iScience, Volume *26*

Supplemental information

Avian obligate brood parasitic lineages evolved variable complex polycrystalline structures to build tougher eggshells

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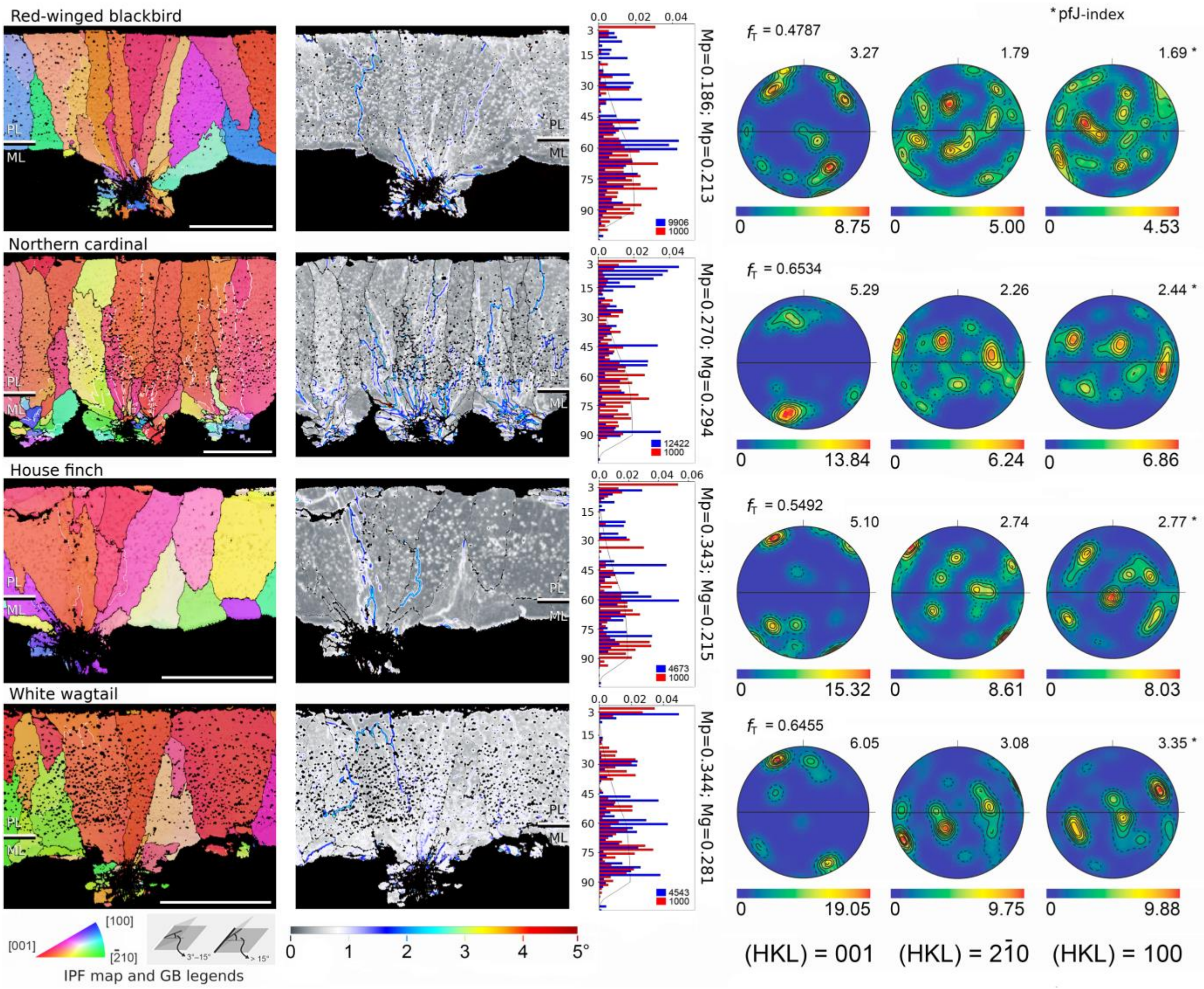


Figure S1. EBSD maps and their derivative information of host eggshells, related to Figure 3. Profiles were obtained by (left to right): inverse pole figure (IPF) maps, KAM maps, distributions of misorientation graphed as histograms and {hkl} pole figures. Transverse Direction Kearns texture factors (f_T) were extracted from each {001} pole figure. White scale bars in the IPF maps indicate reference lengths of 40*μm*. The numbers at the upper right corners of each pole figure are *pfJ* values extracted from each pole figure. Mp and Mg next to histograms mean *M*-index by point and by grain, respectively. For additional information, see Figure 1 and STAR Methods.

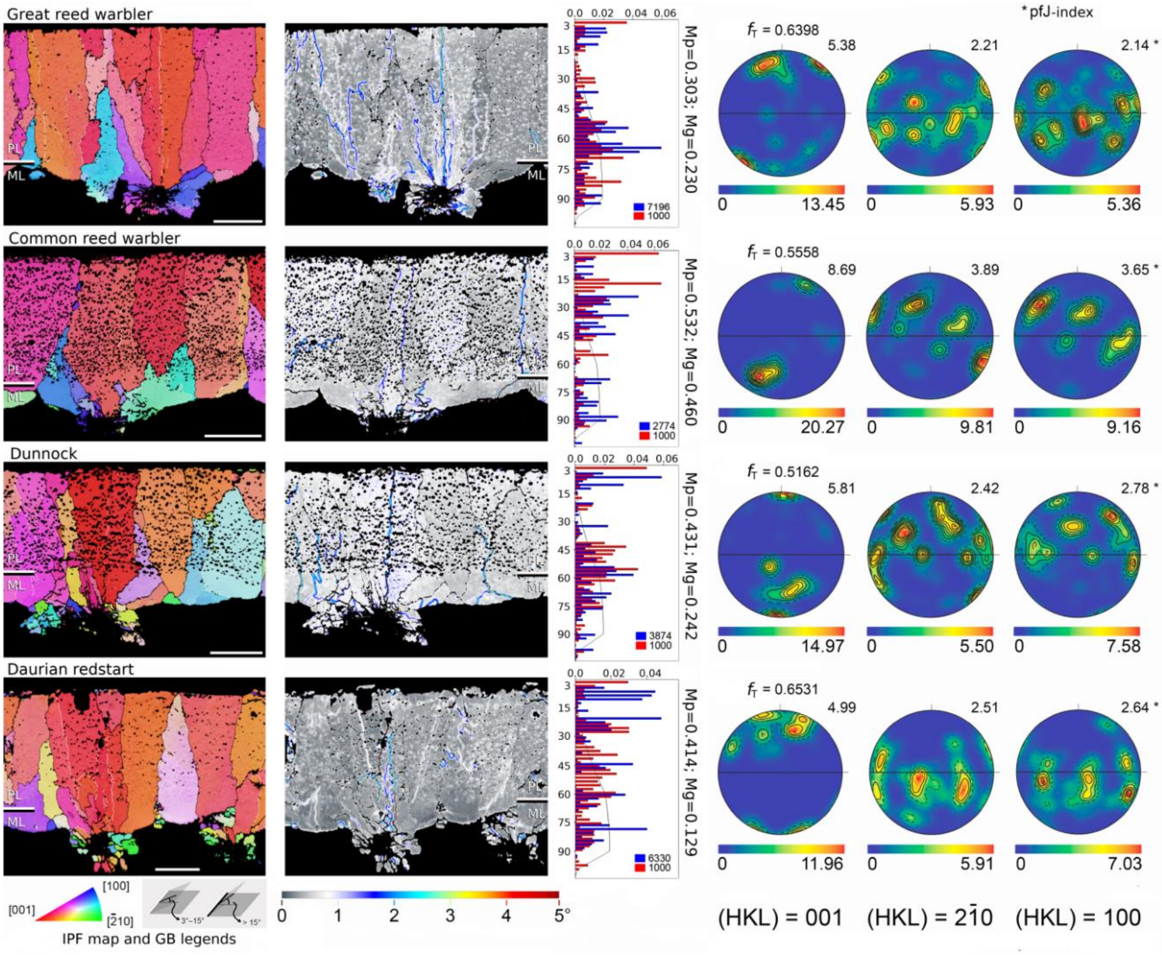


Figure S2. EBSD maps and their derivative information of host eggshells, related to Figure 3. Continuation of the Figure S1. White scale bars in the IPF maps indicate reference lengths of 20*μm*.

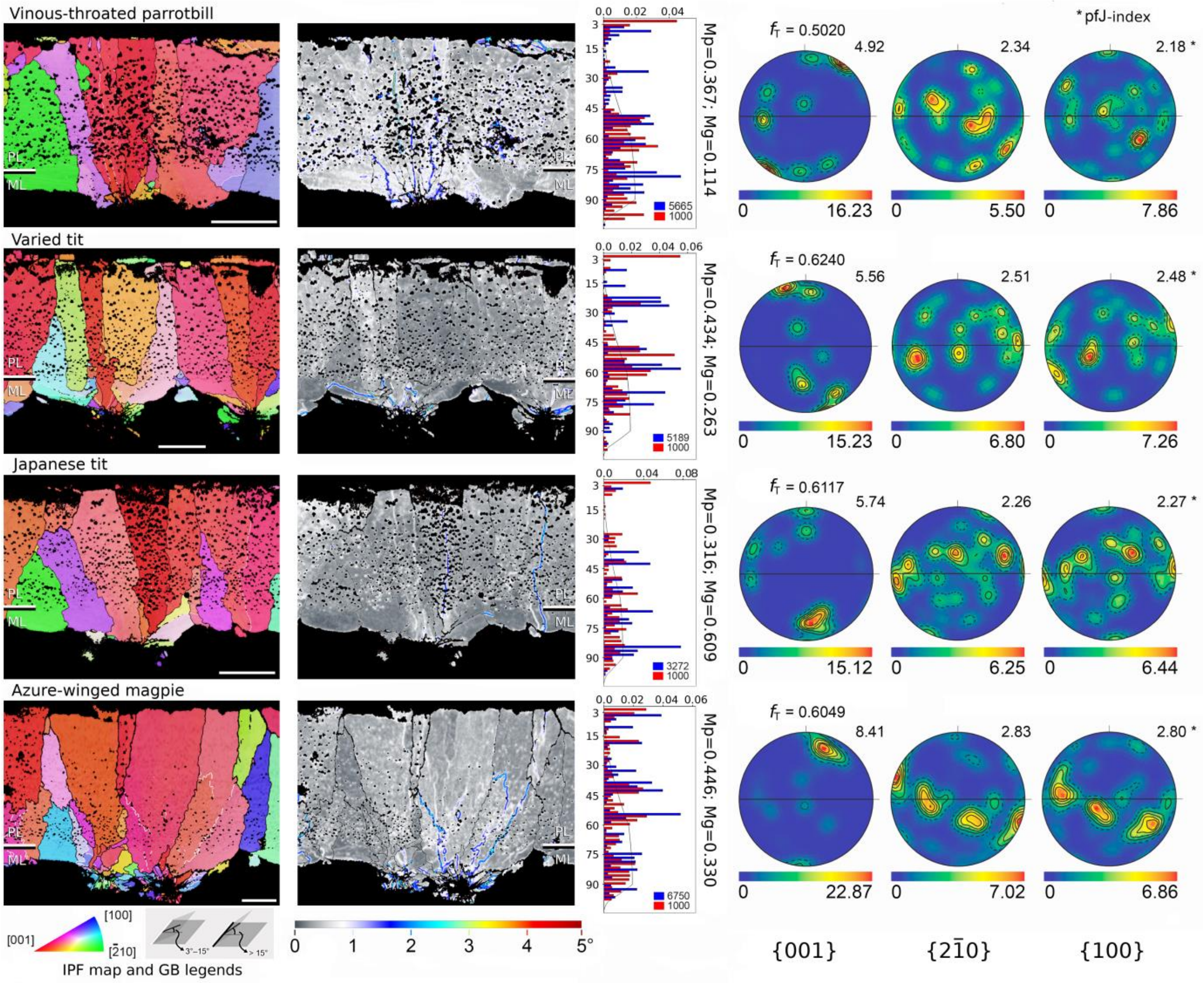


Figure S3. EBSD maps and their derivative information of host eggshells, related to Figure 3. Continuation of the Figures S1 and S2. White scale bars in the IPF maps indicate reference lengths of 20*μm*.

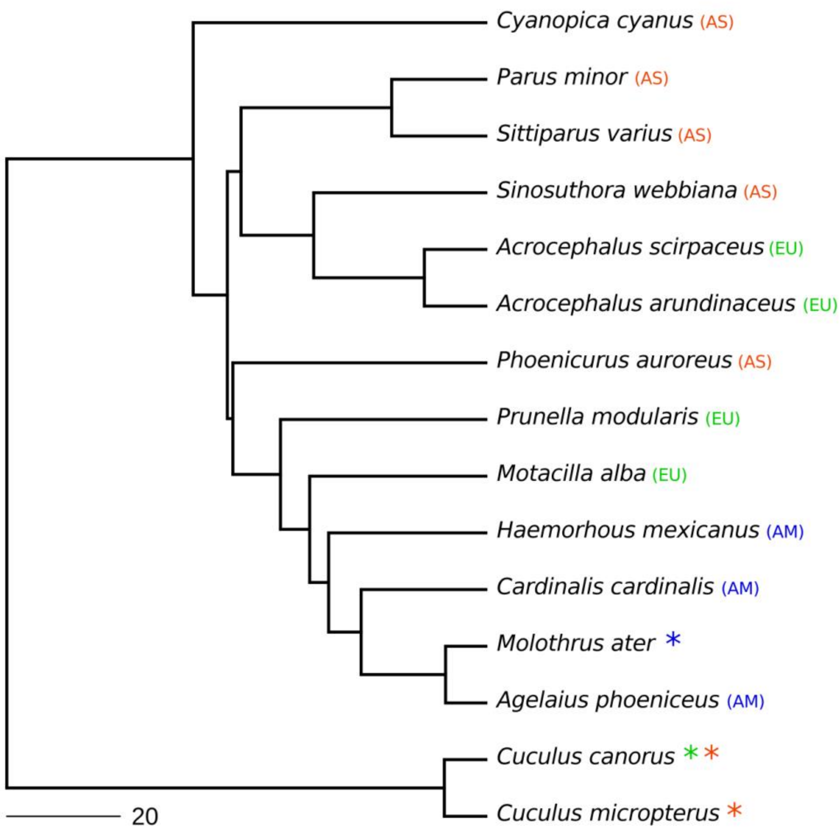
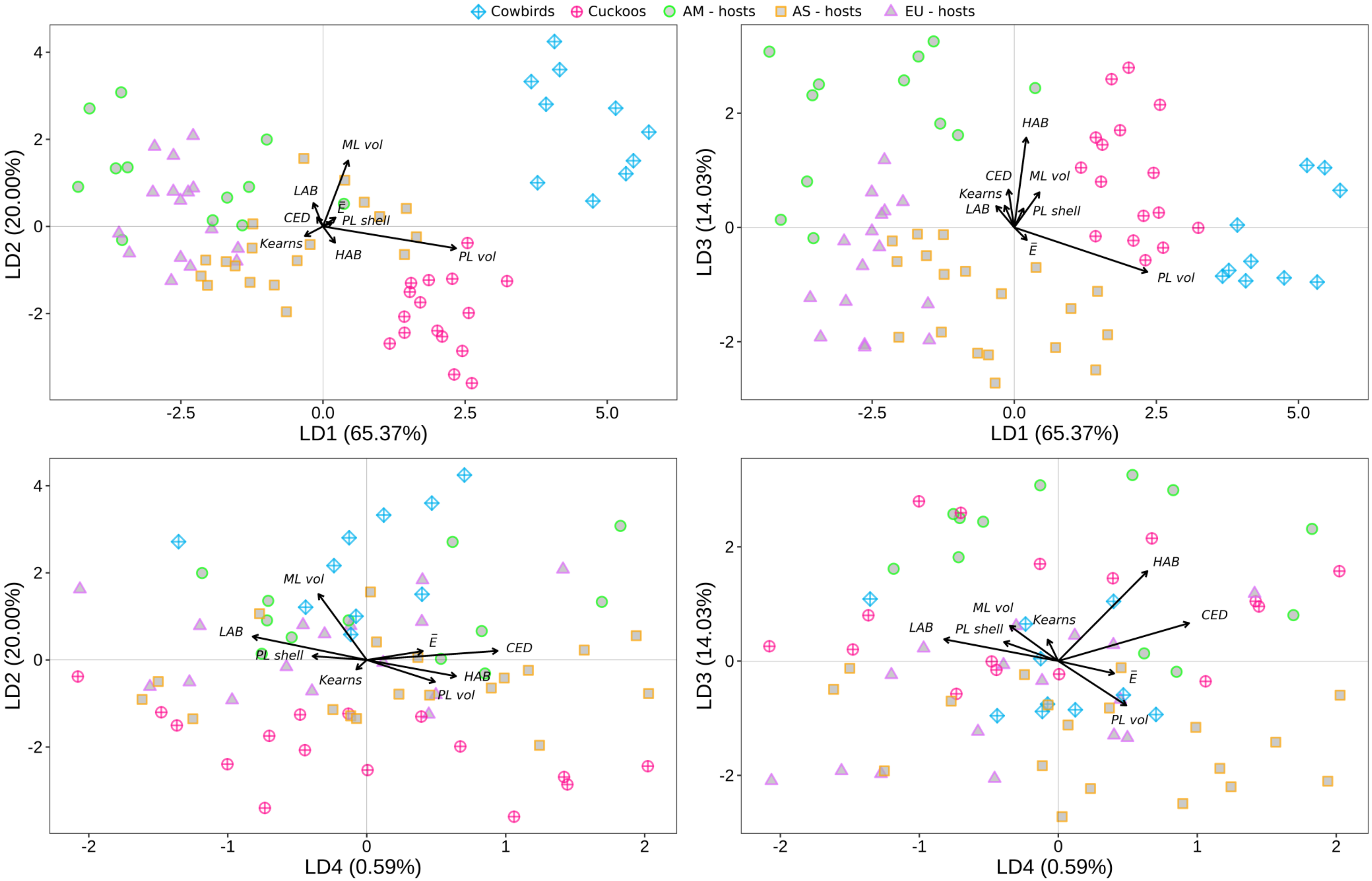


Figure S4. **A phylogeny of all 15 species of brood parasites and their hosts, related to STAR Methods.** Consensus phylogenetic tree with branch lengths expressing divergence time (given in million years). Legend: AS (orange) is host species of *C. canorus* and *C. micropterus* in Asia, EU (green) is host species of *C. canorus* in Europe, and AM (blue) is host species of *M. ater* in North America. Parasitic species are indicated with asterisks.



Cowbirds
Cuckoos
AM - hosts
AS - hosts
EU - hosts
LD1 (65.37%)
LD2 (20.00%)
LD3 (14.03%)
LD4 (0.59%)
ML vol
LAB
CED
Ē
PL shell
Kearns
HAB
PL vol

Figure S5. **Bi-plots of Linear Discriminant Analysis (LDA), related to Table 2, and STAR Methods.** Ordination biplots obtained from LDA output. Each data point combination represents a score resulting from the linear combination of all dependent variables that best separates the groups of eggs. The loadings of each variable are plotted as arrows (or vectors) labeled with the name of the original dependent variable (***ML vol*** is Rel. ML_{vol}, ***PL vol*** is Rel. PL_{vol}, ***PL shell*** is Rel. PL_{shell}, $\bar{E}$ is grain ellipticity, ***CED*** is Rel. CED, ***LAB*** is Rel. LAB, ***HAB*** is Rel. HAB, and ***Kearns*** is Kearns texture factor f_T; for variable definitions, see Table 1). Arrow length indicates the variance, the angle between arrows portrays the degree of correlation between dependent variables, and the angle between arrows and axes portrays the degree of correlation between dependent variables and LDs, reporting which of the original dependent variables contributes more to the discriminant power (see Tables S1 and S2). The discriminate functions (LDs) explained the 65.37%, 20.00%, 14.03%, and 0.59% (LD1–LD4 axes, respectively) of the variance of the group centroids, showing a clear separation of the cowbirds, cuckoos and hosts. We previously tested for multivariate differences among egg groups, and there was a statistically significant effect between egg groups on the combined dependent variables (MANOVA: *Pillai's trace*=2.191, $F_{4,68}$= 9.688, P<0.001). Multivariate *post-hoc* tests showed significant differences between cowbirds vs. cuckoos (P<0.003), cowbirds vs. their hosts (AM-hosts; P<0.001), and cuckoos vs. their hosts (EU-hosts and AS-hosts hosts; P<0.001 for both pairwise comparisons).

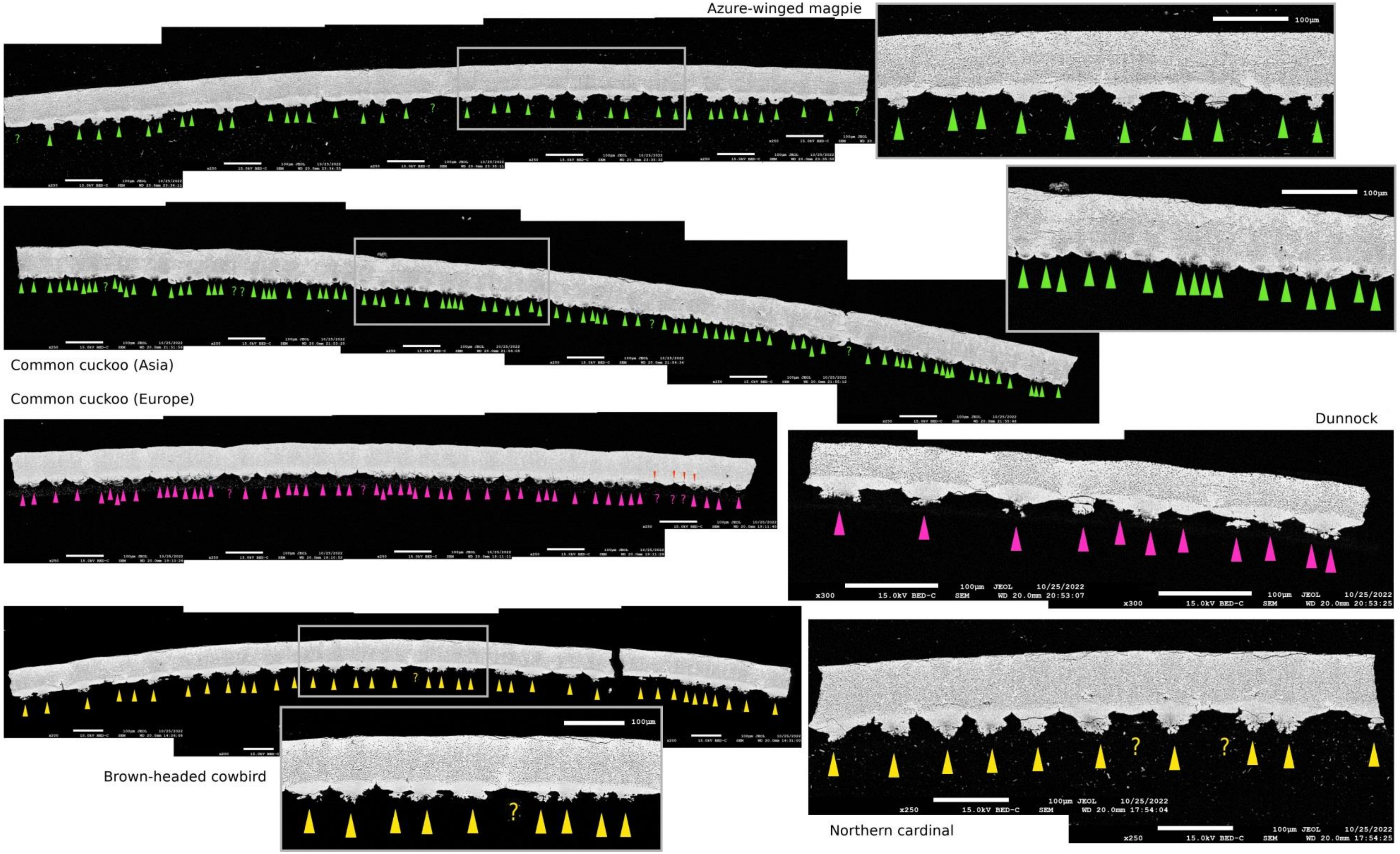


Figure S6. Backscattered electron (BSE) images of eggshell cross sections from brood parasite and host species, related to Figures 2 and 3. Arrows indicate the mammillary cones (MCs). White scale bars indicate a reference length of 100*μm*.

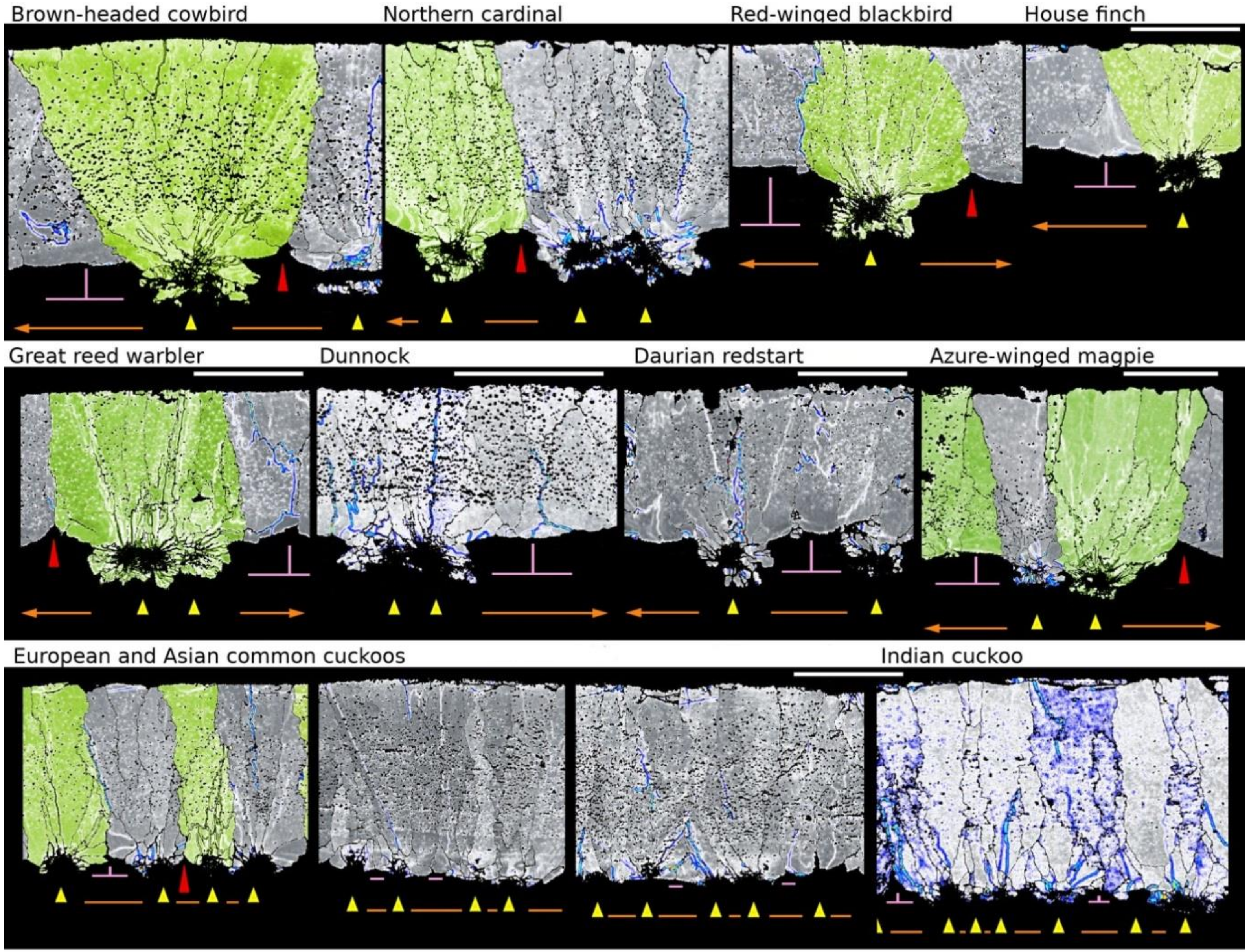

Brown-headed cowbird
Northern cardinal
Red-winged blackbird
House finch
Great reed warbler
Dunnock
Daurian redstart
Azure-winged magpie
European and Asian common cuckoos
Indian cuckoo

Figure S7. **Ultratructural characterization of palisade layer (PL) and mammillary layer (ML), related to Figures 2 and 3.** The images show eggshell cross-sectional profiles of host and brood parasite species. Green color indicates a possible interpretation of the delimitations of the columnar units. To delimit a crystal column unit we take as criteria Figure. 2 in Dunn et al. (2011) and the deep inter-mammillary cone (MC) grooves (red arrows) that include a border line between crystals continuous up to the outer surface. Inter-MC grooves are more difficult to determine in the cuckoos' species. Yellow arrows indicate the MCs. Orange lines show the distances between neighbouring cones. Pink lines show the differences in the thickness of the total eggshell and also in the ML, given by the "gaps" between empty spaces (without cones) and with cones. MC tips are the only spaces anchored to the organic membrane (see supplementary SEM images in López et al., 2021a). White scale bars indicate an approximate reference length of 50μm.

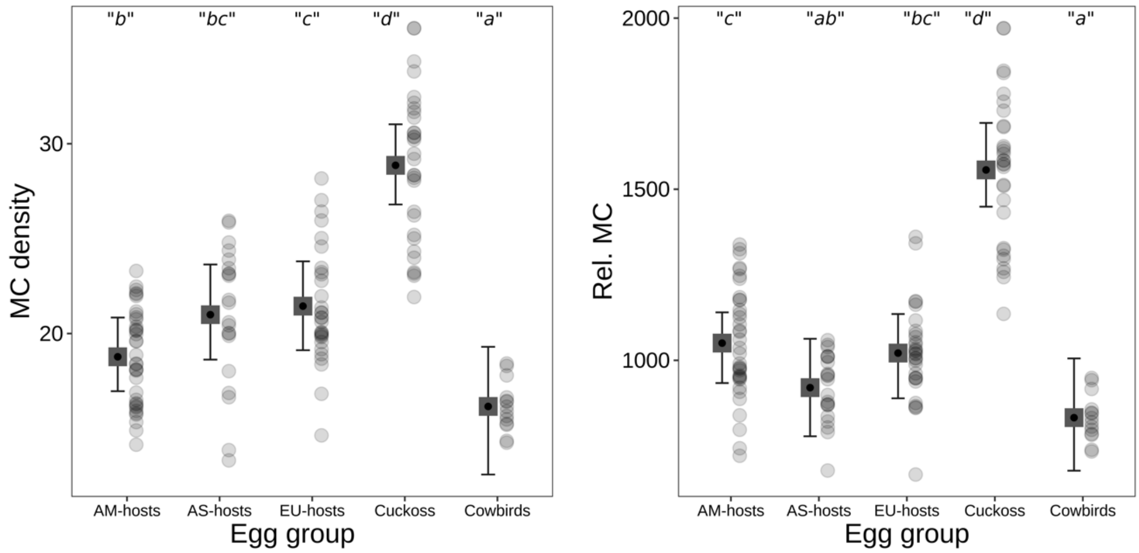


Figure S8. Plots showing difference between egg groups in terms of ML characterization variables, related to Figure 4. Data are represented as means of posterior densities (squares) and associated 95% credible intervals (bars). Lowercase letters indicate significant differences between the means of groups ($P \leq 0.05$). Legend: AM-hosts is American hosts, AS-hosts is Asian hosts, and EU-hosts is European hosts. For additional information and variable definitions, see Figure S6, Table 1 and STAR Methods.

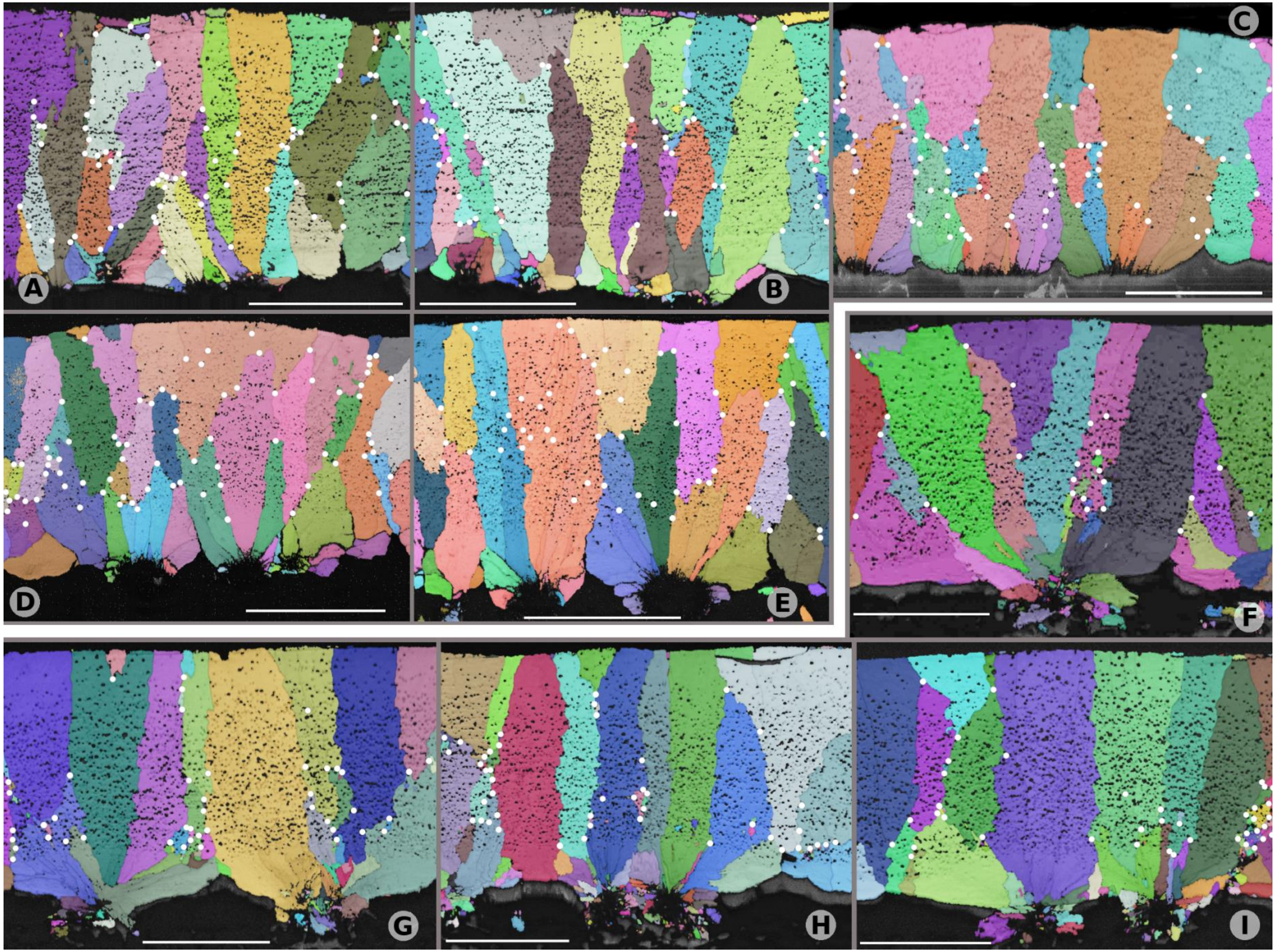

A
B
C
D
E
F
G
H
I

Figure S9. **Microstructural characterization of grain boundaries and triple junctions, related to Figures 2 and 3.** (A–C) Cross-sectional profiles of the Asian common cuckoo eggshell. (D and E) Cross-sectional profiles of the European common cuckoo eggshell. (F–I) Cross-sectional profiles of the brown-headed cowbird eggshell. Approximate visual identification of triple junctions(white dots), which contribute to generate a more complex network of intra- and inter-crystalline borders in the palisade layer (PL) of the cuckoo eggshells compared to the brown-headed cowbird and hosts' (not shown here) eggshells. White polygonal chain separates eggshell samples of cuckoos from cowbirds. White scale bars indicate a reference length of 50*µm.*

Table S1. **Coefficients of linear discriminants, related to Table 2.** For additional information, see Table S2 and Figure S5.

Dependent variables	**LD1**	**LD2**	**LD3**	**LD4**
$\bar{E}$	0.226	0.201	-0.215	0.409
Rel. DEC	-0.103	0.206	0.654	0.957
Rel. LAB	-0.170	0.532	0.376	-0.834
Rel. HAB	0.216	-0.369	1.553	0.652
Kearns factors f_T	-0.322	-0.215	0.370	-0.077
Rel. PL_{vol}	2.381	-0.497	-0.769	0.498
Rel. ML_{vol}	0.452	1.495	0.608	-0.354
Rel. PL_{shell}	0.165	0.087	0.328	-0.396

Table S2. Structure coefficients, related to Table 2. The values indicate the Pearson's r correlation between dependent variables and canonical coefficients. For additional information, see Figure S5 and Table S1.

Dependent variables	**[.,1]**	**[.,2]**	**[.,3]**	**[.,4]**
$\bar{E}$	0.4224	0.0556	0.0441	0.0798
Rel. DEC	-0.5036	0.3403	0.0359	0.5355
Rel. LAB	0.3454	0.1763	0.6072	-0.5098
Rel. HAB	0.4872	-0.3890	0.7471	-0.0308
Kearns factors f_T	0.0353	-0.3094	0.2996	-0.2732
Rel. PL_{vol}	0.9793	-0.1128	0.0106	-0.0509
Rel. ML_{vol}	0.3273	0.8996	0.0018	0.0434
Rel. PL_{shell}	0.2272	-0.8706	0.0372	-0.1773

Table S3. Summary of GLS models using brown-headed cowbird and their hosts (in North America), related to Figures 4 and 5, and STAR Methods. Brown-headed cowbird (*M. ater*), and their large (red-winged blackbird *A. phoeniceus* and northern cardinal *C. cardinalis*) and small (house finch *H. mexicanus*) hosts as the egg groups. Values indicate the mean and associated 95% confidence interval (in square brackets). Letters in parenthesis indicate significant differences between the means of groups ($P \leq 0.05$).

Variable	GLS model	Brown-headed cowbird	Large hosts	Small hosts
Shell thickness	$F_{2,19}$ = 261.228 P < 0.001	105.952 [101.247, 110.658] (*a*)	95.821 [90.561, 101.082] (*a*)	60.067 [52.628, 67.507] (*b*)
PL thickness	$F_{2,19}$ = 361.527 P < 0.001	74.624 [70.276, 78.971] (*a*)	66.731 [61.870, 71.592] (*a*)	37.701 [30.826, 44.575] (*b*)
ML thickness	$F_{2,19}$ = 11.909 P < 0.001	31.495 [29.419, 33.571] (*a*)	28.997 [26.676, 31.318] (*a*)	22.440 [19.157, 25.723] (*b*)
Rel. $Shell_{vol}$	$F_{2,19}$ = 122.257 P < 0.001	25.034 [21.914, 28.154] (*a*)	-2.951 [-6.439, 0.537] (*b*)	-11.820 [-16.753, -6.888] (*c*)
Rel. PL_{vol}	$F_{2,19}$ = 224.331 P < 0.001	17.330 [14.234, 20.427] (*a*)	-4.776 [-8.238, -1.314] (*b*)	-12.442 [-17.338, -7.545] (*c*)
Rel. ML_{vol}	$F_{2,19}$ = 11.641 P < 0.001	8.126 [6.060, 10.192] (*a*)	2.144 [-0.166, 4.453] (*b*)	0.917 [-2.349, 4.184] (*b*)
PL ratio	$F_{2,19}$ = 7.171 P = 0.005	70.449 [68.182, 72.716]	69.400 [66.865, 71.934]	62.918 [59.334, 66.502]

		(*a*)	(*a*)	(*b*)
Rel. PL_{shell}	$F_{2,19}$ = 0.012 P = 0.988	-2.931 [-4.812, -1.051]	-2.766 [-4.869, -0.664]	-3.003 [-5.977, -0.029]
Rel. ML_{shell}	$F_{2,19}$ = 0.055 P = 0.946	3.226 [1.273, 5.180]	2.795 [0.612, 4.979]	3.243 [0.155, 6.331]
MC density	$F_{2,47}$ = 11.258 P < 0.001	16.157 [14.934, 17.382] (*a*)	18.751 [17.901, 19.602] (*b*)	18.856 [17.125, 20.586] (*b*)
Rel. MC	$F_{2,47}$ = 28.207 P < 0.001	832 [763, 900] (*a*)	1089 [1042, 1136] (*b*)	886 [790, 982] (*a*)
Rel. LAB	$F_{2,19}$ = 1.621 P = 0.224	3.263 [2.578, 3.947]	3.413 [2.648, 4.179]	1.890 [0.808, 2.973]
Rel. HAB	$F_{2,19}$ = 7.834 P = 0.003	6.660 [5.803, 7.516] (*a*)	7.7037 [6.746, 8.661] (*a*)	4.567 [3.213, 5.921] (*b*)
Rel. TAB	$F_{2,19}$ = 3.338 P = 0.057	9.383 [7.767, 11.000] (a)	11.117 [9.310, 12.92] (*a*)	6.458 [3.901, 9.014] (*b*)
Rel. CED	$F_{2,19}$ = 43.400 P < 0.001	0.309 [0.288, 0.330] (*a*)	0.359 [0.335, 0.382] (*b*)	0.444 [0.411, 0.477] (*c*)
$\bar{E}$	$F_{2,19}$ = 5.878	0.616	0.573	0.496

	P = 0.010	[0.575, 0.657] (*a*)	[0.527, 0.618] (*a*)	[0.432, 0.561] (*b*)
Kμ	$F_{2,13}$ = 1.803 P = 0.204	0.770 [0.608, 0.932]	0.706 [0.592, 0.821]	0.613 [0.451, 0.775]
Km	$F_{2,13}$ = 4.054 P = 0.043	0.445 [0.352, 0.538] (*ab*)	0.481 [0.416, 0.547] (*a*)	0.332 [0.240, 0.425] (*b*)
pfJ	$F_{2,13}$ = 0.269 P = 0.768	5.567 [4.390, 6.745]	5.080 [4.247, 5.912]	5.202 [4.025, 6.380]
Mp	$F_{2,13}$ = 0.887 P = 0.435	0.293 [0.217, 0.369]	0.327 [0.273, 0.381]	0.359 [0.283, 0.435]
Mg	$F_{2,13}$ = 1.768 P = 0.209	0.155 [0.083, 0.227]	0.231 [0.180, 0.282]	0.216 [0.144, 0.288]
f_T	$F_{2,19}$ = 3.112 P = 0.068	0.572 [0.522, 0.622]	0.648 [0.593, 0.704]	0.552 [0.474, 0.631]

Table S4. **Summary of GLS models using the brood parasitic species (in Europe, Asia, and North and South America), related to Figures 4 and 5, and STAR Methods**. Cuckoos (*C. canorus* and *C. micropterus*), brown-headed cowbirds (*M. ater,* North America), and shiny and screaming cowbirds (*M. bonariensis* and *M. rufoaxillaris*, South America) as the egg groups. Values indicate the mean and 95% confidence interval (in square brackets). Letters in parenthesis indicate significant differences between the means of groups ($P \leq 0.05$).

Variable	**GLS model**	**cuckoos**	**Northern cowbirds**	**Southern cowbirds**
Shell thickness [μm]	$F_{2,35} = 49.107$ $P < 0.001$	95.649 [91.583, 99.714] (*a*)	105.952 [100.810, 111.094] (*b*)	131.614 [126.920, 136.308] (*c*)
PL thickness [μm]	$F_{2,35} = 33.899$ $P < 0.001$	74.104 [70.442, 77.767] (*a*)	74.624 [69.991, 79.257] (*a*)	99.357 [95.127, 103.586] (*b*)
ML thickness [μm]	$F_{2,35} = 60.570$ $P < 0.001$	21.621 [20.162, 23.081] *(a)*	31.495 [29.649, 33.341] *(b)*	31.424 [29.739, 33.109] *(b)*
PL ratio	$F_{2,35} = 19.14$ $P < 0.001$	77.446 [76.013, 78.878] (*a*)	70.449 [68.637, 72.262] (*b*)	75.434 [73.779, 77.088] (*a*)
Grain area [μm^2]	$F_{2,35} = 5.663$ $P = 0.007$	350.397 [323.278, 377.516] (*a*)	418.928 [384.625, 453.231] (*b*)	356.300 [324.986, 387.615] (a)
TAB density [μm^{-1}]	$F_{2,35} = 3.468$ $P = 0.042$	0.157 [0.142, 0.170] (*a*)	0.129 [0.112, 0.146] (*b*)	0.141 [0.125, 0.158] (*a*)
Rel. TAB	$F_{2,35} = 12.096$ $P < 0.001$	11.526 [10.469, 12.583]	9.383 [8.047, 10.721]	13.076 [13.076, 15.517]

		(*a*)	(*b*)	(*c*)

Table S5. Summary of GLS models using parasitic cuckoos as the egg groups (in Europe and Asia), related to Figures 4 and 5, and STAR Methods. Values indicate the mean and associated 95% confidence interval (in square brackets). Letters in parenthesis indicate significant differences between the means of groups ($P \leq 0.05$).

Variable	GLS model	Common cuckoo Beige eggshell (Asia)	Common cuckoo Blue eggshell (Asia)	Common cuckoo (Europe)	Indian cuckoo (Asia)
Rel. $Shell_{vol}$	$F_{3,12}$ = 5.982 P < 0.001	4.817 [2.542, 7.092] (a)	7.326 [5.050, 9.600] (ab)	6.070 [3.796, 8.345] (a)	10.749 [8.475, 13.024] (b)
Rel. PL_{vol}	$F_{3,12}$ = 2.738 P = 0.089	10.266 [8.266, 12.100]	10.101 [8.101, 2.440]	10.182 [8.182, 12.180]	13.217 [11.217, 15.217]
Rel. ML_{vol}	$F_{3,12}$ = 3.489 P = 0.05	-5.020 [-6.771, -3.269] (a)	-2.293 [-4.043, -0.542] (ab)	-3.657 [-5.408, -1.906] (ab)	-1.643 [-3.394, 0.107] (b)
PL ratio	$F_{3,12}$ = 18.200 P < 0.001	80.798 [79.200, 82.396] (*c*)	78.504 [76.906, 80.102] (*bc*)	73.331 [71.734, 74.930] (*a*)	77.149 [75.551, 78.747] (*b*)
Rel. PL_{shell}	$F_{3,12}$= 15.127 P < 0.001	7.937 [6.368, 9.505] (*c*)	5.709 [4.141, 7.278] (*bc*)	1.283 [-0.286, 2.851] (*a*)	4.099 [2.530, 5.667] (*b*)
Rel. ML_{shell}	$F_{3,12}$ = 13.716 P < 0.001	-7.835 [-9.491, -6.178] (a)	-5.459 [-7.116, -3.802] (ab)	-1.157 [-2.813, 0.499] (c)	-3.737 [-5.393, -2.080] (bc)
MC density	$F_{3,26}$ = 6.521	33.962	25.737	28.851	27.275

	$P = 0.002$	[31.067, 36.857] (*a*)	[22.841, 28.631] (*b*)	[27.121, 30.581] (*b*)	[24.633, 29.918] (*b*)
Rel. MC	$F_{3,26} = 6.298$ $P = 0.003$	1854 [1692, 2016] (*a*)	1425 [1263, 1586] (*b*)	1495 [1398, 1591] (*b*)	1559 [1411, 1706] (*b*)
Rel. LAB	$F_{3,12} = 4.215$ $P = 0.029$	1.809 [0.852, 2.765] (*a*)	3.145 [2.189, 4.10] (*ab*)	2.585 [1.629, 3.541] (*ab*)	3.944 [2.987, 4.899] (*b*)
Rel. HAB	$F_{3,12} = 16.634$ $P < 0.001$	7.943 [7.295, 8.590] (*a*)	10.127 [9.479, 10.774] (*b*)	9.126 [8.479, 9.774] (*b*)	7.426 [6.779, 8.074] (*a*)
Rel. TAB	$F_{3,12} = 12.913$ $P < 0.001$	9.752 [8.876, 10.627] (*a*)	13.273 [12.397, 14.148] (*c*)	11.711 [10.835, 12.587] (*b*)	11.370 [10.495, 12.246] (*b*)
Rel. CED	$F_{3,12} = 8.048$ $P = 0.003$	0.257 [0.233, 0.281] (*a*)	0.289 [0.265, 0.313] (*ab*)	0.328 [0.304, 0.352] (*b*)	0.269 [0.246, 0.293] (*a*)
$\bar{E}$	$F_{3,12} = 2.362$ $P = 0.122$	0.611 [0.567, 0.655]	0.539 [0.495, 0.583]	0.590 [0.546, 0.634]	0.592 [0.548, 0.636]
$K\mu$	$F_{3,12} = 104.915$ $P < 0.001$	0.580 [0.523, 0.637] (*a*)	0.442 [0.385, 0.500] (*b*)	0.520 [0.463, 0.577] (*ab*)	1.040 [0.983, 1.097] (*c*)
Km	$F_{3,12} = 161.506$ $P < 0.001$	0.398 [0.361, 0.435]	0.332 [0.296, 0.368]	0.390 [0.354, 0.426]	0.790 [0.754, 0.826]

		(*a*)	(*b*)	(*ab*)	(*c*)
pfJ	$F_{3,12}$ = 2.952 P = 0.076	4.842 [4.092, 5.593]	3.942 [3.192, 4.693]	4.667 [3.917, 5.418]	5.375 [4.624, 6.1254]
Mp	$F_{3,12}$ = 2.616 P = 0.099	0.337 [0.259, 0.415]	0.287 [0.209, 0.364]	0.370 [0.292, 0.448]	0.424 [0.346, 0.502]
Mg	$F_{3,12}$ = 0.148 P = 0.929	0.226 [0.159, 0.293]	0.233 [0.167, 0.300]	0.220 [0.153, 0.287]	0.206 [0.139, 0.273]
f_T	$F_{3,1\ 2}$ = 1.038 P = 0.411	0.655 [0.595, 0.714]	0.641 [0.581, 0.700]	0.679 [0.619, 0.738]	0.704 [0.644, 0.763]

Table S6. Summary of GLS models using common cuckoo and their hosts (in Asia), related to Figures 4 and 5, and STAR Methods. Common cuckoo (*C. canorus*), and their large (azure-winged magpie *C. cyanus*) and small (vinous-throated parrotbil *S. webbiana* and Daurian redstart *P. auroreus*) hosts as the egg groups. Values indicate the mean and associated 95% confidence interval (in square brackets). Letters in parenthesis indicate significant differences between the means of groups ($P \leq 0.05$).

Variable	GLS model	Asian common cuckoo	Large hosts	Small hosts
Rel. $Shell_{vol}$	$F_{2,17}$ = 85.672 P < 0.001	6.071 [2.652, 9.490] (*a*)	-7.131 [-11.966, -2.296] (*b*)	0.259 [-3.160, 3.678] (*c*)
Rel. PL_{vol}	$F_{2,17}$ = 86.888 P < 0.001	10.183 [8.162, 12.205] (*a*)	-4.730 [-7.589, -1.871] (*b*)	0.616 [-1.405, 2.638] (*c*)
Rel. ML_{vol}	$F_{2,17}$ = *2.467* P = 0.114	-3.656 [-5.942, -1.371]	-1.975 [-5.206, 1.257]	-0.260 [-2.546, 2.024]
PL ratio	$F_{2,17}$ = 32.989 P < 0.001	79.651 [77.735, 81.567] (*a*)	73.787 [71.078, 76.496] (*b*)	69.237 [67.322, 71.153] (*c*)
Rel. PL_{shell}	$F_{2,17}$ = 17.306 P < 0.001	6.823 [5.035, 8.611] (*a*)	0.476 [-2.052, 3.005] (*b*)	0.341 [-1.447, 2.129] (*b*)
Rel. ML_{shell}	$F_{2,17}$ = 15.638 P < 0.001	-6.647 [-8.474, -4.820] (*a*)	-0.485 [-3.069, 2.098] (*b*)	-0.351 [-2.178, 1.476] (*b*)
MC density	$F_{3,21}$ = 38.713 P < 0.001	29.849 [27.311, 32.388] (*a*)	14.606 [9.971, 19.240] (*b*)	21.037 [18.617, 23.458] (*c*)

Rel. MC	$F_{3,21}$ = 31.223 P < 0.001	1640 [1504, 1774] (*a*)	917 [671, 1163] (*b*)	880 [751, 1008] (*b*)
Rel. LAB	$F_{2,17}$ = 2.005 P = 0.165	2.477 [1.781, 3.173]	1.334 [0.3497, 2.318]	2.071 [1.376, 2.767]
Rel. HAB	$F_{2,17}$= 19.503 P<0.001	9.035 [7.995, 10.074] (*a*)	5.333 [3.864, 6.803] (*b*)	4.944 [3.904, 5.983] (*b*)
Rel. TAB	$F_{2,17}$ = 12.068 P < 0.001	11.512 [9.975, 13.049] (*a*)	6.667 [4.493, 8.841] (*b*)	7.015 [5.478, 8.552] (*b*)
Rel. CED	$F_{2,17}$ = 6.604 P = 0.007	0.273 [0.251, 0.295] (*a*)	0.286 [0.255, 0.317] (*ab*)	0.328 [0.306, 0.350] (*b*)
$\bar{E}$	$F_{2,17}$ = 2.732 P = 0.094	0.575 [0.542, 0.608]	0.619 [0.572, 0.666]	0.556 [0.523, 0.589]
$K\mu$	$F_{2,17}$ = 2.180 P = 0.143	0.511 [0.349, 0.673]	0.527 [0.298, 0.756]	0.755 [0.593, 0.917]
Km	$F_{2,17}$ = 2.334 P = 0.127	0.365 [0.309, 0.420]	0.333 [0.254, 0.411]	0.398 [0.343, 0.454]
pfJ	$F_{2,17}$ = 0.793	4.393	5.080	5.195

	P = 0.468	[3.266, 5.519]	[3.487, 6.673]	[4.069, 6.321]
Mp	$F_{2,17}$ = 0.492 P = 0.619	0.312 [0.245, 0.379]	0.329 [0.235, 0.424]	0.356 [0.289, 0.423]
Mg	$F_{3,12}$ = 8.981 P=0.002	0.230 [0.191, 0.269] (*a*)	0.295 [0.240, 0.351] (*a*)	0.163 [0.123, 0.202] (*b*)
f_T	$F_{2,17}$ = 2.096 P = 0.154	0.648 [0.595, 0.700]	0.623 [0.549, 0.696]	0.578 [0.525, 0.629]

Table S7. Summary of GLS model using common cuckoo and their hosts (in Europe), related to Figures 4 and 5, and STAR Methods. Common cuckoo (*C. canorus*), and their warbler (great reed warbler *A. arundinaceus* and common reed warbler *A. scirpaceus*) and small (white wagtail *M. alba* and dunnock *P. modularis*) hosts as the egg groups (in Europe). Values indicate the mean and associated 95% confidence interval (in square brackets). Letters in parenthesis indicate significant differences between the means of groups ($P \leq 0.05$).

Variable	**GLS model**	**European common cuckoo**	**Warbler spp.**	**Small hosts**
Rel. $Shell_{vol}$	$F_{2.17}$ = 28.576 P < 0.001	6.070 [3.351, 8.789] (*a*)	-7.127 [-9.050, -5.205] (*b*)	-7.506 [-9.428, -5.584] (*b*)
Rel. PL_{vol}	$F_{2.17}$ = 121.366 P < 0.001	10.182 [7.677, 12.687] (*a*)	-5.465 [-7.236, -3.694] (*b*)	-8.259 [-10.030, -6.488] (*c*)
Rel. ML_{vol}	$F_{2.17}$ = 11.613 P < 0.001	-3.657 [-5.454, -1.859] (*a*)	-1.668 [-2.939, -0.398] (*b*)	1.086 [-0.184, 2.357] (*c*)
PL ratio	$F_{2.17}$ = 27.080 P < 0.001	73.332 [70.971, 75.692] (*a*)	69.496 [67.827, 71.165] (*b*)	65.045 [63.377, 66.714] (*c*)
Rel. PL_{shell}	$F_{2.17}$ = 7.269 P = 0.005	1.283 [-0.487, 3.053] (*a*)	0.108 [-1.143, 1.360] (*a*)	-2.286 [-3.538, -1.035] (*b*)
Rel. ML_{shell}	$F_{2.17}$ = 9.532 P = 0.002	-1.157 [-2.848, 0.535] (*a*)	-0.298 [-1.494, 0.898] (*a*)	2.547 [1.351, 3.74] (*b*)
MC density	$F_{3,40}$ = 25.461 P < 0.001	28.851 [27.101, 30.601]	21.374 [19.684, 23.065]	21.275 [19.525, 23.025]

		(*a*)	(*b*)	(*b*)
Rel. MC	$F_{3,40} = 44.522$	1495	1046	992
	$P < 0.001$	[1411, 1579]	[965, 1127]	[908, 1075]
		(*a*)	(*b*)	(*b*)
Rel. LAB	$F_{2.17} = 1.588$	2.585	1.918	1.842
	$P = 0.233$	[1.833, 3.336]	[1.387, 2.450]	[1.310, 2.373]
Rel. HAB	$F_{2.17} = 24.645$	9.126	4.337	3.885
	$P < 0.001$	[7.771, 10.481]	[3.379, 5.295]	[2.927, 4.844]
		(*a*)	(*b*)	(*b*)
Rel. TAB	$F_{2.17} = 66.787$	11.711	6.310	5.727
	$P < 0.001$	[10.019, 13.403]	[5.113, 7.507]	[4.531, 6.924]
		(*a*)	(*b*)	(*b*)
Rel. CED	$F_{2.17} = 1.184$	0.328	0.350	0.361
	$P = 0.330$	[0.273, 0.382]	[0.312, 0.389]	[0.322, 0.399]
$\bar{E}$	$F_{2.17} = 3.734$	0.590	0.557	0.517
	$P = 0.046$	[0.532, 0.647]	[0.517, 0.598]	[0.476, 0.558]
		(*a*)	(*ab*)	(*b*)
$K\mu$	$F_{2.17} = 81.425$	0.520	0.755	0.940
	$P < 0.001$	[0.346, 0.694]	[0.632, 0.878]	[0.817, 1.063]
		(*a*)	(*b*)	(*b*)
Km	$F_{2.17} = 137.212$	0.390	0.463	0.600
	$P < 0.001$	[0.301, 0.479]	[0.399, 0.525]	[0.537, 0.663]
		(*a*)	(*a*)	(*b*)

pfJ	$F_{2,17}$ = 4.697 *P* = 0.023	4.667 [3.517, 5.818] (*a*)	6.045 [5.231, 6.86] (*ab*)	5.928 [5.115, 6.742] (*b*)
Mp	$F_{2,17}$ = 0.162 *P* = 0.852	0.370 [0.282, 0.459]	0.385 [0.322, 0.448]	0.399 [0.336, 0.462]
Mg	$F_{2,17}$ = 3.699 *P* = 0.046	0.220 [0.122, 0.318] (*a*)	0.279 [0.210, 0.349] (*ab*)	0.352 [0.283, 0.421] (*b*)
f_T	$F_{2,17}$ = 1.888 *P* = 0.182	0.679 [0.586, 0.772]	0.626 [0.561, 0.692]	0.577 [0.512, 0.645]

Table S8. Summary of GLS model using Indian cuckoo and their hosts (in Asia), related to Figures 4 and 5, and STAR Methods. Indian cuckoo (*C. micropterus*), and their large (azure-winged magpie *C. cyanus*) and small (Japanese tit *P. minor* and varied tit *S. varius*) hosts as the egg groups. Values indicate the mean and associated 95% confidence interval (in square brackets). Letters in parenthesis indicate significant differences between the means of groups ($P \leq 0.05$).

Variable	GLS model	Indian cuckoo	Large hosts	Small hosts
Rel. $Shell_{vol}$	$F_{2,13} = 53.918$ $P < 0.001$	10.749 [5.432, 16.066] (*a*)	-7.131 [-12.448, -1.814] (*b*)	4.375 [0.615, 8.135] (*c*)
Rel. PL_{vol}	$F_{2,13} = 41.832$ $P < 0.001$	13.217 [10.219, 16.216] (*a*)	-4.730 [-7.729, -1.732] (*b*)	3.913 [1.793, 6.033] (*c*)
Rel. ML_{vol}	$F_{2,13} = 1.165$ $P = 0.343$	-1.643 [-4.071, 0.784]	-1.974 [-1.974, 0.454]	-0.109 [-1.826, 1.607]
PL ratio	$F_{2,13} = 14.521$ $P < 0.001$	77.149 [74.751, 79.547] (*a*)	73.787 [71.389, 76.185] (*a*)	69.979 [68.283, 71.674] (*b*)
Rel. PL_{shell}	$F_{2,13} = 8.571$ $P = 0.004$	4.098 [1.718, 6.479] (*a*)	0.476 [-1.904, 2.857] (*b*)	0.297 [-1.386, 1.980] (*b*)
Rel. ML_{shell}	$F_{2,13} = 12.244$ $P = 0.001$	-3.737 [-5.461, -2.012] (*a*)	-0.485 [-2.209, 1.239] (*b*)	-0.981 [-2.201, 0.238] (*b*)
MC density	$F_{3,40} = 43.170$	27.275	14.606	23.634

	$P < 0.001$	[25.571, 28.980]	[12.195, 17.016]	[22.056, 25.211]
		(*a*)	(*b*)	(*c*)
Rel. MC	$F_{3,40} = 58.341$	1559	917	982
	$P < 0.001$	[1472, 1644]	[795, 1039]	[903, 1062]
		(*a*)	(*b*)	(*b*)
Rel. LAB	$F_{2,13} = 26.937$	3.943	1.333	0.734
	$P < 0.001$	[3.356, 4.532]	[0.746, 1.921]	[0.318, 1.149]
		(*a*)	(*b*)	(*b*)
Rel. HAB	$F_{2,13} = 23.143$	7.426	5.333	3.364
	$P < 0.001$	[6.247, 8.606]	[4.154, 6.513]	[2.530, 4.198]
		(*a*)	(*b*)	(*c*)
Rel. TAB	$F_{2,13} = 79.439$	11.370	6.667	4.098
	P < 0.001	[10.352, 12.388]	[5.649, 7.685]	[3.378, 4.818]
		(*a*)	(*b*)	(*c*)
Rel. CED	$F_{2,13} = 8.617$	0.270	0.286	0.392
	$P < 0.001$	[0.205, 0.334]	[0.221, 0.351]	[0.346, 0.438]
		(*a*)	(*a*)	(*b*)
$\bar{E}$	$F_{2,13} = 3.987$	0.592	0.619	0.518
	$P = 0.045$	[0.517, 0.667]	[0.544, 0.694]	[0.465, 0.571]
		(*ab*)	(*a*)	(*b*)
$K\mu$	$F_{2,13} = 44.094$	1.040	0.527	0.717
	$P < 0.001$	[0.955, 1.125]	[0.442, 0.612]	[0.657, 0.777]
		(*a*)	(*b*)	(*c*)
Km	$F_{2,13} = 662.245$	0.790	0.332	0.311
	$P < 0.001$	[0.765, 0.814]	[0.308, 0.357]	[0.294, 0.328]

		(*a*)	(*b*)	(*b*)
pfJ	$F_{2,13}$ = 0.851 *P* = 0.450	5.375 [3.768, 6.982]	5.080 [3.473, 6.687]	6.175 [5.039, 7.311]
Mp	$F_{2,13}$ = 1.798 *P* = 0.204	0.424 [0.329, 0.519]	0.329 [0.235, 0.424]	0.426 [0.359, 0.493]
Mg	$F_{2,13}$ = 9.565 *P* = 0.003	0.206 [0.085, 0.327] (*a*)	0.296 [0.175, 0.417] (*a*)	0.487 [0.402, 0.573] (*b*)
f_T	$F_{2,13}$ = 2.183 *P* = 0.152	0.704 [0.558, 0.849]	0.623 [0.477, 0.768]	0.535 [0.432, 0.638]

Refereces

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