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The influence of illumination degrees on the formation of phenological groups of migratory birds at latitude 40^0

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Abstract
As noted at the work, it was determined that, when compared the calendar period of migratory birds with a degree of illumination, 91 studied species migrate at three degrees of illumination at geographical latitude 40^0. In the lowest illumination the spring migration of birds begins in 27 species- 29,69%, autumn migration ends in 31 species- 34,0%. Spring and autumn migrations begin and end at two degrees of illumination: spring $33{\cdot}10^4$ -$53{\cdot}10^4$ lx and $33{\cdot}10^4$ - 82· 10^4 lx, autumn: $55{\cdot}10^4$ -$30{\cdot}10^4$ lx and $80{\cdot}10^4$ - $30{\cdot}10^4$. On average illumination the spring migration begins and ends in 47 species- 57,65%, autumn in 35 species- 38,46%. Spring and autumn migrations begin and end at two degrees of illumination: in 42 species $53{\cdot}10^4$ - $82{\cdot}10^4$ lx and in 5 species $53{\cdot}10^4$ - $53{\cdot}10^4$ lx, autumn $80{\cdot}10^4$ -$55{\cdot}10^4$ lx and $80{\cdot}10^4$ -$80{\cdot}10^4$ lx. At a high degree of illumination spring migration begins and ends in 17 species- 18,68%, autumn in 25 species- 27,48%. In the high degree of light, spring migration begins and ends in two degrees of light: 82-82 $\cdot10^4$ lx and 82-124 $\cdot10^4$ lx, autumn in three degrees 127-$80{\cdot}10^4$ lx; 80-80· 10^4 lx; 80-$55{\cdot}10^4$ lx; Spring migration begins with the increasing illumination degree from South to North: 33- $124{\cdot}10^4$ lx, autumn at a decreasing degree of illumination from North to South 127- $30{\cdot}10^4$ lx. The difference at the illumination degrees 1-$3{\cdot}10^4$ lx is connected with the cloudiness of weather.

Keywords: Illumination, period (term), spring, autumn, migration, birds, latitude

Introduction
The cyclic seasonal movement of birds, also the periods of their offensive are connected with the exogenous and endogenous factors. The primary factors are considered to be physiological of about annual rhythms Dolnick (1975) [1]; Noscov, Rimkevich (2010) [2]; Noscov (2011) [3].The annual cycle of seasonal phenomena include breeding, molting of plumage after mating, the migration from breeding sites to wintering grounds, actually wintering, premarital molting, and back migration to the nesting place Wingfield (2005) [4]; Noscov, Rimkevich (2010) [2]. It is supposed that, the terms of spring migration and even the speed of the migration route are also inheritable features, changing within a year of physiological state of organism Berthold (1990) [5]; Muller *et al*., (2016) [6].
As seen usually, bird seating food of plant origin arrive in the spring much earlier, than insectivorous species. The flight timing of birds from wintering ground scan be also vary widely among species Sokolov *et al*., (1999) [7]; Lehikoinen *et al*., (2004) [8]; Sokolov, (2006) [9]. In strictly photoperiodic species, the length of the day controls the time and rate of development of the spring migration state (fat deposition, gonadal growth). Spring state is controlled by a long-term system of autonomous counting of time, started at the beginning of photoperiodic stimulation period in spring Gavrilov (2013) [10].
Analyzing the influence of meteofactorson the bird migration Madsen (2008) [11]; Huppop (2006) [12]; Zlatkevicus (2007) [14]; Newton (2011) [15], it has been concluded that, such factors as temperature, cloudiness, wind act only as signals of general trend of weather change. Which external environmental factors act as accurate synchronizing signals in nature, is still unknown. The aim of this investigation –is to study an ultimatum signal, to determine the beginning and end of the flight of birds in spring and autumn. The tasks of the investigation -to study the warning signal, to synchronize the beginning and end of migration for the spring and autumn periods in nature.

Materials and Methods

The study of the influence of light on the time of migration of birds in the territory of Azerbaijan began in 2000 and continues to this day. Natural lighting in Azerbaijan peninsula was measured by luxmeter L-116. The term of the beginning and end of spring, autumn migrations of 91 bird species was determined. The difference of total illumination of summer and winter half-year has been identified (2-3·10^4 lx). The difference of total illumination is associated with the cloudiness and other factors during migration days. The term of the beginning and end of spring, autumn migrations was compared with the total illumination by the method of Musayev, Sadigova, Aliyev (2006) [16]. Hesitation limits and total illumination schedule for the cloudy and cloudless skies were taken from Barteneva *et al*, (1971) [17]. Long-term indications (2000-2016) of the beginning and end terms of spring, autumn migrations of mass bird species in the north-eastern part of Azerbaijan Karabanova (1990) [18] were compared with the territory of the Republic Azerbaijan.

Results

Comparing long-term indications of the beginning and end terms of spring, autumn migrations with the corresponding degrees of illumination, we identified 4 main groups of birds. Table.

Early arriving species include in the first group, in which the spring arrival starts in mid-February, is completed in different terms: at the end of March (II- III) and late in April (II-IV).In the first groupthe spring arrival starts at the 33·10^4 lx illumination degree, is completed at various illumination degrees of 53·10^4 lx and 82·10^4 lx.In this group spring migration proceeds with an increasing degree of illumination (33·10^4-82·10^4 lx.).

Mid-migrating birds include in the second group,in which arrival starts in the first decade of Marchand is completed late in April (III-IV). In the second group spring arrival starts at the 53·10^4 lux illumination degree, is completed at the 82·10^4 lx. In this group, spring migration proceeds with an increasing degree of illumination (33·10^4-82·10^4 lx.).

Late migrating birds include in the third group, in which the arrival starts in mid-April, is completed in the first decade of May (IV-V). In the third group the spring arrival starts at the 82·10^4 lx, ends at the 124·10^4 lx. In the third group the spring migration proceeds with an increasing degree of illumination (82·10^4 -124·10^4 lx.).

Analyzing spring migration at given latitude were identified the following phonological groups. During the departure period the flight in the first group begins in mid-August, ends in the third decade of September (VIII-IX). In the first group spring departure starts at the 55·10^4 lx, is completed at the 30·10^4 lx illumination. In the first group, spring migration proceeds with the decreasing degree of illumination (55·10^4-30·10^4 lx).

Table. Average long-term periods of spring and autumn migrations and the degrees of illumination of mass bird species in Azerbaijan for 1979-2016 years.

№	Species of birds	Spring arrival	Autumn arrival	illumination,10^4lx	
				spring.	autumn
1	*Podiceps rificollis* Pall., 1764	22·02-23·03.	17·10-18·11	33-53	55-30
2	*Podiceps grisegena* Bodd., 1783;	20.02-24·03.	11.10-21.11	33-53	55-30
3	*Podiceps cristatus cristatus* Linn.,1758	20.02-30.03	10.10-22.11	33-53	55-30
4	*Pelecanus crispus* Bruch., 1832	21.02-29.03	18.10-25.11	33-53	55-30
5	*Pelecanus onocrotalus*., 1758;	23.02-26.03	19.10-23.11	33-53	55-30
6	*Phalacrocorax carbo* sinensis., 1796	17.02-25.03	19.10 -1.11	33-53	55-30
7	*Phalacrocorax pygmaeus*., 1773;	25.02-30.03	15.10-19.11	33-53	55-30
8	*Botaurus stellaris stellaris* Linn.,1758	1.03-13.04	11.09-29.11	53-82	80-30
9	*İxobrychusminutusminutus* Linn., 1766	24.02-30.03	20.10-23.11	33-53	55-30
10	*Egretta alba alba* Linn., 1758;	29.02-28.04	11.09-11·11	33-82	80-30
11	*Egretta garzetta* Linn., 1766	25.02-5.04	10.09-24.10	33-82	80-30
12	*Ardea purpupea purpurea* Linn., 1766	1.03-10.04	11.09-9·10	53-82	80-55
13	*Ardea cinerea cinerea* Linn., 1758	5.03-3.04	13.09-13.10	53-82	80-55
14	*Ardeola ralloides* Scop., 1769	12.03-16.04	16.09-13.10	53-82	80-55
15	*Bulbulukus ibis* Linn.,1758;	12.03-16.04	16.09-13.10	53-82	80-55
16	*Platalea leucorodia leucorodia* Linn., 1758;	6.03-13.04	10.09-7.10	53-82	80-55
17	*Plegadis falcinellus* Linn., 1766	22.03-26.04	14.09-10.10	53-82	80-55
18	*Phoenicopterus roseus* Linn., 1758	10.03-5.04	6.09-2.10	53-82	80-55
19	*Anser anser* Linn., 1758	20.02-30.03	15.09-25.11	33-53	55-30
20	*Anser albifrons albifrons* Scop., 1769	7.03-12.04	24.09-28.10	53-82	80-55
21	*Cygnus olor* Gm., 1789	21.02-16.03	10.10-15.11	33-53	55-30
22	*Cygnus cugnus* Linn., 1758	20.02-18.03	11.10-19.11	33-53	55-30
23	*Tadorna ferruginea* Pal., 1764	2.03-4.04	12.09-9.10	53-82	80-55
24	*Tadorna tadorna* Linn., 1758;	27.02-4.04	13.09-14.11	33-82	80-30
25	*Anas plathrhynchoss* Linn., 1758	21.02-1.04	12.09-22.11	33-82	80-30
26	*Anas creca* Linn., 1758	12.03-10.04	27.08-13.09	53-82	127-80
27	*Anas strepera* Linn., 1758	25.02-2.04	12.09-17.11	33-82	80-30
28	*Anas penolopa* Linn., 1758	6.03-6.04	8.09-10·10	53-82	80-55
29	*Anas acutaacuta* Linn., 1758	24.02-7.04	30.09-22·11	33-82	80-30
30	*Anas guerguedula* Linn., 1758	10.03-17.04	22.09 -2.10	53-82	80-55
31	*Anas clypeata* Linn., 1758;	6.03-10.04	6.09-10.10	53-82	80-55
32	*Netta rufina* Pall., 1773	26.02-31.03	10.09-16.11	33-53	80-30
33	*Aythya ferina* Linn., 1758	15.02-24.03	15.09-27.11	33-53	80-30
34	*Aythya nyroca* Guld.,1770	16.03-5.04	17.09-19.10	53-82	80-55

35	*Aythya fuligula* Linn., 1758	26.02-30.03	15.09-17.11	33-53	80-30
36	*Aythya marila* Linn., 1761	20.02-30.03	12.09-27.11	33-53	80-30
37	*Busephala clangula* Linn., 1758	20.02-30.03	15.09-27.11	33-53	80-30
38	*Mergus serrator* Linn., 1758	24.02-26.03	19.09-12.10	33-53	80-30
39	*Circus macrourus* Gm., 1771	12.03-14.04	14.09-16.10	53-82	80-55
40	*Circus pygargus* Linn., 1758;	10.03-30.04	16.09-2.10	53-82	80-55
41	*Haliaeetus albicilla* Linn., 1758	12.03-10.04	14.09-23.10	53-82	80-55
42	*Falco vespertinus* Linn., 1766	13.03-17.04	11.09-10.10	53-82	80-55
43	*Falco naumanni* Linn., 1758	15.03-7.04.	9.09-14.10	53-82	80-55
44	*Grus grus grus* Lin., 1758	23.03-30.03	12.09-4.10	53-53	80-55
45	*Tetrax tetrax* Linn., 1758	15.03-7.04.	9.09-14.10	53-82	80-55
46	*Porzana parva* Scop., 1769;	17.02-7.03	23.10-28.11	33-53	55-30
47	*Fulica arta arta* Linn., 1758	25.02-30.03	26.09-25.11	33-53	55-30
48	*Charadricus dubius curonicus* Gm Scop., 1786;	19.04-20.05	15.08-18.09	82-124	127-80
49	*Arenaria interpress interpress* Linn., 1758;	12.03-10.04	14.09-23.10	53-82	80-55
50	*Himantopus himantopus* Linn., 1758;	6.03-12.04	25.09-29.10	53-82	80-55
51	*Vanellus vanellus* Linn., 1758;	18.03-13.04	30.09-19.10	53-82	80-55
52	*Haemantopus ostralegus longipes* But., 1910;	18.03-13.04	27.09-26.10	53-82	80-55
53	*Actitis hypoleucos* Linn., 1758	20.03-17.04	20.08-19.09	53-82	127-80
54	*Phalaropus lobatus* Linn., 1758;	18.03-15.04	21.08-24.09	53-82	127-80
55	*Calidris alpina* Linn., 1758;	23.03-20.04	16.08-18.09	53-82	127-80
56	*Lymnocoryptes minimus* Brun., 1764;	26.03-17.04	25.08-21.09	53-82	127-80
57	*Scolapax rusticola* Linn., 1758,	22.03-16.04	15.08-14.09	53-82	127-80
58	*Gallinago gallinago* Linn., 1758	18.03-20.04	15.08-20.09	53-82	127-80
59	*Numenius arguata arguata* Linn., 1758	24.03-17.04	20.08-13.09	53-82	127-80
60	*Numenius tenuirostris* Vieil., 1817;	25.03-17.04	20.08-13.09	53-82	127-80
61	*Larus minutes*., Pall, 1776	1.03-30.03	11·-24.11	53-53	55-30
62	*Larus rudibundus* Linn., 1766	27.02-26.03	16.10-15.11	33-53	55-30
63	*Larus argentatus argentatus* Pont., 1763	1.03-30.03	13.10-15.11	53-53	55-30
64	*Chidonias niger niger* Linn., 1758;	5.03-27.03	11.10-8.11	53-53	55-30
65	*Sterna hirundo hirundo* Linn., 1758	12.03-31.03	8.10-3.11	53-53	55-30
66	*Streptopelia decaocto* Frik., 1838	5.03-1.04	12.09-8.10	53-82	80-55
67	*Streptopelia turtur turtur* Linn., 1758	16.03-12.04	20.09-14.10	53-82	80-55
68	*Cuculus canorus canorus* Linn., 1758	19.04-4.05	9.08-24.09	82-124	127-80
69	*Coracias garrulus garrulus* Linn., 1758	13.04-5.05	9.08-1.09	82-124	127-80
70	*Meropos apiaster* Linn., 1758	13.04-5.05	9.08-1.09	82-124	127-80
71	*Merops superciliosus* Linn., 1758	13.04-5.05	9.08-1.09	82-124	127-80
72	*Upupa epops epops* Linn., 1758	26.04-27.05	8.08-3.09	82-124	127-80
73	*Hirundo rustica rusticf* Linn., 1758	26.03-17.04	25.09-21.09	53-82	127-80
74	*Delichon urbica urbica* Linn., 1758	18.03-16.04	26.09-25.09	82-124	127-80
75	*Galerida cristata caucasica* Tacz., 1887	31.03-25.04	15.09-17.09	53-82	127-80
76	*Motacilla alba alba* Linn., 1758;	10.04-7.05	22.09-14·09-	82-124	127-80
77	*Motacilla flava flava* Linn., 1758	15.03-20.04	25.09 -28.10	53-82	80-55
78	*Sturnus vulgaris tauricus* Butur., 1904	19.03-18.04	27.09 -20.10	53-82	80-55
79	*Oriolus oriolus oriolus* Linn., 1758	18.03-16.04	26.08-25.09	82-124	127-80
81	*Remiz penduliunus pendiliunus* Linn., 1758	16.03-12.04	20.09-14.10	53-82	80-55
82	*Locustella naevia stranminea* Seeb., 1881	25.04-10.05	1.08-19.09	82-124	127-80
83	*Emberiza schoeniculus schoeniculus* Linn., 1758.	14.04-25.04	10.09-25.09	82-82	80-80
84	*Muscicapa striata* Pall., 1764	18.04-7.05	13.08-22.09	82-124	127-80
85	*Saxicola rubertra* Linn., 1758;	12.04-2.05	29.08-20.09	82-124	127-80
86	*Oenanthe oenanthe oenanthe* Linn., 1758;	15.03-10.04	7.09-25.10	53-82	80-55
87	Phoenicrus phoenicrus phoenicrus Linn., 1758;	27.03-22.04	3.09-25.10	53-82	80-55
88	*Erithacus rubecula rubecula* Linn,1758,	14.04-25.04	10.09-25.09	82-82	80-80
89	*Luscinia megarhynchos* Breh., 1831	18.04-7.05	13.08-22.09	82-124	127-80
90	*Emberiza calandra calandra*, Linn, 1758	5.04-23.04	1.09-28.09	82-82	80-80
91	*Emberiza melanocephala* Scop., 1769.	23.04-16.05	28.08-16.09	82-124	127-80

During the departure period the flight in the second group begins early in September, ends in the third decade of November (IX-XI). In the second group spring departure starts at the $80 \cdot 10^4$ lx illumination degree, is completed in various degrees of illumination $55 \cdot 10^4$lx and $30 \cdot 10^4$lx. As in the first group, also in this group spring migration proceeds with decreasing degree of illumination ($80 \cdot 10^4$- $30 \cdot 10^4$ lx
In the third group autumn departure begins at the $127 \cdot 10^4$ lx illumination degree, ends at $80 \cdot 10^4$ lx and autumn migration proceeds with decreasing degree of illumination ($127 \cdot 10^4$- $80 \cdot 10^4$ lx).

Discussion

At the given geographical latitude, compared the calendar period with the illumination degree from 91 studied species in the lowest degree, spring migration begins and is completed in 27 species- 29,67%, autumn in 31species – 34,07%. Spring migration begins and ends at two illumination degrees: 33-$53 \cdot 10^4$ lx and 33-$82 \cdot 10^4$ lx. Autumn migration as spring begins and ends at two illumination degrees: 55-30 $\cdot 10^4$ lx and

80-30·10^4 lx. On average degree of illumination spring migration starts and is completed in 47 species-57, 65%, autumn in 31 species- 34,97%. Spring migration starts and is completed at two degrees of illumination: in 42 species at 53-82·10^4 lx, in 5 species 53-53·10^4 lx. Autumn migration starts and is completed at the same illumination degree: 80-55·10^4 lx. At the highest illumination degree spring migration starts and is completed in 17 species- 18,68%, autumn migration in 26 species- 28,57%. Spring migration starts and is completed at two degrees of illumination: 82-124·10^4 lx; 82-82·10^4 lx. Spring migration starts and is completed at three degrees of illumination:127-80·10^4 lx; 80-55·10^4 lx; 80-80·10^4 lx. So, at geographical latitude 40^0, in which illumination degree the migrating birds arrive or complete spring migration and at the same illumination degree they begin and complete autumn migration.

The results show that for the ultimatum signal factor the birds use the length of the day and the illumination, as they have a strict annual cycle Dolnick (1975) [1]; Karabanova (1990) [18]. The length of the day and the illumination as a signal has a strict annual cyclicality, is accessible for perception by sight and correlated in its changes with the cycles of environmental conditions, is quite universal in all geographic latitudes and environmental situations. Barteneva *et al*. (1971) [17]; Musayev, Sadigova, Aliyev (2006) [16].

Conclusion

Spring migration of birds starts and ends with increasing illumination from South to North (33·10^4-124·10^4 lx), autumn migration begins and is completed with decreasing illumination from North to South (127-30·10^4 lx).

At 40^0 geographical latitude, the birds migrate at three illumination degrees: at the lowest illumination spring and autumn migrations begin and end at two illumination degrees: spring 33-53·10^4 lx and 33-82·10^4 lx, autumn 55-30·10^4 lx and 80-30·10^4 lx. On average illumination degree spring migration begins and ends at two illumination degrees: 53-82·10^4 lx and 55-53·10^4 lx, autumn at one 80-55·10^4 lx. At the highest illumination degree spring migration begins and ends at two illumination degrees: 82-82·10^4 lx and 82-124·10^4 lx, autumn at three degrees: 127-80·10^4 lx; 80-80·10^4 lx; 80-55·10^4 lx;

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