****

**Figure S1.** Correlation analysis between the pairwise *F*ST*/*(1*–F*ST) values and the geographic distance based on mtDNA *COI* **s**equences: for (a) Clade I, Zaisan populations; (b) Clade II, Dzungar populations; (c) all data.



**Figure S2.** The Jackknife analysis of regularized training gain from retained environmental variables that highly contributed to the distribution model.

**Table S1. List of analyzed specimens, geographical origin, clade assignment and GenBank accession number.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Site number** | **Voucher****number** | **Haplotype number** | **Locality** **(Lat./Long.)** | **Clade/****Subclade** | **GenBank****accession number** |
| Site 1 | Guo3161 | H6 | Ulungur (47.01/87.26) | IIc3 | MW856942 |
| Site 1 | Guo3168 | H6 | Ulungur (47.01/87.26) | IIc3 | MW856943 |
| Site 1 | Guo3169 | H12 | Ulungur (47.01/87.26) | IIc3 | MW856944 |
| Site 1 | Guo3170 | H6 | Ulungur (47.01/87.26) | IIc3 | MW856945 |
| Site 1 | Guo3171 | H13 | Ulungur (47.01/87.26) | IIc3 | MW856946 |
| Site 2 | GXG294 | H6 | Karamay (46.41/85.95) | IIc3 | MW857007 |
| Site 2 | GXG295 | H6 | Karamay (46.41/85.95) | IIc3 | MW857008 |
| Site 2 | GXG296 | H31 | Karamay (46.41/85.95) | IIc3 | MW857009 |
| Site 2 | GXG297 | H13 | Karamay (46.41/85.95) | IIc3 | MW857010 |
| Site 2 | GXG298 | H32 | Karamay (46.41/85.95) | IIc3 | MW857011 |
| Site 2 | GXG299 | H33 | Karamay (46.41/85.95) | IIc3 | MW857012 |
| Site 2 | GXG303 | H34 | Karamay (46.41/85.95) | IIc3 | MW857013 |
| Site 2 | GXG654 | H31 | Karamay (46.41/85.95) | IIc3 | MW857058 |
| Site 2 | GXG655 | H6 | Karamay (46.41/85.95) | IIc3 | MW857059 |
| Site 3 | Guo2320 | H6 | Karamay (45.13/85.05) | IIc3 | MW856928 |
| Site 3 | Guo2321 | H7 | Karamay (45.13/85.05) | IIc3 | MW856929 |
| Site 3 | Guo2322 | H6 | Karamay (45.13/85.05) | IIc3 | MW856930 |
| Site 3 | Guo2324 | H6 | Karamay (45.13/85.05) | IIc3 | MW856931 |
| Site 4 | GXG352 | H41 | Hoboksar (46.76/85.74) | IIc3 | MW857029 |
| Site 4 | GXG353  | H41 | Hoboksar (46.76/85.74) | IIc3 | MW857030 |
| Site 4 | GXG354 | H13 | Hoboksar (46.76/85.74) | IIc3 | MW857031 |
| Site 4 | GXG355 | H41 | Hoboksar (46.76/85.74) | IIc3 | MW857032 |
| Site 4 | GXG356 | H13 | Hoboksar (46.76/85.74) | IIc3 | MW857033 |
| Site 4 | GXG357 | H13 | Hoboksar (46.76/85.74) | IIc3 | MW857034 |
| Site 4 | GXG358 | H41 | Hoboksar (46.76/85.74) | IIc3 | MW857035 |
| Site 4 | GXG359 | H41 | Hoboksar (46.76/85.74) | IIc3 | MW857036 |
| Site 4 | GXG360 | H13 | Hoboksar (46.76/85.74) | IIc3 | MW857037 |
| Site 4 | GXG665 | H41 | Hoboksar (46.76/85.74) | IIc3 | MW857062 |
| Site 4 | GXG666 | H41 | Hoboksar (46.76/85.74) | IIc3 | MW857063 |
| Site 5 | GXG315 | H6 | Hoboksar (46.57/85.64) | IIc3 | MW857014 |
| Site 5 | GXG316 | H35 | Hoboksar (46.57/85.64) | IIc3 | MW85701 |
| Site 5 | GXG318 | H36 | Hoboksar (46.57/85.64) | IIc3 | MW857016 |
| Site 5 | GXG319 | H36 | Hoboksar (46.57/85.64) | IIc3 | MW857017 |
| Site 5 | GXG320 | H35 | Hoboksar (46.57/85.64) | IIc3 | MW857018 |
| Site 5 | GXG321 | H35 | Hoboksar (46.57/85.64) | IIc3 | MW857019 |
| Site 6 | GXG325  | H37 | Hoboksar (46.50/85.14) | IIc3 | MW857020 |
| Site 6 | GXG326 | H6 | Hoboksar (46.50/85.14) | IIc3 | MW857021 |
| Site 6 | GXG327 | H38 | Hoboksar (46.50/85.14) | IIc3 | MW857022 |
| Site 6 | GXG328 | H38 | Hoboksar (46.50/85.14) | IIc3 | MW857023 |
| Site 6 | GXG329 | H37 | Hoboksar (46.50/85.14) | IIc3 | MW857024 |
| Site 6 | GXG330  | H39 | Hoboksar (46.50/85.14) | IIc3 | MW857025 |
| Site 6 | GXG331 | H37 | Hoboksar (46.50/85.14) | IIc3 | MW857026 |
| Site 6 | GXG332 | H6 | Hoboksar (46.50/85.14) | IIc3 | MW857027 |
| Site 6 | GXG657 | H38 | Hoboksar (46.50/85.14) | IIc3 | MW857060 |
| Site 6 | GXG658 | H47 | Hoboksar (46.50/85.14) | IIc3 | MW857061 |
| Site 7 | GXG351 | H40 | Emin (46.20/84.53) | IIc1 | MW857028 |
| Site 8 | Guo2300 | H4 | Toli (45.88/84.49) | IIc3 | MW856984 |
| Site 8 | Guo2301 | H4 | Toli (45.88/84.49) | IIc3 | MW856926 |
| Site 8 | Guo2302 | H5 | Toli (45.88/84.49) | IIc3 | MW856927 |
| Site 9 | GXG293  | H4 | Toli (45.93/84.62) | IIc3 | MW857006 |
| Site 9 | GXG652 | H4 | Toli (45.93/84.62) | IIc3 | MW857057 |
| Site 10 | GXG572 | H6 | Fuyun (46.42/89.02) | IIc3 | MW857051 |
| Site 10 | GXG573 | H6 | Fuyun (46.42/89.02) | IIc3 | MW857052 |
| Site 10 | GXG574 | H6 | Fuyun (46.42/89.02) | IIc3 | MW857053 |
| Site 10 | GXG575 | H6 | Fuyun (46.42/89.02) | IIc3 | MW857054 |
| Site 10 | GXG710 | H6 | Fuyun (46.42/89.02) | IIc3 | MW857073 |
| Site 10 | GXG711 | H6 | Fuyun (46.42/89.02) | IIc3 | MW857074 |
| Site 11 | GXG379 | H6 | Jeminay (47.31/86.76) | IIc3 | MW857038 |
| Site 11 | GXG380 | H6 | Jeminay (47.31/86.76) | IIc3 | MW857039 |
| Site 11 | GXG381 | H42 | Jeminay (47.31/86.76) | IIc3 | MW857040 |
| Site 11 | GXG382 | H43 | Jeminay (47.31/86.76) | IIc3 | MW857041 |
| Site 11 | GXG383 | H44 | Jeminay (47.31/86.76) | IIc3 | MW857042 |
| Site 11 | GXG384 | H45 | Jeminay (47.31/86.76) | IIc3 | MW857043 |
| Site 11 | GXG385 | H38 | Jeminay (47.31/86.76) | IIc3 | MW857044 |
| Site 11 | GXG387 | H6 | Jeminay (47.31/86.76) | IIc3 | MW857045 |
| Site 11 | GXG390 | H46 | Jeminay (47.31/86.76) | IIc3 | MW857046 |
| Site 11 | GXG404 | H6 | Jeminay (47.31/86.76) | IIc3 | MW857047 |
| Site 11 | GXG681 | H6 | Jeminay (47.31/86.76) | IIc3 | MW857064 |
| Site 11 | GXG682 | H48 | Jeminay (47.31/86.76) | IIc3 | MW857065 |
| Site 11 | GXG683 | H6 | Jeminay (47.31/86.76) | IIc3 | MW857066 |
| Site 12 | Guo2208 | H1 | Shihezi (44.64/86.18) | IIc3 | MW856918 |
| Site 13 | Guo4240 | H16 | Fukang (44.95/88.43) | IIc2 | MW856953 |
| Site 13 | Guo4241 | H17 | Fukang (44.95/88.43) | IIc2 | MW856954 |
| Site 13 | Guo4242 | H18 | Fukang (44.95/88.43) | IIc2 | MW856955 |
| Site 13 | Guo4292 | H17 | Fukang (44.95/88.43) | IIc2 | MW856961 |
| Site 14 | Guo4300 | H21 | Fukang (44.53/88.28) | IIc2 | MW856962 |
| Site 14 | Guo4472 | H21 | Fukang (44.53/88.28) | IIc2 | MW856963 |
| Site 14 | Guo4473 | H17 | Fukang (44.53/88.28) | IIc2 | MW856964 |
| Site 15 | Guo4576 | H21 | Fukang (44.68/88.26) | IIc2 | MW856966 |
| Site 15 | Guo4577 | H21 | Fukang (44.68/88.26) | IIc2 | MW856967 |
| Site 16 | Guo4579 | H22 | Jimsar (44.51/88.82) | IIc2 | MW856968 |
| Site 16 | Guo4580 | H22 | Jimsar (44.51/88.82) | IIc2 | MW856969 |
| Site 16 | Guo4581 | H23 | Jimasar (44.51/88.82) | IIc2 | MW856970 |
| Site 16 | Guo4286 | H16 | Jimsar (44.51/88.82) | IIc2 | MW856960 |
| Site 17 | GXG255 | H27 | Ebinur (45.11/82.61) | IIc1 | MW856994 |
| Site 17 | GXG256 | H30 | Ebinur (45.11/82.61) | IIc1 | MW856995 |
| Site 18 | Guo7432 | H25 | Ebinur (44.77/82.87) | IIc1 | MW856978 |
| Site 19 | Guo6433 | H24 | Bortala (44.61/81.69) | IIc1 | MW856975 |
| Site 19 | Guo6434 | H24 | Bortala (44.61/81.69) | IIc1 | MW856976 |
| Site 19 | Guo7437 | H24 | Bortala (44.61/81.69) | IIc1 | MW856979 |
| Site 19 | Guo7438 | H24 | Bortala (44.61/81.69) | IIc1 | MW856980 |
| Site 19 | Guo7439 | H26 | Bortala (44.61/81.69) | IIc1 | MW856981 |
| Site 19 | Guo7440 | H24 | Bortala (44.61/81.69) | IIc1 | MW856982 |
| Site 19 | Guo7441 | H24 | Bortala (44.61/81.69) | IIc1 | MW856983 |
| Site 20 | GXG283 | H3 | Bortala (45.19/82.60) | IIc1 | MW857005 |
| Site 21 | Guo4087 | H14 | Kuytun (44.36/85.11) | IIc1 | MW856947 |
| Site 22 | GXG234  | H27 | Bole (44.92/81.69) | IIc1 | MW856985 |
| Site 22 | GXG235 | H28 | Bole (44.92/81.69) | IIc1 | MW856986 |
| Site 22 | GXG236 | H24 | Bole (44.92/81.69) | IIc1 | MW856987 |
| Site 22 | GXG237 | H28 | Bole (44.92/81.69) | IIc1 | MW856988 |
| Site 22 | GXG238 | H24 | Bole (44.92/81.69) | IIc1 | MW856989 |
| Site 22 | GXG239 | H24 | Bole (44.92/81.69) | IIc1 | MW856990 |
| Site 22 | GXG242 | H27 | Bole (44.92/81.69) | IIc1 | MW856991 |
| Site 22 | GXG244 | H24 | Bole (44.92/81.69) | IIc1 | MW856992 |
| Site 22 | GXG246  | H29 | Bole (44.92/81.69) | IIc1 | MW856993 |
| Site 22 | GXG635 | H27 | Bole (44.92/81.69) | IIc1 | MW857055 |
| Site 22 | GXG637 | H27 | Bole (44.92/81.69) | IIc1 | MW857056 |
| Site 23 | Guo4562 | H19 | Qitai (44.19/90.03) | IIa | MW856965 |
| Site 24 | Guo4258 | H2 | Qitai (44.54/90.02) | IIb | MW856956 |
| Site 24 | Guo4259 | H19 | Qitai (44.54/90.02) | IIa | MW856957 |
| Site 24 | Guo4260 | H20 | Qitai (44.54/90.02) | IIa | MW856958 |
| Site 24 | Guo4262 | H19 | Qitai (44.54/90.02) | IIa | MW856959 |
| Site 25 | GXG257 | H3 | Alashankou (45.25/82.62) | IIc1 | MW856996 |
| Site 25 | GXG258 | H3 | Alashankou (45.25/82.62) | IIc1 | MW856997 |
| Site 25 | GXG259 | H30 | Alashankou (45.25/82.62) | IIc1 | MW856998 |
| Site 25 | GXG260  | H27 | Alashankou (45.25/82.62) | IIc1 | MW856999 |
| Site 25 | GXG262 | H3 | Alashankou (45.25/82.62) | IIc1 | MW857000 |
| Site 25 | GXG263  | H3 | Alashankou (45.25/82.62) | IIc1 | MW857001 |
| Site 25 | GXG268 | H30 | Alashankou (45.25/82.62) | IIc1 | MW857002 |
| Site 25 | GXG270 | H3 | Alashankou (45.25/82.62) | IIc1 | MW857003 |
| Site 25 | GXG271 | H3 | Alashankou (45.25/82.62) | IIc1 | MW857004 |
| Site 26 | Guo2209 | H2 | Jinghe (44.54/82.65) | IIb | MW856919 |
| Site 26 | Guo2210 | H2 | Jinghe (44.54/82.65) | IIb | MW856920 |
| Site 26 | Guo2211 | H2 | Jinghe (44.54/82.65) | IIb | MW856921 |
| Site 26 | Guo2212 | H2 | Jinghe (44.54/82.65) | IIb | MW856922 |
| Site 26 | Guo2213 | H2 | Jinghe (44.54/82.65) | IIb | MW856923 |
| Site 26 | Guo2214 | H2 | Jinghe (44.54/82.65) | IIb | MW856924 |
| Site 26 | Guo4095 | H15 | Jinghe (44.54/82.65) | IIb | MW856948 |
| Site 26 | Guo4096 | H2 | Jinghe (44.54/82.65) | IIb | MW856949 |
| Site 26 | Guo4100 | H2 | Jinghe (44.54/82.65) | IIb | MW856950 |
| Site 26 | Guo4101 | H2 | Jinghe (44.54/82.65) | IIb | MW856951 |
| Site 26 | Guo4102 | H2 | Jinghe (44.54/82.65) | IIb | MW856952 |
| Site 27 | Guo541 | H2 | Jinghe (44.54/82.58) | IIb | MW856971 |
| Site 27 | Guo542 | H3 | Jinghe (44.54/82.58) | IIc1 | MW856972 |
| Site 27 | Guo544 | H2 | Jinghe (44.54/82.58) | IIb | MW856973 |
| Site 27 | Guo545 | H2 | Jinghe (44.54/82.58) | IIb | MW856974 |
| Site 28 | Guo7427 | H3 | Jinghe (44.56/83.37) | IIc1 | MW856977 |
| Site 29 | Guo2285 | H3 | Jinghe (44.54/82.58) | IIc1 | MW856925 |
| Site 30 | Guo3084 | H11 | Bolade (48.16/86.66) | I | MW856941 |
| Site 31 | Guo3064 | H10 | Buerjin (48.03/86.90) | I | MW856936 |
| Site 31 | Guo3065 | H10 | Buerjin (48.03/86.90) | I | MW856937 |
| Site 31 | Guo3066 | H10 | Buerjin (48.03/86.90) | I | MW856938 |
| Site 31 | Guo3067 | H10 | Buerjin (48.03/86.90) | I | MW856939 |
| Site 31 | Guo3068 | H10 | Buerjin (48.03/86.90) | I | MW856940 |
| Site 32 | GXG411 | H9 | Buerjin (47.68/86.81) | I | MW857048 |
| Site 32 | GXG412 | H9 | Buerjin (47.68/86.81) | I | MW857049 |
| Site 32 | GXG413 | H9 | Buerjin (47.68/86.81) | I | MW857050 |
| Site 32 | GXG692 | H9 | Buerjin (47.68/86.81) | I | MW857067 |
| Site 32 | GXG693 | H9 | Buerjin (47.68/86.81) | I | MW857068 |
| Site 32 | GXG694 | H9 | Buerjin (47.68/86.81) | I | MW857069 |
| Site 32 | GXG695 | H9 | Buerjin (47.68/86.81) | I | MW857070 |
| Site 32 | GXG696 | H9 | Buerjin (47.68/86.81) | I | MW857071 |
| Site 32 | GXG697 | H9 | Buerjin (47.68/86.81) | I | MW857072 |
| Site 33 | Guo3028 | H8 | Zaisan (47.71/85.59) | I | MW856932 |
| Site 33 | Guo3030 | H8 | Zaisan (47.71/85.59) | I | MW856933 |
| Site 33 | Guo3038 | H9 | Zaisan (47.71/85.59) | I | MW856934 |
| Site 33 | Guo3040 | H9 | Zaisan (47.71/85.59) | I | MW856935 |
| Site 34 | KZL118 | H9 | Kurchum (47.94/85.08) | I | MW857082 |
| Site 34 | KZL119 | H9 | Kurchum (47.94/85.08) | I | MW857078 |
| Site 34 | KZL120 | H50 | Kurchum (47.94/85.08) | I | MW857079 |
| Site 34 | KZL121 | H9 | Kurchum (47.94/85.08) | I | MW857080 |
| Site 34 | KZL122 | H9 | Kurchum (47.94/85.08) | I | MW857081 |
| Site 35 | KZ202 | H49 | Kurchum ***type locality***(48.85/83.38) | I | MW857075 |
| Site 36 | KZL107 | H49 | Kokpekty district E KZ (48.80/83.42) | I | MW857076 |
| Site 36 | KZL108  | H49 | Kokpekty district E KZ (48.80/83.42) | I | MW857077 |
| **Sequences from previous studies** |
| Site 37 | KF691725 | H52 | Bukhtarma (48.83/83.43) | I | [38] |
| Site 37 | MK461427 | H56 | Bukhtarma (48.83/83.43) | I | [32] |
| Site 38 | MK461428 | H54 | Alakol (45.64/82.17) | IIc1 | [38] |
| Site 38 | KF691726 | H51 | Alakol (45.64/82.17) | IIc1 | [38] |
| Site 39 | MF567976 | H51 | Dzungar Gate (45.31/82.42) | IIc1 | [32] |
| Site 40 | MK461426 | H53 | Zaisan county (47.65/85.54) | I | [32] |
| Site 41 | MK461384 | H55 | Zhalanashkol Lake (45.40/82.09) | IIc1 | [32] |
| Site 42 | MK461456 | H55 | Dzungar Gate (45.23/82.48) | IIc1 | [32] |
| Site 43 | MK461378 | H57 | Black Irtysh (47.90/85.01) | I | [32] |
| Site 44 | MK461377 | H58 | Aygyrkum (47.64/85.23) | I | [32] |

**Table S2.** Environmental variables highly contributed to the SDM of *P. melanurus* with Pearson correlation coefficients *r* ≥ 0.8.

|  |  |
| --- | --- |
| **Environmental variable**  | **Contribution %** |
| Annual mean temperature (Bio 1) | 38.7% |
| Precipitation of driest month (Bio 14) | 14.5% |
| Mean diurnal range of temperature (Bio 2) | 12.7% |
| Temperature of the wettest quarter (Bio 8) | 9%  |
| Isothermality (Bio 3) | 6.3% |

**Table S3.** Sampling sites retained after rarefication for species distribution modeling.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Number | Site | Sampling Site | Longitude | Latitude |
| 1 | Site 1 | Ulungur | 87.26 | 47.01 |
| 2 | Site 2 | Karamay | 85.95 | 46.41 |
| 3 | Site 3 | Karamay | 85.05 | 45.13 |
| 4 | Site 4 | Hoboksar  | 85.74 | 46.76 |
| 5 | Site 6 | Hoboksar  | 85.14 | 46.50 |
| 6 | Site 7 | Emin | 84.53 | 46.20 |
| 7 | Site 8 | Toli | 84.49 | 45.88 |
| 8 | Site 10 | Fuyun  | 89.02 | 46.42 |
| 9 | Site 11 | Jeminay | 86.76 | 47.31 |
| 10 | Site 12 | Shihezi | 86.18 | 44.64 |
| 11 | Site 13 | Fukang | 88.43 | 44.95 |
| 12 | Site 14 | Fukang | 88.26 | 44.68 |
| 13 | Site 16 | Jimsar | 88.82 | 44.51 |
| 14 | Site 17 | Ebinur | 82.61 | 45.11 |
| 15 | Site 18 | Ebinur | 82.87 | 44.77 |
| 16 | Site 19 | Bortala | 81.69 | 44.61 |
| 17 | Site 21 | Kuytun | 85.11 | 44.36 |
| 18 | Site 22 | Bole | 81.69 | 44.92 |
| 19 | Site 23 | Qitai | 90.03 | 44.19 |
| 20 | Site 24 | Qitai | 90.02 | 44.54 |
| 21 | Site 26 | Jinghe | 82.65 | 44.54 |
| 22 | Site 29 | Jinghe | 82.58 | 44.54 |
| 23 | Site 30 | Bolade | 86.66 | 48.16 |
| 24 | Site 32 | Buerjin  | 86.81 | 47.68 |
| 25 | Site 33 | Zaisan  | 85.59 | 47.71 |
| 26 | Site 34 | Kurchum | 83.38 | 48.85 |
| 27 | Site 35 | Kokpekty | 83.42 | 48.80 |
| 28 | Site 38 | Alakol  | 82.17 | 45.64 |
| 29 | Site 39 | Dzungar Gate | 82.48 | 45.23 |
| 30 | Site 41 | Zhalanashkol | 82.09 | 45.40 |
| 31 | Site 44 | Aygyrkum | 85.23 | 47.64 |

**Table S4.** Hierarchical analysis of AMOVA for testing the genetic subdivision of populations of *P.* *melanurus* using *COI* sequences. Statistical significance at *p* ≤ 0.001.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source of variation** | ***d.f.*** | **Sum of squares** | **Variance** **components** | **% of variation** | **Fixation indices****(*p-value*)** |
|  **2 groups (Zaisan Basin, Dzungar Basin)** |
| Among groups | 1 | 322.178 | 7.00170  | 73.94 | 0.73936 (*p* = 0.000) |
| Among populations within groups | 33 | 253.319 | 1.59203  | 16.81 | 0.64502 (*p* = 0.000)  |
| Within populations | 119 | 104.263 | 0.87616  | 9.25 | 0.90748 (*p* = 0.000) |
| Total | 153 | 679.760 | 9.46989 |  |  |
| **4 groups (Zaisan Basin, Central, Southwest, and Southeast of Dzungar Basin)** |
| Among groups | 3 | 460.058 | 4.23897  | 73.11 | 0.73105 (*p* = 0.000) |
| Among populations within groups | 31 | 115.439 | 0.68332  | 11.78 | 0.43817 (*p* = 0.000) |
| Within populations | 119 | 104.263 | 0.87616  | 15.12 | 0.84890 (*p* = 0.000) |
| Total | 153 | 679.760 | 5.79845 |  |  |