RESEARCHES REGARDING THE INFLUENCE OF THE WEATHER ON THE FLIGHT OF THE WHITE STORKS (*Ciconia ciconia*) IN THE SPRING MIGRATION ACROSS THE DOAMNEI RIVER HYDROGRAPHICAL BASIN (ARGEŞ COUNTY, ROMANIA) (I)

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Abstract. The authors show a preliminary study regarding the influence of the weather on the flight (soaring, gliding and flapping flight) of the white storks (*Ciconia ciconia*) in the spring migration across the Doamnei River hydrographical basin. The research is based on 289 observations and 3153 individuals observed during 1998 – 2010. The lapse of time, the temperature of the air, the atmospheric nebulosity, the type of clouds, and the wind intensity were considered. We stated that the presence of the ascendant air played a major role in the migratory flight, this rising air being used by birds in their economical flight that combine the soaring flight and the gliding one.

Keywords: white stork (*Ciconia ciconia*), flight, migration, Doamnei River hydrographical basin, Romania.

INTRODUCTION

This paper is a continuation of the article "Some aspects regarding the migratory dynamics of the white stork (*Ciconia ciconia*) in the Doamnei River hydrographical basin (Argeş County, Romania)" [20], it being, rather, a preliminary study, which should be sustained in the following years.

As we said earlier, data concerning the biodiversity from Romania are still missing at European level [11].

The white stork (*Ciconia ciconia*) is a species protected by laws: Bern Convention, Bonn Convention, Bird Directive, etc. It is included in the Red Book of the Vertebrates from Romania [22] and it is in SPEC 2 Category and vulnerable regarding the threat status [10].

At the national level, except some studies done in Rădăuţi Depression [26], scientific researches about the influence of the weather on the flight in migration of the white stork have not been done until now; the researches were centred mainly on the distribution, size and dynamics of the population [2, 15]. However, in recent years, data regarding the arrivals in Romania are collected and, probably, they will be processed (cf. http://www.ciconia.ro/SA.html). At the international level, the latest such studies about the migration are carried out mainly by radio and satellite tracking [7, 27]. Also, in Romania, similar researches began to be done (cf. http://www.ciconia.ro/SA.html).

The researches were performed in the Doamnei River hydrographical basin, one of the main affluent of the Argeş River. It is favourable for many species of birds (for breeding, wintering and passage) because it includes a large variety of landscapes and habitats and the anthropogenic impact is still low.

Regarding the birds migration across the Doamnei River hydrographical basin are few data in the scientific literature and about the migration of the white stork there is no information [17-19, 22].

The hydrographical basin of the Doamnei River is important because it shelters many protected species of animals in Romania, mainly in the upper sector, such as the glacial relict species: *Cottus transsilvaniae* [8], *Lissotriton montandoni* [5], and *Pelophylax lessonae* [6]. Close by, in the upper basin of the Vâlsan River, lives the *Romanychthys valsanicola* [9]. The refuge of a *Bombina variegate* group has been recently identified in the area of Curburii Carpathians [13].

Because the avifauna from the Doamnei River hydrographical basin was, generally, little studied until few years ago, our aim is to contribute with new data to its knowledge and, particularly, to the knowledge of the white stork migration at a national level.

MATERIALS AND METHODS

The Doamnei River has its sources in the Fagaraş and Iezer-Păpuşa Mountains. It has 109.1 km of distance, from the Moldoveanu Peak (2544 m) up to the point of confluence with the Argeş River (260 m) [3] (Fig. 1).

The vegetation is diverse; it is composed principally by woods of *Picea abies*, *Fagus sylvatica* and *Carpinus betulus*, in the mountain floor, and by woods of *Fagus sylvatica*, *Quercus robur*, *Q. petraea*, etc., in the hilly floor [1]. Generally, the fauna is common for the hilly and mountain regions from Romania and the climate is continental temperate, with mountain features in the north half and with hilly features in the south half [3].

White stork is a bird from the Ciconiiformes order ranged almost over all Europe [25]. In Romania it is wide-spread, breeding mainly in settlements [21]. In the Doamnei River hydrographical basin it breeds in few localities (Aninoasa, Berevoeşti, Câmpulung, Corbi, Coşeşti, Dârmăneşti, Domneşti, Furnicoşi, Mărăcineni, Mihăeşti, Mioarele, Pietroşani, Schitu-Goleşti, Ţiţeşti, Vlădeşti). Its diet is mainly consisting in frogs and insects [16]. In passage, the birds transit the Southern Carpathians through the corridors Rucăr-Bran and Cozia-Turnu Roşu and even over the mountains [4, 14, 17, 24]. They winter south from Sub-Saharian Africa [12].

Our study is based on data collected during 1998 – 2010. We noted, each observation, the date, the number of individuals, the exact time (in the Romanian Standard Hour), the type of flight, the height of flight (visually approximated), the atmospheric nebulosity, the type of clouds, the temperature of the air at 2 meters height above the soil, the wind speed by Beaufort scale, the locality and the type of overflow ecosystem and other details, by case. The time for researches varied along the diurnal part of the day.

Over 95% of the observations were performed in the hilly side of the area, preponderantly in the perimeter of the Dârmăneşti. Other localities were: Bălileşti, Corbi, Mărăcineni, Valea Mare-Pravăţ and Ştefăneşti (Fig. 1).

In this paper, we refer only to the influence of some aspects of the weather (the temperature of the air, the atmospheric nebulosity, the type of clouds and the wind intensity) as well as of the lapse of time on the migratory flight.

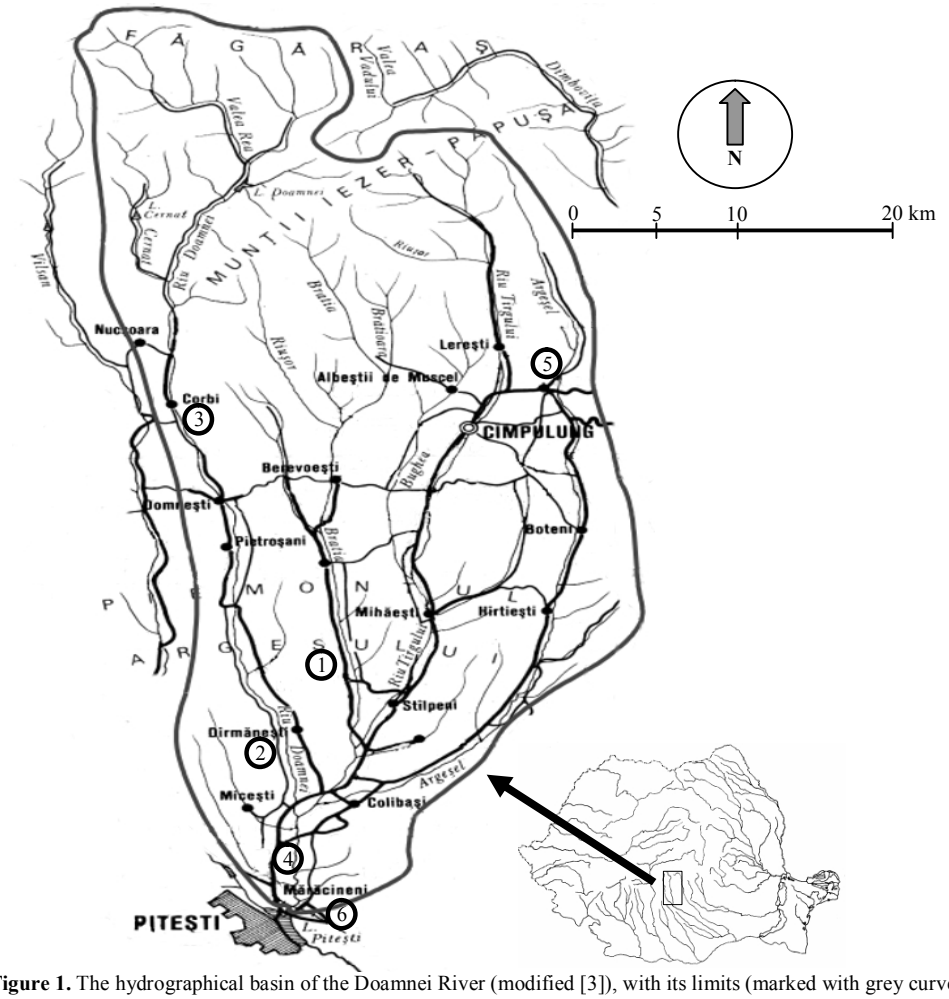

Figure 1. The hydrographical basin of the Doamnei River (modified [3]), with its limits (marked with grey curve).
O- location of observations (1 – Bălileşti, 2 – Dârmăneşti, 3 – Corbi, 4 – Mărăcineni, 5 – Valea Mare-Pravăţ, 6 – Ştefăneşti).

RESULTS

The 289 observations effectuated in the spring totalised 3153 individuals.

Considering the influence of the lapse of time, the individuals were observed in flight between 9:00 and 22:00 (the first – 9:50 on 25 March 2000, the latest – 21:00 on 18 June 2008); their maximum presence: between 14:00-15:00 [20].

Taking into account only 8:00 – 18:00 time, when we considered that the number of hours of field observations was sufficient (e.g. 433.75 hours in March, April, and May during 2007 – 2008), we observed small percentage of the individuals that flown below 100 m maximum level of flight. Between 100 and 500 m, the percentages increased, their curve of variation being, apparently, concave, with the bigger values in the extremities of the lapse of time and with the smaller values positioned from 14:00 to 16:00. Between 500 and 1000 m, the percentages of individuals progressed unregulated, their maximums being in the intervals 10:00 – 11:00 (the secondary one) and 15:00 – 16:00 (the principal one). Between 1000 and 1500 m maximum height of flight, the percentage varied around 20 – 25%, excepting 11:00 – 12:00 interval, when it was 0. Above 1500 m, the birds were observed from 13:00 to 19:00, the maximum percentage of the individuals being from 16:00 to 17:00 (Table 1).

Table 1. The percentage of the individuals according to the lapse of time and the maximum level of flight (during the spring migration, 1998 – 2010).

Lapse of time	Height (m)				
	0-100	100-500	500-1000	1000-1500	over 1500
4:00-5:00	0	0	0	0	0
5:00-6:00	0	0	0	0	0
6:00-7:00	0	0	0	0	0
7:00-8:00	0	0	0	0	0
8:00-9:00	0	0	0	0	0
9:00-10:00	0	100	0	0	0
10:00-11:00	0	0	70.59	29.41	0
11:00-12:00	6.78	44.63	48.59	0	0
12:00-13:00	0.41	16.36	60.25	22.98	0
13:00-14:00	0	16.86	52.11	26.44	4.60
14:00-15:00	0	4.09	69.75	25.09	1.07
15:00-16:00	0	6.78	73.37	18.84	1.01
16:00-17:00	0	10.65	55.21	20.58	13.56
17:00-18:00	2.14	12.82	51.26	20.97	12.82
18:00-19:00	0	19.90	52.04	15.31	12.76
19:00-20:00	3.23	0	61.29	35.48	0
20:00-21:00	0	64	36	0	0
21:00-22:00	100	0	0	0	0
22:00-23:00	0	0	0	0	0
Total	1.30	13.76	59.12	20.46	5.36

Regarding the statistical parameters of the maximum height of flight (Table 2), the mean was 719.55 m, the range was 2190 m and the maximum level of flight was 2200 m (attained on 18 April 2010).

Table 2. The statistical parameters concerning the maximum height of flight.

Parameter	Value
Mean	719.55
Standard Error	20.62
Standard Deviation	350.57
Range	2190
Minimum	10
Maximum	2200
Confidence Level (95.0%)	40.58

About the difference between the minimum height and the maximum height of flight (the ascension), noted each observation, we stated that its mean was 125.64 m; the range and the maximum were 1000 m (Table 3).

Table 3. The statistical parameters regarding the difference between the minimum level of flight and the maximum level of flight, noted each observation.

Parameter	Value
Mean	125.64
Standard Error	9.95
Standard Deviation	169.09
Range	1000
Minimum	0
Maximum	1000
Confidence Level (95.0%)	19.58

The flapping flight was effectuated between 11:00 and 22:00 and the gliding and soaring flights were effectuated between 9:00 and 22:00. Taking again into account only 8:00 – 18:00 when we considered that the number of hours of field observations was sufficient, the flapping flight had the maximum percentage from 11:00 to 12:00 and the minimum from 15:00 to 16:00. The percentage of the individuals that used the gliding flight was at all times over the minimum of 93.22% (registered from 11:00 to 12:00). The soaring flight had the maximum percentage from 9:00 to 10:00 and minimum percentage from 16:00 to 17:00. Per total, in spring, 78.34% of the individuals were observed soaring, 97.84% gliding and 20.68% displacing in flapping flight (Table 4).

Table 4. The percentage of the individuals observed in spring migration during 1998 – 2010, according to the type of flight and the lapse of time.

Lapse of time	Type of flight		
	Soaring	Gliding	Flapping flight
4:00-5:00	0	0	0
5:00-6:00	0	0	0
6:00-7:00	0	0	0
7:00-8:00	0	0	0
8:00-9:00	0	0	0
9:00-10:00	100	100	0
10:00-11:00	80.39	100	0
11:00-12:00	78.53	93.22	40.11
12:00-13:00	94	96.69	11.59
13:00-14:00	80.84	100	39.08
14:00-15:00	86.48	99.29	14.59
15:00-16:00	74.62	100	6.28
16:00-17:00	59.08	95.88	18.89
17:00-18:00	68.74	100	32.62
18:00-19:00	96.94	90.82	2.04
19:00-20:00	64.52	96.77	3.23
20:00-21:00	36	100	100
21:00-22:00	100	100	100
22:00-23:00	0	0	0
Total	78.34	97.84	20.68

Depending on the temperature of the air, we noticed that the maximum percentage of the observations was between 15 and 20 ^{0}C and the maximum percentage of the individuals observed was between 20 and 25 ^{0}C. The flights were registered between 5 and 30 ^{0}C (Table 5). The mean of the air temperatures noted at the moment of the observations was 17.15 ^{0}C (with 7.46 the standard deviation).

Regarding the percentage of the observed individuals, the flapping flight had a raised value between 10 and 15 ^{0}C, the values decreasing toward the limits of the general interval of temperature. The percentage in the case of the gliding flight slowly varied between 95.89% (from 20 to 25 ^{0}C) and 100% (from 25 to 30 ^{0}C). The percentage in the case of the soaring flight was maximum from 25 to 30 ^{0}C and minimum from 15 to 20 ^{0}C (Table 5).

Taking into account the maximum level of flight attained by individuals during each observation, between 0 and 100 m the observations were recorded from 15 to 25 ^{0}C, between 100 and 1500 m from 5 to 30 ^{0}C and over 1500 m from 10 to 30 ^{0}C. The percentage of the individuals that flight under 100 m was maximum from 20 to 25 ^{0}C. The percentage of the individuals that flight between 100 and 500 m was maximum from 15 to 20 ^{0}C and minimum from 25 to 30 ^{0}C, the percentage of the individuals that flight between 500 and 1000 m was maximum from 5 to 10 ^{0}C and minimum from 15 to 20 ^{0}C and the percentage of the individuals that flight over 1500 m height was

maximum from 25 to 30 ^{0}C and minimum from 10 to 15 ^{0}C (Table 6).

Regarding the percentage of the number of observations and of the observed individuals number, according to the atmospheric nebulosity (0 – clear sky, 10 – completely cloudy sky), we obtained a maximum for the 5 – 6 interval (in the first case) and for the 7 – 8 interval (in the second case). The minimum was (both situations) for the 9 – 10 interval (Table 7).

The flapping flight has had the biggest percentage into the 0 – 2 and 7 – 8 intervals and the smallest into the 5 – 6 interval. The gliding flight and the soaring flight have had the biggest percentages into the 0 – 2 interval; they had the smallest percentages into the 9 – 10 interval. The percentage of the soaring flight, generally, decreased with the increasing of the nebulosity interval (Table 7).

Table 5. The percentage of the observations number and of the observed individuals' number, depending on the type of flight and temperature (^{0}C).

Interval of temperature (^{0}C)	Observations	Individuals	Soaring	Gliding	Flapping flight
5-10	5.19	2.89	73.63	97.80	7.69
10-15	26.64	27.31	85.60	99.30	29.73
15-20	33.22	21.79	69.87	97.96	25.76
20-25	29.76	35.46	72.54	95.89	13.51
25-30	5.19	12.56	94.70	100	15.40

Table 6. The percentages of the individuals depending on the interval of temperature (^{0}C) and height (m).

Interval of temperature (^{0}C)	Maximum height (m)				
	0-100	100-500	500-1000	1000-1500	over 1500
5-10	0	10.99	87.91	1.10	0
10-15	0	6.74	81.88	10.92	0.46
15-20	2.04	31.44	39.16	20.52	6.84
20-25	2.42	11.54	56.62	26.03	3.40
25-30	0	5.30	44.70	29.80	20.20

Table 7. The percentage of the observations number and of the individual observed number, as well as of the observed individuals depending on the type of flight and the atmospheric nebulosity.

Interval of nebulosity	Observations	Individuals	Soaring	Gliding	Flapping flight
0-2	13.49	11.16	92.05	100	26.42
3-4	19.72	18.05	80.84	97.89	16.34
5-6	29.07	30.89	82.34	96.71	14.68
7-8	28.72	31.24	70.96	99.39	26.19
9-10	9.00	8.66	67.77	93.41	23.81

Under 100 m, individuals were observed from the 0 to 6 nebulosity, between 100 and 500 m, 500 – 1000 m and 1000 – 1500 m, from the 0 to 10 nebulosity and over 1500 m from the 0 to 8 nebulosity. With these considerations, under 100 m, the percentage of individuals decreased with the increasing interval of nebulosity. Between 100 and 500 m, the percentage was maximum into the 9 – 10 interval and minimum into the 7 – 8 interval. Between 500 and 1000 m, the percentage was maximum into the 7 – 8 interval and minimum into the 3 – 4 interval. Between 1000 and 1500 m, the percentage was maximum into the 3 – 4 interval and minimum into the 9 – 10 interval and over 1500 m, the percentage was maximum into the 5 – 6 interval and minimum into the 0 – 2 interval (Table 8).

Table 8. The percentage of the individuals according to the interval of nebulosity and maximum height of flight (m).

Interval of nebulosity	Maximum height (m)				
	0-100	100-500	500-1000	1000-1500	over 1500
0-2	3.13	12.78	57.39	25	1.70
3-4	2.11	26.01	34.80	33.39	3.69
5-6	1.85	9.34	52.57	24.74	11.50
7-8	0	6.40	79.70	10.86	3.05
9-10	0	31.87	61.17	6.96	0

The maximum of the percentage of the observations and of the observed individuals was associated with the clouds from middle level. The minimum was associated with the inferior clouds and with the clear sky (Table 9).

The flapping flight has had percentages of 20 – 24% in the case of the medium clouds and superior clouds, otherwise they being 0. The percentage of the gliding flight was maximum in the case of the inferior clouds and of the clear sky, and minimum in the case of the superior clouds. The percentage of the soaring flight was maximum in the case of the inferior clouds and minimum in the case of the superior clouds (Table 9).

Table 9. The percentage of the observation number and of the observed individual number as well as of the observed individuals depending on the type of flight and the kind of clouds.

Type of clouds	Observations	Individuals	Soaring	Gliding	Flapping flight
Inferior clouds	0.35	1.33	100	100	0
Medium clouds	73.70	74.09	81.38	98.24	20.42
Superior clouds	23.53	23.34	67.12	96.33	23.78
Clear sky	2.42	1.24	84.62	100	0

For the 0 – 100 m and 100 – 500 m intervals of flight, maximum of the percentage was for the clear sky; for the 500 – 1000 m, maximum of the percentage was for the inferior clouds; for the 1000 – 1500 m, maximum of the percentage was for the medium clouds; for over 1500 m, maximum of the percentage was for the superior clouds. In the case of inferior clouds, for 0 – 100 m, 100 – 500 m, 1000 – 1500 m and over 1500 m maximum level of flight, did not been observed birds. Equally for clear sky at over 1500 m. At 500 – 1000 m, minimum of the percentage was for the clear sky (Table 10).

Table 10. The percentage of the individuals depending on the type of clouds and the maximum level of flight (m).

Type of clouds	Maximum height (m)				
	0-100	100-500	500-1000	1000-1500	over 1500
Inferior clouds	0	0	100	0	0
Medium clouds	0.77	14.08	54.32	24.87	5.95
Superior clouds	1.63	12.64	74.18	7.47	4.08
Clear sky	28.21	30.77	17.95	23.08	0

The biggest percentages for the observations and observed individuals were for wind of category 1. The lowest percentages were for wind of category 3 and 4 (Table 11).

The flapping flight has had the biggest percentage for the wind of intensity 4 and the least for the wind of intensity 3. In opposite mode, the gliding flight and the soaring flight have had the biggest percentages for the wind of intensity 3 and the least for the wind of intensity 4 (Table 11).

Table 11. The percentage of the observation number and of the observed individual number as well as of the observed individuals depending on the type of flight and the wind intensity.

Wind intensity	Observations	Individuals	Soaring	Gliding	Flapping flight
V0	14.19	14.49	84.90	95.40	44.86
V1	68.51	73.10	78.26	98.57	14.45
V2	15.22	11.29	71.07	96.63	29.78
V3	0.69	0.60	100	100	0
V4	1.38	0.51	37.50	87.50	50

The biggest percentages of the individuals that flown under 100 m and between 100 and 500 m were for the wind of intensity 0 and the least for the wind of intensity 1 (excepting the categories 3 and 4, where they were 0). Between 500 and 1000 m, the biggest percentage was for the wind of intensity 4 and the least for the wind of intensity 2. Between 1000 and 1500 m, the biggest percentage was for the wind of intensity 3 and the least for the wind of intensity 0. Over 1500 m, for wind of categories 0, 3 and 4, did not been observed individuals, the biggest percentage being for wind of intensity 1 (Table 12).

Table 12. The percentage of the observed individuals depending on the wind intensity and maximum level of flight (m).

Wind intensity	Maximum height (m)				
	0-100	100-500	500-1000	1000-1500	over 1500
V0	5.91	24.51	58.86	10.72	0
V1	0.09	10.41	62.73	19.70	7.07
V2	3.37	23.03	36.52	35.39	1.69
V3	0	0	42.11	57.89	0
V4	0	0	68.75	31.25	0

DISCUSSIONS

For the beginning, we mention that the considered intervals (the intervals of lapse of time, the intervals of maximum level of flight, the intervals of air temperature and the intervals of atmospheric nebulosity) included their inferior limits, not the superior ones (excepting the superior limit of the last interval from the each case).

Also, we underline that the results should be considered with caution at the extremities of the lapse of time (because of the more reduced number of the observation effectuated at this time), of the general interval of temperatures, of the general interval of atmospheric nebulosity and of the predominant types of clouds (because of the small number of observations registered in these conditions). Similarly, for 3 and 4 intensity of the wind, the results should be viewed with moderation; because of the small number of

observations, the few data can lead to the wrong conclusions.

About the kind of flight, we notice that the birds can practice during their aerial movements more types of flight, because the flapping flight (the active flight, with repeated beating of wings), may be accompanied by the gliding flight, with the immobile and back curved wings and, more rarely, by the soaring one, in the thermals, with the wings laterally outstretched at the same level. The gliding flight may follow both the flapping flight and the soaring flight.

The variation of the percentage reflects both the preference of the birds to fly at the respective values of temperatures of the air and the frequency of occurrence of these temperatures. In the same way it was for the atmospheric nebulosity, the type of clouds and the wind intensity.

We observed white storks flying up to 2200 m maximum height of flight but in the Rădăuți Depression they were observed flying up to 3100 m [26]. In western Sudan, maximum recorded level of flight was ca. 3300 m [23].

Our data confirm that the birds are highly adapted for migration using alternatively the soaring and the gliding flights [23]. The flight is strongly correlated with the formation of the thermals that appear only on sunny days. In our case, the first observation was recorded at 9:50; in other cases the storks were sighted flying not before 9:00 – 10:00 (in Egypt [23]). However, in Israel, during March – May, they started to take off from 7:30 to 10:30 [26]. The catchy wind obstructs the flight; it may retain the birds on ground [23].

In the wake of the experimental observations, data processing and interpretation of the obtained results, we can jump to the following conclusions:

- across the hydrographical basin of the Râul Doamnei, the white storks preferred to fly at the midday and in the afternoon, when the thermals were present;
- in majority, the birds displaced between 500 and 1000 m maximum level of flight; at the inferior heights, they seem to move preponderantly in the morning and in the evening; at the maximum level of flight they were seen, chiefly, in the afternoon;
- rarely, the storks were seen in flapping flight; usually they combined the soaring flight with the gliding flight to move from a thermal to another;
- depending on the temperature of the air, the birds were observed the most frequently between 20 and 25 ^{0}C when they used especially the gliding flight;
- over 500 m level of flight, the maximum level of flight of the individuals increased directly proportional with the increasing of the temperature;
- in majority, the birds preferred to fly on a 50 – 80% cloudy sky;
- preponderantly, the white storks flown when the sky was covered by the clouds situated at the medium level, case when the individuals were seen attaining the highest levels of flight;
- the major part of the individuals was observed on the wind of intensity 1;
- the percentage of the individuals that used the soaring flight seem to decrease with the increasing of the wind intensity;
- the highest levels of flight were recorded particularly on the wind of intensity 1.

In synthesis, we can say that the flight of the migratory white storks across the Râul Doamnei hydrographical basin was influenced by the weather conditions which determined the formations of the thermals used in the economical flight (the combination of soaring flight and gliding flight).

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