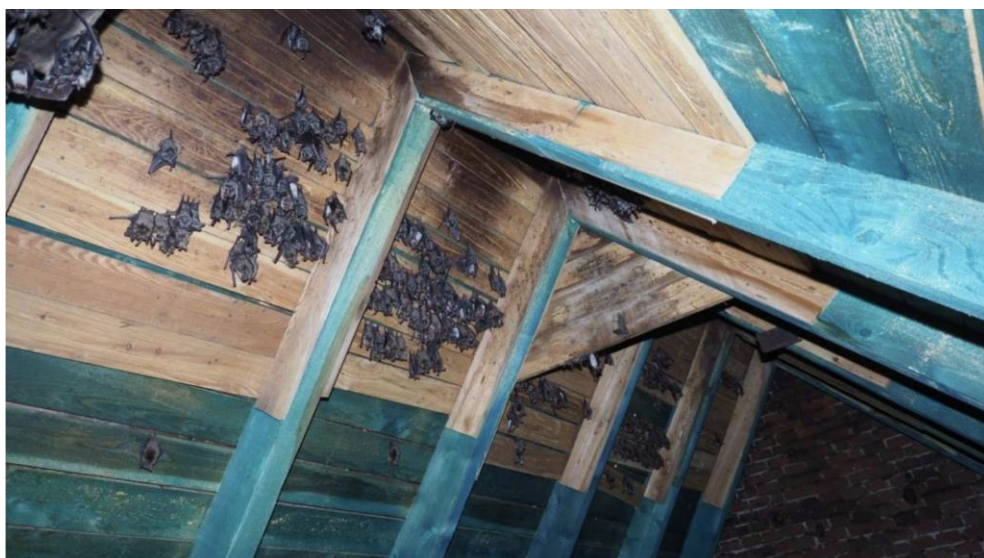




Analysis and recommendations regarding the use of methods and measures for wood protection in bat habitats.

THE SUMMARY



Polskie Towarzystwo Przyjaciół Przyrody „pro Natura”

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LIFE PODKOWIEC PLUS: back to the forest – holistic conservation of bat breeding habitats

LIFE20 NAT/PL/001427

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Wood protection and conservation agents play a crucial role in preserving the durability of wooden structures and mitigating material degradation caused by biological factors. In the 21st century, the use of such agents, including organic biocides, has been on the rise. However, their application entails serious environmental consequences, especially for animal species that utilize anthropogenic wooden structures as roosting sites. Bats are in a particularly vulnerable position, as their biological and ecological characteristics make them exceptionally sensitive to the effects of chemical substances.

Bats represent the second largest order of mammals worldwide. They are primarily forest animals, typically roosting in tree cavities, under bark crevices, caves, or cliffs. However, with increasing anthropogenic pressure, they more and more rely on human-made structures - such as attics, bridges, basements, and buildings. In temperate climates, buildings now often provide critical sites for breeding and hibernation.

The biology and ecology of bats render them highly sensitive to environmental change. They are long-lived mammals (with lifespans reaching up to 40 years), reach sexual maturity relatively late, and typically give birth to a single offspring annually. Pregnancy and lactation periods are long, resulting in slow population recovery. In temperate climate zones, hibernation serves as an energy-saving strategy during periods of food shortage. While advantageous for survival, hibernation exposes bats to the risk of rapid reduction of fat reserves due to sudden awakening during cold periods. Echolocation, their key physiological adaptation, enables orientation and prey detection. Yet, this reliance also makes bats highly sensitive to neurological impairments or auditory damage caused by toxins, which may severely compromise survival.

Main threats to bats are caused by human activities, those include: habitat loss and fragmentation, agricultural intensification and pesticide use, development of infrastructure, light pollution, and colony disturbance in caves and buildings. Such anthropogenic pressures reduce quality of foraging grounds, thereby diminishing reproductive success. According to IUCN data, over one-third of bat species worldwide are considered threatened. In Poland, all bat species are strictly protected by both national and European Union law.

Among the threats, chemical agents, particularly wood preservatives, require special attention. Biocide-based treatments may enter bat organisms via three main pathways: ingestion, inhalation, and dermal absorption. The oral route includes the consumption of insects contaminated with pesticides or water polluted with chemical compounds. The inhalation route involves the uptake of vapors and aerosols, especially in spaces where wood treatment is applied. The dermal route is particularly critical in bats due to their thin, vascularized wing membranes, which constitute 80% of body surface area and allow rapid absorption of lipophilic compounds, especially when skin integrity is compromised.

The toxic effects of wood preservatives can be acute or chronic. A particularly dangerous phenomenon is bioaccumulation, whereby compounds stored in adipose tissue are released into the bloodstream during periods of increased metabolism (migration, reproduction, awakening from hibernation). Moreover, biocides may pass into maternal milk, thus transferring toxins to offspring during lactation. Biocide poisoning can impair internal organ function, disrupt hormonal, immune, and neurological systems, and ultimately reduce population survival. Studies show that bats exposed to wood preservatives exhibit higher susceptibility to parasitic diseases, lower body mass, and decreased white blood cell counts, limiting their capacity to combat infections. Research in the UK demonstrated that the re-impregnation of old wooden structures may re-activate toxic chloro- and organophosphorus compounds used decades earlier, posing long-term risks to bat colonies inhabiting such sites.

Scientists recognize biocide exposure as one of the leading drivers of bat mortality, contributing to population declines. A key challenge in bat conservation is the development of a more comprehensive, standardized database on accumulation levels of biocide as well as correlations between exposure and both lethal and sublethal outcomes, including synergistic and antagonistic effects.

Wood is a natural material with significant technical, technological, aesthetic, and ecological advantages, but it is also very vulnerable. Many cultural heritage structures are composed mostly of wood, due to its historical popularity as a construction material. Such wooden monuments are particularly susceptible to biotic agents (fungi, bacteria, insects) and abiotic factors: chemical (salts), physico-mechanical (rain, snow, fluctuating humidity, dust, wind), and physico-chemical (fire, solar radiation). Each of these threats is countered by specific wood protection agents with active components tailored to the need.

This study includes Appendix 1, which lists products for the treatment, protection, and conservation of wood, as well as decorative-protective coatings and cleaning agents. The products are divided into four categories: Category 1 (green) includes agents recommended for use in bat habitats and their vicinity; Categories 2 and 3 include second- and third-choice products; Category 4 comprises products prohibited for use anywhere near bat habitats. Appendix 1 provides product names, distributors/manufacturers, solvent types, brief information on applications and functions, recommended treatment methods, intended user groups, and guidelines containing recommendations within the mentioned categories.

Importantly, some manufacturers modify product formulations without changing the label design. Batch numbers must therefore be checked, as they are the only reliable indicator of differences in composition or concentration of active ingredients.

Safe alternatives to wood preservation exist, both for heritage protection and broader applications. In Poland and internationally, conservation organizations recommend natural, non-toxic methods (biocide-free agents, ventilation, oil-based treatments), alongside

compensatory solutions such as bat boxes or substitute roosting shelters. Further research into alternative preservation strategies is essential to balance technical requirements with biodiversity conservation.

In conclusion, effective wood preservation must account for the broader ecological and legal context. While protective agents safeguard materials, they pose significant threats to bats. It is therefore essential to develop and implement integrated conservation strategies that reduce toxin exposure, safeguard habitats, and stabilize populations. Bat conservation is not merely about protecting a single animal group, but about protecting biodiversity and sustaining ecosystem functions, where bats play a vital role as regulators of insect populations.