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COMPLEX EVALUATION OF THE NUMBER DYNAMICS OF COLONIAL WATERBIRD COMMUNITIES (THE CASE OF SOME ISLANDS OF SIVASH REGION)

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The problem of the mathematical analysis of the number dynamics of the nesting waterbirds for the islands of the south of Ukraine is examined. The algorithm of the evaluation of changes in the number of island birds is proposed. Data of the long-term monitoring of the number of birds were analyzed according to this algorithm. The necessity of the implementation of the statistical indices together with the graphic representation of island birds' turnover is proved. The trends of population dynamics are determined for the key species. The discussed procedure of the complex evaluation is proposed for the management planning of the island bird species and their habitats.

The performed analysis of the number dynamics of the key-stone breeding island birds showed that, with the exception of little tern, the population status and the prognosis of number are sufficiently favorable. From the data of long-term monitoring we came up with the conclusion about the existence of island habitats with carrying capacity to maintain the additional number of breeding birds. In the case of unfavorable conditions like strengthening of anthropogenic press, concurrent interrelations, deficiency of feed resources or drastic reduction of breeding biotopes, the birds due to turnover are capable to successfully react even without reducing their number and breeding success. The extinction rate of the breeding bird species from the island sites directly correlates with the number of breeding species. For the species with equal abundance, the extinction probability is higher for birds, whose numbers are unstable and characterized by significant fluctuations. This testifies the urgency of the constant monitoring and analysis of the number dynamics of breeding bird species in region.

The suggested procedure of analysis is recommended for drawing up of management plans and performing of prognoses of number of breeding island bird species. More detail analysis with use of quantitative data on breeding birds will be the next step of the study of the island birds' turnover. The results of the analysis of population dynamics assist to count the minimal population size for the colonization of new islands and stable existence of bird communities. Detailed analysis will allow to estimate the effect of competition on population and to determine the competitive variability inside and between the species breeding on islands.

Key words: Ukraine, colonial waterbirds, islands, dynamics of number, analysis

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ФАКТОРИ, ЩО ОБУМОВЛЮЮТЬ РОЗПОДІЛ КОЛОНІАЛЬНИХ ПТАХІВ РОДИНИ LARIDAE НА ОСТРОВАХ СИВАШУ

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Наведено комплексний аналіз факторів, що обумовлюють просторовий розподіл колоніальних навколоводних птахів на островах Азово-Чорноморського регіону. Розглянуто ступінь впливу різноманітних факторів на видове різноманіття птахів острівних систем. Доведено, що домінуючий вплив на колонії має антропогенний прес та система міжвидових зв'язків в угрупованнях гніздових птахів.

Ключові слова: острова, угруповання птахів, антропогенний вплив, міжвидові взаємозв'язки, аналіз.

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ФАКТОРЫ РАСПРЕДЕЛЕНИЯ КОЛОНИАЛЬНЫХ ПТИЦ СЕМЕЙСТВАLARIDAE НА ОСТРОВАХ СИВАША

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Приводится комплексный анализ факторов, обуславливающих пространственное распределение колониальных околоводных птиц островов Азово-Черноморского региона. Рассмотрена степень влияния различных факторов на видовое разнообразие птиц островов. Доказано, что доминирующее воздействие на колонии оказывает антропогенный фактор и система межвидовых взаимоотношений в сообществах гнездящихся птиц.

Ключевые слова: острова, сообщества птиц, антропогенное воздействие, межвидовые взаимоотношения, анализ.

The islands are the components of landscape, which could be characterized by high vulnerability and restricted resilience. The islands are the excellent model sites for ecological monitoring and managements due to their limited territory and high concentration of colonially breeding waterbirds.

Birds as bioindicators can be used not only for determining the ecological value of wetland but also for the biological monitoring of wetland condition. The number of families, genera and species of aquatic and semi-aquatic birds reflect diversity of bird communities and level of the ecological prosperity of the wetlands. For the selection of wetlands of international or national importance the species diversity and number of birds are the reliable indicators of the ecological value of ecosystems and degree of anthropogenic pressure.

This investigation is devoted to the study of the dynamics of the number of breeding bird communities of the islands of the South and South-eastern parts of Ukraine. Occupying comparatively small areas (in the comparison with other habitats, like saline lands and reed belts), the island systems are characterized by the high level of specific diversity and number of birds. They also have the great value in the maintenance of general biodiversity being the breeding and roosting sites for the colonially nesting waterbirds. Several birds that breed mainly on the islands are listed in the Red Data Book of Ukraine (*Charadrius alexandrinus* (Linnaeus, 1758), *Haematopus ostralegus* Linnaeus, 1758, *Himantopus himantopus* (Linnaeus, 1758), *Larus ichtyaetus* Pallas, 1773, *Hydroprogne caspia* Linnaeus, 1758).

The ability of community to resist against environmental factors could be expressed by the number dynamics of its species. The analysis of the number dynamics of insular bird communities is associated with definite constrains, namely dispersion of data on the bird numbers and inadequate level of territory investigation.

Beginning from the middle of past century, the isolated information about number and distribution of the nesting birds on the islands of Sivash and Azov Sea region were presented in some papers (Ardamatskaya, 1975; Zubakin, 1975; Zubakin, Kostin, 1977; The inventory, 1993; Siokhin, Chernichko, Ardamatskaya, 1988; Lysenko, 1975; Filonov, Lysenko, Siokhin, 1974). Subsequently, the intensive surveys of the colonially nesting waterbirds (including island communities) acquired the systematic character. The mutual projects of bird counts performed by the collaborators of the Azov-Sea Ornithological Station together with Wetlands International in 1997 and WIWO-Foundation (Netherlands) in 1998 allow fulfilling the existing gaps and evaluating the islands' carrying capacity during the breeding period.

The clear procedure of the evaluation of the dynamics of island birds' number is still absent. The development of this procedure would make it possible to adequately reflect the changes in the quantitative and qualitative composition of bird communities, to conduct the comparison of different island systems, and to create the ecological models for nature conservation. Furthermore, the specific properties (extinction, immigration, and the strong susceptibility to the weather conditions) lead to the significant fluctuations not only in the numbers of nesting birds, but also in the species composition. The mathematical indices as well as the methods of graphic representation that were used until now, do not reflect the changes in the island bird communities. Thus, the primary task of investigation was the development of the procedure of the evaluation of number dynamics of the island breeding bird communities.

MATERIAL AND METHODS

This research was carried out on the base of Azov-Black Sea Ornithological station of The Institute of Zoology Academy of Science of Ukraine and Melitopol State Pedagogical University. The field material was collected in the period from 1993 to 1998; the data from previous time were also used (Ardamatskaya, 1975; Zubakin, 1975; Zubakin, Kostin, 1977; The inventory, 1993). The annual counts of the colonially nesting birds were conducted by the detailed calculation of all island nests – i.e., the so-called absolute count method was used (Mikityuk, 1997).

In the course of the monitoring works we investigated the islands of Ukrainian and Crimean part of Sivash, Azov and partially Black Sea coasts. All monitoring investigations and analysis of the dynamics of number were performed for the key-stone colonially breeding bird species.

RESULTS AND DISCUSSION

To obtain the preliminary results, which characterizes the changes in the distribution and the numbers of birds breeding on the islands, the initial analysis was executed (Table 1).

Table 1

Changes in numbers and distribution of some colonial breeding birds of island communities

Species	Abundance	Distribution*	Time
Larus cachinnans	9,4	18,0	1973-1998
Larus ichthyaetus	4,0	2,0	1973-1998
Larus melanocephalus	25,6	11,0	1973-1998
Larus genei	3,0	7,0	1973-1998
Gelochelidon nilotica	1,6	4,0	1973-1998
Sterna hirundo	1,1	2,6	1973-1998
Sterna albifrons	0,4	2,0	1973-1998
Sterna sandvicensis	1,5	1,0	1973-1998
Sterna caspia	27,0	1,0	1973-1998
Charadrius dubius	0,2	2,0	1984-1998
Charadrius alexandrinus	1,7	3,0	1984-1998
Himantopus himantopus	1,8	2,0	1991-1998
Recurvirostra avosetta	3,2	8,0	1973-1998
Haematopus ostralegus	2,0	3,7	1984-1998
Tringa totanus	4,0	1,9	1984-1998
Phalacrocorax carbo	26,0	2,5	1983-1998

* The ratio between the numbers of birds and quantity of islands on which they were registered within the limits of time period. Some 34 islands with total square of 573 ha were analyzed.

According to the results of Table 1 it is possible to obtain the approximate evaluation of the trends of the birds' dynamics of number and colonization of new territories. This method allowed executing the preliminary analysis, but it needs to be improved. The high values of indices do not always adequately reflect the species breeding strategy by their biotope selectivity. The total number of birds and the sizes of colonies also influence the index value. Sometimes the artificial regulation of the number of species occurs: fishermen periodically ruin the colonies of *Phalacrocorax carbo*, which leads to its disappearance from these areas. The turnover of some species can be considered as well (for instance, sharp increase in number of *Larus melanocephalus* Temminck, 1820 occurred as a result of its immigration from the islands of Black Sea to the Azov sea islands). Several species (*Larus ichtyaetus*, *Hydroprogne caspia*) historically nest on one-two islands within this region.

The values of the index of changes in the number adequately reflect the processes of the population dynamics of species in general, especially with respect to the rare species (*Sterna albifrons* Pallas, 1764, *Charadruis dubius* Scopoli, 1786, *Charadrius alexandrinus*, *Haematopus ostralegus*). In combination with the index of distribution, it is possible to obtain the reliable representation about the general dynamics of the nesting bird species. For the obtaining of the tendencies of the dynamics of birds' number it is expedient to design the indices of number variance, like coefficient of fluctuation (Sauer, Droege, 1990; Underhill, Prys-Jones, 1994). This coefficient was calculated for the period analyzed above (Table 2).

Table 2

The indices that reflect the number dynamics of colonially breeding birds of island systems

Species	N'	CV	CF	N	σ	R
Larus cachinnans	14,38	0,81	2,75	8241,35	6642,30	0,67*
Larus ichthyaetus	0,49	0,68	2,81	284,86	193,99	0,66*
Larus melanocephalus	4,59	1,91	8,20	2635,05	5044,39	0,16
Larus genei	4,37	1,08	4,00	2504,79	2714,54	0,27
Gelochelidon nilotica	0,72	1,11	6,39	412,76	459,38	0,16
Sterna hirundo	6,22	0,88	2,53	3569,85	3128,08	-0,14
Sterna albifrons	1,03	1,18	4,51	593,42	697,07	-0,09
Sterna sandvicensis	5,39	0,98	2,88	3088,12	3012,14	-0,12
Sterna caspia	0,51	0,83	3,65	292,92	241,29	0,10
Charadrius dubius	0,03	0,56	2,49	17,10	9,59	0,38
Charadrius alexandrinus	0,22	0,56	7,22	127,20	70,89	0,41
Recurvirostra avosetta	0,68	1,65	3,38	391,67	645,09	0,07
Himantopus himantopus	0,21	0,41	3,23	121,88	50,01	0,18
Haematopus ostralegus	0,04	0,45	3,01	21,90	9,84	0,15
Tringa totanus	0,23	0,53	3,23	131,18	69,23	0,14
Vanellus vanellus	0,03	0,82	5,46	17,25	14,37	0,17
Glareola platincola	0,03	0,20	1,41	15,33	3,22	0,09
Ardea cinerea	0,14	0,71	2,33	78,74	55,80	0,19

Ardea purpurea	0,04	0,55	8,38	22,83	12,02	0,21
Egretta alba	0,21	1,46	6,75	123,72	179,08	0,25
Egretta garzetta	0,11	0,99	5,70	63,35	61,93	0,20
Phalacrocorax carbo	13,20	0,43	2,91	7591,94	3254,59	0,69*
Total	53,59	-	-	-	-	-

CF - coefficient of fluctuation, $\Sigma (\log N_i - \log \tilde{N}) / (t - 1)$ (1)
where: N_i - the number of species (in breeding pairs) at moment *i*, *t* – number of observation years, $\tilde{N}$ - the average density (breeding pairs per 100 ha)

We can characterize the status of population by the method of the calculating of the average density per preset area (here 100 ha) and the coefficient of fluctuation (1). It is supposed that the density of population in different years does not exceed the value, equal to this coefficient. For *Larus cachinnans*, for example, the average density Ñ will vary in the limits from $\tilde{N}$/2.75 to 2.75$\tilde{N}$, where 2.75 is the coefficient of fluctuation. The values of this coefficient within the limits from one to five make it possible to consider the dynamics as stable for *Larus ichtyaetus, Larus genei, Sterna hirundo, Thalasseus sandvicensis, Hydroprogne caspia, Charadrius dubius, Recurvirostra avosetta, Himantopus himantopus, Tringa totanus,* and *Phalacrocorax carbo*, the last species, however, is characterized by the periodic epizooty, because of its intrinsic tendency of the expansion.

The number dynamic of species with coefficient of fluctuation is more than five, is defined as unstable: *Larus melanocephalus, Gelochelidon nilotica, Charadrius alexandrinus,* and *Charadrius dubius*. For first and second species this can be explained by their labiality and high turnover among the islands; the number of last species to the high extend depends upon condition of breeding biotopes. In recent ecological papers the trend conception is widely used as the mathematical expression of changes in animal numbers. The value of trend is designed by mean of the regression analysis. This index is static and reflects the general picture, whereas the researchers and nature conservationists are interested in more complete data, which would help them to carry out the detail analysis. The phenomenon of cycle variations of number must be considered for the evaluation of the ornithological situation and for the studying the population dynamics.

The fluctuations in number of breeding island species have periodic pattern - on average, in the course of ten years population is characterized by alternating of abundance increase and decrease. For the comparison of the dynamics for different temporary periods, the calculations of trend were performed of the average bird numbers, converted into decimal logarithm (O'Connor, 1990). According to the Table 3, the statistically significant results were obtained for: *Larus cachinnans* (more higher increase for 1991-1998 and 1982-1990 in comparison with 1973-1981); for *Larus ichtyaetus* (the same for 1991-1998 in comparison with 1973-1981); for *Gelochelidon nilotica* (decrease in numbers of 1982-1990 in comparison with 1973-1981); for *Hydroprogne caspia* (the same for 1991-1998 in comparison with 1973-1981); for *Thalasseus sandvicensis* and *Recurvirostra avosetta* (numbers' decrease in 1982-1990 compared to 1973-1981); for *Haematopus ostralegus* (slight increase in numbers within 1991-1998 in the comparison with 1973-1981).

Table 3

The trends of some bird species for different temporary periods

Species	Trend (1)	SD	Annual fluctuation, %
Larus cachinnans	0,66*	0,13	357
Larus ichthyaetus	0,65*	0,22	347
Larus melanocephalus	0,44	0,26	175
Larus genei	0,53	0,20	239
Gelochelidon nilotica	0,29	0,27	95
Sterna caspia	0,09	0,20	23
Sterna hirundo	-0,14	0,21	-28
Sterna sandvicensis	-0,13	0,22	-26
Sterna albifrons	-0,09	0,20	-19
Recurvirostra avosetta	0,19	0,25	55
Charadrius dubius	0,14	1,38	38
Charadrius alexandrinus	-1,57	0,96	-97
Haematopus ostralegus	0,05	0,23	12
Tringa totanus	0,33	0,45	114
Himantopus himantopus	0,16	0,46	45
Egretta alba	0,81*	0,17	546
Egretta garzetta	0,89*	0,16	676
Ardea cinerea	0,97*	0,16	833
Phalacrocorax carbo	0,71*	0,20	413

(1) - Trend, calculated by linear regression, SD - standard deviation, * $p < 0,05$;

CONCLUSIONS

1. The performed analysis of the number dynamics of the key-stone breeding island birds showed that, with the exception of little tern, the population status and the prognosis of number are sufficiently favorable.
2. From the data of long-term monitoring we came up with the conclusion about the existence of island habitats with carrying capacity to maintain the additional number of breeding birds. In the case of unfavorable conditions like strengthening of anthropogenic press, concurrent interrelations, deficiency of feed resources or drastic reduction of breeding biotopes, the birds due to turnover are capable to successfully react even without reducing their number and breeding success.
3. The extinction rate of the breeding bird species from the island sites directly correlates with the number of breeding species. For the species with equal abundance, the extinction probability is higher for birds, whose numbers are unstable and characterized by significant fluctuations. This testifies the urgency of the constant monitoring and analysis of the number dynamics of breeding bird species in region.

POTENTIAL FOR FURTHER INVESTIGATIONS

The suggested procedure of analysis is recommended for drawing up of management plans and performing of prognoses of number of breeding island bird species.

More detail analysis with use of quantitative data on breeding birds will be the next step of the study of the island birds' turnover. The results of the analysis of population dynamics assist to count the minimal population size for the colonization of new islands and stable existence of bird communities.

Detailed analysis will allow to estimate the effect of competition on population and to determine the competitive variability inside and between the species breeding on islands.

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