

Banded karyotypes of the Northern pike, *Esox lucius* (Esocidae) in TurkeyAtilla ARSLAN^{1*}, Zafer ALPASLAN²¹ Department of Biology, Faculty of Science, Selçuk University, Konya, Turkey² Graduate School of Natural Applied Sciences, Selçuk University, Konya, Turkey*Corresponding Author: aarslan@selcuk.edu.tr**Research Article**

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How to Cite: Arslan, A., & Alpaslan, Z. (2020). Banded karyotypes of the Northern pike, *Esox lucius* (Esocidae) in Turkey. *Acta Aquatica Turcica*, 16(4), 511-515. <https://doi.org/10.22392/actaquatr.733738>**Abstract**

In this study, cytogenetic properties of *E. lucius* in Sakarya River were investigated using standard Giemsa staining, C- and Ag-NOR banding techniques. The number of diploid chromosomes (2n) of individuals studied is 50 and karyotype consists of 50 acrocentric chromosomes with decreasing sizes. Secondary constriction was observed on the third autosomal pair in the karyotype. Morphologically distinguishable sex chromosomes were not detected in male and female individuals. Some chromosomes were centromeric C-positive, while some chromosomes were negative. Active NOR is localized in the pericentromeric region of the third autosomal pair and it is related to C-heterochromatin. Our results are similar to those of other studies and this result shows that the cytogenetic properties of the species are quite stable. Moreover, these results may contribute to the cytogenetic and phylogenetic studies of the *Esox* species in the future.

Keywords: Chromosome, Ag-NOR band, C-band, northern pike, Turkey**Türkiye'deki Turna Balığı, *Esox lucius* (Esocidae)'un Bantlı Karyotipleri****Özet**

Bu çalışmada, Sakarya Nehri'ndeki *E. lucius*'un geleneksel Giemsa boyama, C- ve Ag-NOR bantlama teknikleri kullanılarak sitogenetik özellikleri araştırıldı. Çalışılan bireylerin diploid kromozom sayısı (2n) 50'dir ve karyotip azalan büyüklükte 50 akrosentrik kromozomdan oluşmaktadır. Karyotipte, üçüncü otozomal çiftte ikincil boğum gözlemlendi. Erkek ve dişi bireylerde morfolojik olarak ayırt edilebilir cinsiyet kromozomları tespit edilmedi. Bazı kromozomlar sentromerik C-pozitif iken, bazıları negatifti. Aktif NOR'lar üçüncü otozomal çiftin perisentromerik bölgesinde lokalizedir ve C-heterokromatin ile ilişkilidir. Bulgularımız diğer çalışmaların sonuçları ile benzerdir ve bu sonuç, türün sitogenetik özelliklerinin oldukça stabil olduğunu göstermektedir. Ayrıca bu sonuçlar gelecekte *Esox* türlerinin sitogenetik ve filogenetik çalışmalarına katkı sağlayabilir.

Anahtar kelimeler: Kromozom, Ag-NOR bant, C-bant, turna balığı, Türkiye**INTRODUCTION**

The genus *Esox* consists of five species distributed in North America, Europe, and Eurasia (Gandolfi et al., 2017). Northern pike *Esox lucius* (Linnaeus, 1758) is a broadly distributed predatory fish in the fresh waters of Eurasia and North America (Lieberman et al., 2019).

Until now, the karyological properties of different populations of the genus *Esox* in the world have been studied (Table 1). The number of diploid chromosomes (2n) of the genus *Esox* in Sweden (Nygren et al., 1968), Canada (Beamis et al., 1971; Ráb and Crossman, 1994), USA (Davisson, 1972), Czechia (Ráb and Mayr, 1987; Symonová et al., 2017), Poland (Jankun et al., 1998) and China (Zou and Li, 2006) populations was 50.

E. lucius distributed in many freshwater ecosystems in the Black Sea and Central Anatolia in Turkey (Fricke et al., 2007). There is no study on the cytogenetic properties of Northern pike. This study aims to investigate the cytogenetic properties of Northern pike in Turkey.

Table 1. Chromosomal records of *Esox* species.

Species	Locality	2n	Karyotype	NF	Reference
<i>E. lucius</i>	Sweden			-	Nygren et al., 1968
	Canada			-	Beamis et al., 1971
	USA			-	Davisson, 1972
	Czech			-	Rab and Mayr, 1987
	Canada			-	Rab and Crossman, 1994
	Poland			50	Jankun et al., 1998
	China			50	Zou and Li, 2006
	Czechia			50	Symonová et al., 2017
	Turkey			50	This study
<i>E. americanus</i>	USA	50	50A	-	Davisson, 1972
	Canada			-	Rab and Crossman, 1994
	USA			-	Davisson, 1972
	Canada			-	Rab and Crossman, 1994
<i>E. masquinongy</i>	Canada			-	McGregor, 1970
	USA			-	Davisson, 1972
<i>E. niger</i>	USA			-	Rab and Crossman, 1994
	USA			-	Davisson, 1972
<i>E. reicherti</i>	USA			-	Davisson, 1972

MATERIALS and METHODS

Three specimens of *E. lucius* were collected from River Sakarya (39°20' N, 32°0' E), Ankara, Turkey (Figure 1). The study was undertaken and the specimens were obtained with the permission of the Republic of Turkey, Ministry of Forest and Water Works (Permit no. 21264211-288.04-E.789508). The fish specimens were transported alive to the laboratory and kept in well-aerated aquaria until analysis. Chromosomes were prepared directly from the head kidney according to the method of Collares-Pereira (1992). Air-dried slides were stained conventionally by 10% Giemsa for 10 minutes. Constitutive heterochromatin and nucleolar organizer regions (NORs) were detected by the techniques of C-banding (Sumner, 1972) and Ag-NOR staining (Howell and Black, 1980), respectively. From each specimen, 10 to 20 slides were prepared, and at least 20 well-spread metaphase plates were analyzed. Definition of the shapes of the chromosomes was established according to Levan et al. (1964).

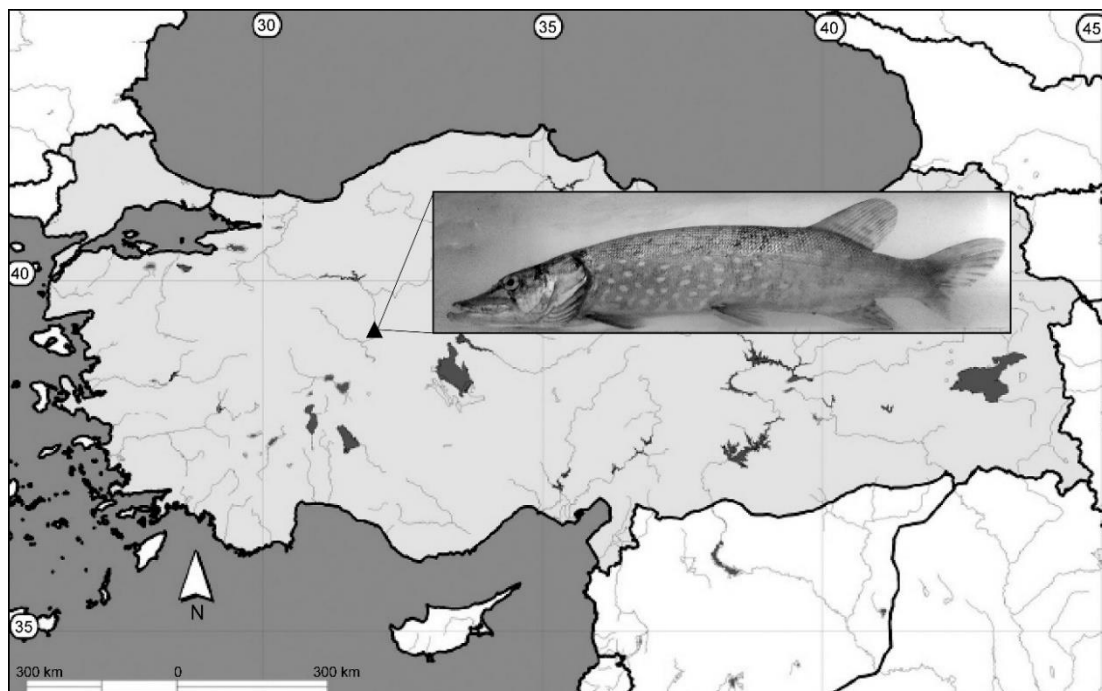


Figure 1. Collecting site in River Sakarya from Ankara.

RESULTS

The number of diploid chromosomes ($2n$) of Northern pike is 50. The chromosome set consists of 50 acrocentric chromosome pairs ($NF = 50$). No morphologically distinguishable sex chromosomes were detected in the set. Secondary constriction was observed in the medium-sized chromosome pair (no: 3) (Figure 2). While C-heterochromatin bands were observed in the centromeric regions of some autosomal pairs, other autosomal pairs were negative (Figure 3). Active NOR is localized in the pericentromeric region of a pair of medium-sized acrocentric chromosomes (no: 3) and it is related to C-heterochromatin (Figure 4).

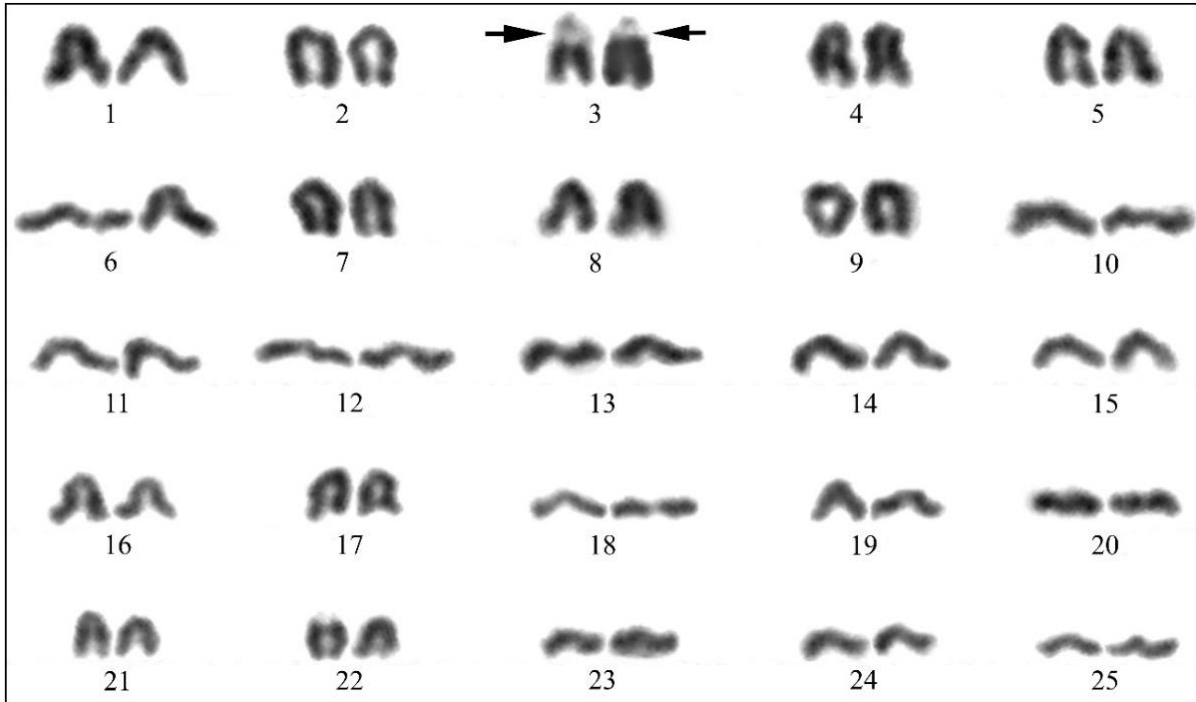


Figure 2. Standard Giemsa staining karyotype of *Esox lucius*. Arrows indicate the position of secondary constrictions.

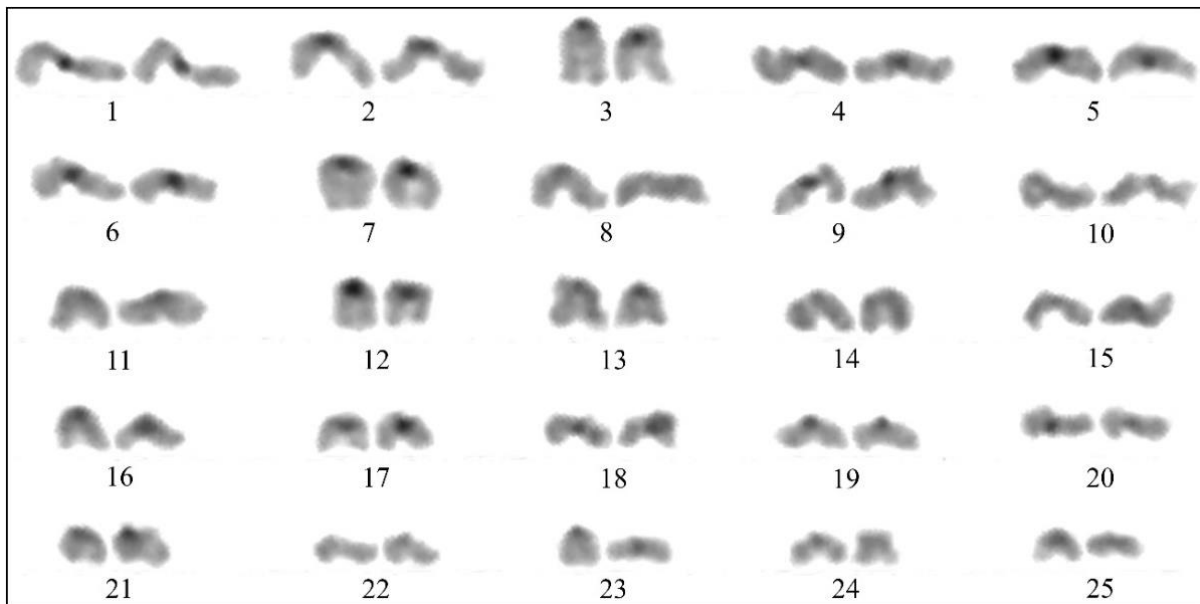


Figure 3. C-banded karyotype of *Esox lucius*

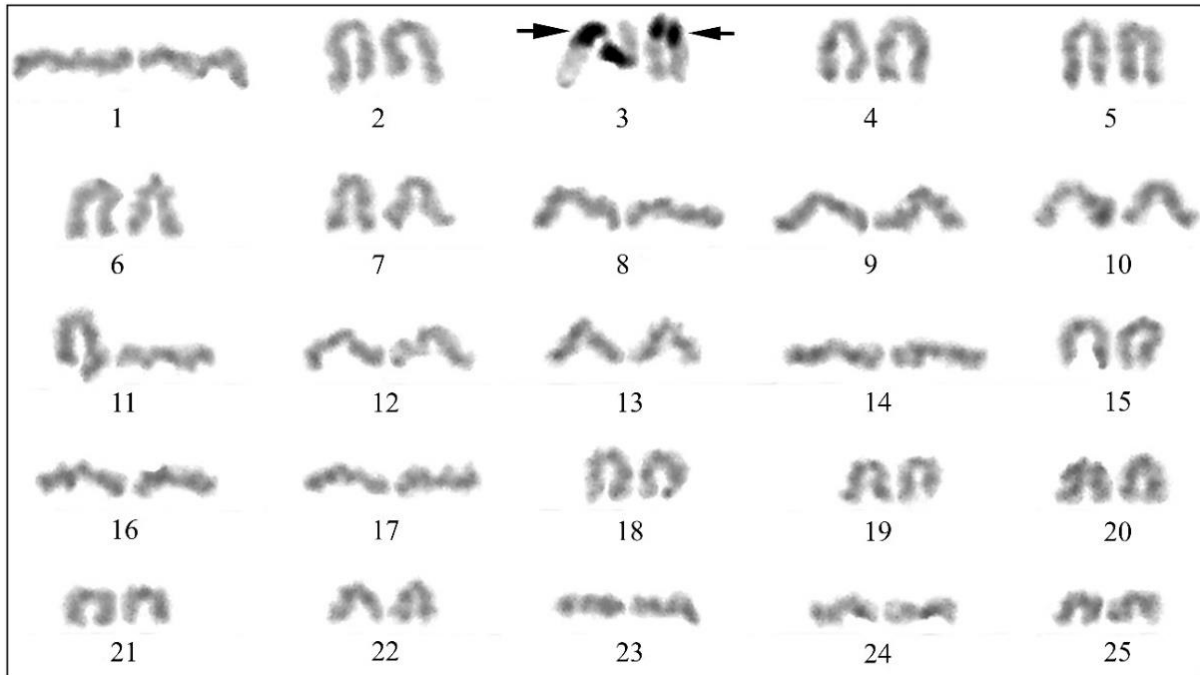


Figure 4. Silver-stained karyotype of *Esox lucius*. Arrows indicate the position of active Ag-NORs.

DISCUSSION

The karyological properties of *E. lucius* from Turkey were investigated in this study for the first time. The diploid chromosome number ($2n$) is 50, and all the chromosomes are acrocentric. The karyological findings of *E. lucius* in Turkey are consistent with the results of studies in North America, Asia, and Europe (Nygren et al., 1968; McGregor, 1970; Beamis et al., 1971; Davisson, 1972; Rab and Mayr, 1987; Rab and Crossman, 1994; Jankun et al., 1998; Zou and Li, 2006; Symonová et al., 2017). Besides, a secondary constriction was identified in medium-sized chromosome pairs in both Turkey population and other populations (Rab and Mayr, 1987). In this study, sex chromosomes of *E. lucius* were not detected.

Heterochromatin bands contain highly repetitive DNA and are transcriptionally inactive (Sumner, 1982). The number, size, and form of the bands vary even in individuals of the same species and they are generally localized in the centromeric and telomeric regions of the chromosomes (John and Miklos, 1979). DAPI C-heterochromatin bands in *E. lucius* individuals from Poland are located near the centromeres of some chromosomes (Jankun et al., 1998). Turkey's population that some chromosomes have centromeric C-heterochromatin bands are compatible with the Polish population.

Locations and phenotypes of active NORs have proven useful in fish cytotaxonomy (Crossman and Rab, 2001). It has been reported in previous studies that an active NOR in the *Esox* and *Umbra* species was localized near the centromeric or pericentromeric region of the medium-sized acrocentric chromosome pair (Rab, 1981; Rab and Mayr, 1987; Rab and Crossman, 1994; Jankun et al., 1998). Rab and Crossman (1994) stated that NORs are not related to heterochromatin. However, Jankun et al. (1998) found that this NOR is related to C-heterochromatin as a result of C-banding and DAPI staining. Also the NORs is relate with heterochromatin in Turkey population. The results obtained both in this study and in other studies show that the karyotype and NORs phenotypic structure of *E. lucius* is homogeneous. Moreover, our results support the hypothesis that the NOR position of North American and European populations is shared characteristically (Rab and Crossman (1994). As a result, the karyotype properties of Northern pike with all acrocentric ($2n = 50$) chromosomes are compatible with the findings in other studies.

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REFERENCES

- Beamish, R., Merrilees, M., & Crossman, E. (1971). Karyotypes and DNA values for members of the suborder Esocoidei (Osteichthyes: Salmoniformes). *Chromosoma*, 34, 436-447.
- Collares-Pereira, M. (1992). In vivo direct chromosome preparation (protocol for air drying technique). *Paper presented at the First International Workshop on Fish Cytogenetic Techniques*. 14-24 September, Concarneau, France.
- Crossman, E., & Ráb, P. (2001). Chromosomal NOR phenotype and C-banded karyotype of Olympic Mudminnow, *Novumbra hubbsi* (Euteleostei: Umbridae). *Copeia*, 3, 860-865.
- Davisson, M. T. (1972). Karyotypes of the teleost family Esocidae. *Journal of the Fisheries Board of Canada*, 29, 579-582.
- Fricke, R., Bilecenoglu, M., & Sarı, H. (2007). Annotated checklist of fish and lamprey species of Turkey, including a red list of threatened and declining species. *Stuttgarter Beitr Naturkunde, Serie A (Biologie)*, 706, 1-169.
- Gandolfi, A., Ferrari, C., Crestanello, B., Girardi, M., Lucentini, L., & Meraner, A. (2017). Population genetics of pike, genus *Esox* (Actinopterygii, Esocidae), in Northern Italy: evidence for mosaic distribution of native, exotic and introgressed populations. *Hydrobiologia*, 794, 73-92.
- Howell, W. M., & Black, D. A. (1980). Controlled silver-staining of nucleolus organizer regions with a protective colloidal developer: a 1-step method. *Experientia*, 36(8), 1014-1015.
- Jankun, M., Woznicki, P., Dajnowicz, G., Demska-Zakes, K., Luczynski, M. J., & Luczynski, M. (1998). Heterochromatin and NOR location in northern pike (*Esox lucius*). *Aquatic Sciences*, 60, 17-21.
- John, B., & Miklos, G. L. G. (1979). Functional aspects of satellite DNA and heterochromatin. *International Review of Cytology*, 58, 1-114.
- Levan, A., Fredga, K., & Sandberg, A. A. (1964). Nomenclature for centromeric position on chromosomes. *Hereditas*, 52 (2), 201-220.
- Liberman, E., Voropaeva, E., & Kozlov, S. (2019). Parasitofauna of pike *Esox lucius* of the Lower Tobol (Russia). *Biosystems Diversity*, 27(3), 214-220.
- McGregor, J. F. (1970). The chromosomes of the maskinonge (*Esox masquinongy*). *Canadian Journal of Genetics and Cytology*, 12(2), 224-229.
- Nygren, A., Edlund, P., Hirsch, U., & Åhsgren, L. (1968). Cytological studies in Perch (*Perca fluviatilis* L.), Pike (*Esox lucius* L.), Pike-Perch (*Lucioperca lucioperca* L.), and Ruff (*Acerina cernua* L.). *Hereditas*, 59(2-3), 518-524.
- Ráb, P. (1981). Karyotype of European mudminnow, *Umbra krameri*. *Copeia*, 911-913.
- Ráb, P., & Crossman, E. (1994). Chromosomal NOR phenotypes in North American pikes and pickerels, genus *Esox*, with notes on the Umbridae (Euteleostei: Esocae). *Canadian Journal of Zoology*, 72, 1951-1956.
- Ráb, P., & Mayr, B. (1987). Chromosome banding studies in European esocoid fishes: localization of nucleolar organizer regions in *Umbra krameri* and *Esox lucius*. *Copeia*, 4, 1062-1067.
- Sumner, A. (1972). A simple technique for demonstrating centromeric heterochromatin. *Experimental Cell Research*, 75, 304-306.
- Sumner, A. (1982). The nature and mechanisms of chromosome banding. *Cancer Genetics and Cytogenetics*, 6, 59-87.
- Symonová, R., Ocalewicz, K., Kirtiklis, L., Delmastro, G. B., Pelikánová, Š., Garcia, S., & Kovařík, A. (2017). Higher-order organisation of extremely amplified, potentially functional and massively methylated 5S rDNA in European pikes (*Esox* sp.). *BMC genomics*, 18, 391.
- Zou, S. M., & Li, S. F. (2006). The study on chromosomes of white spot pike (*Esox lucius*). *Journal of Shanghai Fisheries University*, 2, 203-211.