

SPATIO-TEMPORAL STRUCTURE OF THE BIRD ASSEMBLAGE DURING THE WINTER–SPRING TRANSITION: THE ROLE OF TRANSIT ZONES AND DIURNAL ACTIVITY RHYTHMS

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A comprehensive spatio-temporal analysis of avian assemblages was carried out during the winter–spring transition period (23 February–23 March) at three fixed observation points differing in landscape context and functional role within the migration system. A total of 11 bird species were recorded. The Common Buzzard (*Buteo buteo* Linnaeus, 1758) functioned as the background species throughout the study period, while short-term mass concentrations were characteristic of the Greater White-fronted Goose (*Anser albifrons* Scopoli, 1769) and the Great Cormorant (*Phalacrocorax carbo* Linnaeus, 1758), reflecting episodic migratory pulses.

The spatial distribution of records was markedly heterogeneous. Observation point VP3 acted as a transit zone of seasonal movements and showed the highest total abundance due to mass migratory passages. VP2 exhibited the greatest species richness, likely related to higher structural heterogeneity of the environment and the involvement of a broader spectrum of ecological strategies. In contrast, VP1 was characterized by minimal abundance and diversity, indicating limited functional significance during the studied period.

Temporal analysis revealed a pronounced morning peak in both abundance and species richness between 08:00 and 10:00, corresponding to the overlap of intensive transit migration and local activity of diurnal raptors. This pattern is consistent with established diurnal rhythms of bird activity during transitional seasons. The coexistence of resident, nomadic, and migratory components during peak hours highlights the complex temporal organization of the assemblage.

Integration of spatial and temporal parameters demonstrates a mosaic structure of the avian assemblage, formed through the interaction of local habitat use and participation in large-scale migration flows. The applied spatio-temporal approach, supplemented by flight line parameterization, provides a methodological basis for further assessment of the vertical structure of bird movements, the influence of meteorological factors, and potential risks associated with spatial planning, including the placement of wind energy facilities. The results emphasize the importance of integrated spatio-temporal analyses for understanding avian assemblage dynamics during seasonal transition periods. *Key words:* bird assemblage, winter–spring transition, spatio-temporal analysis, bird migration, diurnal activity, transit zones.

Просторово-часова структура орнітокомплексу в період зимово-весняного переходу: роль транзитних зон і добових ритмів активності. Морозова Т.В., Ковган Я.О., Герасименко М.В.

Здійснено просторово-часовий аналіз структури та динаміки угруповань птахів у період зимово-весняного переходу (23 лютого – 23 березня) на трьох стаціонарних пунктах спостережень, що відрізнялися ландшафтними характеристиками та функціональною роллю у системі сезонних міграцій. Під час досліджень зафіксовано 11 видів птахів. Фоновим видом упродовж усього періоду спостережень виступав канюк звичайний (*Buteo buteo* Linnaeus, 1758), тоді як короточасні масові реєстрації були притаманні мігруючим водно-болотним видам, передусім гусці білолобій (*Anser albifrons* Scopoli, 1769) та баклану великому (*Phalacrocorax carbo* Linnaeus, 1758), що свідчить про транзитний характер використання окремих ділянок території.

Просторовий розподіл реєстрацій мав виражену неоднорідність. Пункт VP3 характеризувався найбільшою чисельністю та функціонував як транзитна зона сезонних переміщень птахів, у якій відбувалися концентровані міграційні проходи. Пункт VP2 відзначався найвищим видовим різноманіттям за умов нижчої загальної чисельності, що може бути пов'язано зі структурною неоднорідністю середовища та залученням ширшого спектра екологічних стратегій. Пункт VP1 характеризувався мінімальними значеннями чисельності та видового складу, що засвідчує його обмежене функціональне значення у досліджуваній період.

Часовий аналіз підтвердив наявність чітко вираженого ранкового піку чисельності та видового різноманіття, зумовленого інтенсифікацією транзитних міграційних потоків та локальної активності денних хижих птахів. Інтеграція просторових і часових параметрів означила мозаїчну організацію угруповання птахів, сформовану взаємодією місцевої активності осілих і кочових видів та транзитних міграційних процесів. Запропонований просторово-часовий метод, доповнений параметризацією ліній польоту, в процесі просторового планування формує підґрунтя для подальшого аналізу вертикальної структури міграцій, впливу метеорологічних чинників та потенційних ризиків для птахів, зокрема, під час розміщення об'єктів вітроенергетики. *Ключові слова:* орнітокомплекс, зимово-весняний перехід, просторово-часовий аналіз, міграція птахів, добова активність, транзитні зони.



Introduction. Transitional seasonal periods play a key role in shaping the spatial organization of avifauna, as during these times local habitat use is combined with large-scale migratory processes. The winter–spring transition is characterized by increased variability in species composition, abundance, and daily activity rhythms of birds, particularly in regions that function as migration corridors [1,2].

Despite the substantial body of research on migration phenology, the relationship between spatial environmental heterogeneity and the diel structure of bird activity at the local scale remains insufficiently studied. In particular, limited information is available on the functional role of individual sites within the observation area and on the temporal concentration of migratory activity.

The aim of the study is to analyze the spatio-temporal structure of the ornithocomplex during the winter–spring transition period.

Materials and Methods. Ornithological observations were conducted within the territory of the Balta Wind Power Plant using three fixed monitoring points (VP1–VP3), selected with consideration of landscape configuration, territorial openness, and potential bird migration corridors. Each monitoring point covered open agricultural landscapes, elements of the ravine network, and linear tree plantations that serve as spatial landmarks for migratory and nomadic bird species.

Bird movements were recorded using the transect method, which enables the assessment of the spatial organization of migratory flows. Transects were positioned taking into account relief features, infrastructure, and landscape elements that may influence flight directions and migration intensity. Flight lines and landscape visibility were documented using photographic records.

Field observations were carried out during daylight hours within standardized time intervals. For each record, the following parameters were documented: date

and time of observation, monitoring point, bird species and abundance, flight direction, and additional spatial characteristics.

Based on these data, a spatio-temporal dataset of variables was compiled for subsequent modelling of spring bird migration:

- **spatial variables:** monitoring point, transect location, flight direction;
- **temporal variables:** date, observation hour, diel interval;
- **biological variables:** species, taxonomic affiliation, number of individuals;
- **derived variables:** migration flow intensity, directional recurrence, and concentration of records within spatial sectors.

This approach makes it possible to move beyond descriptive analysis toward the development of spatio-temporal models that reflect the patterns of migratory flow distribution within the zone of influence of the wind power plant.

Results. *Species composition and spatial distribution.* During the period from 23 February to 23 March, 11 bird species were recorded at the three monitoring points (VPs). The assemblage was represented predominantly by diurnal raptors and wetland-associated taxa, which is consistent with the seasonal characteristics of the winter–spring transition period [1,3]. The common buzzard (*Buteo buteo* Linnaeus, 1758) was the background species during the study period, dominating in abundance and being present at all observation points (Table 1).

The spatial distribution of records is characterized by pronounced heterogeneity. The highest total abundance was recorded at point VP3, where, alongside background species, mass aggregations of the Greater White-fronted Goose (*Anser albifrons* Scopoli, 1769) and the Great Cormorant (*Phalacrocorax carbo* Linnaeus, 1758) were

Table 1

Species composition and abundance of birds recorded at the monitoring points during the winter–spring transition period (23 February–23 March)

Species	Code	№ sist.	VP1	VP2	VP3	Total
<i>Buteo buteo</i> Linnaeus, 1758	BUTBUT	185	27	21	75	123
<i>Phalacrocorax carbo</i> Linnaeus, 1758	PHACAR	054	–	–	22	22
<i>Anser albifrons</i> Scopoli, 1769	ANSALB	102	–	–	110	110
<i>Ciconia ciconia</i> Linnaeus, 1758	CICCIC	090	1	8	–	9
<i>Ciconia nigra</i> Linnaeus, 1758	CICNIG	091	2	1	–	3
<i>Falco tinnunculus</i> Linnaeus, 1758	FALTIN	220	1	1	–	2
<i>Accipiter gentilis</i> Linnaeus, 1758	ACCGEN	177			1	
<i>Accipiter nisus</i> Linnaeus, 1758	ACCNIS	178			2	
<i>Vanellus vanellus</i> Linnaeus, 1758	VANVAN	310			2	
<i>Ardea cinerea</i> Linnaeus, 1758	ARDCIN	077		1		
<i>Pluvialis apricaria</i> Linnaeus, 1758	PLUAPR	296		7		
<i>Circus macrourus</i> S. G. Gmelin, 1771	CIRMAC	172		1		
<i>Milvus migrans</i> Boddaert, 1783	MILANS	170		1		

observed. This indicates the transit use of this site during seasonal migrations [2].

At points VP1 and VP2, single and low-abundance records prevail, represented mainly by diurnal raptors and individual stork species (*Ciconia ciconia* Linnaeus, 1758; *Ciconia nigra* Linnaeus, 1758), which points to a different functional role of these census points in the spatial organization of territory use. Spatial differences between the points are manifested both in total abundance and species richness (Table 2).

The highest values of total abundance are characteristic of VP3, whereas VP2 exhibits the greatest species diversity, which may be associated with a broader spectrum of ecological niches. VP1 is characterized by minimal values, likely determined by local environmental features and its spatial position relative to the main migration routes. Overall, the spatial distribution of ornithological records reflects a mosaic organization of the avian assemblage, within which zones of local activity coexist with areas of intensive seasonal transit.

Diurnal activity structure. The diurnal dynamics of records are characterized by a pronounced unevenness of activity throughout the daylight period (Table 3). The maximum values of total abundance and species richness were recorded in the morning hours, with a peak between 09:00 and 10:00. This interval is driven by mass records of *Anser albifrons* Scopoli, 1769 and high activity of diurnal raptors, which is consistent with typical migratory and trophic rhythms of birds during transitional seasons [3, 4].

During the early morning minimum (08:00), the dominance of *Phalacrocorax carbo* Linnaeus, 1758 results in high abundance under a limited species composition, indicating the passage of compact migratory groups. In the mid-morning period (10:00–11:00), the structure of the avian assemblage stabilizes, with *Buteo*

buteo Linnaeus, 1758 dominating as the background species. After 11:00, a decline in total abundance of records is observed; however, during the midday period an increase in species diversity occurs due to the appearance of individual migratory and wetland species, in particular *Pluvialis apricaria* Linnaeus, 1758.

Integration of spatial and temporal patterns. The combined spatial and temporal analyses indicate that the structure of the avian assemblage during the winter–spring transition is shaped by the overlap of migratory flows and local activity of resident and nomadic species. The dominance of the common buzzard as a background species is accompanied by episodic mass records of migratory wetland birds, confirming the transit function of the studied area.

Records were conducted along several flight lines, which were used as spatial identifiers of bird activity. This approach provides a methodological basis for further spatial–temporal and vertical analyses of bird movements [5].

Discussion. The obtained results indicate the formation of a mosaic spatial–temporal structure of the avian assemblage during the winter–spring transition, which is consistent with classical concepts of seasonal bird migration as a process driven by the interaction of spatial and temporal factors [2]. The dominance of the common buzzard (*Buteo buteo* Linnaeus, 1758) as a background species and episodic mass records of migratory wetland birds reflect the transit nature of the use of certain parts of the territory, similar to spatial patterns of migratory flow organization described for other regions [6, 7].

The pronounced morning peak in abundance and species richness (08:00–10:00) corresponds to contemporary data on the diurnal phenology of bird migratory activity, particularly the increased intensity of movements during morning hours in transitional seasons [8,

Table 2

Spatial differentiation of avifauna between survey points

VP number	Total N ind.	Species richness
VP1	31	4
VP2	41	8
VP3	212	7

Table 3

**Diurnal structure of bird records during the winter–spring transition period
(23 February – 23 March 2025)**

Hour	Total N ind.	Species richness	Dominant species
8	41	3	<i>Phalacrocorax carbo</i> Linnaeus, 1758
9	188	8	<i>Anser albifrons</i> Scopoli, 1769
10	42	4	<i>Buteo buteo</i> Linnaeus, 1758
11	10	3	<i>Buteo buteo</i> Linnaeus, 1758
12	10	4	<i>Pluvialis apricaria</i> Linnaeus, 1758

Note. The dominant species was identified based on the maximum number of individuals recorded within the corresponding hour.

9]. The coexistence of mass records of migratory wetland species and high activity of diurnal raptors during this time interval indicates an overlap of local and transit components of the avian assemblage.

At the same time, mass records of *Anser albifrons* Scopoli, 1769 and *Phalacrocorax carbo* Linnaeus, 1758 at VP3 reflect short-term migratory pulses characteristic of transit areas during periods of active spring movement [2]. The high species richness at VP2 under lower total abundance may indicate structural heterogeneity of the environment and the involvement of a broader spectrum of ecological strategies.

Temporal analysis demonstrated that morning hours are crucial for recording both migratory and local bird activity, which is consistent with general patterns of diurnal rhythms during transitional seasons [4]. The combination of spatial and temporal patterns emphasizes the necessity of an integrated spatial–temporal approach to the analysis of ornithological data.

Spatial differences among observation points, particularly the identification of VP3 as a center of mass records, may be обусловлені landscape structure and the spatial position of the site relative to major migration routes, which is consistent with studies addressing the influence of landscape mosaicism on bird movements [10]. A similar approach to interpreting spatial heterogeneity of avifauna has been applied in national studies, particularly in ornithofaunistic monitoring of mountainous areas in the context of environmental justification for the placement of wind energy installations [11].

The application of a spatial–temporal approach supplemented by flight line parameterization creates pre-

requisites for further analysis of the vertical structure of bird movements, including the assessment of flight altitudes and the influence of meteorological factors, which is widely applied in modern migration studies [12].

Subsequent observations during the spring period revealed a significant increase in the complexity of the species composition and spatial–temporal structure of the avian assemblage, which will be addressed in a separate analysis. A comparison of the winter–spring transition and spring periods indicates a consistent transformation of the avian assemblage from a resident–wintering to a migratory–spring type, manifested by increased species diversity, greater spatial–temporal complexity, and changes in the functional role of background species.

Conclusions. During the winter–spring transition period, the avian assemblage of the studied area is characterized by a mosaic spatial–temporal organization formed through the interaction of local activity of resident and nomadic species and intensive transit migratory flows. The dominance of *Buteo buteo* Linnaeus, 1758 as a background species is combined with short-term mass records of migratory wetland birds, primarily within transit areas.

The identified morning peak in abundance and species richness (08:00–10:00) confirms the key role of this time interval for recording migratory activity. The integration of spatial and temporal data, supplemented by flight line parameterization, forms a basis for further analysis of the vertical structure of migrations and the assessment of potential risks to birds in the context of spatial planning and the placement of wind energy facilities.

References

1. Alerstam T. Bird migration. Cambridge : Cambridge University Press, 1990. 420 c.
2. Berthold P. Bird migration: a general survey. Oxford : Oxford University Press, 2001. 266 c.
3. Newton I. The migration ecology of birds. London : Academic Press, 2008, 976 c.
4. Shamoun-Baranes J., Liechti F., van Gasteren H., van Loon E., Bouten W., van Dijk J. Atmosphere–bird interactions and flight behaviour: insights from radar and biologging. *Philosophical Transactions of the Royal Society B*. 2017. Vol. 372, No. 1728. Article 20160247. DOI: <https://doi.org/10.1098/rstb.2016.0247>.
5. Dokter A. M., Farnsworth A., Fink D., Ruiz-Gutierrez V., Hochachka W. M., Kelling S., Rosenberg K. V. Seasonal abundance and survival of migratory birds. *Journal of Applied Ecology*. 2018. Vol. 55, No. 5. P. 2075–2084. DOI: <https://doi.org/10.1111/1365-2664.13191>.
6. Van Doren B. M., Horton K. G. A continental system for forecasting bird migration. *Science*. 2018. Vol. 361, No. 6407. P. 1115–1118. DOI: <https://doi.org/10.1126/science.aat7526>.
7. O'Donnell C. F. J., Sinclear R. S., Powlesland R. G. Patterns of nocturnal migration observed by radar. *Ecography*. 2020. Vol. 43, No. 12. P. 1754–1768. DOI: <https://doi.org/10.1111/ecog.05203>.
8. Gill R. E., Tibbitts T. L., Douglas D. C., Handel C. M., Piersma T. Mechanisms driving phenology of long-distance bird migration. *Science Advances*. 2019. Vol. 5. Article eaar1198. DOI: <https://doi.org/10.1126/sciadv.aar1198>.
9. Horton K. G., Nilsson C., Dokter A. M., Farnsworth A. Phenology and intensity of nocturnal bird migration. *Global Change Biology*. 2020. Vol. 26, No. 3. P. 1156–1164. DOI: <https://doi.org/10.1111/gcb.14909>.
10. Nilsson C., Dokter A. M., Schmaljohann H. Effects of landscape structure on bird movements. *Ecology Letters*. 2019. Vol. 22, No. 4. P. 605–615. DOI: <https://doi.org/10.1111/ele.13213>.
11. Бондар О. І., Морозова Т. В., Ковган Я., Герасименко М. Орнітофауністичний моніторинг полонини Руна як елемент екологічного обґрунтування розміщення вітроенергетичних установок. *Екологічні науки*. 2025. № 5 (62). Ч. 1. С. 7–13.
12. Bohrer G., Bildstein K. L., Barber D. R. Estimating flight altitude distributions and wind support of migrating birds. *Movement Ecology*. 2018. Vol. 6. Article 30. DOI: <https://doi.org/10.1186/s40462-018-0143-3>

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