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Effect of desert climate on singing behaviour of bulbuls

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Abstract
We studied the effect of ambient temperature on the start of singing for white-cheeked bulbuls (*Pycnonotus leucotis*) all year round in a quiet site in a desert environment. Bulbuls started dawn chorus almost unusually early towards the end of January which is marked by increasing ambient temperatures and photoperiod and also coincides with the beginning of the breeding season. They continued early singing until July which is marked by decreasing photoperiod regardless of minor temperature fluctuations. This is the first study that shows evidence that daily start of singing is directly and significantly influenced by day to day fluctuations in temperature. It is concluded that early singing is initiated by increasing temperatures and is susceptible to daily fluctuations and that these birds must have evolved to start their daily activities by singing early and foraging before temperature becomes very hot upon sunrise.

Keywords: Dawn chorus, Temperature, Weather, Bulbuls

1. Introduction
The dawn chorus in all its aspects is likely to be the result of a number of social, environmental and intrinsic factors [1, 2]. It is influenced by both abiotic and biotic environmental factors. Ambient temperature is the major abiotic factor [3] that influences the occurrence of dawn chorus. Different song birds start singing (dawn chorus) at different times before sunrise depending on species. It is a geographically widespread regular phenomenon and typically begins 30-90 minutes before sunrise [4]. The song input intensity and duration noticeably increases during the breeding season. Many theories give explanation to dawn chorus phenomenon [5, 6]. Avian abundance in arid areas is primarily determined by presence of trees and grasses [7]. White-cheeked bulbuls (*Pycnonotus leucotis*) are the main singing residential birds that are widely spread in Riyadh area. They are found in abundance in house gardens and residential areas all year round.
Weather conditions are major factors in influencing all aspects of bird activity including singing and foraging [8]. Birds and mammals living in desert conditions have managed to develop many adaptive strategies for coping with extreme temperatures and lack of water [9]. Ambient temperature especially at night has been shown to influence the song output of dawn chorus of some birds [10, 11] but the influence on the start of dawn chorus was not investigated.
There is plenty of research and literature on all aspects of dawn chorus but there are only few studies that reported a real shift to an earlier start of dawn chorus. Examples are: playback simulation of territorial intrusion [12], Light [13] and noise pollution [14]. An earlier study of the effect of weather conditions on 3 bird species including bulbuls (different species) and sparrows showed that some seasonal variation in the singing time is observed but it was not to the extent shown in this study and no direct effect of temperature was observed [15]. The objective of this study is to discover the reason for the early start of singing and to find its relation to ambient temperature and other environmental factors.

2. Methods
The start of dawn chorus for bulbuls was recorded for a period of 12 months from April 2014 to March 2015 at a University Housing Compound that is located east of Riyadh city, 24^0 76' N 46^0 86 'E. Altitude is 576 m above sea level. This is a quiet and very large housing compound with lots of shrubs, trees. It has almost zero traffic noise (noise level did not exceed 30 dB) but it is well lit during nights. White-cheeked bulbuls (*Pycnonotus leucotis*) are the only bulbul species freely observed at this location.

The start of dawn chorus was recorded on a calendar that shows times for dawn, sunrise and sunset times. The difference between the start of singing and sunrise is calculated and plotted against different variables using Excel 2010 software.

Criteria for Recording start of Dawn Chorus

The exact number of singing birds was not determined but there has to be more than one incidence of continued singing at more than one position to be considered as true start of dawn chorus thus avoiding any accidental odd singing. Normally there are more than two positions that start singing continuously within few minutes of each other.

Measurement of Weather Parameters

Minimum night temperatures were taken at time of singing. This time at dawn is the coldest of the night. This can be also be confirmed by following the hourly forecast during nights in Riyadh. Maximum day temperatures were taken from appropriate websites (weatherolnline.co.uk, www.accuweather.com/en/sa/riyadh). Photoperiod (Day length) was taken from (www.riyadh.climatemps.com/sunlight.php).

Statistical Analysis

Pearson correlation coefficient was calculated to determine the strength of association between start of dawn chorus and daily ambient temperature. Early morning chorus was correlated separately with day and night temperatures for the months of January, February and March 2015. The correlation coefficient was considered significant if the test p-value was <0.05.

3. Results

The relationship between photoperiod (day length) and the average start of singing for bulbuls for a whole year is shown in Figure 1. The figure shows that the start of early singing which occurs in January and February 2015 coincided with the increase of day length. It also shows that the return to late singing coincided with the start of decrease in day length. The figure also shows that the biggest variations (error bars) are noticed in January and February 2015.

Table 1. Correlation and significance between start of singing and day, night temperatures.

Variable	Bulbul	
	r	p- value
Jan – Feb 2105		
Day temperature	0.648	<0.0001
Night temperature	0.693	<0.0001

R: Pearson correlation coefficient

Similarly Figure 2 shows the relationship between start of singing for a whole year and the average maximum day and minimum night temperatures. It is noticed that increasing temperatures early in the year in January and February 2015 after continued lower temperatures in November and December 2014 induce early singing for bulbuls. The return to later singing towards the end of summer months is mainly associated with decreasing photoperiod but not temperature.

Figure 3 shows the effect of daily/nightly fluctuations in ambient temperatures on the start of singing for bulbuls for the months of January and February 2015. It shows that start of singing fluctuates in a manner that is clearly dependent on ambient temperatures. It is noted that shift to early singing starts if day temperatures start to exceed 30 ^{0}C and night temperatures start to exceed 20 ^{0}C and it reverts to late singing if day temperature re less than 20 ^{0}C accompanied by night temperatures of less than 10 ^{0}C.

The data in figure 3 and 4 was used to find if there is a real positive correlation between day/night temperatures and start of singing using Pearson correlation coefficient (Table 1).

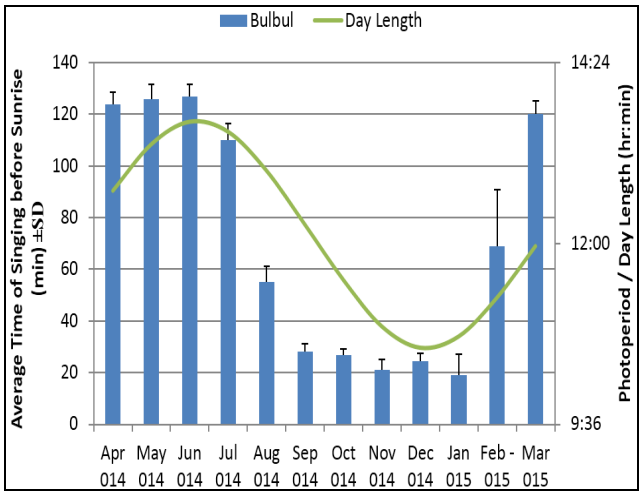

Fig 1: Relationship between photoperiod and average start of singing for a twelve month period

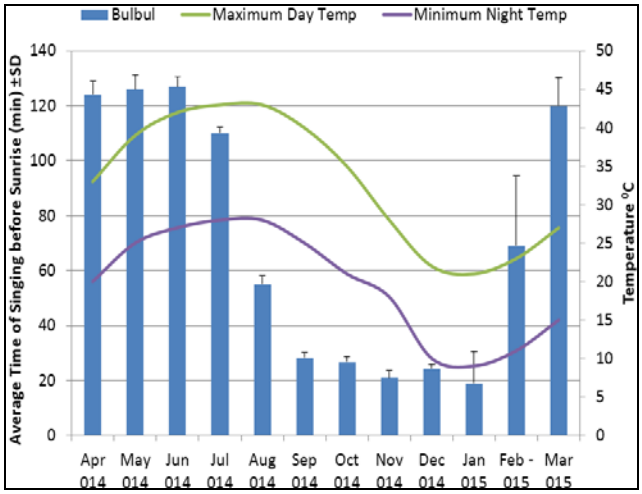

Fig 2: Relationship between start of singing and average day / night temperatures for a twelve month period

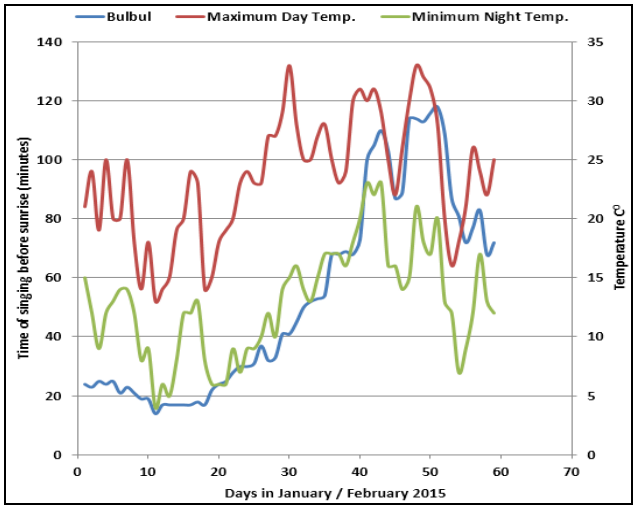

Fig 3: Effect of day to day fluctuations in temperatures on the start of singing

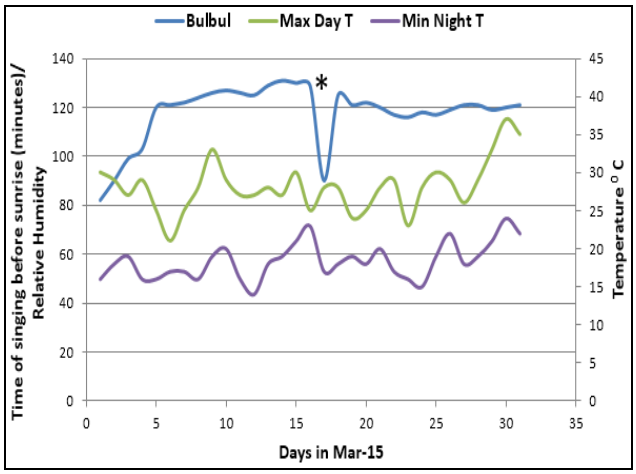

Fig 4: Relationship between start of singing and day/ night temperatures (* moderate rain during time of singing) during March 2015

4. Discussion

Temperature is a major parameter of any regional climate and can affect sun irradiance [16]. There is a positive relationship between overnight temperatures and singing behavior (amount of singing) in cold climates [10, 17].

This study shows that longer days (short nights) induce a shift to early singing. This is paradoxical because it might be suggested that birds need to sleep more and exhibit delay in start of singing at dawn but is widely accepted that sun light (amount of light and photoperiod) is the main initiator of dawn chorus [18]. The start of early singing shown in our study can also be explained by the fact that increased day length (photoperiod) coincides with warmer temperatures and the beginning of the breeding season. But what is very interesting in our study is that it shows that within this frame, variations in day to day temperature can influence the time of day to day singing.

The effect of seasonal variations, noise and light pollution on the start of singing was investigated in three bird species in a Mediterranean moderate climate [15]. It was concluded that the start of singing was not directly affected by fluctuations in daily temperatures. Similarly different geographical locations and altitude but with varying temperatures did not affect start of dawn chorus when comparing two locations one in Palestine and another in Jordan [19].

This study supports an earlier investigation which compared singing start times of bulbuls and sparrows in a different location in mid-town Riyadh/Saudi Arabia to another location in Tulkarm/Palestine [20] which showed that temperature could be the direct effector of dawn chorus start time. Although the bulbuls in these studies are not the same (white-cheeked versus common garden bulbul), they showed very similar singing times except the time where the big shift to early singing started to appear (Jan/Feb 2015) in Riyadh location.

This brings the question: Is this climate induced change and why? Evidence shown here suggests that this is the case. There is evidence that climate variability and geographical location affect song behavior in birds [21]. It was also suggested that harsh environmental conditions could induce the evolution of intraspecific divergence in birds [22]. We can presume that this early start of singing is designed to give birds extra time to sing and to forage before sunrise where it will be very hot to continue with their activities.

It is worth mentioning that effect of temperature can only be seen during January and February 2015 for three reasons. First, it comes after colder, short day months of November and December. Second, it coincides with warmer, longer days and start of breeding season. Third, big fluctuations in daily temperatures can occur.

Therefore, start of singing for bulbuls is prone to fluctuations in temperature in January and February only. The shift to late singing in late summer is not temperature dependent and can be attributed to decreasing photoperiods.

Birds sing early at the coldest time of the day because they have more fat reserves [23]. Therefore, it is assumed that when temperatures start to go up in the season (sometime in January), birds have more energy reserves than they are used to, so they start singing earlier but if temperatures drop too much during these times they switch back to later singing. This might be supported by the repot that suggests that lower overnight temperatures are found to decrease song output [24].

In summary, we can conclude that birds will shift to early singing for three combined reasons: time of the year, increasing temperatures, and breeding season. Only fluctuations in ambient temperature in this time of the year are found to be accompanied by changes in start of singing in both birds studied.

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