Short communication

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# Sea fog increases the total mercury level in the terrestrial ecosystem (on the example of the tiger *Panthera tigris altaica* Temminck, 1844)

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**ABSTRACT.** This study discusses one of the aspects of the mercury problem, which is the relationship between aquatic and terrestrial ecosystems. We indicate that the mercury concentration in the Amur tiger fur (*Panthera tigris altaica*) is higher in the coastal area than in the inland area because the coastal areas are exposed to the impact of marine atmospheric fog, a potential source of monomethylmercury. The total mercury concentration from the Khasansky District varied from 0.16 to 0.45 mg/kg, on average 0.22 ± 0.04 mg/kg, in tiger fur, from 0.07 to 1.01 mg/kg, on average 0.64 ± 0.05 mg/kg, in leopard fur (*P. pardus orientalis*) and from 0.055 to 1.233 mg/kg, on average 0.336 ± 0.056 mg/kg, in Himalayan bear fur (*Ursus thibetanus*). The total mercury concentration in the fur of the last predators from the inland areas is unknown. Further research is needed.

***Keywords***: aquatic and terrestrial ecosystems, total mercury, *Panthera tigris altaica, P. pardus orientalis, Ursus thibetanus*

## 1. Introduction

The Russian Far East is a region where gold is mined, or the deposits of mercury-containing minerals are found. At the same time, the southern regions of the Russian Far East are unique in the number of Mesozoic relics, species that require special conservation measures. The Amur tiger is on the list of rare animals. Tigers 'crown' ecological pyramids and, therefore, have the potential for bioaccumulation. We have studied the mercury concentration in the body of a tiger, the top link of the food web of coastal and inland ecosystems of the south of the Russian Far East. This is a continuation of our pioneering research on the assessment of mercury concentrations in the fur of Amur tigers. The diet of animals of this tiger subspecies includes 85 species of vertebrates, the main part of which consists of five species of ungulates, while bears, pheasants, hares, and badgers are much less likely to be involved (e.g. Yudin and Yudina, 2009; Poddubnaya and Kolomiytsev, 2016; Salkina et al., 2018). Tigers can eat reptiles, fish, small mammals, and, sometimes, domestic animals. In recent years, tigers have been consuming more and more carrion and food waste collected and left by humans in certain places. It is a generally recognized fact that different fish species are the main source of mercury supply into the predator body and the trophic web of the ecosystem. In some areas of the Far East, the seasonal abundance of salmon can provide tigers with protein. Amur tigers can take fish from fishermen. However, our observations and data on mercury concentration indicate that tigers do not often eat salmon (especially compared to bears), and they definitely do not hunt the redfin dace (*Tribolodon hakonensis*) (Poddubnaya et al., 2021).

## 2. Materials and methods

The total mercury (Total Hg, THg) concentration was analyzed in 29 tiger fur samples collected from animals killed by poachers until 2014 from different locations in the south of the Russian Far East (Fig. 1).

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As one sample of tiger and that of Far Eastern leopard fur (*Panthera pardus orientalis*) with the highest mercury level were from the south-western Primorye, we collected additional samples of tiger (n = 8), Far Eastern leopard (n = 8) and Himalayan bear (n = 22) fur (*Ursus thibetanus*) from this area (Khasansky District). The analysis was carried out on a RA-915M mercury analyzer (Lumex).

## 3. Results and discussion

The mean individual concentrations of total mercury in the tiger fur from the coastal area of the Sea of Japan ranged from 0.115 to 0.918 mg/kg, on average 0.434 ± 0.067, while the tiger fur from the inland areas had lower THg concentrations (from 0.057 to 0.950 mg/kg, on average 0.239 ± 0.075); the differences between the mean values of the two plots were statistically significant (P = 0.02) (Poddubnaya et al., 2021). Despite the small amount of sampling, there were significant differences in pairs: tiger fur from the coastal and inland areas; young and adult tiger fur; female fur from the coastal and inland areas (Fig. 2). The total mercury content in the *Usnea* sp lichens from the coastal and inland subregions was additionally analyzed; the results averaged 0.170 ± 0.017 mg/kg and 0.065 ± 0.004 mg/kg, respectively. The only sample with the maximum mercury concentration of 1.402 mg/kg (age and gender unknown) was from the southwestern Primorye, which is located on the coast with nearby cinnabar deposits. This sample was not used in the total analysis. Interestingly, the available sample of a young female Far Eastern leopard fur from the same site had practically the same mercury concentration (1.456 mg/kg). Local increased mercury concentrations in the body of tigers can be associated with deposits of mercury-containing minerals (Poddubnaya et al., 2021).

The total mercury concentration in the tiger fur collected in the Khasansky District of the Primorsky Krai varied from 0.16 to 0.45 mg/kg, on average 0.22 ± 0.04 mg/kg. This value was lower than the mercury concentration in the Amur tiger fur from the inland and coastal areas. The total mercury concentration in the leopard fur collected in the Khasansky District varied from 0.07 to 1.01 mg/kg, on average 0.64 ± 0.05 mg/kg. This value was higher than the mercury concentration in the Amur tiger fur from the inland and coastal areas. The total mercury concentration in the fur of the last predator from the inland areas is unknown. The total mercury content in the Himalayan bear fur collected in the Khasansky District varied from 0.055 to 1.233 mg/kg, on average 0.336 ± 0.056 mg/kg (Poddubnaya et al., 2022). This value was higher than the mercury concentration in the Amur tiger fur from the inland areas and lower than that from the coastal areas. The total mercury concentration in the fur of the last predators from the inland areas is unknown. Further research is needed.

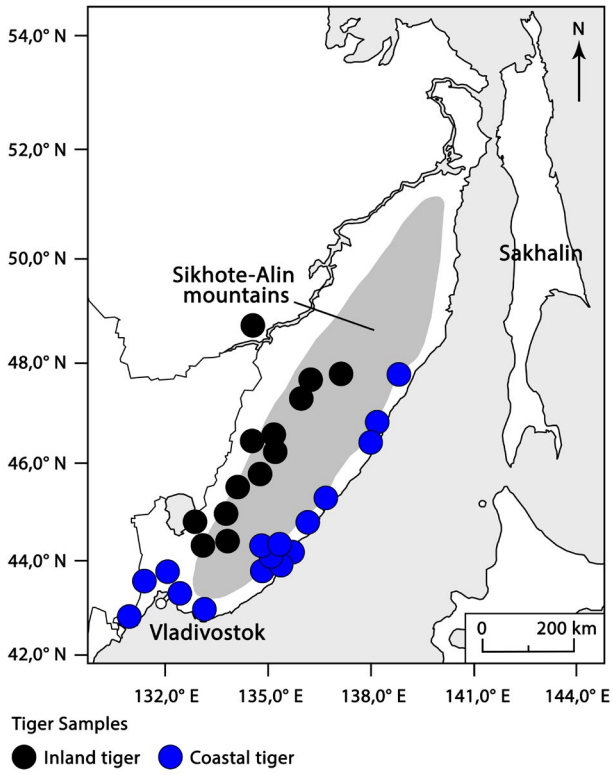


**Fig.1.** Map of sampling sites and mean values of total Hg in tiger fur. Blue circles represent samples from the coastal subregion, and the black ones – from the inland subregion.

Our data on higher mercury levels in lichens and tigers of the coastal area compared to inland areas were obviously related to the impact of coastal

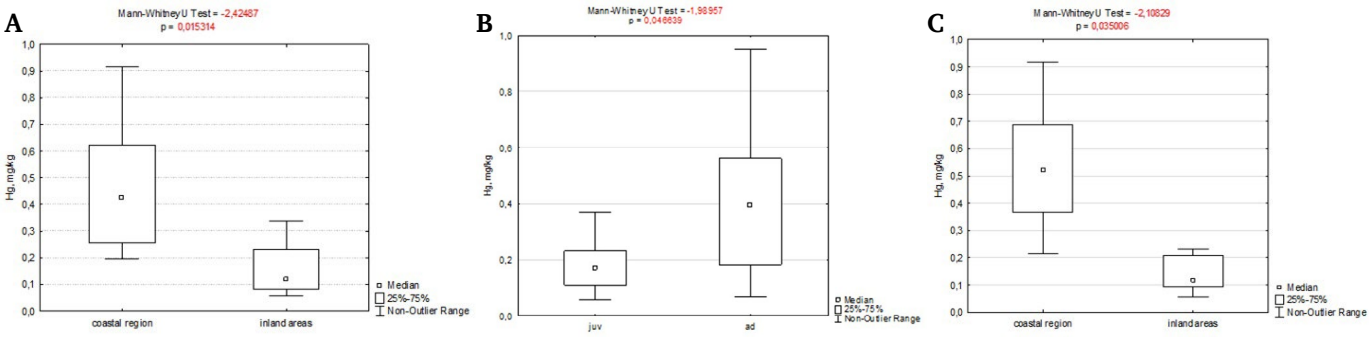


**Fig.2.** Statistics on the subsets of the concentration data: A – tigers from the coastal and inland areas, B – young and adult tigers and C – female tiger. All concentrations are presented in mg/kg.

marine atmospheric fog, a potential source of monomethylmercury (mmHg) formed in the ocean (Weiss-Penzias et al., 2019). A local elevated mercury concentration in the body of tigers may also be associated with deposits of mercury-containing minerals (southwest of Primorye), but this statement has not yet been confirmed by studies (a high THg concentration in the Himalayan bear of 1.233 mg/kg was recorded only for one individual). The mercury concentration that we detected in Siberian tigers from the Russian Far East was approximately four times lower than the mercury content in the fur of a cougar from California. Apparently, such differences were due to the position of these regions relative to the zones of deep faults of the East Pacific Platform mantle formation. The studies of mercury in pink salmon support this: fish from the Sea of Japan contained much less mercury than fish from the Kuril region closer to the fault zone (from 0.045 to 0.087 mg/kg wet weight) (Khristoforova et al., 2015).

## 4. Conclusions

Thus, in the south of the Russian Far East, there are risks for predators, which are associated with mercury and, possibly, as a consequence, with changes in behavior and deterioration of the health of animals. Therefore, in the study of rare and endangered animals, it seems to be appropriate to start research on the mercury concentrations in the fur of predators in comparison with their behavior. In this regard, it makes sense to place fur traps next to camera traps.

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## Conflict of interest

The authors declare no conflict of interest.

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