**Supplementary Materials from "*Using natural history collections to investigate changes in pangolin (Pholidota: Manidae) geographic ranges through time.*"**

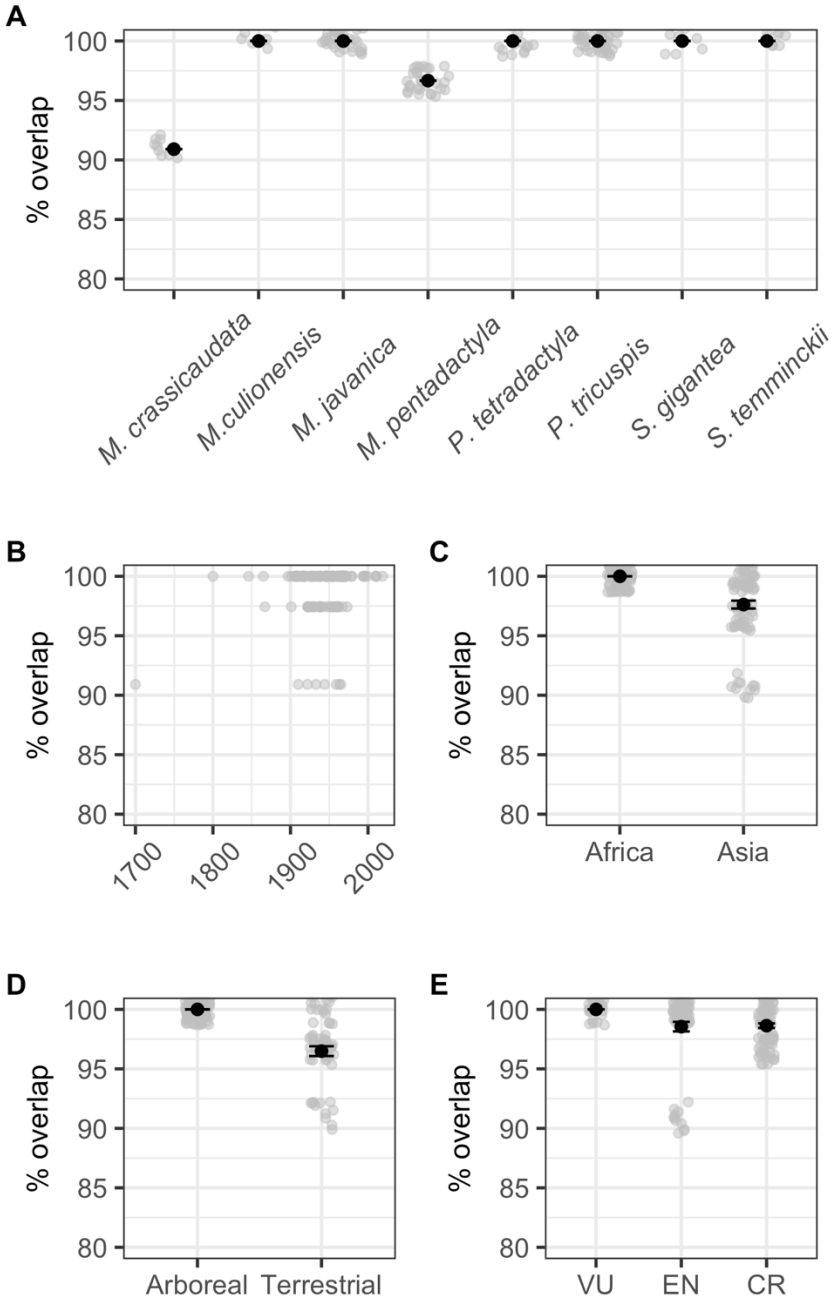


*Figure S1: Correlates of percentage locality overlaps for each species, for specimens with certainty scores ≥ 50%, extents < 50km and excluding duplicates. (A) Species. (B) Collection year. (C) Continent. (D) Ecology. (E) IUCN Red List status. Black points are means, error bars are standard errors, grey points are the raw data.*

*Table S1: Specimens excluded from our analyses after georeferencing. We excluded zoo animals, specimens recorded from ports rather than collection localities, and specimens with localities more than 100km from the current species range and not unambiguously within the range of another closely related species. This does not include specimens with extents > 1000km as these are automatically removed from the analyses.*

| Specimen | Species | Justification |
|---|---|---|
| NHMUK_27.12.1.203 | *Manis crassicaudata* | Outside of current range but inside the range of *M.pentadactyla* and *M.javanica*. Unclear if this is a taxonomic error. |
| NHMUK_76.139 | *Manis crassicaudata* | Zoo animal (Sri Lanka) |
| MCZ_38282 | *Manis javanica* | Outside of current range but inside the range of *M.pentadactyla*. Unclear if this is a taxonomic error or range shift. |
| NHMUK_98.10.5.48 | *Manis javanica* | Zoo animal (Thailand) |
| MHNG_MHNG-MAM-1183.049 | *Manis javanica* | Tanjung Gelang is the port so likely a shipping location. |
| PSM_Mammal-09256 | *Manis pentadactyla* | Zoo animal (Honduras) |
| ISU_431 | *Manis pentadactyla* | Zoo animal (Bloomington, USA) |
| UMMZ_113318 | *Manis pentadactyla* | Zoo animal (Detroit, USA) |
| UMMZ_113316 | *Manis pentadactyla* | Zoo animal (Detroit, USA) |
| UMMZ_113317 | *Manis pentadactyla* | Zoo animal (Detroit, USA) |
| NHMUK_32.3.3.9 | *Manis pentadactyla* | Zoo animal (India) |
| NHMUK_12.12.3.3 | *Phataginus tricuspis* | Lindi is a port on the coast of Tanzania outside of the species range. |

| | | |
|---|---|---|
| NHMUK_no reg 9 | *Phataginus tricuspis* | Mombasa is a port on the coast of Kenya outside of the species range. |
| NHMUK_87.12.1.103 | *Phataginus tricuspis* | Locality is Sudan, but no current pangolin ranges do not go this far north. |
| NHMUK_7.12.1.102 | *Phataginus tricuspis* | Locality is Sudan, but no current pangolin ranges do not go this far north. |
| BOUM_11.Man.1 | *Phataginus tricuspis* | This genus is not found in southern Africa, so locality or taxonomy must be incorrect. |
| MVZ_MVZ:Mamm:4829 | *Phataginus tricuspis* | This genus is not found in southern Africa, so locality or taxonomy must be incorrect. |
| AMNH_M-216259 | *Phataginus tricuspis* | This genus is not found in southern Africa, so locality or taxonomy must be incorrect. |
| SUI_18440 | *Phataginus tricuspis* | This genus is not found in southern Africa, so locality or taxonomy must be incorrect. |
| O_18156 | *Phataginus tricuspis* | This genus is not found in southern Africa, so locality or taxonomy must be incorrect. |
| GNM_Ma ex 1292 | *Phataginus tricuspis* | This genus is not found in southern Africa, so locality or taxonomy must be incorrect. |
| GNM_CollAn 7491 | *Phataginus tricuspis* | This genus is not found in southern Africa, so locality or taxonomy must be incorrect. |
| MNHN_MO-1869-43 | *Phataginus tricuspis* | Zoo animal (Gold Coast, Australia) |
| UMMZ_156537 | *Phataginus tricuspis* | This genus is not found in Asia, so locality or taxonomy must be incorrect. |
| MNHN_MO-1899-647 | *Phataginus tricuspis* | This genus is not found in Asia, so locality or taxonomy must be incorrect. |

*Table S2: Specimen records modified after georeferencing. There are two types of edit;* ***Taxonomy****, where we corrected the taxonomy of specimens with localities more than 100km from the current species range and unambiguously within the range of another closely related species; and* ***Coordinates****, where we corrected incorrect GBIF coordinates. This does not include specimens with extents > 1000km as these are automatically removed from the analyses.*

| Specimen | Species | Edit | Justification |
|---|---|---|---|
| RBINS_301B | *Manis crassicaudata* | Taxonomy | Recorded in GBIF as *M. pentadactyla* but this species does not occur in Sri Lanka so must be *M. crassicaudata.* |
| ROM_2603230109 | *Manis crassicaudata* | Taxonomy | Recorded in GBIF as *M. pentadactyla* but this species does not occur in India so must be *M. crassicaudata.* |
| NHMUK_77.3.14.8 | *Manis crassicaudata* | Taxonomy | Recorded in GBIF as *M. pentadactyla* but this species does not occur in Sri Lanka so must be *M. crassicaudata.* |
| NHMUK_91.1.31.1 | *Manis crassicaudata* | Taxonomy | Recorded in GBIF as *M. pentadactyla* but this species does not occur in India so must be *M. crassicaudata.* |

| | | | |
|---|---|---|---|
| FMNH_62918 | *Manis culionensis* | Coordinates | GBIF coordinates are in the ocean. |
| AMNH_M-242095 | *Manis culionensis* | Coordinates | GBIF coordinates are in the ocean. |
| KU_165510 | *Manis culionensis* | Coordinates | GBIF coordinates were for the wrong locality. |
| FMNH_62921 | *Manis culionensis* | Coordinates | GBIF coordinates were for the wrong locality. |
| MZLU_L897/3277 | *Manis javanica* | Taxonomy | Recorded in GBIF as *M. pentadactyla* but this species does not occur in Indonesia so must be *M. javanica.* |
| AMNH_M-102180 | *Manis javanica* | Coordinates | GBIF coordinates were for the wrong locality. |
| NHMUK_22.12.17.248 | *Smutsia gigantea* | Taxonomy | Recorded in GBIF as *S.temminckii* but this species does not occur in West Africa so must be *S.gigantea* |
| MNHN_AC-VI-253 | *Smutsia gigantea* | Taxonomy | Recorded in GBIF as *S.temminckii* but this species does not occur in West Africa so must be *S.gigantea* |

| | | | |
|---|---|---|---|
| MHNG_MHNG-MAM-601.080 | *Smutsia gigantea* | Taxonomy | Recorded in GBIF as *S.temminckii* but this species does not occur in West Africa so must be *S.gigantea* |
| MHNG_MHNG-MAM-601.074 | *Smutsia gigantea* | Taxonomy | Recorded in GBIF as *S.temminckii* but this species does not occur in West Africa so must be *S.gigantea* |
| O_18155 | *Smutsia gigantea* | Taxonomy | Recorded in GBIF as *S.temminckii* but this species does not occur in West Africa so must be *S.gigantea* |

*Table S3: Percentage locality overlaps and mean percentage area overlaps for various subdivisions of the data.* ***All data*** *includes all specimens except those with certainty scores of zero.* ***High quality data*** *includes only specimens with certainty scores ≥ 50% and extents < 50km.* ***No duplicates data*** *excludes duplicates, i.e. multiple specimens of the same species collected at exactly the same locality.*

| ***All data (n = 676)*** | | | | |
|---|---|---|---|---|
| **Species** | **Number specimens** | **% locality overlaps** | **Mean % area overlap** | **SE % area overlap** |
| *Manis crassicaudata* | 23 | 65.22 | 16.85 | 5.11 |
| *Manis culionensis* | 11 | 90.91 | 11.10 | 2.66 |
| *Manis javanica* | 150 | 58.00 | 12.92 | 1.53 |
| *Manis pentadactyla* | 136 | 53.68 | 10.98 | 1.79 |
| *Phataginus tetradactyla* | 50 | 64.00 | 27.87 | 4.90 |
| *Phataginus tricuspis* | 239 | 67.36 | 31.36 | 2.27 |
| *Smutsia gigantea* | 34 | 50.00 | 17.50 | 5.33 |
| *Smutsia temminckii* | 33 | 42.42 | 28.56 | 6.54 |
| **Continent** | **Number specimens** | **% locality overlap** | **Mean % area overlap** | **SE % area overlap** |
| Africa | 359 | 66.40 | 29.04 | 1.84 |
| Asia | 317 | 56.25 | 12.43 | 1.12 |
| **Ecology** | **Number specimens** | **% locality overlap** | **Mean % area overlap** | **SE % area overlap** |
| Arboreal/semi-arboreal | 450 | 64.73 | 24.33 | 1.47 |
| Terrestrial | 226 | 53.19 | 15.13 | 1.76 |

| IUCN Red List status | Number specimens | % locality overlap | Mean % area overlap | SE % area overlap |
|---|---|---|---|---|
| VU | 83 | 57.45 | 28.14 | 3.91 |
| EN | 296 | 67.00 | 28.64 | 1.99 |
| CR | 297 | 56.15 | 11.97 | 1.13 |
| ***No duplicates (n = 362)*** | | | | |
| **Species** | **Number specimens** | **% locality overlap** | **Mean % area overlap** | **SE % area overlap** |
| *Manis crassicaudata* | 18 | 66.67 | 18.53 | 6.33 |
| *Manis culionensis* | 8 | 87.50 | 9.98 | 3.02 |
| *Manis javanica* | 79 | 65.82 | 15.77 | 2.63 |
| *Manis pentadactyla* | 59 | 59.32 | 15.35 | 3.66 |
| *Phataginus tetradactyla* | 33 | 75.76 | 33.96 | 6.07 |
| *Phataginus tricuspis* | 114 | 72.81 | 38.25 | 3.52 |
| *Smutsia gigantea* | 26 | 57.69 | 18.51 | 5.98 |
| *Smutsia temminckii* | 25 | 48.00 | 30.60 | 7.37 |
| **Continent** | **Number specimens** | **% locality overlap** | **Mean % area overlap** | **SE % area overlap** |
| Africa | 199 | 71.32 | 33.81 | 2.59 |
| Asia | 163 | 63.73 | 15.73 | 1.96 |
| **Ecology** | **Number specimens** | **% locality overlap** | **Mean % area overlap** | **SE % area overlap** |
| Arboreal/semi-arboreal | 234 | 70.87 | 29.09 | 2.22 |
| Terrestrial | 128 | 58.19 | 19.42 | 2.70 |

| IUCN Red List status | Number specimens | % locality overlap | Mean % area overlap | SE % area overlap |
|---|---|---|---|---|
| VU | 58 | 65.64 | 32.51 | 4.66 |
| EN | 158 | 71.93 | 32.76 | 2.89 |
| CR | 146 | 63.65 | 15.28 | 2.05 |
| ***High quality data (n = 269)*** | | | | |
| **Species** | **Number specimens** | **% locality overlap** | **Mean % area overlap** | **SE % area overlap** |
| *Manis crassicaudata* | 12 | 91.67 | 24.80 | 8.81 |
| *Manis culionensis* | 9 | 100.0 | 12.10 | 2.99 |
| *Manis javanica* | 48 | 100.0 | 25.14 | 3.36 |
| *Manis pentadactyla* | 68 | 98.53 | 20.33 | 2.95 |
| *Phataginus tetradactyla* | 17 | 100.0 | 40.91 | 8.64 |
| *Phataginus tricuspis* | 97 | 100.0 | 47.67 | 3.05 |
| *Smutsia gigantea* | 11 | 100.0 | 45.72 | 12.27 |
| *Smutsia temminckii* | 7 | 100.0 | 62.00 | 5.10 |
| **Continent** | **Number specimens** | **% locality overlap** | **Mean % area overlap** | **SE % area overlap** |
| Africa | 132 | 100.0 | 47.40 | 2.71 |
| Asia | 137 | 98.88 | 21.87 | 2.04 |
| **Ecology** | **Number specimens** | **% locality overlap** | **Mean % area overlap** | **SE % area overlap** |
| Arboreal/semi-arboreal | 171 | 100.0 | 38.80 | 2.32 |
| Terrestrial | 98 | 98.38 | 26.70 | 2.95 |

| IUCN Red List status | Number specimens | % locality overlap | Mean % area overlap | SE % area overlap |
|---|---|---|---|---|
| VU | 24 | 100.0 | 47.06 | 6.54 |
| EN | 120 | 99.88 | 45.20 | 2.88 |
| CR | 125 | 99.03 | 21.58 | 2.08 |
| ***No duplicates, high quality data (n = 162)*** | | | | |
| **Species** | **Number specimens** | **% locality overlap** | **Mean % area overlap** | **SE % area overlap** |
| *Manis crassicaudata* | 11 | 90.91 | 26.81 | 940 |
| *Manis culionensis* | 6 | 100.0 | 11.11 | 3.63 |
| *Manis javanica* | 37 | 100.0 | 26.14 | 4.33 |
| *Manis pentadactyla* | 30 | 96.67 | 26.47 | 6.01 |
| *Phataginus tetradactyla* | 13 | 100.0 | 43.37 | 9.72 |
| *Phataginus tricuspis* | 49 | 100.0 | 54.11 | 4.36 |
| *Smutsia gigantea* | 9 | 100.0 | 43.23 | 13.19 |
| *Smutsia temminckii* | 7 | 100.0 | 62.00 | 5.10 |
| **Continent** | **Number specimens** | **% locality overlap** | **Mean % area overlap** | **SE % area overlap** |
| Africa | 78 | 100.0 | 51.77 | 3.55 |
| Asia | 84 | 98.31 | 25.27 | 3.12 |
| **Ecology** | **Number specimens** | **% locality overlap** | **Mean % area overlap** | **SE % area overlap** |
| Arboreal/semi-arboreal | 105 | 100.00 | 40.47 | 3.13 |
| Terrestrial | 57 | 96.44 | 33.54 | 4.45 |

| IUCN Red List status | Number specimens | % locality overlap | Mean % area overlap | SE % area overlap |
|---|---|---|---|---|
| VU | 20 | 100.0 | 49.89 | 6.77 |
| EN | 69 | 99.58 | 94.76 | 3.97 |
| CR | 73 | 98.70 | 25.04 | 3.32 |

*Table S4: Results of beta regression models investigating correlates between percentage area overlaps for each specimen, and collection year; continent; ecology, IUCN Red List status and species. The analyses use specimens with certainty scores ≥ 50%, extents < 50km and excluding duplicates and specimen MVZ_MVZ:Mamm:125554 (n = 161). Type refers to whether the best fitting model was one with fixed or variable precision (ϕ) for each group, and the reported ϕ values are those for the best fitting model, i.e. overall ϕ for fixed and ϕ for each group for variable ϕ models.*

| predictor/group | type | mean | se | z | p | ϕ | ϕ se | ϕ z | ϕ p | pseudo $r^2$ |
|---|---|---|---|---|---|---|---|---|---|---|
| **Species** | | | | | | | | | | |
| *Manis crassicaudata* | fixed | -0.737 | 0.354 | -2.083 | 0.037 | 1.512 | 0.141 | 10.71 | <0.001 | 0.148 |
| *Manis culionesis* | | -0.466 | 0.585 | -0.797 | 0.426 | | | | | |
| *Manis javanica* | | 0.163 | 0.401 | 0.406 | 0.685 | | | | | |
| *Manis pentadactyla* | | 0.116 | 0.412 | 0.282 | 0.778 | | | | | |
| *Phataginus tetradactyla* | | 0.827 | 0.482 | 1.715 | 0.086 | | | | | |
| *Phataginus tricuspis* | | 1.065 | 0.394 | 2.705 | 0.007 | | | | | |
| *Smutsia gigantea* | | 0.887 | 0.530 | 1.675 | 0.094 | | | | | |
| *Smutsia temminckii* | | 1.008 | 0.570 | 1.769 | 0.077 | | | | | |
| **Year** | fixed | 0.008 | 0.004 | 2.905 | 0.004 | 1.389 | 0.133 | 10.45 | <0.001 | 0.058 |
| **Continent** | | | | | | | | | | |
| Africa | variable | 0.258 | 0.136 | 1.897 | 0.058 | 0.375 | 0.131 | 2.866 | 0.004 | 0.134 |
| Asia | | -0.926 | 0.192 | -4.817 | <0.001 | 0.052 | 0.186 | 0.279 | 0.780 | |
| **Ecology** | | | | | | | | | | |
| Arboreal/semi-arboreal | variable | -0.116 | 0.118 | -0.984 | 0.325 | 0.320 | 0.111 | 2.877 | 0.004 | 0.013 |
| Terrestrial | | -0.253 | 0.204 | -1.238 | 0.216 | -0.144 | 0.188 | -0.765 | 0.444 | |
| **IUCN** | | | | | | | | | | |
| VU | variable | 0.159 | 0.262 | 0.606 | 0.545 | 0.463 | 0.260 | 1.784 | 0.075 | 0.070 |
| EN | | -0.0387 | 0.300 | -0.126 | 0.900 | -0.187 | 0.293 | -0.638 | 0.523 | |
| CR | | -0.810 | 0.300 | -2.703 | 0.007 | -0.049 | 0.296 | -0.167 | 0.868 | |

*Table S5: Results of beta regression models investigating correlations between percentage area overlaps for each specimen, and changes in human population size or land-use since 1850, 1900 or 1950. Human population size variables are log population count (popc) and log population density (popd). Land-use types are forested primary land (primf), non-forested primary land (primn) and urban land (urban). The analyses use specimens with certainty scores ≥ 50%, extents < 50km and excluding duplicates and specimen MVZ_MVZ:Mamm:125554 (n = 161). Type refers to whether the best fitting model was one with fixed or variable precision (ϕ) and the reported ϕ values are those for the best fitting model.*

| predictor/ time bin | type | mean | se | z | p | ϕ | ϕ se | ϕ z | ϕ p | pseudo $r^2$ |
|---|---|---|---|---|---|---|---|---|---|---|
| **popc** | | | | | | | | | | |
| 1850 | variable | -0.075 | 0.035 | -2.118 | 0.034 | 0.051 | 0.032 | 1.570 | 0.116 | 0.027 |
| 1900 | variable | -0.074 | 0.035 | -2.109 | 0.035 | 0.050 | 0.032 | 1.561 | 0.119 | 0.028 |
| 1950 | variable | -0.070 | 0.036 | -1.940 | 0.052 | 0.051 | 0.033 | 1.543 | 0.123 | 0.021 |
| **popd** | | | | | | | | | | |
| 1850 | variable | -0.0094 | 0.040 | -2.363 | 0.018 | 0.059 | 0.037 | 1.583 | 0.113 | 0.032 |
| 1900 | variable | -0.094 | 0.040 | -2.350 | 0.029 | 0.059 | 0.037 | 1.577 | 0.115 | 0.032 |
| 1950 | variable | -0.091 | 0.041 | -2.227 | 0.026 | 0.059 | 0.038 | 1.556 | 0.120 | 0.028 |
| **primf** | | | | | | | | | | |
| 1850 | fixed | 1.261 | 0.124 | 0.363 | 0.716 | 1.368 | 0.125 | 10.96 | < 0.001 | 0.065 |
| 1900 | fixed | 1.349 | 0.123 | 2.815 | 0.005 | 1.352 | 0.123 | 11.00 | < 0.001 | 0.052 |
| 1950 | fixed | 1.681 | 0.763 | 2.202 | 0.028 | 1,327 | 0.120 | 11.06 | < 0.001 | 0.033 |
| **primnc** | | | | | | | | | | |
| 1850 | fixed | -0.122 | 0.533 | -0.228 | 0.820 | 1.287 | 0.115 | 11.15 | <0.01 | <0.001 |
| 1900 | fixed | -0.109 | 0.553 | -0.197 | 0.844 | 1.287 | 0.115 | 11.15 | < 0.001 | <0.001 |
| 1950 | variable | 0.216 | 0.663 | 0.326 | 0.745 | -1.605 | 0.743 | -2.161 | 0.031 | <0.001 |
| **urban** | | | | | | | | | | |
| 1850 | variable | -0.309 | 0.815 | -0.380 | 0.704 | -0.644 | 0.706 | -0.911 | 0.362 | <0.001 |
| 1900 | variable | -0.470 | 0.945 | -0.497 | 0.619 | -0.707 | 0.826 | -0.856 | 0.392 | 0.001 |
| 1950 | variable | -0.864 | 1.300 | -0.664 | 0.506 | -0.745 | 1.160 | -0.642 | 0.521 | 0.002 |