

Reviving the Alpine Ibex: Addressing Genetic and Health Concerns of Slovenian Ibex with Broader Implications in Biodiversity

Reševanje alpskega kozoroga: Genetski in zdravstveni problemi slovenskih kozorogov s širšimi posledicami za biodiverziteto

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This issue's cover illustration depicting the Alpine ibex against the backdrop of iconic Slovenia's Triglav mountain is inspired by the manuscript by Bužan et al. published in the current issue and serves as a poignant reminder of a lost legacy and biodiversity due to greed and overhunting. These magnificent creatures thrived entire European Alpine region before their extermination in the 19th century, with the only surviving wild population of Alpine ibex in the Gran Paradiso National Park (then a royal hunting reserve) in Italy. Reintroduction initiatives from this small population have since rebounded ibex to tens of thousands across the Alpine region. However, as the article on the Slovenian population of Alpine ibex by Bužan et al. in this issue clearly shows, while current numbers seem more promising, the genetic bottleneck they experienced from this near-extinction event has left lasting impacts on their genetic diversity.

Biodiversity is decreasing worldwide due to factors such as habitat destruction, pollution, climate change, and overexploitation of species. Additionally, low genetic diversity within populations makes species more vulnerable to disease, environmental changes, and other threats, further exacerbating the decline. Lost genetic diversity in the Alpine ibex

Ilustracija na naslovnici te številke, ki prikazuje Alpskega kozoroga pred ikonično goro Slovenije, Triglavom, je navdihnjena po članku Bužan s sod., objavljenem v tej številki, in služi kot opomin izgubljeni dediščini in biodiverziteti zaradi pohlepa in prekomernega lova. Te veličastne živali so uspevale v celotni evropski Alpski regiji, preden so bile iztrebljene v 19. stoletju, z edino preživelo divjo populacijo v Narodnem parku Gran Paradiso (takrat kraljevi lovski rezervat) v Italiji. Ponovne naselitve iz te majhne populacije so od takrat od danes dvignile število kozorogov na deset tisoče v celotni Alpski regiji. Vendar, kot članek o slovenski populaciji Alpskih kozorogov avtorice Bužan s sod. jasno kaže, čeprav se trenutna številka zdi obetavna, pa je genetsko ozko grlo, nastalo zaradi prekomernega lova, pustilo trajne posledice na njihovi genetski raznolikosti.

Biodiverziteta se po vsem svetu zmanjšuje zaradi dejavnikov, kot so uničevanje habitata, onesnaževanje, podnebne spremembe in prekomerno izkoriščanje vrst. Poleg tega nizka genetska raznolikost znotraj populacij povzroči, da so vrste bolj ranljive za bolezni, okoljske spremembe in druge faktorje. Izguba genetske raznolikosti pri Alpškem kozorogu ni več tematika za akademske razprave ali politično

is far from being a mere academic consideration or a politically attractive topic. It has tangible and dire repercussions. This isn't just about yet another genetic screening project exemplified in the article of Bužan et al. It affects the health and survival of this species and has negative consequences on the diversity and health of the ecosystem as a whole. A limited genetic pool cripples the ibex's ability to ward off even the mildest of microbial and parasitic infections. The Scabies mite, causing Sarcoptic mange, serves as a glaring example. In a robust and genetically diverse population, such a parasite might cause concern but not alarm.

Yet, for the genetically inbred Alpine ibex, it represents a profound threat, intensifying concerns for both their conservation and management. This is not about genetic nuances; it's a life-and-death struggle influenced directly by their genetic resilience, or lack thereof.

Veterinarians have been at the forefront of combating Sarcoptic mange in wild Alpine ibex populations. As the condition progresses, afflicted animals experience immense suffering, enduring severe dehydration, weight loss, and secondary infections, ultimately leading to a painful and protracted demise. Veterinarians' efforts span from field surveillance, and diagnostics to direct interventions, such as treating afflicted individuals and preventive measures for those at risk. Modern veterinary medicine does offer a range of treatments, from antiparasitic medications to immune boosters. However, the challenge lies in administering these treatments to wild populations, ensuring they reach those most in need, and assessing their long-term efficacy. However, the rugged, steep, and rocky Alpine terrains make it almost impossible for veterinarians to reach and treat afflicted ibex directly, exacerbating their prolonged suffering before their agonizing end. The real efficacy lies not just in treating the symptoms but in fortifying the ibex's natural genetic defenses. This emphasizes, once again, the profound importance of genetic diversity, as a diverse gene pool would naturally equip the ibex with a better defense mechanism against such diseases.

While molecular methods have elucidated the genetic plight of many populations, Slovenian ibex remained unstudied until now. Our analysis of the mitochondrial DNA for both neutral and adaptive loci of ibex from Slovenian Julian and Kamnik-Savinja Alps revealed a startling lack of genetic diversity. The two Slovenian populations possess just one mtDNA haplotype and a single functional allele for MHC DRB exon 2, emphasizing the dire need for diversity reintroductions. Regulatory constraints label the ibex as non-native in Slovenia, hindering conservation. Regrettably, the narrative of overhunting echoes loudly here. These majestic creatures were hunted to oblivion in several regions, only to face the current plight of being treated as 'non-native' in lands they once roamed freely. Given current findings of genetic depletion, there's an urgent call for a policy shift to recognize the ibex as native to Slovenia, facilitating vital conservation actions. International and interdisciplinary

privlačna tema. Ima oprijemljive in hude posledice. Tu ne gre le za genetske karte ali še en genetski presejalni projekt, kot je prikazan v članku Bužan s sod.. Izguba genetske biodiverzitete vpliva na zdravje in preživetje te vrste in ima negativne posledice za raznolikost in zdravje celotnega ekosistema. Nizka genetska raznolikost onemogoča kozorogu, da se obrani pred celo najšibkejšimi mikrobnimi in parazitskimi okužbami. Primer takšne okužbe je s pršico *Sarcoptes scabiei*, ki povzroča garje. V robustni in genetsko raznoliki populaciji bi takšen parazit morda povzročil zaskrbljenost, vendar ne bi povzročil alarma. Vendar pa za genetsko osiromašene kozoroge to predstavlja resno grožnjo za njihovo ohranitev in upravljanje s populacijo. Tu gre dejansko za boj za življenje in smrt, kjer je vpletena njihova genetska odpornost, ali bolje rečeno, pomanjkanje le-te.

Veterinarji so na čelu boja proti povzročiteljici garij pri divjih populacijah kozorogov. Ko se stanje poslabša, prizadete živali doživljajo veliko trpljenja, prenašajo hudo dehidracijo, izgubo telesne mase in sekundarne okužbe, kar na koncu vodi v bolečo in dolgotrajno smrt. Prizadevanja veterinarjev segajo od terenskega nadzora in diagnostike do neposrednih intervencij, kot je zdravljenje prizadetih živali in preventivni ukrepi za tiste, ki so ogroženi. Sodobna veterinarska medicina ponuja različne metode zdravljenja, od zdravil proti parazitom do imunskih stimulantov. Toda izziv leži v upravljanju teh zdravljenj na divjih populacijah, zagotavljanju, da dosežejo tiste, ki jih najbolj potrebujejo, in monitoring njihove dolgoročne učinkovitosti. Skalnati in strm alpski teren skorajda onemogoča veterinarjem, da bi neposredno dosegli in zdravili prizadete kozoroge, kar še poslabša njihovo dolgotrajno trpljenje, preden doživijo svoj mučen konec. Prava učinkovitost ni le v zdravljenju simptomov, temveč tudi v utrjevanju naravnega genetskega obrambnega mehanizma kozoroga. To še enkrat poudarja pomen genetske raznolikosti, saj bi bolj raznolik genski bazen naravno opremil kozoroge z boljšim imunskim odzivom proti takšnim boleznim.

Čeprav so molekularne metode razjasnile genetsko strukturo mnogih populacij, slovenski kozorogi doslej še niso bili raziskani. Naša analiza mitohondrijske DNA za nevtralne in adaptivne genetske lokuse kozorogov iz slovenskih Julijskih in Kamniško-Savinjskih Alp je razkrila presenetljivo pomanjkanje genetske raznolikosti. Obe slovenski populaciji imata le en mtDNA haplotip in en funkcionalen alel za MHC DRB ekson 2, kar poudarja nujno potrebo po oplemenjevanju. Regulativne omejitve označujejo kozoroge kot tujerodne v Sloveniji, kar omejuje ohranjanje biodiverzitete. Da se jih danes obravnava kot 'tujerodne' je nesmiselno že v luči poznavanja zgodovine o prekomernem lovu v slovenskih Alpah. Glede na trenutne ugotovitve nizke genetske raznolikosti je nujen poziv k spremembi politike in priznanju kozorogov kot domorodnih v Sloveniji, kar bo omogočilo ključne nadaljnje ukrepe za ohranjanje. Usoda Alpskega kozoroga služi kot še en opomin na zapleteno prepletenost med zgodovino, genetiko, zdravjem živali in politiko ohranjanja. V tem

cooperation, thorough health screenings, and community involvement will be essential to this endeavor. The destiny of the Alpine ibex serves as yet another reminder of the intricate bond between history, genetics, animal health, and conservation. At this crucial juncture, we appeal to policy-makers, conservationists, and the public at large.

In the end, it may be appropriate to mention a Slovenian Folk tale, "Zlatorog" (Goldhorn), featuring an Alpine ibex with golden horns as a protector of natural land and an indicator of how greed and ambition can ruin the environment. Originally written by Dežman and published in the "Laibacher Zeitung" in 1868, this story has been integral in Slovenian culture and has been retold and popularized by many, most notably by the poet Rudolf Baumbach in his ballad "Zlatorog," translated in many languages. The story revolves around a hunter who seeks the treasure hidden in the Triglav mountains, guarded by Goldhorn. Driven by jealousy, greed, and ambition, the hunter shoots Goldhorn to be able to get to the treasure. However, as the Goldhorn bleeds, he eats the magical Triglav rose, his horns start glowing with intense golden light to dazzle the hunter and drive him over the cliff to his tragic end. In his fury, Goldhorn transformed a once fertile and biodiverse mountainous region into a barren expanse of stone scree. This can be seen as a cautionary tale: if we mistreat and exploit nature, it may reach a tipping point of imbalance and self-destruction. The ancient tale of Goldhorn is a profound allegory that underscores the perils of unbridled greed and ambition juxtaposed against the sanctity of nature.

This intrinsic value of the natural world is one that beckons a resurgence through dedicated research, such as the insights offered in the mentioned article. Interdisciplinary research is crucial in preserving biodiversity and maintaining healthy ecosystems, as it integrates diverse perspectives and methodologies to comprehensively address complex environmental challenges. Only through a collaborative approach, drawing from multiple disciplines, can we truly understand and effectively protect the intricate web of life on our planet. Yet, it's not just research that holds the key. Our moral compass and policy directions play an equally pivotal role. Conserving the ibex and their pristine habitats isn't a mere environmental prerogative; it's a testament to our shared commitment to the future. In protecting them, we don't just ensure our own survival but also uphold a shared legacy of the legend that binds man, wildlife to ensure the balance in the nature.

ključnem trenutku pozivamo odločevalce, strokovne organizacije in širšo javnost h ukrepanju.

Na koncu bi bilo morda primerno omeniti slovensko ljudsko legendo »Zlatorog,« v kateri nastopa Alpski kozorog z zlatimi rogovi kot zaščitnik naravnega okolja in kazalnik, kako človekova nezmernost uničujeta okolje. Zgodbo je prvotno napisal Dežman in objavil v »Laibacher Zeitung« leta 1868. Ta zgodba je postala del slovenske kulture in jo je veliko ljudi povzelo in populariziralo. Najbolj znana je pesnitev Rudolfa Baumbacha »Zlatorog,« ki je prevedena v mnoge jezike. Zgodba se vrti okoli lovca, ki išče zaklad, skrit v Triglavskih gorah, ki ga varuje Zlatorog. Poganjan z ljubosumjem in pohlepom o, je lovec ustrelil Zlatoroga, da bi prišel do zaklada. Toda ko Zlatorog krvavi, poje čarobno Triglavsko rožo, njegovi rogovi začnejo svetiti z intenzivnimi zlatimi žarki, ki oslepi lovca, da le ta omahne čez rob skalne police do tragičnega konca. V svoji jezi je Zlatorog nekoč rodovitno in biodiverzitetno gorsko regijo spremenil v pusto kamnito pokrajino. To se lahko razume kot opozorilna zgodba: če naravo zlorablamo in izkoriščamo, lahko doseže točko neravnovesja in samouničenja. Stara zgodba o Zlatorogu je globoka alegorija, ki poudarja nevarnosti neukrotljive človekove sebičnosti, nasproti ravnovesju narave.

Interdisciplinarno raziskovanje je ključno pri ohranjanju biotske raznovrstnosti in vzdrževanju zdravih ekosistemov, saj integrira različne perspektive in metodologije za celovito obravnavanje kompleksnih okoljskih izzivov. Le preko sodelovanja, ki črpa znanje iz več disciplin, lahko resnično razumemo in učinkovito zaščitimo zapleteno mrežo življenja na našem planetu. Vendar pa ni le raziskovanje tisto, ki zagotavlja preživetje. Naš moralni kompas in usmeritve politike igrajo enako pomembno vlogo. Ohranjanje kozorogov in njihovih neokrnjenih habitatov ni le okoljska dolžnost; to je dokaz naše skupne zavezanosti prihodnosti. S tem, ko jih ščitimo, ne zagotavljamo le svojega preživetja, ampak tudi uresničujemo skupno dediščino, ki, kot pravi legenda, zahteva sobivanje človeka in živali za zagotavljanje ravnotežja v naravi.