THE ROLE OF GREAT CORMORANT (*PHALACROCORAX CARBO SINENSIS*) FOR FISH STOCK AND DISPERSAL OF HELMINTHES PARASITES IN THE CURONIAN LAGOON AREA

Saulius Švažas[1,*], Natalia Chukalova[2], Gennady Grishanov[3], Žilvinas Pūtys[1], Aniolas Sruoga[4], Dalius Butkauskas[1], Liutauras Raudonikis[1], Petras Prakas[1]
[1]*Nature Research Centre, Akademijos str. 2, LT-08412 Vilnius, Lithuania*
[2]*Atlantic Research Institute of Marine Fisheries and Oceanography, D. Donskoy 5, Kaliningrad, 236 000 Russia*
[3]*I. Kant State University, Universitetskaya 2, Kaliningrad, 236 000 Russia*
[4]*Vytautas Magnus University, K. Donelaicio 58, LT-44248 Kaunas, Lithuania*

**Corresponding author:*
Nature Research Centre, Akademijos str. 2, LT-08412 Vilnius, Lithuania; e-mail:svazas@ekoi.lt

Summary. The population trends, diet composition and helminthes fauna were investigated in the newly established colonies of great cormorant located at the coasts of the Curonian Lagoon of the Baltic Sea. The numbers of breeding birds have increased from 0 in the 1970s to about 10000 pairs in the 2000s. These newly formed colonies of great cormorant are among the largest in Europe. 25 fish species were identified in the diet composition of great cormorants. Freshwater fish species, mostly percids (*Percidae*) and cyprinids (*Cyprinidae*), dominate in the diet composition of birds in the Curonian Lagoon area, comprising more than 90% by number and biomass. 17 helminthes species were found in great cormorants. The recent establishment of great cormorant as a new and very abundant species was one of the determining factors for introduction of new parasite species in the Curonian Lagoon area. Nematode *Contracaecum rudolphii*, potentially pathogenic for animals and people, and cestodes *Paradilepis scolecina,* which has caused fish disease dilepidosis revealed in bream (*Abramis brama*), were found in the Curonian Lagoon area in 2004.
Keywords: great cormorant, diet composition, helminthes fauna, Curonian Lagoon.

DIDŽIOJO KORMORANO (*PHALACROCORAX CARBO SINENSIS*) SVARBA ŽUVŲ IŠTEKLIAMS IR PARAZITINIŲ KIRMĖLIŲ PAPLITIMUI KURŠIŲ MARIŲ REGIONE

Saulius Švažas[1*], Natalia Chukalova[2], Gennady Grishanov[3], Žilvinas Pūtys[1], Aniolas Sruoga[4], Dalius Butkauskas[1], Liutauras Raudonikis[1], Petras Prakas[1]
[1]*Gamtos tyrimų centras, Akademijos g. 2, LT-08412 Vilnius*
[2] *Atlanto žuvininkystės ir okeanografijos mokslo tyrimų institutas, D. Donskoy 5, Kaliningradas, 236 000 Rusija*
[3] *I. Kanto valstybinis universitetas, Universitetskaya 2, Kaliningradas, 236000 Rusija*
[4] *Vytauto Didžiojo universitetas, K. Donelaičio g. 58, LT-44248 Kaunas*
[*]*Gamtos tyrimo centras, Akademijos g. 2, LT-08412 Vilnius; el. paštas: svazas@ekoi.lt*

Santrauka. Buvo tiriama vienų didžiausių Europoje didžiojo kormorano kolonijų svarba žuvų ištekliams ir parazitinių kirmėlių paplitimui Kuršių marių regione. Perinčių kormoranų skaičius Kuršių marių pakrantėse per pastaruosius 30 metų išaugo nuo 0 iki 10 000 porų. Nustatyta, kad šiame regione kormoranai maitinasi 25 rūšių žuvimis. Didžiąją jų maisto dalį sudaro verslinės ešerinių (*Percidae*) ir karpinių (*Cyprinidae*) šeimų žuvys. Ištyrus 14 didžiųjų kormoranų, rasta 17 helmintų rūšių. Tikėtina, kad itin sparčiai plintantys didieji kormoranai perneša į Kuršių marių regioną naujas parazitinių kirmėlių rūšis. Tirtuose paukščiuose nustatytos penkios anksčiau šiame regione neaptiktos helmintų rūšys. Naujų pavojingų parazitinių kirmėlių *Contracaecum rudolphii* (galimai patogeninė rūšis žmogui ir naminiams gyvūnams) bei *Paradilepis scolecina* (dilepidozės Kuršių marių karšiams sukėlėja) atsiradimas Kuršių marių regione (abi rūšys pirmą kartą aptiktos 2004 m.) siejamas su itin greitu didžiojo kormorano populiacijos išplitimu ir gausumu.
Raktažodžiai: didysis kormoranas, kormoranų mityba ir parazitinės kirmėlės, Kuršių marios.

Introduction. An exponential increase in numbers of the continental subspecies of great cormorant (*Phalacrocorax carbo sinensis*) was recorded in Europe during the last decades of the 20th century. The total breeding population in Northern and Central Europe was estimated at about 4000 pairs in the 1960s, while in the 1990s – at up to 135000 pairs (Delany, Scott, 2006). A marked eastwards and northwards breeding range expansion of the species was observed since the 1970s, with new colonies of great cormorants established in all countries of the Baltic Sea region (Hagemeijer, Blair, 1997).

First nests of great cormorant at the coast of the Curonian Lagoon of the Baltic Sea were found in the 1980s, while at present the local breeding sub-population is estimated at about 10000 breeding pairs. Such rapid increase in numbers of this fish-eating species has significantly affected the fish stock and species composition of parasites in the ecosystem of the Curonian Lagoon. Cer-

tain species of parasites, associated with great cormorant, can be potentially pathogenic to people, domestic animals and commercial fish species.

The aim of this study was to investigate population trends, diet composition and the helminthes fauna of the newly established colonies of great cormorants at the coast of the Curonian Lagoon.

Material and methods. The distribution and population trends of great cormorant were continuously studied in their colonies located along the coast of the Curonian Lagoon (in its Lithuanian and Russian parts) since the 1980s (Gražulevičius, 1994; Švažas et al., 1999; Grishanov, Belyakov, 2000; Žydelis et al., 2002; Švažas, Raudonikis, 2009). All colonies of great cormorant were monitored and mapped.

The diet composition of great cormorant was investigated in the breeding colony located at Juodkrantė settlement on the Curonian Spit, at the western coast of the Curonian Lagoon (Lithuania), in 2005-2007. The pellet analysis (220 samples) was used (Pūtys, Zarankaitė, 2010).

The infestation of great cormorants with helminthes parasites was investigated in July 2009 in the breeding colony located near Belomorskoe village, at the southern coast of the Curonian Lagoon (Kaliningrad Region of Russia). The entire alimentary tracts of 14 juvenile birds were examined by total dissection parasitological method (Dubinina, 1971). The parasite taxa were identified following Ryzhikov et al. (1985) and Sonin (ed.) 1985, 1986. The following indices of infestation were used: prevalence (P,%), abundance (A, sp.), range of intensity (I, sp.) and density (D, sp.) (Margolis et al., 1982). The Jaccard similarity coefficient was used for comparison of parasite fauna of different populations of great cormorant. The published data about parasite fauna of great cormorants in northern Poland (Kanarek, Rokicki, 2005) and in Germany (Ossmann, 2008) were used in this study.

Results. In Lithuanian part of the Curonian Lagoon area first nest of great cormorant were recorded in the colony of the grey heron (*Ardea cinerea*) in 1989 (Gražulevičius, 1994). They were found on the Curonian Spit, at the western coast of the Curonian Lagoon, close to Juodkrantė se-ttlement. It was the same place, where a large colony of great cormorants existed since the early the 19th century, but was abandoned due to human persecution in 1887 (Ivanauskas, 1957). During initial period of formation of a new colony the number of nests of great cormorants has increased from 3 in 1989 to 600 in 1995 (Fig. 1). The maximum number of nests (3336) was recorded in 2008. During the last years this colony annually holds about 3000 pairs of great cormorants due to special regulation measures aimed to stop further increase of nesting birds. Two smaller colonies of great cormorant have established in Lithuanian part of the Nemunas River delta area (at the eastern coast of the Curonian Lagoon) since 2001, with 550 nest counted in 2005. Nesting birds were not recorded there in 2006-2009 due to human persecution (Švazas, Raudonikis, 2009). In Russian part of the Curonian Lagoon area the largest breeding colony of great cormorant has established in the forest near Belomorskoe village, at the southern coast of the Curonian Lagoon. The numbers of nesting birds in this colony has increased from 30 pairs in 1985 to 700 in 1993 (Grishanov, Belyakov, 2000). The maximum number of breeding pairs (8500) was observed in 2005, while in 2008-2010 about 6000 – 6500 pairs were counted in this colony. The other small breeding colony at southwestern coast of the Curonian Lagoon (at Sosnovka village) holds about 100 pairs of great cormorant. The total subpopulation of great cormorant in the Curonian Lagoon area is currently estimated at about 10000 breeding pairs and more than 3000 non-breeding individuals.

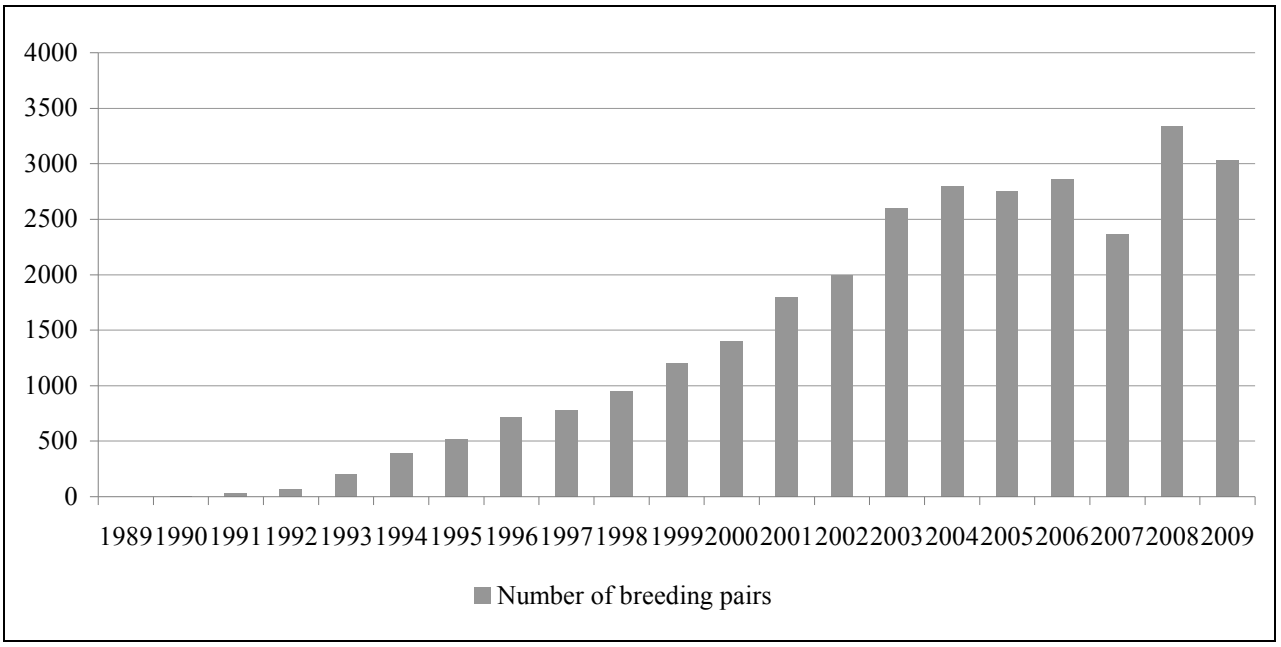

Figure 1. **The number of breeding pairs of great cormorants in Juodkrante colony** (western coast of the Curonian Lagoon, Lithuania) **in 1989 – 2009**

25 fish species were identified in the diet composition of great cormorants in Juodkrantė colony, but only three dominated by abundance (82.9%) and biomass (73.6%): ruffe (*Gymnocephalus cernuus*), perch (*Perca fluviatilis*) and roach (*Rutilus rutilus*) (Fig. 2). Frequency of occurrence in pellets of these species exceeded 75%. Besides dominant prey species, only smelt (*Osmerus eperlanus*) by number, pikeperch (*Sander lucioperca*) and white bream (*Blicca bjoerkna*) by biomass exceeded 5% in the diet composition. Among other prey species, bream (*Abramis brama*) and flounder (*Platychthis flesus*) had more substantial portion in great cormorant diet. Their frequency of occurrence in the pellets exceeded 10%. Great cormorant preyed mostly on small fish. The mean length of fish found in pellets was 9.5±4.7 cm and the mean weight – 16.8±31 g. Commercially important fish species comprised 82.8% by biomass and 57.3% by number in great cormorant diet composition. Roach and perch were the most important commercial fish, contributing to 42.3% and 17.1% by biomass respectively. Pikeperch was important as well, contributing to 5.9% by biomass in great cormorant diet composition.

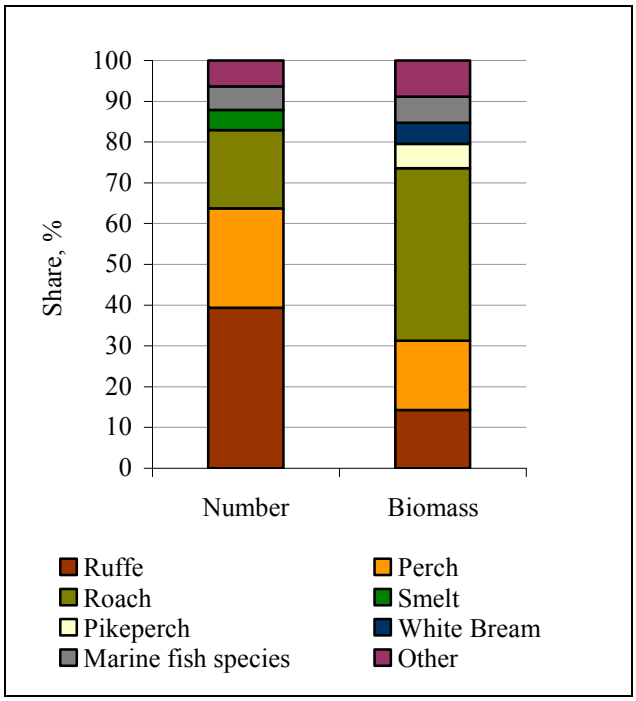

Figure 2. **Diet composition of great cormorant by numbers and biomass at the Juodkrante colony (western coast of the Curonian Lagoon, Lithuania) in 2005–2007**

Totally 17 taxa of metazoan species from 3 systematic groups were found in the alimentary tract of great cormorant (Table 1): Cestoda (7 taxa), Trematoda (7 species) and Nematoda (6 taxa). Most of them (64.7%) are non-specific for great cormorant. Five parasite species (*Petasiger phalacrocoracis, Paryphostomum radiatum, Holostephanus dubinini, Syncuaria squamata* and *Cosmocephalus obvelatus*) were found in the southern part of the Curonian Lagoon for the first time. Specific for great cormorant species (cestodes *Paradilepis scolecina*, trematodes *Petasiger phalacrocoracis*, *Paryphostomum radiatum*, *Holostephanus dubinini* and nematodes *Contracaecum rudolphii, Syncuaria squamata*) dominated in parasite fauna of birds with the highest prevalence (more than 90%) and abundance (up to 1528 sp.). Infestation of great cormorant by cestodes of *Paradilepis* and *Dilepis* genera, as well as by trematodes *Hysteromorpha triloba, Echinochasmus coaxatus, Metorchis xanthosomus* and nematodes *Contracaecum microcephalum* ranged from 14.3 to 78.6%. Rare species found in cormorants were cestodes *Gryporhynchus* sp., trematodes *Tylodelphys clavata* and nematodes of *Eustrongylides* and *Capillaria* genera.

Discussion. During the 19th century and the first half of the 20th century great cormorant was exterminated as a breeding bird in most countries of the Baltic Sea region (van Eerden, Gregersen, 1994). Its recovery both in population size and in breeding range was recorded in the Baltic region since the 1970s, and was mainly caused by effective protection measures implemented in the southern Baltic countries (Bregnballe et al., 2003). Great cormorant is a species which benefits from eutrophication and the global climate change was a positive factor contributing to its recent breeding range expansion (Burton, 1995). In 2006 the total number of great cormorants in the Baltic Sea countries was estimated at about 157000 pairs (Hermann et al., 2009). The highest population density of great cormorant in the Baltic region was found around the highly eutrophic estuaries (Goc et al., 2005; Hermann et al., 2009). First nests of great cormorant at the coast of the Curonian Lagoon of the Baltic Sea were found in the 1980s, while at present the newly formed colonies of great cormorant at the coasts of the Curonian Lagoon are among the largest in Europe (Hermann et al., 2009).

Freshwater fish species, mostly percids (*Percidae*) and cyprinids (*Cyprinidae*), dominate in the diet composition of great cormorant in the colony located at the western coast of the Curonian Lagoon, comprising more than 90% by number and biomass. Their proportion can be even higher at the southern coast of the lagoon, as it is located further from the Baltic Sea. Similar diet composition is characteristic of cormorants feeding in other highly eutrophic water bodies of the eastern Baltic region. Roach, ruffe and perch form 77-84% of the total biomass in the diet of cormorants breeding in the Polish part of the Vistula Lagoon (Stempniewicz et al., 2003).

This new and abundant waterbird species can significantly contribute to parasite dispersal in the southeastern Baltic region. The parasite fauna of great cormorant includes about 110 taxa of metazoan parasites (Ossmann, 2008). 17 helminthes species were found in birds breeding at the coast of the Curonian Lagoon. The species composition of helminthes found in great cormorants in the Curonian Lagoon area is less diverse than in cormorants breeding in the Polish part of the Vistula Spit (22 taxa), but richer than in birds investigated at the Baltic coast of Germany (15 species) (Kanarek, Rokicki, 2005; Ossmann, 2008). Birds breeding at the coast of the Curonian Lagoon have 45.5% of common parasite species

with cormorants from the Vistula Lagoon and 17% - with cormorants breeding at the coast of Germany. The infestation indices for common parasite species tend to increase from Germany and the Vistula Lagoon to the Curonian Lagoon for cormorant specific taxa, whereas opposite trends were found for nonspecific parasites. The revealed differences of infestation of great cormorants from different breeding colonies of the southeastern Baltic region can be possibly explained by differences in their diet composition and peculiarities of parasite infestation in various fish species.

Table 1. **Helminthes fauna of great cormorant at the southern coast of the Curonian Lagoon in 2009**

Parasite species	Intermediate hosts		Infestation of the great cormorant in 2009				
	1st	2nd	Prevalence, %	Abundance, sp.	Range of intensity, sp.		Density, sp.
					min	max	
Cestoda							
Paradilepis scolecina	Zooplancton *Eudiaptomus graciloides*	Cyprinid, percid and gobiid fishes	100	31.0	1	63	31.0
Paradilepis sp.	Zooplancton *Eudiaptomus* sp., *Diaptomus* sp.	Cyprinid, percid and gobiid fishes	14.3	0.7	1	7	5.0
Dilepis sp.	Zooplancton *Diaptomus* sp., *Eudiaptomus* sp., *Cyclops* sp.	Cyprinid, percid and gobiid fishes	14.3	0.9	3	8	6.5
Gryporhynchus sp.	Zooplancton *Mesocyclops* sp., *Cyclops* sp.	Cyprinid, percid and gobiid fishes	7.1	0.5	6	6	7.0
Trematoda							
Petasiger phalacrocoracis	Molluscs *Gyraulus* sp., *Planorbis* sp.	Cyprinid, percid and gobiid fishes	100	1528.0	160	3880	1528.0
Echinochasmus coaxatus	Molluscs *Bithynia* sp., *Codiella* sp., *Lithoglyphus* sp.	Cyprinid, percid and gobiid fishes	21.4	0.9	1	6	4.0
Paryphostomum radiatum	Molluscs *Planorbis* sp.	Cyprinid fishes	92.9	12.4	1	34	13.3
Holostephanus dubinini	Molluscs *Bithynia* sp.	Cyprinid fishes	92.9	13.9	2	36	14.9
Hysteromorpha triloba	Mollusks *Gyraulus* sp.	Cyprinid, percid and gobiid fishes	78.6	6.6	1	30	8.4
Metorchis xanthosomus	Molluscs *Bithynia* sp.	Cyprinid fishes	14.3	0.3	1	1	2.0
Tylodelphys clavata	Molluscs *Lymnaea* sp.	Cyprinid fishes	7.1	0.1	1	1	2.0
Nematoda							
Contracaecum rudolphii	Copepods	Cyprinid, percid and gobiid fishes	100	210.6	43	665	210.6
C. microcephalum	Copepods	Cyprinid, percid and gobiid fishes	57.1	2.0	1	6	3.5
Syncuaria squamata	Ostracods	Cyprinid fishes	100	38.5	9	89	38.5
Cosmocephalus obvelatus	Ostracods	Cyprinid fishes	71.4	2.1	1	3	3.0
Eustrongylides sp.	Copepods	Predatory fish	7.14	0.1	1	1	2.0
Capillaria gen. sp.	Copepods	Cyprinid, percid and gobiid fishes	7.14	0.2	2	2	3.0

All helminthes detected in great cormorants breeding in the Curonian Lagoon area use aquatic invertebrates and fish species as intermediate and reservoir hosts. 12 parasites taxa up to now were known in aquatic fauna of this region (Rauckis, 1988; Rolbiecki et al., 1999; Chukalova, Starovoytov, 2007; Stanevičiūtė et al., 2008; Rakauskas, Blaževičius, 2009). Freshwater fish species, mostly percids (*Percidae*) and cyprinids (*Cyprinidae*) are the principal intermediate hosts for those helminthes. Larval stages of 5 helminthes species found in great cormorant earlier were not recorded in fish species of the region. Therefore it is likely that these species infested great cormorants during their seasonal migrations from the wintering grounds located in Southern and Western Europe to the breeding sites in the Baltic Sea region. Seasonal migrations of cormorants are particularly important for parasite dispersal in the southeastern Baltic region. Eggs of parasites in faeces produced by great cormorants can continue developmental stages in water bodies. Appropriate environmental conditions and presence of many suitable first and second intermediate hosts for development of the whole life cycle of parasites can lead to establishment of stable centers for circulation of helminthes in the region.

It is likely that the range expansion and a rapid increase in numbers of great cormorant has caused the spread of nematode *Contracaecum rudolphii* and cestodes *Paradilepis scolecina,* recorded in the ecosystem of the Curonian Lagoon since 2004 (Chukalova, 2008a).

The nematode *Paradilepis scolecina* is widely distributed in Southern Europe (in basins of the Black and Azov Sea, etc.), in Central Europe, also in Africa and Australia. First cases of parasitizing of fish by larval stage (plerocercoid) of *Paradilepis scolecina* were reported in carp (*Cyprinus carpio*) and crucian carp (*Carassius carassius*) in Lithuanian fish farms in the 1980s (Rauckis, 1988). During that period fish infestation was low and did non affect fish health. In 2004 the fish disease dilepidosis caused by *Paradilepis scolecina* was revealed in bream (*Abramis brama*) in the Russian part of the Curonian Lagoon (Chukalova, 2008b). The disease was diagnosed in heavily infected fish (I = 71-193 sp.). The fish liver and spleen were the most affected. Histological examination has revealed the infiltration of fish liver tissue by lymphocytes and growing of the connective tissue around the encysted parasites. The increase of concentrations of basophilic and eosinophilic leukocytes in blood of infested bream was significantly higher than in healthy fishes (Chukalova, 2009). Bream is one of the most important commercial fish species in the Curonian Lagoon and large-scale infestation can negatively affect the fishery trade in this area.

The cestodes *Contracaecum rudolphii* is a cosmopolite species widely distributed in Europe (in Germany, the Czech Republic, Poland, Ukraine, basins of the Black and Azov Sea, etc.), also in Asia and Africa. It was found in great cormorants breeding in northeastern Poland (Dziekońska-Rynko, Rokicki, 2008). In the Curonian Lagoon this species was found in bream (Chukalova, Starovoytov, 2007). Nematode larvae were localized in serous membranes of fish internal organs. Infestation indices of bream were high (P= 59.3%; D= 14.0 sp.; A= 8.3 sp.). *Contracaecum rudolphii* is a representative of *Anisakidae* family. Some genera of *Anisakidae* (*Anisakis, Porrocaecum, Psoudoterranova*) are known as pathogenic for human and animal health. Earlier only few species of *Contracaecum* genera finishing the life cycle in marine mammals (e.g. *Contracaecum osculatum*, etc.) were considered as dangerous for humans and animals. It was believed that species finishing the life cycle in fish-eating birds are not pathogenic for mammals. However the pathogenity of contracaecums for domestic cats was proved in the laboratory conditions (Gaevskaya, 2005). Therefore at present *Contracaecum rudolphii* as well as other representatives of *Contracaecum* genera finishing the life cycle in birds are known as potentially pathogenic for animals and people. Humans and animals can be infected via fish holding larvae of pathogenic nematodes.

Conclusions:

1. The newly formed sub-population of great cormorant in the Curonian Lagoon area is estimated at more than 20000 individuals. Colonies of great cormorant in this area are among the largest in Europe.

2. Freshwater fish species, mostly percids (*Percidae*) and cyprinids (*Cyprinidae*), dominate in the diet composition of great cormorants nesting at the Curonian Lagoon. Commercially important fish species comprise 82.8% by biomass in great cormorant diet composition.

3. 17 taxa of metazoan species were found in great cormorants in the Curonian Lagoon area, including 5 species, which earlier were not recorded in this region.

4. The recent establishment of great cormorant as a new and very abundant waterbird species was one of the determining factors for introduction of new helminthes species in the Curonian Lagoon area.

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