**Independent variation of avian sensitivity to climate change and trait-based adaptive capacity along a tropical elevational gradient**

**Supporting information**

**Data and Methods**

**S1: Alternative measure of climatic niche breadth following Broennimann et al. (2012)**

The method recommended by Broennimann et al. (2012) defines species’ climatic niche breadth in a two-dimensional climate space. Hence we utilized the first two axes from a principal component analysis carried out across all 215 bird species considering unique occurrence points and 17 bioclimatic variables (see main manuscript). The two-dimensional climate space was gridded (100 x 100 cells) and for each species a value of occupancy in each of the cells in the climate space was computed. To this end, kernel density smoothing was used to generate density surfaces of the available climate and species occurrences and species’ occupancy was estimated as occurrence density divided by climate density (Broennimann et al. 2012). Species climatic niche breadth was then estimated as Shannon diversity index accounting for the number of cells a species occupies in the climate space and the evenness of species’ occupancy (Laube et al. 2015, Eyres et al. 2020). These analyses were performed with the R packages ‘ecospat’ and ‘vegan’.

**S2: Museum specimen (frugivorous birds)**

The list below provides specimen number and collection acronyms for measured bird specimen: FMNH - Field Museum of Natural History Chicago, LSUZM - Zoological Museum of the Louisiana State University Baton Rouge, BMNH - The Natural History Museum (Bird Group) Tring, NMB - Museum of Natural History Basel, SMF - Senckenberg Museum Frankfurt, SNSD - Senckenberg Natural History Collections Dresden, ZFMK – Zoological Research Museum A. Koenig Bonn. This list has originally been provided in the supplementary material of Dehling et al. (2014).

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| **Species** | **Collections and specimens measured** |
| *Tinamus tao* | BMNH 1902.3.13.1858-59 |
| *T.osgoodi* | FMNH 208073-74,77 |
| *T.major* | BMNH 1892.6.9.12, ZFMK 52.126 |
| *T.guttatus* | BMNH 1869.5.25.142-143 |
| *Nothocercus nigrocapillus* | FMNH 415930, SMF 24689-90 |
| *Crypturellus cinereus* | BMNH 1892.6.9.43, ZFMK 61.276-78 |
| *C.soui* | ZFMK 61.269-71 |
| *C.obsoletus* | ZFMK 52.128, 56.95, 57.245-246 |
| *C.undulatus* | ZFMK 61.272,75 |
| *C.strigulosus* | BMNH 1845.8.25.57, 1892.6.9.85 |
| *C.atrocapillus* | FMNH 213777, 320360, 419703-04 |
| *C.variegatus* | BMNH 1933.10.21.4, 9, SMF 24757 |
| *C.bartletti* | BMNH 1870.6.14.4, 1892.6.9.129 |
| *Ortalis guttata* | BMNH 1899.6.30.749, ZFMK 61.280, 282-83 |
| *Penelope montagnii* | BMNH 1927.2.14.3, ZFMK 52.158-59 |
| *P.jacquacu* | BMNH 1889.6.1.231, ZFMK 52.156, 61.287 |
| *Pipile cumanensis* | BMNH 1889.6.1.248, 1902.3.13.1852, ZFMK 52.160 |
| *Aburria aburri* | BMNH 1899.6.30.764 |
| *Chamaepetes goudotii* | BMNH 1874.5.19.50, 1899.6.30.763 |
| *Mitu tuberosa* | BMNH 1889.6.1.178, 1902.3.13.1849 |
| *Odontophorus speciosus* | FMNH 208141, 43, SMF 24337-38 |
| *O.balliviani* | FMNH 418895, SMF 24362, 64 |
| *O.stellatus* | FMNH 419251, 419569-70, NMB 20654, SMF 24367 |
| *Psophialeucoptera* | BMNH 1890.2.14.31, 1902.3.13.1644, 46 |
| *Columba fasciata* | BMNH 1946.49.220, ZFMK 52.196, 54.634-35 |
| *C.cayennensis* | BMNH 1899.6.6.30.918, ZFMK 61.242 |
| *C.plumbea* | ZFMK 61.219, 221-22, 54.633 |
| *C.subvinacea* | BMNH 1953.68.89-90, SMF 21706, 08 |
| *Claravis mondetoura* | BMNH 1889.4.20.363-64, SMF 22286 |
| *Geotrygon montana* | BMNH 89.4.20.495, ZFMK 61.239-40 |
| *Ara ararauna* | BMNH 1920.11.13.41, ZFMK 52.203, 54.806 |
| *A.militaris* | BMNH 1889.1.30.3, 1896.12.1.9 |
| *A.macao* | BMNH 1950.64.67, SMF 89989 |
| *A.chloroptera* | ZFMK 52.204, 61.189-90, 61.1959 |
| *A.severa* | ZFMK 54.90-91, 61.1951-52 |
| *Orthopsittica manilata* | BMNH 89.1.30.31, 89.1.30.32, 90.6.1.10 |
| *Propyrrhura couloni* | ZFMK 61.174-76, 61.1954 |
| *Aratinga mitrata* | BMNH 1902.3.13.1315,1946.49.281-83, ZFMK52.207 |
| *A.leucophthalmus* | BMNH 1890.6.1.39, 1891.1.23.65-67, FMNH 283657, 286590-91, NMB 22433, 81577 |
| *A.weddellii* | ZFMK 61.1945-46, 85.133-34 |
| *Pyrrhura picta* | ZFMK 61.170, ZFMK 61.1929, 1932-33 |
| *P.rupicola* | BMNH 1892.12.24.27, FMNH 285079, 287763, SMF 26026-27 |
| *Bolborhynchus orbygnesius* | BMNH 1889.1.30.177, 1890.6.1.116, 1899.6.30.420-21 |
| *B.lineola* | BMNH 1969.25.777-78, SMF 26119, 23 |
| *Forpussclateri* | BMNH 1869.5.12.18-19, 1889.1.20.645, 1889.1.30.482 |
| *Brotogeris cyanoptera* | ZFMK 61.172-73, 61.1949-50 |
| *B.sanctithomae* | BMNH 1869.1.30.497-98, 1889.1.30.231, 1890.6.1.146 |
| *Nannopsittaca dachilleae* | LSUMZ 156193-94, 96, 99 |
| *Touit huetii* | BMNH 1857.11.11.5, 1890.6.1.250 |
| *Pionites leucogaster* | BMNH 91.4.1.49, SMF 26430 |
| *Pionopsitta barrabandi* | ZFMK 61.185, 187, 1961-62 |
| *Pionus menstruus* | BMNH 1902.3.13.1410, ZFMK 54.647, 61.1935, 1937 |
| *P.tumultuosus* | BMNH 1889.1.30.390-91, 1890.6.1.215, ZFMK 57.236 |
| *Amazona ochrocephala* | ZFMK 61.191-93 |
| *A.mercenaria* | BMNH 1902.3.13.18.1407-08 |
| *A.farinosa* | ZFMK 61.195-97, 1957 |
| *Steatornis caripensis* | BMNH 99.6.30.473, ZFMK 52.224, 54.975-76 |
| *Trogon curucui* | SMF 34125-27, 48454 |
| *T.viridis* | SNSD C16849, ZFMK 61.134, 137, 141-42 |
| *T.violaceus* | BMNH 1869.5.25.4, 1881.5.1.5206, 1888.8.20.111, 114 |
| *T.collaris* | BMNH 1869.5.25.5, 1888.8.20.64, 1902.3.13.1443 |
| *T.personatus* | BMNH 1888.8.20.74-75, 99.6.30.135-36 |
| *T.melanurus* | ZFMK 52.258, 61.123, 126 |
| *Pharomachrus antisianus* | ZFMK 52.257, 53.58 |
| *P.auriceps* | BMNH 1899.6.30.118-19, ZFMK 52.256 |
| *P.pavoninus* | BMNH 1851.5.1.5080, 1888.8.20.301, 1890.4.20.153 |
| *Capito auratus* | SNSD C56401, ZFMK 60.565, 568, 570, 72 |
| *Eubucco richardsoni* | ZFMK 60.582, 588, 590, 592 |
| *E.tucinkae* | FMNH 251720-21, 260903-04 |
| *E.versicolor* | BMNH 1888.12.20.55-56, 1902.3.13.1881, ZFMK 54.670 |
| *Aulacorhynchus prasinus* | BMNH 1899.6.30.79, SNSD C62369, ZFMK 54.988 |
| *A.derbianus* | BMNH 1889.1.8.165-67, 1889.9.27.172 |
| *A.coeruleicinctis* | ZFMK 52.277, 54.636, 57.258-59 |
| *Pteroglossus inscriptus* | ZFMK 61.2076, 2078-79, 62.240 |
| *P.azara* | BMNH 1889.1.8.204, SNSD C16799, ZFMK 52.278, 60.182, 62.240 |
| *P.castanotis* | ZFMK 61.2041-42, 2044, 2048 |
| *P.beauharnaesii* | ZFMK 61.2049-50, 2055-56 |
| *Andigena hypoglauca* | BMNH 1899.6.30.48-49 |
| *Selenidera reinwardtii* | ZFMK 60.184, 251, 2070, 2085 |
| *Ramphastos vitellinus* | ZFMK 61.2008, 2014, 2020, 2022 |
| *R.cuvieri* | BMNH 1881.5.1. 3392, 3406, 3419, 1889.9.27.119 |
| *Piculus rubiginosus* | ZFMK 52.284-85, 53.54, 54.679 |
| *Celeus elegans* | ZFMK 60.483-85, 488 |
| *C.flavus* | ZFMK 60.514, 516, 519, 522 |
| *C.grammicus* | ZFMK 60494-95, 500, 503 |
| *C.spectabilis* | FMNH 185602, 320269, SMF 48246 |
| *C.torquatus* | BMNH 1898.3.10.2370, ZFMK 60.508-10 |
| *Laniisoma elegans* | BMNH 1857.11.28.122, 1974.3.1 |
| *Laniocera hypopyrra* | BMNH 1869.5.25.68, 1888.1.13.1541-42, 1888.1.20.607 |
| *Ampelion rubrocristata* | BMNH 1946.49. 784, 793-94, SNSD C16907, ZFMK 52.635 |
| *A.rufaxilla* | BMNH 1899.5.1.575, ZFMK 54.738, 57.276-77 |
| *Pipreola intermedia* | BMNH 1888.1.20.770, ZFMK 56.87, 57.195, 275 |
| *P.arcuata* | BMNH 1888.1.20.752, ZFMK 54.665, 1285, 57.196 |
| *P.pulchra* | FMNH 287810, SMF 41553 |
| *P.frontalis* | BMNH 1888.1.20.773, ZFMK 54.737, 474-75 |
| *Ampelioides tschudii* | FMNH 282600, 296721, 322429, 322427, SMF 41497, 99 |
| *Iodopleura isabellae* | BMNH 1869.5.25.77, 1888.1.20.966, 1888.1.13.1671, 1673 |
| *Snowornis subalaris* | FMNH 322434-36, 39 |
| *Lipaugus vociferans* | ZFMK 61.2354, 2356, 2362-63 |
| *Porphyrolaema porphyrolaema* | BMNH 1854.12.20.21, 60.1.16.30-31 |
| *Cotinga maynana* | BMNH 1881.5.1.4897, 1888.1.20.826 |
| *C.cayana* | ZFMK 61.2335-36, 2338-39 |
| *Conioptilon mcilhennyi* | FMNH 299818 |
| *Gymnoderus foetidus* | BMNH 1920.11.13.82-83, ZFMK 61.2391 |
| *Querula purpurata* | ZFMK 61.2321, 2324, 2329, 2331 |
| *Cephalopterus ornatus* | BMNH 1888.1.20.873, 1899.5.1.596, 1902.3.13.1297, 1920.11.13.67 |
| *Rupicola peruviana* | BMNH 1902.3.13.956-957, 961-962 |
| *Xenopipo unicolor* | FMNH 299673, 322551-53 |
| *X.holochlora* | BMNH 1910.6.14.8, ZFMK 87.200-201 |
| *Manacus manacus* | BMNH 1888.1.20.266, 287 |
| *Chiroxiphia pareola* | BMNH 1888.1.20.37-38 |
| *C.boliviana* | ZFMK 61.303, 84153, 87198-99 |
| *Pipra fasciicauda* | ZFMK 62.1073, 1077, 1079, 1082 |
| *P.chloromeros* | ZFMK 52.374, 62.1119, 87.259-60 |
| *Lepidothrix coronata* | ZFMK 62.1103-04, 1112, 1114 |
| *L.coeruleocapilla* | BMNH 1892.12.24.15, 1901.8.2.20-21, 1902.3.13.934 |
| *Machaeropterus pyrocephalus* | BMNH 54.11.28. 149, 152, BMNH 54.1220.39 |
| *Neopelma sulphureiventer* | FMNH 53072, 53704, 180716, 320310 |
| *Elaenia spectabilis* | ZFMK 61.2258-61 |
| *E.flavogaster* | BMNH 1846.9.9.211, 1888.1.13.528, 1910.5.14.242, SMF 41890, 41897 |
| *E.albiceps* | BMNH 1940.3.3.16, 1952.648, 1954.139, 1955.879 |
| *E.parvirostris* | BMNH 1888.1.1.727, 1888.1.13.566, 1899.4.20.329 |
| *E.strepera* | FMNH 249511-12, 284951-52 |
| *E.gigas* | ZFMK 54.952, 61.2255-56 |
| *E.obscura* | ZFMK 52.505, 55.831, 57.287 |
| *E.pallatangae* | BMNH 1902.3.13.807, 1946.49.1000 |
| *Mionectes striaticollis* | ZFMK 54.674, 87.229-30 |
| *M.olivaceus* | BMNH 1888.1.1.509, 1936.1.21.104, SMF 81668 |
| *M.oleaginous* | ZFMK 61.2284, 2287, 2295, 2297 |
| *M.macconnelli* | BMNH 1888.1.1.530, 533 |
| *Zimmerius bolivianus* | BMNH 1888.1.13.501, ZFMK 52.502, 54.1295, 1297 |
| *Z.cinereicapillus* | FMNH 315847-50 |
| *Z.gracilipes* | BMNH 1888.1.1.653-54, 658 |
| *Lophotriccus pileatus* | BMNH 1899.4.20.264, ZFMK 87.227 |
| *Tyrannus tyrannus* | BMNH 1888.1.1.1677, 1888.1.13.1164 |
| *T.savanna* | 1888.1.1.1770, BMNH 1911.5.29.29 |
| *Tityra cayana* | ZFMK 54.888, 61.2367-69 |
| *T.semifasciata* | BMNH 1902.3.13.935-36, ZFMK 54.914, 61.2365 |
| *T.inquisitor* | BMNH 1888.1.20.415-16, SMF 40890-91 |
| *Oxyruncus cristatus* | BMNH 1895.4.1.903-904, SMF 80420 |
| *Myadestes ralloides* | BMNH 1885.3.2.527, ZFMK 52.367, 54.667-68 |
| *Entomodestes leucotis* | BMNH 1902.3.13.49, ZFMK 56.85, 57.270 |
| *Catharus fuscater* | BMNH 1896.10.6.2-3 |
| *C.ustulatus* | ZFMK 57.411, 62.1378, 1380, 1382 |
| *Platycichla leucops* | BMNH 1885.3.2.334, 1886.8.2.152 |
| *Turdus chiguanco* | SNSD C16901, ZFMK 52.361, 53.284, 63.513 |
| *T.fuscater* | ZFMK 52.631, 54.77-78, 57269 |
| *T.serranus* | BMNH 1921.1969, ZFMK 52.362, 57.242-43 |
| *T.nigriceps* | BMNH 1886.8.2.161, 1896.6.1.622, 624, ZFMK 53.285 |
| *T.amaurochalinus* | BMNH 1902.3.13.8, 1920.11.13.65, ZFMK 54.676, 57.238 |
| *T.ignobilis* | ZFMK 54.911, 62.1383, 1388, 1392 |
| *T.hauxwelli* | BMNH 1881.2.24.35, 1885.3.2.219, 1885.3.2.219, ZFMK 52.363, 62.1393 |
| *T.albicollis* | ZFMK 52.364, 61.2104-06 |
| *Cyanocorax yncas* | BMNH 1896.10.6.395, 397, 1927.2.14.15, SNSD C16836, ZFMK 54.963 |
| *C.cyanomelas* | ZFMK 52.369, 53.61, 55.403, 56.93 |
| *C.violaceus* | ZFMK 54.87, 61.2393-94, 2397 |
| *Conirostrum speciosum* | BMNH 1884.7.12.114, 1884.7.31.112, 1885.4.1.179 |
| *C.cinereum* | BMNH 1884.7.31.66, 1946.49.621, ZFMK 54.1382, 56.1044 |
| *Schistochlamys melanopis* | BMNH 1885.6.12.1097, 1896.10.6.256, ZFMK 53.80, 54.885 |
| *Cissopis leveriana* | BMNH 1885.6.12.993, ZFMK 62.1298, 1300 |
| *Chlorornis riefferii* | BMNH 1896.10.6.252-54, ZFMK 54.660 |
| *Chlorospingus ophthalmicus* | ZFMK 52.439-40, 55.39, 57.204 |
| *C.parvirostris* | BMNH 1885.6.8.39, 1902.3.13.333 |
| *C.flavigularis* | BMNH 1869.5.25.138, 1885.6.8.38, 1885.6.12.860, 1902.3.13.332 |
| *C.canigularis* | BMNH 1921.12.29.87, 169 |
| *Thlypopsis sordida* | BMNH 1885.6.12.826, BMNH 1902.3.13.347, 1905.1.30.178 |
| *Tachyphonus cristatus* | BMNH 1885.6.12.754-55, 1898.12.14.542 |
| *Tachyphonus rufiventer* | ZFMK 62.1316, 1318-20 |
| *Trichothraupis melanops* | BMNH 1844.11.7.163, 1896.10.6.199, SMF 49542 |
| *Pirangarubra* | BMNH 1885.6.12.611, 4167, NMB 19940 |
| *P.leucoptera* | BMNH 1885.6.7.403, 1885.6.12.642 |
| *Ramphocelus nigrogularis* | ZFMK 62.1267-68, 1270, 1272 |
| *R.carbo* | ZFMK 62.1277, 62.1286-88 |
| *Thraupis episcopus* | ZFMK 53.79, 54.942, 62.1257-58 |
| *T.cyanocephala* | ZFMK 54.919, 54.950-51, 57.207 |
| *T.bonariensis* | ZFMK 52.456-457, 55.848, 57.294 |
| *T.palmarum* | ZFMK 62.1261-62, 1264-65 |
| *Buthraupis montana* | BMNH 1896.10.6.170-71, 1902.3.13.287-88, ZFMK 52.444 |
| *Anisognathus igniventris* | BMNH 1902.3.13.291, ZFMK 52.442-43, 84.155 |
| *A.somptuosus* | BMNH 1885.6.12.439, 1896.10.6.173-74 |
| *Iridosornis analis* | BMNH 1896.10.6.160-61, 1902.3.13.280, SMF 49753 |
| *I.jelskii* | BMNH 85.6.7.7-8, SMF 49749-52 |
| *Dubusia taeniata* | BMNH 1925.12.24.266, 1938.12.20.123 |
| *Delothraupis castaneoventris* | BMNH 1902.3.13.282-84, ZFMK 52.460 |
| *Pipraeidea melanonota* | BMNH 1896.10.6.138, 1902.3.13.13.253, 1925.12.24.365 |
| *Euphonia chlorotica* | BMNH 1885.6.4.90, 1885.6.12.59, 1896.10.6.136, ZFMK 54.843 |
| *E.laniirostris* | ZFMK 53.289, 62.1196, 1200- 01 |
| *E.mesochrysa* | BMNH 1885.6.4.261, 1885.8.12.172 |
| *E.chrysopasta* | ZFMK 62.1219-20, 1223-24 |
| *E.minuta* | ZFMK 62.1202, 1205-07 |
| *E.xanthogaster* | BMNH 1896.10.6.135, ZFMK 62.1225-27 |
| *E.rufiventris* | BMNH 1885.6.12.159, ZFMK 62.1210, 1214, 1218 |
| *Chlorophonia cyanea* | BMNH 1885.6.12.15, ZFMK 52.461-62 |
| *Chlorochrysa calliparaea* | BMNH 1902.3.13.225-27, 1903.10.12.6 |
| *Tangara mexicana* | ZFMK 62.1228-29, 1231, 1234 |
| *T.chilensis* | ZFMK 54.852, 62.1249-51 |
| *T.schrankii* | ZFMK 62.1239-40, 1243, 1245 |
| *T.arthus* | BMNH 1885.6.4.423, 1885.6.12.268, 1902.3.13.228-29 |
| *T.chrysotis* | BMNH 1885.6.12.392, 1903.10.12.4, SMF 59160 |
| *T.xanthocephala* | BMNH 1885.6.4.648, 1905.1.30.241-42, SMF 59180 |
| *T.parzudakii* | BMNH 1896.10.6.152-53, 1925.12.24.318, SMF 59304 |
| *T.xanthogastra* | BMNH 1885.6.4.404, SMF 59249, ZFMK 55.875, 62.1248 |
| *T.punctata* | BMNH 1885.6.4.383, 1952.17.4 |
| *T.gyrola* | BMNH 1885.6.4.515, 1902.3.13.237-38, ZFMK 54.925 |
| *T.ruficervix* | BMNH 1885.6.4.532 |
| *T.cyanotis* | BMNH 1885.6.12.376, SMF 59198 |
| *T.cyanicollis* | ZFMK 54.947, 55.883, 84.163-64 |
| *T.nigrocincta* | BMNH 1881.5.1.3895, 3900, 1896.10.6.147, 1902.3.13.249 |
| *T.nigroviridis* | BMNH 1892.12.24.12, 1896.10.6.146, 1916.9.21.133 |
| *T.vassorii* | BMNH 96.10.6.140, 142, ZFMK 53.150, 55.902 |
| *T.viridicollis* | BMNH 1885.6.12.402, 1896.10.6.156, ZFMK 52.468-469 |
| *T.velia* | BMNH 1885.6.12.184, ZFMK 62.1252, 1254-55 |
| *T.callophrys* | BMNH 1881.5.1.3845, 3847 |
| *Iridophanes pulcherrima* | BMNH 98.12.14.197-198 |
| *Dacnis albiventris* | BMNH 1884.7.31.75, 1885.4.1.168, ZFMK 61.307-308 |
| *D.lineata* | ZFMK 62.1137, 1140, 1143, 1145 |
| *D.flaviventer* | BMNH 1884.1.31.100, 1885.4.1.159, ZFMK 62.1157 |
| *D.cayana* | ZFMK 62.1148, 1150, 1154, 1156 |
| *Chlorophanes spiza* | ZFMK 61.306, 62.1175, 1177, 1183 |
| *Cyanerpes caeruleus* | BMNH 1885.4.1.262-263, 1927.2.14.19 |
| *C.cyaneus* | ZFMK 62.1170-73 |
| *Tersina viridis* | ZFMK 54.855, 54.1299, 62.1188, 1191 |
| *Catamblyrhynchus diadema* | BMNH 1902.3.13.414-15, SMF 58759, 69904 |
| *Diglossa sittoides* | BMNH 1885.4.1.73, ZFMK 52.297, 54.699 |
| *D.mystacalis* | BMNH 96.10.6.91-93 |
| *D.brunneiventris* | BMNH 1902.3.13.188, ZFMK 52.294-296 |
| *D.glauca* | BMNH 1903.3.13.191, 1936.1.31.2 |
| *D.caerulescens* | BMNH 1896.10.6.111-114 |
| *D.cyanea* | BMNH 96.10.6.109-110, ZFMK 55.843, 57.200 |
| *Saltator coerulescens* | ZFMK 62.1344-47 |
| *S.maximus* | ZFMK 62.1348-52 |
| *S.grossus* | ZFMK 62.1353-54, 1356 |
| *S.aurantiirostris* | BMNH 1896.10.6.242, ZFMK 54.81, 55.854, 57.304 |
| *Pheucticus chrysogaster* | BMNH 1896.10.6.254, 1946.49.726, ZFMK 53.147, 56.1048 |
| *P.aureoventris* | ZFMK 53.86, 88, 55.392, 57.306 |
| *P.ludovicianus* | BMNH 5539, BMNH 1885.12.14.176, 188, 1916.9.21.96 |
| *Cyanocompsa cyanoides* | BMNH 1857.11.28.199, ZFMK 62.1357-59 |
| *Molothrus oryzivora* | ZFMK 52.309, 61.2445a, 2447a |
| *Icterus icterus* | BMNH 1885.11.2.445, 1914.12.1.630, SMF 75204, 75210, SNSD 3219 |
| *Cacicus cela* | ZFMK 61.2426, 2430, 2437, 2438a |
| *C.haemorrhous* | BMNH 1888.9.1.107, 1885.12.7.58, SMF 74880-81 |
| *C.chrysonotus* | SMF 74449, 57, ZFMK 54.650, 57.283 |
| *Psarocolius oseryi* | ZFMK 61.2400, 2402, 2405-06 |
| *P.decumanus* | ZFMK 52.307, 54.685, 61.2416, 2418 |
| *P.atrovirens* | ZFMK 52.308, 54.686-87, 57.232 |
| *P.angustifrons* | BMNH 1885.7.12.28, 1896.10.6.385, ZFMK 52306, 61.2414 |
| *P.bifasciatus* | BMNH 1885.7.12.15, SMF 74784 |

**S3: Additional information on the habitat niche breadth**

The habitat data were derived from the International Union for Conservation of Nature (IUCN) habitat classification version 3. We were considering the following 11 habitat classes: 1 Forest, 2 Savanna, 3 Shrubland, 4 Grassland, 6 Rocky Areas, 8 Desert, 14.1 Arable Land, 14.2 Pastureland, 14.3 Plantations, 14.4 Rural gardens, 14.6 Subtropical/Tropical Heavily Degraded Former Forest.

**S4: Phylogenetic analyses**

We based the phylogenetic analyses on the global phylogeny for birds (Jetz et al., 2012). We downloaded a subset of 1000 posterior trees for our 215 bird species from the global avian phylogeny at BirdTree.org (2019) selecting the version V2.iii (*i.e.* Stage 2: MayrAll Hacket). For further analyses, we created a consensus tree with the software TreeAnnotator (Bouckaert et al., 2019).

**Tables**

**Table S1:** Bioclimatic variables and their correlations with principal component (PC) axes. Given are the 17 bioclimatic variables considered in our study and their correlation with the first, second, third and fourth PC axis. Further given is the amount of variance in the bird species' occurrences explained by the respective PC axis. The first and second PC axis (highlighted in grey) were utilized to estimate species’ climatic niche as two-dimensional hypervolume in the main text (see table S2 for consideration of more dimensions).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Bioclimatic variable** |  **PC1** | **PC2** | **PC3** | **PC4** |
| Minimum Temperature of Coldest Month | 0.90 | -0.38 | -0.23 | 0.01 |
| Mean Temperature of Driest Quarter | 0.88 | -0.44 | -0.13 | 0.00 |
| Mean Temperature of Coldest Quarter | 0.88 | -0.44 | -0.16 | 0.02 |
| Annual Mean Temperature | 0.85 | -0.52 | 0.04 | -0.02 |
| Mean Temperature of Warmest Quarter | 0.80 | -0.57 | 0.18 | -0.05 |
| Mean Temperature of Wettest Quarter | 0.79 | -0.57 | 0.15 | -0.03 |
| Annual Precipitation | 0.79 | 0.58 | 0.14 | 0.11 |
| Maximum Temperature of Warmest Month | 0.76 | -0.59 | 0.24 | -0.07 |
| Precipitation of Wettest Quarter | 0.75 | 0.48 | 0.17 | 0.38 |
| Precipitation of Wettest Month | 0.74 | 0.49 | 0.18 | 0.38 |
| Precipitation of Coldest Quarter | 0.68 | 0.43 | -0.03 | 0.03 |
| Precipitation of Driest Quarter | 0.67 | 0.61 | 0.09 | -0.32 |
| Precipitation of Driest Month | 0.67 | 0.60 | 0.10 | -0.34 |
| Precipitation of Warmest Quarter | 0.45 | 0.63 | 0.28 | 0.16 |
| Temperature Seasonality | -0.24 | -0.30 | 0.83 | -0.18 |
| Precipitation Seasonality | -0.45 | -0.46 | 0.15 | 0.64 |
| Mean Diurnal Range | -0.58 | -0.12 | 0.62 | -0.06 |
|  |  |  |   |   |
| Amount of variance explained (%) | 51.7 | 24.89 | 8.78 | 5.85 |

**Table S2:** Pearson correlation coefficients between different estimates of species’ climatic niche breadth. We computed and contrasted climatic niche breadth estimated with two-, three- and four-dimensional hypervolumes (2d-, 3d- and 4d-hypervolume) based on the first two, three, or four climatic PC axes (Table S1), respectively, following Blonder et al (2014), and climatic niche breadth estimated with kernel density smoothing in two-dimensional climate space based on the first two climatic PC axes (see supplementary methods) following Broennimann et al. (2012). p-value < 0.001 for all correlation tests.

|  |  |  |  |
| --- | --- | --- | --- |
|  | 2d-hypervolume | 3d-hypervolume | 4d-hypervolume |
| Broennimann | 0.67 | 0.68 | 0.54 |
| 2d-hypervolume |  | 0.79 | 0.71 |
| 3d-hypervolume |  |  | 0.92 |

**Table S3:** Response traits and number of occurrence points for 215 avian frugivores considered in our study (uploaded to Dryad- DOI: https://doi.org/10.5061/dryad.ksn02v766)**.**

**Table S4:** Relationships between elevation (not transformed) and response traits related to species’ sensitivity to climate change and to their adaptive capacity. We performed a separate fourth corner analysis for each of the traits; this tests the relationships based on species’ occurrences at 12 elevational levels every 300 m along the Manú gradient (300-3,600m a.s.l.). Given are the Pearson correlation coefficient *r* and the *p*-value for the respective relationship.

|  |  |  |
| --- | --- | --- |
| Test | Pearson’s *r* | *p*-value |
| Climatic niche breadth | 0.29 | 0.024  |
| Wing pointedness | -0.11 | 0.066  |
| Bill width | -0.11 | 0.070  |
| Habitat niche breadth | 0.05 | 0.453 |

**Figures**

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**Figure S1:** Frequency distribution of the range coverage of the cleaned GBIF data of the 215 avian frugivore species. The vertical red line denotes the median. We computed range coverage and geographical bias scores of the cleaned GBIF data in comparison with geographic range maps from BirdLife applying the method of Meyer et al. (2016). These metrics are based on the great-circle distance (km) of 1000 random points, placed across each geographic range map, to their geographically closest GBIF occurrence records (Meyer et al., 2016).

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**Figure S2:** Frequency distribution of the geographical bias score of the cleaned GBIF data of the 215 avian frugivore species. The vertical red line denotes the median.

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