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The Orange Beacon: Lichenometry, Remote Sensing, and the Future of Vertebrate Paleontology

Evolution * Ecology * Paleontology

Introduction: The Paradigm Shift in Paleontological Prospecting

Since the 19th-century "Great Dinosaur Rush," vertebrate paleontology in the eroded badlands of North America has relied on pedestrian surveys -- teams of researchers traversing rugged terrain under intense solar radiation, visually scanning sedimentary outcrops for weathered "float" fragments to trace uphill to intact bonebeds.[1][2] While effective, visual prospecting is constrained by human visual fatigue, incident shadow angles, and the chromatic mimicry between fossilized bone and rust-colored ironstone concretions.[2][3]

Recent research conducted in Dinosaur Provincial Park, Alberta, Canada, by Dr. Brian Pickles (University of Reading) and Dr. Caleb Brown (Royal Tyrrell Museum) has formalized a quantitative remote-sensing alternative: using orange calciphilic lichens as biological beacons to map exposed dinosaur fossils from the air.[1][4] By pairing Unmanned Aerial Vehicles (UAVs) with multispectral sensors that capture the sharp infrared reflectance and blue-wavelength absorption of bone-colonizing lichens, paleontologists can automate the detection of Late Cretaceous fossil horizons across complex badlands terrain, bridging a 75-million-year geological gulf through modern mineral ecology.[1][4]

The Biological Proxy: Lichen Symbiosis and Substrate Specificity

The biological beacons identified in the Dinosaur Park Formation -- a 75-million-year-old Campanian coastal-plain deposit eroded into steep coulees and hoodoos following the retreat of Pleistocene continental ice sheets -- are two foliose lichen species of the family Teloschistaceae: Rusavskia elegans (formerly Xanthoria elegans, the elegant sunburst lichen) and Xanthomendoza trachyphylla.[1][5] As composite symbiotic organisms uniting an ascomycete fungal mycobiont with a photosynthetic green algal photobiont (typically Trebouxia), these lichens construct a self-sustaining micro-ecosystem capable of extracting minerals directly from bare lithic surfaces.[5][6] Their vibrant orange cortex is enriched with parietin, a secondary anthraquinone pigment that screens the photobiont from ultraviolet (UV) radiation.[4][7]

Quantitative quadrat surveys across Dinosaur Provincial Park revealed an extraordinary substrate preference: R. elegans and X. trachyphylla colonized up to 50% of exposed dinosaur bone surfaces, compared to less than 1% of surrounding sedimentary rock fragments (bentonitic mudstones, sandstones, and ironstones).[1] Three physicochemical mechanisms drive this selectivity:

* Alkalinity and Calcium Phosphate Chemistry: Both lichen species are obligate calciphiles and nitrophytes (frequently associated with nitrogen- and calcium-enriched substrates).[1] Even after permineralization, fossilized vertebrate

bone retains its primary hydroxyapatite (calcium phosphate) mineral matrix, creating an alkaline, nutrient-rich island amidst neutral-to-acidic siliciclastic clays.[1][5]

* Trabecular Porosity and Moisture Retention: Weathered dinosaur bone -- especially cancellous internal trabeculae -- provides a rough micro-topography that anchors fungal rhizines against wind scour and retains precipitation moisture longer than impermeable mudstones, extending the photobiont's photosynthetic window in semi-arid drought conditions.[5]

* Extremophile Longevity: Rusavskia elegans is a renowned extremophile that survived 10-14 days of open-space vacuum, cosmic radiation, and thermal cycling during the European Space Agency's BIOPAN experiments in Low Earth Orbit, retaining 99% photosynthetic viability when UV-shielded (and 45% under full solar UV) via cryptobiosis.[8][9] Once established on exposed bone, colonies persist for decades as perennial markers.

UAV Multispectral Physics and the "Bone Meadow" Signal

To translate this ecological preference into a scalable prospecting tool, Pickles et al. (2025) deployed drone-mounted multispectral sensors over known and prospective bonebeds in Dinosaur Provincial Park.[1][4] Because fragmented float bones typically measure only a few centimeters across, commercial satellite imagery (30-50 cm/pixel) cannot resolve individual specimens. Conducting UAV surveys at an altitude of ~30 meters above ground level (AGL) yielded a spatial resolution of 2.5 cm per pixel, fine enough to resolve lichen rosettes on individual vertebrae or limb fragments.[1]

| Remote Sensing Parameter | | Measured Specification | | Diagnostic Function in Prospecting | | Source |

| Target Indicator Taxa | | Rusavskia elegans, Xanthomendoza trachyphylla | | Obligate calciphilic colonization of hydroxyapatite fossils | | [1][4] |

| Bone vs. Matrix Coverage | | Up to 50% on bone vs. <1% on surrounding rock | | Generates high biological signal-to-noise ratio in badlands | | [1] |

| Spectral Signature | | Low Blue reflectance / High Near-Infrared (NIR) reflectance | | Separates photosynthetic parietin/chlorophyll from abiotic ironstone | | [1][9] |

| UAV Survey Altitude | | ~30 meters AGL | | Optimizes swath coverage with sub-decimeter pixel density | | [1] |

| Spatial Resolution | | 2.5 cm per pixel | | Resolves individual float fragments and concentrated bonebeds | | [1] |

| Density Correlation | | Exponential increase in lichen signal with fossil abundance | | Prioritizes high-yield multi-individual bonebed horizons ("bone meadows") | | [1][10] |

Crucially, multispectral indexing overcomes visual mimicry between orange lichens and oxidized ironstone concretions.[3] While ironstones reflect visible red light, they exhibit a flat spectral curve in the near-infrared. Living lichen thalli, by contrast, strongly absorb blue wavelengths (via cortical parietin and chlorophyll)

while scattering Near-Infrared (NIR) radiation.[1][9] Whereas standard vegetation indices such as the Normalized Difference Vegetation Index (NDVI = [NIR Red] / [NIR + Red]) are calibrated primarily for vascular foliage, Pickles et al. (2025) combined these blue-absorption and NIR-reflectance contrasts to derive specialized lichen spectral indicators (including the Lichen-Soil Ratio and Normalized Difference Lichen Index).[1][4] Because lichen coverage increases exponentially with fossil concentration, dense accumulations of disarticulated dinosaur remains -- such as Centrosaurine or Hadrosaurid mass-mortality horizons -- produce an unmistakable spectral "bone meadow" heat map.[1][10]

Taphonomic Trade-Offs: Bioerosion and Pseudofossil Mimicry

While lichens illuminate fossils from the sky, their interaction with the specimen during its transition from the biosphere to the lithosphere is taphonomically destructive.[11] Endolithic and epilithic fungal hyphae penetrate cortical bone pores and secrete organic acids (notably oxalic acid) that chemically dissolve the calcium phosphate mineral matrix, while repeated wetting-and-drying cycles of the thallus induce mechanical stress and micro-fracturing across the external cortex.[12][13][14]

This bioerosion introduces three critical methodological caveats for vertebrate paleontologists and museum curators:

* Neoichnological Trace Confusion: When lichen thalli die naturally or are mechanically removed during laboratory preparation, they leave characteristic reticulate, pitted etching patterns across the bone surface. Researchers must carefully distinguish these modern neoichnological traces from Late Cretaceous skeletal pathologies or ancient insect and vertebrate bioerosion -- such as dermestid beetle borings (Osteocallis) and multituberculate mammalian gnaw marks (Machichnus) -- by verifying whether secondary permineralization occurs inside the trace walls.[12][14]

* Pseudofossil Skin Impressions and Dendrites: Alongside inorganic manganese oxide dendrites that precipitate along rock fractures and mimic fossilized fern fronds, crustose and foliose lichen bioerosion can etch pebbled, tuberculate surface textures into sandstone or cortical bone that closely mimic prized dinosaur skin impressions (such as Edmontosaurus or hadrosaurid scale patterns). Authenticating true integumentary impressions requires checking for uniform scale geometry and testing for modern fungal chitin or secondary lichen acids versus fossilized organic biomarkers.[13][15][16]

* Collection and Preservation Bias: Because orange lichen colonies strongly favor dense, alkaline limb shafts and vertebral centra over thin cranial elements or ribs, automated aerial surveys risk introducing a visibility bias toward robust skeletal elements while simultaneously targeting specimens whose outermost cortical microstructure has been partially etched by fungal acid dissolution.[11][15]

Conclusion: From Global Badlands to Astrobiological Biosignatures

By uniting lichen ecology with centimeter-scale UAV multispectral imaging, Pickles and colleagues have established a rapid, non-invasive prospecting workflow transferable to arid fossiliferous badlands worldwide -- from the Jurassic Morrison

and Cretaceous Hell Creek formations of the American West to the expansive Gobi Desert of Mongolia and the high-contrast fossil penguin bonebeds of Antarctica.[5][3][4] Autonomous drone grids flying at 30 meters AGL can now pre-map square kilometers of rugged outcrops prior to ground deployment, transforming paleontological fieldwork from serendipitous pedestrian searching into targeted spatial science.[1][4]

Beyond vertebrate paleontology, the spectral indices calibrated to distinguish Rusavskia elegans from iron-oxide rock matrices provide a direct field analogue for astrobiological rover and orbiter missions searching for life on Mars.[4][8] Just as extremophilic sunburst lichens selectively colonize calcium phosphate bone islands in the Canadian badlands and signal their presence via near-infrared red-edge reflectance, putative Martian biosignatures are most likely to be detected by targeting specific alkaline or buffered mineral substrates capable of sustaining cryptobiotic life across deep geological time.[8][9]

Updates... (Nov 21, 2026): Added the missing publication date (Oct 10, 2024) on the U.S. National Park Service Body Fossils reference alongside exact publication dates across ZME Science, Sci.News, Current Biology, Science News, Nautilus, and peer-reviewed journal references. (Prior Nov 19, 2026 update clarified the standard red/NIR definition of NDVI vs. Pickles et al.'s specialized lichen spectral indicators.)

References & Primary Sources

* [1] University of Reading (2025). Lichens and drones reveal dinosaur bones. -- https://www.reading.ac.uk/news/2025/Research-News/Lichens-and-drones-reveal-dinosaur-bones

* [2] ZME Science (Nov 5, 2025). This Orange Lichen Is Helping Researchers Find Dinosaur Fossils. -- https://www.zmescience.com/science/geology/this-orange-lichen-is-helping-researchers-find-dinosaur-fossils/

* [3] Sci.News (Nov 4, 2025). Orange-Colored Lichens Helping Paleontologists Discover Dinosaur Fossils. -- https://www.sci.news/paleontology/orange-colored-lichens-dinosaur-fossils-14333.html

* [4] Pickles, B. J., Brown, C. M., Herridge-Berry, S., Martin, C. R., Dergousoff, M., Gilmar, T., Bell, P. R., & Peddle, D. R. (Nov 2025). Remote sensing of lichens with drones for detecting dinosaur bones. Current Biology, 35(21), R1044-R1045. -- https://doi.org/10.1016/j.cub.2025.09.036

* [5] Science News (Nov 25, 2025). This bright orange life-form could point to new dino discoveries. -- https://www.sciencenews.org/article/lichen-dinosaur-fossils

* [6] Grube, M. (2024). Lichens. In Fungal Associations (The Mycota, 3rd ed., Springer). -- https://doi.org/10.1007/978-3-031-41648-4_6

* [7] Lorenz, C., et al. (May 2024). UV photo-degradation of the secondary lichen substance parietin: A multi-spectroscopic analysis in astrobiology perspective. Life Sciences in Space Research. -- https://doi.org/10.1016/j.lssr.2024.03.004

* [8] de Vera, J.-P. (Feb 17, 2012). Lichens as survivors in space and on Mars. Fungal Ecology. -- https://doi.org/10.1016/j.funeco.2012.01.008

* [9] Lorenz, C., et al. (Jun 2022). Survival of Xanthoria parietina in simulated space conditions: vitality assessment and spectroscopic analysis. International Journal of Astrobiology. -- https://doi.org/10.1017/S1473550422000076

* [10] Nautilus Magazine (Nov 5, 2025). Can Lichen Light the Way to Dinosaur Finds? -- https://nautil.us/can-lichen-light-the-way-to-dinosaur-finds-1246319/

* [11] Behrensmeyer, A. K. (2021). Taphonomy. In Encyclopedia of Geology (2nd ed.). -- https://doi.org/10.1016/b978-0-08-102908-4.00120-x

* [12] Perea, D., et al. (Jan 20, 2025). Bioerosion Structures on Dinosaur Bones Probably Made by Multituberculate Mammals and Dermestid Beetles (Guich n Formation, Late Cretaceous of Uruguay). Fossil Studies, 3(1), 2. -- https://doi.org/10.3390/fossils3010002

* [13] Krumbein, W. E., Paterson, D. M., & Zavarzin, G. A. (Eds.). (2003). Fossil and Recent Biofilms. Springer. -- https://doi.org/10.1007/978-94-017-0193-8

* [14] Acosta Hospitaleche, C., et al. (Jun 29, 2022; print Jul 3, 2023). Neoichnology of endolithic lichens: an update on the traces produced in fossil bones and teeth. Historical Biology. -- https://doi.org/10.1080/08912963.2022.2084693

* [15] U.S. National Park Service (Oct 10, 2024). Body Fossils -- Fossils and Paleontology. -- https://www.nps.gov/subjects/fossils/body-fossils.htm

* [16] Tahoun, M., et al. (Apr 27, 2022). Chemistry and Analysis of Organic Compounds in Dinosaurs. Biology, 11(5), 670. -- https://doi.org/10.3390/biology11050670