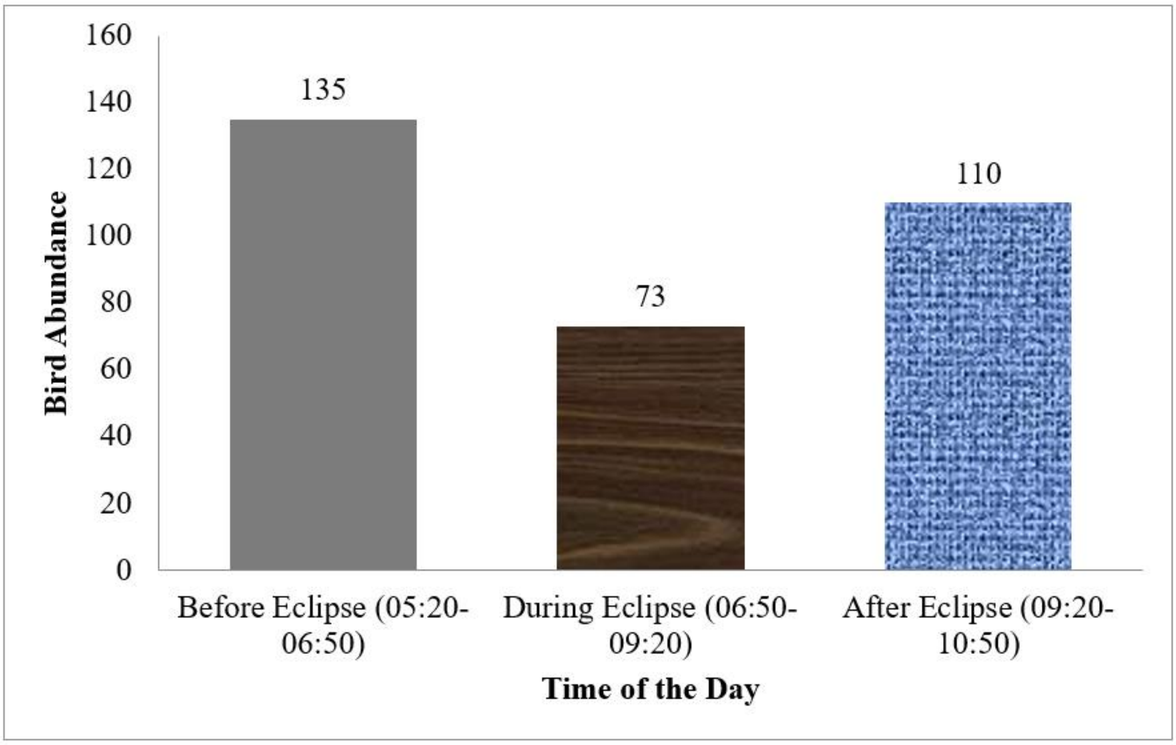

Fig. 1: The abundance of birds before (05:20-06:50), during (06:50-09:20) and after (09:20-10:50) the eclipse situations.

Behavioural Observation:

The observed behaviours of birds before, during and after the eclipse are presented in Table 2. Of the average 395 bird calling that were formally recorded, 143 (36.20%), 70 (17.72%) and 182 (46.08 %) were exhibits before, during and after the eclipse, respectively. The smallest 7 (11.29%) singing sound records were noted during an eclipse than before 25 (40.32%) and after eclipse 30 (48.39%). Before solar eclipse birds were used most 107 (52.45%) of their times to flying or moving followed by foraging 82 (40.20%), and courtship 6 (2.94%) respectively, but there was no roosting/resting observation at this time. Except for the percentage difference, the same fashion also was observed during the eclipse. However, most (36.31%) of daily time spent was foraging followed by flying/moving after the eclipse, while roosting/resting was exhibited 14(14.58%) and 4 (2.38%) of time spent during the eclipse and after the eclipse, respectively. Nevertheless, scan samples did not differ significantly within each of the phases of the day time (t-test; $p > 0.005$ in all cases of behavioural records), so average values for each phase were used in subsequent statistical tests (Table 2).

Table 2: Bird vocalization (Calling and singing) and Behaviour at Debre Berhan town, Ethiopia on 21 June 2021 solar eclipse

No.	Bird Behaviour	Before Eclipse [05:20-06:50)	During Eclipse [06:50-09:20]	After Eclipse (09:20-10:50]	Total	P-value
Vocalization						
1.	No. of Calling	143	70	182	395	0.057
2.	No. of Singing	25	7	30	62	0.098
Behavioural activities						
3.	Foraging	82	28	61	171	0.068
4.	Courtship	6	5	19	30	0.157
5.	Preening	5	2	16	23	0.213
6.	Flying/moving	107	45	52	204	0.074
7.	Floating	4	2	16	22	0.235
8.	Roosting	0	14	4	18	0.286
Total Behavioural activities		**204**	**96**	**168**	**468**	

As above table showed, except for roosting, all observed behaviours of birds were reduced at the eclipse time period as compared with before and after the eclipse. However, foraging and flying/moving were greatest before the eclipse happened. Likewise calling, singing, courtship and floating were highest after the eclipse.

Behavioural and Abundance Alteration of Birds on Solar Eclipse Times of Day:

It can be seen from Figure (2) that the abundance, calling and singing of birds increased at 05:50 to 06:50 a.m. before the eclipse, while when the eclipse begins initially at 06:50h these were peaks. It is also observed that the calling and singing activity of birds were declined during the eclipse time, whereas after the eclipse of the time these activities increased as before eclipse. Surprisingly, during the maximum eclipse that happened at 07:50, the calling and singing sound of birds was decreased from 109 to 16 and from 9 to 2, respectively. However, the abundance of birds' slowdown from before eclipse-to-eclipse time periods of the day and then increased after the eclipse passed.

There were a varied significantly differences (paired samples t-test) between times of the day and abundance of birds ($t= -8.599$, $df= 10$, $P= 0.000$), and number of call ($t= -5.259$, $df= 10$, $P= 0.000$). However, birds songs were not significant differences ($t= -3.015$, $df= 10$, $P= 0.013$) with these times of day. The numbers of call and song were not showing significance differences ($X^2= 110.0$, $df= 90$, $P= 0.232$), that is, singing exhibited were independent of calling.

Before 90 minutes (at 05:20-05:30a.m.) the solar eclipse starts, foraging and flying were extreme crownings (Fig. 3). However, at the initial time of the eclipse (06:50a.m.) the flying was increased from eclipse to 96 to 110 before 30 minutes eclipse start (06:20-06:49). During the eclipse period (from 06:50 to 09:20), the intensity of roosting or resting activity increased, while feeding, preening, courtship, flying and floating were decreased as compared to before and after the eclipse. At the maximum solar eclipse (07:50h), foraging and moving were radically decreased and courtship, preening and floating activity became zero. However, roosting or resting pattern of birds was increased. Clear changes in the behaviour of birds were observed at 07:20, during maximum eclipse.

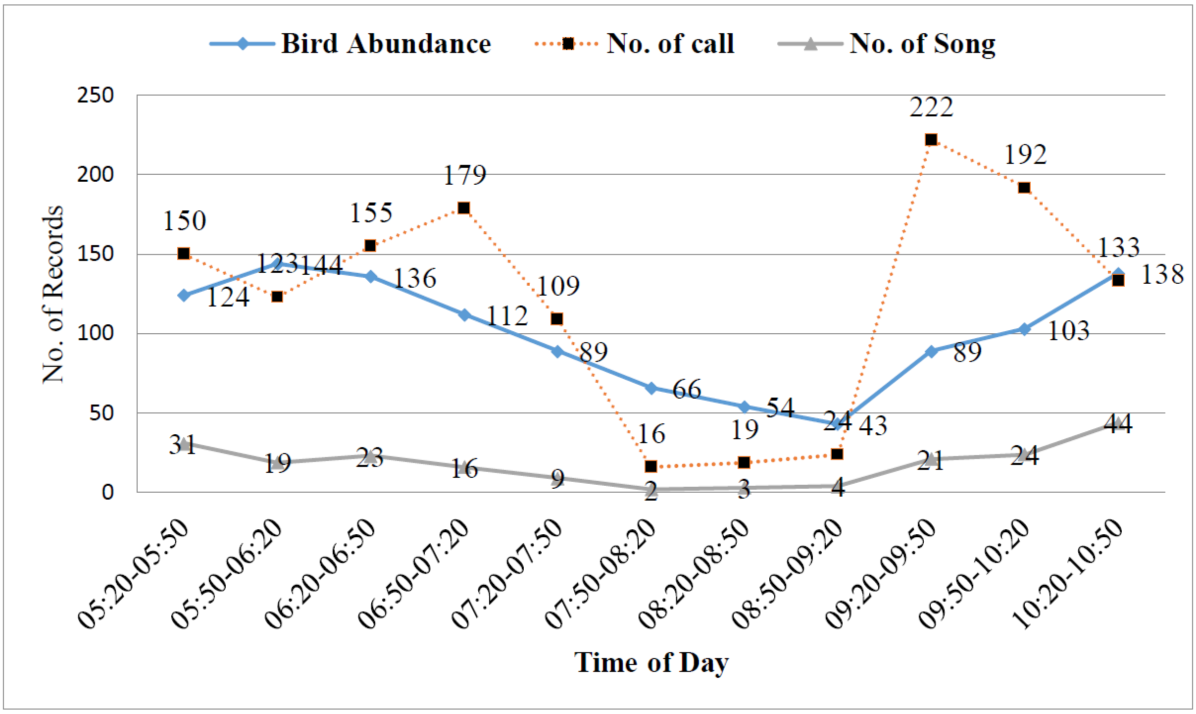

Fig. 2: Bird abundance, calling and singing recorded at a different time of Eclipse day, June 21, 2020

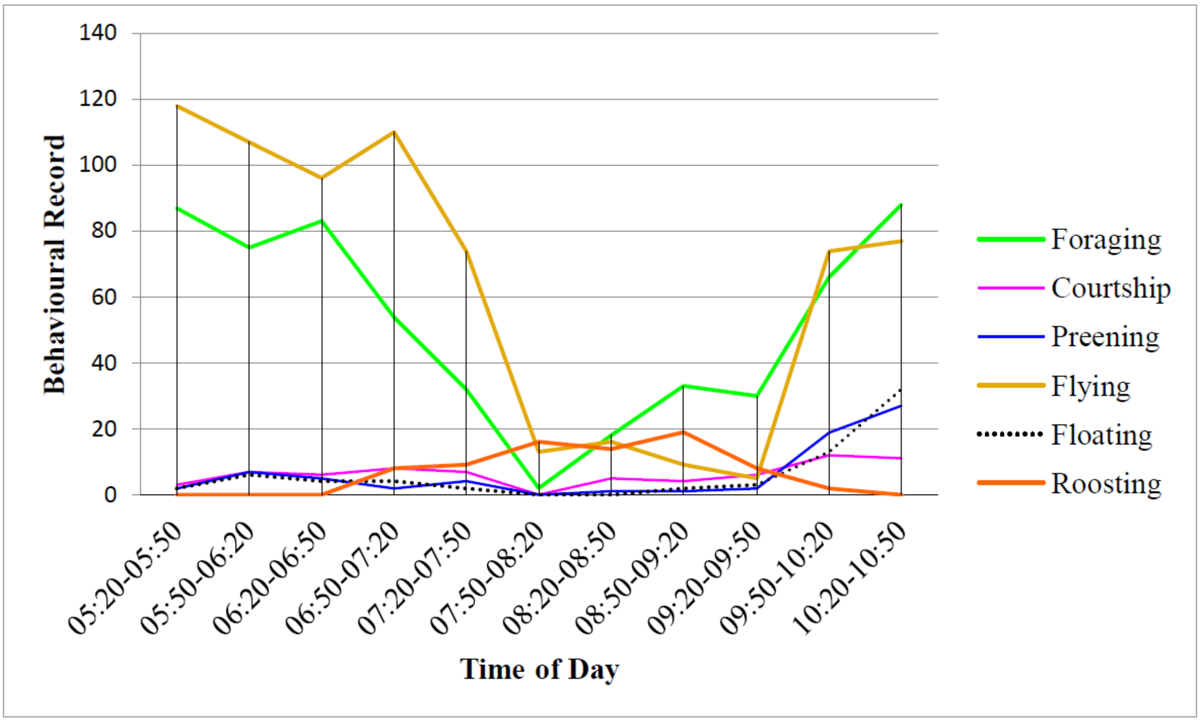

Fig.3. Bird behaviours at different times of eclipse day, June 21, 2020.

A paired samples t-test of scan sampled birds revealed significant differences between time periods of day and their foraging (t= -4.857, df= 10, P= 0.001) and flying (t= -4.113, df=

10, P= 0.002). However, there were not significant differences among times of day and courtship (t= -0.255, df= 10, P= 0.804), washing (t= -0.164, df= 10, P= 0.873), preening (t= -0.076, df= 10, P= 0.941), and roosting (t= -0.429, df= 10, P= 0.677).

DISCUSSION

This study showed that the abundance of birds was decreased during eclipse phases of the day time as compared with before eclipse and after (post) eclipse (Fig. 1), suggesting that the changes in environmental factors such as light, temperature and wind speed (Dubrovsky and Tartar, 2008 and Como, 2017), that birds might be left (fly out) from the habitat and/or unobservable. Thus, the decrease in bird presence following the eclipse could simply be a representation of the random movement of birds to roost (Dubrovsky and Tartar, 2008).

Birds are excellent bio-indicators for environmental change. They have been used as indicator species for a range of environmental parameters (Mekonen, 2017). During solar eclipses, numerous animal species primarily birds and mammal changed their behaviours such as increased levels of anxiety, shelter-seeking, and changes in vocal and behavioural activity (Wojtusiak and Majlert, 1976). On such a cloudy, damp and chilly day due to eclipse, it seems to have been more variations in the intensity of the daylight than changes in temperature and humidity due to radiation variation that accounted for the change in birds' behaviour (Kullenberg, 1955). For example, changes in light, air temperature and wind speed are factors of bird behaviour (Burt, 2018). The brief changes in temperature and wind speed are possible sensed by birds and, in combination with reduced light, are interpreted as the beginning of nocturnal changes (Wheeler *et al*., 1935; Rabin and Doviak, 1989; Uetz *et al*., 1994 and Anderson, 1999) or large storm, potentially enhancing bird vocalizations as instinctive behaviour (Hartstone-Rose *et al*., 2020).

The eclipse that we studied was a late-summer, early-morning time, which is imperative when considering the impacts of temporary darkness and reduced solar intensity on the vocalizing behaviour of wildlife (Buckley *et al*., 2018). For example, late summer is an active time for calling insects (Buckley *et al*., 2018 and Nemec and Bragg, 2008) and songbird communities tend to call most frequently in the early morning hours (Cuthill and Macdonald, 1990; Bruni *et al*., 2014 and Buckley *et al*., 2018). Moreover, a variety of environmental factors impact the singing and calling start times of different wildlife species within the dawn chorus, including the presence of moonlight at dawn, the temperature at nautical twilight, cloud cover and precipitation (Sharpe *et al*., 2001; Bruni *et al*., 2014 and Buckley *et al*., 2018).

The average abundance of birds was higher before the eclipse begin, with decreased during eclipse conducting periods (Fig. 2) that might be birds were left from the habitat or unseen due to the darkness of the day in eclipse. Furthermore, as anthropogenic changes in the timing and intensity of light have been shown to impact atmospheric conditions and wildlife (Wild *et al*., 2005 and Helm *et al*., 2013), the solar eclipse provided a unique opportunity to observe how organisms and atmospheric factors respond to a rapid and drastic decrease in solar illumination (Buckley *et al*., 2018).

The focal bird species observed during the eclipse exhibited behaviours that qualitatively differed from their behaviours before, during and after the eclipse. Except roosting, we detected that all of the observed behaviours of birds were declined at the eclipse time period as compared with before and after the eclipse (Table 2). Unlike, Buckley *et al*. (2018) observation, we perceived a statistically insignificant change in vocalization (call and song) and behavioural activities of birds associated with the eclipse phases (before/pre, during and post/after the eclipse).

Bird calls and song increased just before and after the eclipse, but decreased at the eclipse. Bird's vocalization reduction resulted during the eclipse is similarly reported in other previous studies (Kellogg and Hutchinson, 1964; Loftin, 1971; Kumar, 1981; Gauthreaux, 2012 and Mendoza, 2017). Our results also argued with numerous studies in other parts of the world reports, including increased roosting behaviour (Kellogg and Hutchinson, 1964; Loftin, 1971; Kumar, 1981 and Mendoza, 2017) and changes in movement (flying) patterns of the bird during the eclipse (Uetz *et al*., 1994 and Gauthreaux, 2012). The countervailing trends in bird calling singing activity, influenced by a myriad of individual species' natural histories, precipitated a changing yet the relatively constant stream of biophony throughout the eclipse recordings. These results suggest that the rapid change in solar radiance, accompanied by altered ambient temperature conditions, influenced the activity of a wide range of biota (Buckley *et al*., 2018).

Calling and singing of birds increased starting 30 minutes (at 05:50 to 06:50 a.m.) before eclipse start, whereas there were peaks when the eclipse began initially at 06:50h (Fig. 2) coincided with increased bird activity following the light and temperature change (Sharpe *et al*., 2001; Bruni *et al*., 2014 and Buckley *et al*., 2018). The wetland and river were very noisy and birds began to fly out from the area. This was argued with the finding of Conway (2011) who noted an increase in bird calls starting ~40 minutes prior to the eclipse when both light and temperature were dropping. During the maximum eclipse that happened at 07:50, the calling and singing sound of birds was decreased from 109 to 16 and from 9 to 2, respectively. This is consistent with observations by Murdin (2001) and Hughes *et al*. (2014) which reported birds quieting during totality and then starting a second dawn chorus when the sun re-emerged. This could account for the often-reported effect of birds going silent during the eclipse. For example, during an eclipse in a Maine forest, Kellogg and Hutchinson (1964) reported that bird calls didn't actually stop, but just dropped to a low-level during totality. Similarly, in coastal Maine, Mousley (1933) reported herring Gulls (*Larus argentatus*) "calling much as they do toward nightfall" 5 minutes before totality, and plovers, sandpipers and turnstones starting to call just prior to totality (Mendoza, 2017). The causes of the variation in the song intensity of the different birds during the solar eclipse cannot be stated of course without experimental knowledge of the respective species' general reactions to changes in the various environmental factors involved [43]. However, after the eclipse, bird calls and song were increased, however, occurred much more rapidly than that after dawn, when calls and song remain at an elevated level (Kullenberg, 1955 and Conway, 2011).

Temperature and light intensity have a potential impact on the calling and singing behaviour of insects and birds during the solar eclipse (Fischer, 2001 and Buckley *et al*., 2018). Temperature fluctuations likely resulted in gradual changes to call frequency, while steeper changes in light intensity likely resulted in more sudden changes to calling activity patterns of particular wildlife species. According to Fischer (Fischer, 2001), the diurnal grasshopper's and katydid's song activity slowly declined during the partial eclipse and ceased during the total eclipse before resuming normal song activity. Our results also suggest that both the changes in light conditions and temperature associated with solar eclipse can influence birds calling behaviour (Buckley *et al*., 2018).

At 06.00 hours, many individuals of birds flew in the water and, interacted with each other, foraged, made courtship, washed their bodies, floated on water and flapped their wings more often and, they showed similar behaviour in the morning until solar eclipse began. For decades scientists have known that changes in light can affect animal diurnal activities (Littman and Willcox, 1991). The light intensity decrease during the eclipse reflects the situation close to night or evening (Wheeler *et al*., 1935). It was predicted that this unusual behaviour was a response to the environmental factor changes which suddenly happened during the solar eclipse, especially the decrease in temperature and darkness (Wheeler *et al*., 1935 and Tranmer, 2000). This situation triggered birds to produce the advertisement call. Birds fly out from the area during the eclipse was argued because of the darker sky and cooling, creating a similar situation as the evening when they emerge daily (Wheeler *et al*., 1935 and Krzanowski, 1959). Most birds also displayed similar behaviours of returning to their evening roosts. This behaviour designates consistent circadian trouble during which changes in light and potentially temperature appear to stimulate routine end-of-day behaviours (Hartstone-Rose *et al*., 2020). For example, the significant temperature change might affect the activities of these birds making them less active (Maccarone, 1997 and Wiantoro *et al*., 2019). Light is a powerful stimulus for a great diversity of organisms (Forward, 1976; Pohl, 2000 and Nilsson *et al*., 2018).

Interestingly, during the maximum eclipse (07:50 to 08:20 hours), the habitat was very quiet; all individuals hung stably, and all birds roosted (Fig 2 and 3). Most of them flew away, probably back to their nests and leave out from the water. Only 2 foraged activities of bird records and did not make a courtship, preening and floating during the maximum solar eclipse (Fig. 3). Our observations showed a similar pattern with previous studies (Maccarone, 1997 and Tramer, 2000), and agreed that although the solar eclipse was short, reduced light levels sufficiently interrupted normal avian diurnal behaviour patterns (Hartstone-Rose *et al*., 2020). Many observers also reported birds descending and exhibiting roost-like behaviours during the eclipse (Van Doren *et al*., 2017 and Nilsson *et al*., 2018). Diurnal birds such as pelicans sought out their evening roosts in Venezuela in the 1998 solar eclipse (Tramer, 2000). Similarly, during an eclipse over Kansas in 1994, at least four species of diurnal birds (great egrets, cattle egrets, snowy egrets, and little blue herons) were reported to instigate their evening routines at the onset of the event (Maccarone, 1997). The decrease of biological activity started at low levels of obscuration. The closest analogy to the sudden decrease of solar radiation (light and temperature) for flying animals like birds might be rapidly increasing cloud cover, which could lead to a decrease in activity at low levels of obscuration (Nilsson *et al*., 2018). All of these unusual behaviours are assumed as the exogenous rhythm expressions, and they revert to normal behaviour when conditions are stable (Hardy, 1970 and Wiantoro *et al*., 2019).

Birds ceased their activities, went back to their nests, or took the rest position, and also reactive after the solar eclipse passed (Hardy, 1970). At 09:20 a.m. some individuals flew around the tree and grassroots and come back, similar to morning the time before the eclipse and produced noisy calling, singing, feeding and flying. Birds reappeared to the area and continued their normal behaviours or activities after the eclipse was argued that the sun began to become brighter and normal rising, creating a similar situation as the morning when they emerge night (Krzanowski, 1959; Holmes *et al*., 2004 and Wiantoro *et al*., 2019).

Conclusion

Generally, I detected that calls and songs of birds were perceptibly higher at the beginning of the eclipse time, declining eclipse coverage periods, and increasing again after light returned time. Vibrant changes in the behaviour of birds have also been observed at the eclipse started and at 07:20 when the maximum eclipse happened. Birds ceased their activities, went back to their nests, or took the rest position during the eclipse, and then reactive through the solar eclipse ends. All of these bizarre behaviours are expected as the exogenous rhythm expressions, and they revert to normal behaviour when the solar eclipse passed. In daily normal conditions (after 09:20), these birds produce an audible calling-sound which can be heard directly, and move in the habitat to forage, courtship, floating, courtship, and the like. Bird community is viewed as possessing dynamic stability that tends toward an equilibrium composition of the environment. Moreover, this study argued in conjunction with numerous scholars noted in our discussion section, environmental factor changes (such changes in light, air temperature and wind speed) associated with the solar eclipse might be the root cause of the observed behavioural changes. Future studies of birds' behaviour during solar eclipses should strive to monitor in a particular area for an extended period of time prior to environmental factor changes.

Ethics Approval and Consent to Participate:

All work undertaken towards the manuscript conforms to the legal requirements of Ethiopian patent right, to the Journal's policy on these matters.

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Consent for Publication:

This manuscript does not contain any individual person's data, and further consent for publication is not required/ applicable.

Conflict of Interest:

To the authors' knowledge, no conflict of interest exists. That is, no interest or relationship, financial or otherwise that might be perceived as influencing an author's objectivity exists.

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REFERENCES

Alcock, J. (1990). *Animal Behavior: An Evolutionary Approach*. Sinauer Assoc., Sunderland.

Altmann J. 1974. Observational study of behavior: sampling methods. *Behaviour*, 49: 227-265.

Amat, J. A. and Green, A. J. (2012). *Waterbirds as Bioindicators of Environmental Conditions:* C. Hurford *et al*. (eds.), Conservation Monitoring in Freshwater Habitats: Sevilla, Spain.

Anderson J. (1999). Meteorological changes during a solar eclipse. *Weather*, 54, 207 – 215. (doi:10.1002/ j.1477-8696. 1999.tb06465.x)

Anderson RC, Keefer DR, Myers OE. (1972). Atmospheric pressure and temperature changes during 7 March 1970 solar eclipse. *Journal of the Atmospheric Sciences*, 29: 583-587.

Branch, J.E.; Gust, D.A. (1986). Effect of solar eclipse on the behavior of a captive group of chimpanzees (*Pan troglodytes*). *American Journal of Primatology*, 11, 367–373.

Bruni, A., Mennill, D.J. & Foote, J.R. Dawn chorus start time variation in a temperate bird community: relationships with seasonality, weather, and ambient light. *Journal of Ornithology*, **155,** 877–890 (2014). https://doi.org/10.1007/s10336-014-1071-7

Buckley, E.M.B., Caven, A.J., Gottesman, B.L., Harner, M.J., Pijanowski, B.C. and Forsberg, M.L. (2018). Assessing biological and environmental effects of a total solar eclipse with passive multimodal technologies. *Ecological Indicators*, 95, 353–369

Burt, S. (2018). Meteorological impacts of the total solar eclipse of 21 August 2017. *Weather*, 73, 90–95.

Como, A. (2017). Searching for Bats in Rare Daytime Darkness: Bat Behavior during the Total Solar Eclipse in Cascade, Idaho, 21 August 2017

Conway, C. (2011). Standardized North American marsh bird monitoring protocol. *Water birds*, 34:319–346; doi 10.1675/063.034.0307.

Cuthill, I.C., Macdonald, W.A., (1990). Experimental manipulation of the dawn and dusk chorus in the blackbird Turdus merula. *Behavioural Ecology and Sociobiology,* 26, 209–216

Dawkins, M.S.; Martin, P.; Bateson, P. (1994). Measuring Behaviour. An Introductory Guide. *Journal of Animal Ecology*, 63, 746.

Deen, J.L. and Bruner, M. H. (1933). The effect of the 1932 eclipse upon the width of stomatal openings in gray birch. *Ecology*, 14:76–77.

Drickamer, L. and Vessey, S. (1991). *Animal Behavior: Mechanisms, Ecology, and Evolution*, W. C. Brown, Publ., Dubuque.

Dubrovsky, Y. and Tartar, V. (2008). Changes in the Dynamics of Weather Conditions and Behavioral Activity of Animals on the Day of the Total Solar Eclipse on August 1, 2008. *GISAP Earth and Sciences*, 521-523.

Fischer, F.P., (2001). Total eclipse silences grasshoppers' and bushcrickets' songs. *Journal of Zoology*, 254, 447–448.

Forward RB. (1976). Light and diurnal vertical migration: photobehavior and photophysiology of plankton. In Photochemical and photobiological reviews (ed. KC Smith), pp. 157–209. Boston, MA: Springer.

Founda D, Melas D, Lykuodis S, Lisaridis I, Gerasopoulos E, Kouvarakis G, Petrakis M, Zerefos C. (2007). The Effect of the Total Solar Eclipse of 29 March 2006 on Meteorogical Variables in Greece. *Atmospheric Chemistry and Physics*, 7: 543-553.

Gauthreaux, S. A, (2012). *Animal Migration, Orientation, and Navigation*. Acad. Press, New York.

Gil-Burmann, C., Beltrami, M., (2003). Effect of solar eclipse on the behavior of a captive group of hamadryas baboons (Papio hamadryas). *Zoo Biology*, 22, 299–303.

Giroud, C. and Balvay. G. (1999). The solar eclipse and the migration of some planktonic crustacea in Lake Geneva. *Arch Science*, 52:199–208.

Greenbank DO, Schaefer GW, Rainey RC. (1980). Spruce budworm (Lepidoptera: Tortricidae) moth flight and dispersal: new understanding from canopy observations, radar, and aircraft. *Mem. Entomol. Soc. Canada* 112, 1–49. (doi:10.4039/ entm112110fv)

Greenfield, M.D., (1997). *Acoustic communication in orthoptera*. In: International, C.A.B. (Ed.), the Bionomics of Grasshoppers, Katydids, and Their Kin. Walling ford, UK, pp. 197–230

Gregory, D.R. and Strien, A. (2010). Wild bird indicators: using composite population trends of birds as measures of environmental health. SPECIAL Feature monitoring Bird Populations. *Ornithological Science*, 9: 3–22.

Gregory, R. D., van Strien, A., Vorisek, P., Meyling, A. W. G., Noble, D. G., Foppen, R. P. B. and Gibbons, D. W. (2005). Developing indicators for European birds. *Philosophical Transactions of the Royal Society*, 360: 269-88.

Grier, J. W. and Burk, T. (1992). *Biology of Animal Behavior*. Mosby Year Book, Publ., St. Louis.

Hardy GS. (1970). Circadian rhythms. *Tuatara*, 18(3): 124–131.

Hartstone-Rose, A., Dickinson,E., Paciulli, L.M., Deutsch, A.R., Tran, L., Jones, G. and Leonard, K.C. (2020). Total Eclipse of the Zoo: Animal Behavior during a Total Solar Eclipse. *Animals*, 10(587) 1-16

Helm B, Ben-Shlomo R, Sheriff MJ, Hut RA, Foster R, Barnes BM, Dominoni D. 2013 Annual rhythms that underlie phenology: biological time-keeping meets environmental change. *Proc R Soc B* 280: 20130016. http://dx.doi.org/ 10.1098/ rspb.2013.0016

Holmes, S. B., Burke, D. M., Elliott, K. A., Cadman, M. D. and Friesen, L. (2004). Partial cutting of woodlots in an agriculture-dominated landscape. *Canadian Journal of Forest Research,* 34: 2467-76.

Hughes, S., Wimmer,J. Towsey , M., Fahmi , M., Winslett,G., Dubler,G., Le Prou, A. and Loose, D. (2014). The greatest shadow on Earth. *Physics Education,* 49, 88

Jennings S, Bustamante RH, Collins K, Mallinson JM. (1998). Reef fish behaviour during a total solar eclipse at Pinta Island, Gala´pagos. *Journal of Fish Biology,* 53, 683 –686. (doi:10.1006/jfbi.1998.0720)

Kavanau, J.L., Rischer, C.E., (1973). Ground squirrel behaviour during a partial solar eclipse. *Italian Journal Zoology*, 40, 217–221.

Kellogg, P. P. and Hutchinson, C. M. (1964). The solar eclipse and bird song. *Living Bird,* 3 (390), 185-192

Krzanowski, A. (1959). Behavior of Bats during the Total Solar Eclipse in Poland on June 30th 1954. *Acta Theriologica*, 2(14): 281- 283.

Kullenberg, B. (1955). Biological Observations during the Solar Eclipse in Southern Sweden (Province of Öland) on 30th June 1954. *Oikos*, 6, (1), 51-60

Kumar, S. A. (1981). Solar eclipse: Notes on the behavior of egrets. *Journal of Bombay Natural History and Sociology*, 78, 594-597

Lawler, J. J., White, D., Sifneos J. C. and Master,L. L. (2003). Rare species and the use of indicator groups for conservation planning. *Conservation Biology,* 17: 875-82.

Littman, M. and Willcox, K. (1991). Totality: Eclipses of the Sun. University of Hawaii Press, Honolulu.

Loftin, R. W. (1971). Waterfowl react to solar eclipse.Fi. *Natur*. 44, 50-51

Maccarone, A.D. (1997). Direction of foraging flights by wading birds during an annular eclipse. *Colon Waterbird*, 20: 537-539.

Mac-Nally, R., Ellis, M. & Barrett G. (2004). Avian biodiversity monitoring in Australian rangelands *Austral Ecology,* 29: 93-9.

Mekonen, S., (2017). Birds as Biodiversity and Environmental Indicator. *Journal of Natural Sciences Research*, 7 (21) 28-34

Mendoza, A. (2017). The effect of a total eclipse of the sun on bird calls at Market Lake Wildlife Management Area just north of Roberts, Idaho, on 21 August 2017. Tucson, Arizona

Mousley, h. (1933). Bird actions during the total eclipse of the sun, August 31, 1932. *Auk* 50:125–126; doi 10.2307/4076610.

Mukherjhee, R. P. (1984). Behaviour of rhesus macaque (Macucu muluttu) at Puri (Orissa) during the total solar eclipse of 1980. In: Current Primate Researches. (Roonwal, M. L., Mohnot, S. M. and Rathore, N. S., eds.) Jodphur University Press, Jodphur, pp. 259-262.

Murdin, P., (2001). Effects of the 2001 total solar eclipse on African wildlife. *Astronomy Geophysics,* 42, 40–42.

Nemec, K.T., Bragg, T.B., (2008). Plant-feeding hemiptera and orthoptera communities in native and rdestored mesic tallgrass prairies. *Restoration Ecology*, 16, 324–335.

Nilsson, C., Horton, K.G., Dokter, A.M., Van Doren, B.M., Farnsworth, A. (2018). Aeroecology of a solar eclipse. *Biology Letter*,14:20180485. http://dx.doi.org/ 10. 1098/rsbl.2018.0485

Pandey, K. and Shukla, J. P. (1982). Behavioral studies of freshwater fishes during a solar eclipse. *Environmental Biology of Fish*, 7, 63-64.

Pasachoff, J.M. (2009). Scientific Observations at Total Solar Eclipse. *Research in Astronomy and Astrophysics,* 9: 613-634.

Pohl H. (2000). Circadian control of migratory restlessness and the effects of exogenous melatonin in the brambling, Fringilla montifringilla. *Chronobiology International*, 17, 471 –488. (doi:10.1081/CBI-100101058)

Rabin RM, Doviak RJ. (1989). Meteorological and astronomical influences on radar reflectivity in the convective boundary layer. *Journal of Applied Meteorology*, 28, 1226 –1235. (doi:10.1175/1520-0450(1989)028 ,226: MAAIOR.2.0.CO;2)

Ritson, R., Ranglack, D.H and Bickford, N. (2019). Comparing Social Media Observations of Animals during a Solar Eclipse to Published Research Methods. *Animals*, 9(59) 1-12; doi:10.3390/ani9020059

Sambandan, K., Seethala Devi, K., Santosh Kumar, S., Nancharaiah, M.and Dhatchanamoorthy, N. (2012). Effects of solar eclipse on photosynthesis of Portulaca oleraceaand Phyla nodiflorain coastal wild conditions. *Journal of Phytology*, 4(2): 34-40.

Sanchez, O.; Vargas, J.A.; Lopez-Forment, W. (1999). Observations of bats during a total solar eclipse in Mexico. Southwest. *Nature*, 44, 112–115.

Shanida, S.S., Lestari, T.H. and Partasasmita, R. (2016). The effect of total solar eclipse on the daily activities of Nasalis larvatus (Wurmb.) in Mangrove Center, Kariangau, East Kalimantan. *Journal of Physics: Conference Series*, 771 (2016) 012017

Sharpe, R.S., et al., (2001). *Birds of Nebraska: Their Distribution & Temporal Occurrence*. University of Nebraska Press.

Temple, A.S. and Wiens, A.J. (1989). Bird populations and environmental changes: can birds be bio indicators? *Population study*, 43(2), 260-270

Tramer, E.J. (2000). Bird behavior during a total solar eclipse. *The Wilson Bulletin*, 112, 431 –432. (doi:10.1676/ 0043-5643(2000)112[0431: BBDATS]2.0.CO;2)

Uetz GW, Hieber CS, Jakob EM, Wilcox RS, Kroeger D, McCrate A, Mostrom AM. (1994). Behavior of colonial orb-weaving spiders during a solar eclipse. *Ethology*, 96, 24 –32. (doi:10.1111/j.1439-0310. 1994.tb00878.x)

Van Doren, B.M., Farnsworth, A. and Davies, I. (2017). BirdCast: what do birds do during a total eclipse? Observations from eBird and radar on August 21, 2017. BirdCast.info. See http://birdcast.info/forecast/eclipse/ (accessed 15 May 2018).

Waterman, T. H. (1989). *Animal Navigation*. Science of America Library, New York.

Welling, P., Koivula, K. and Lahti, K. (1995). The dawn chorus is linked with female fertility in the willow tit Parus montanus. *Journal Avian Biology*, 26, 241–246.

Wheeler, W.M.; MacCoy, C.V.; Griscom, L.; Allen, G.M.; Coolidge, H.J., Jr. (1935). Observations on the behavior of animals during the total solar eclipse of August 31, 1932, USA. *Proclamation of American Academy and Arts Science*, 70, 33–70 (doi:10.2307/20023118).

Wiantoro, S., Narakusumo,R.P., Sulistyadi, E. Hamidy, A. and Fahri, F. (2019). Effects of the total solar eclipse of March 9, 2016 on the animal behavior. *Journal of Tropical Biology and Conservation*, 16: 137-149

Wild, M., Gilgen, H., Roesch, A., Ohmura, A., Long, C., Dutton, E., Forgan, B., Kallis, A., Russak, V. and Tsvetkov, A. (2005). From dimming to brightening: decadal changes in solar radiation at Earth's surface, Washington. *Science*, 308, 847–850.

Wojtusiak, R. J. and Majlert, Z. (1976). Ethological and ecological analysis of animal behavior during behavior of colonial web-building spiders. *Natural Geography Research*, 6, 22-40.

Zirker, J. B. 1995. *Total Eclipses of the Sun*, Princeton University Press, New Jersey, USA, pp 228.