**Additional file 1:**

**Table S1 Stopover sites used by the Whimbrels from MB (Moreton Bay) and RB (Roebuck Bay) during northward and southward migration**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Northward migration** | | | | |
| Population | Longitude | Latitude | Stopover duration | Site |
| MB | 130.574 | 30.425 | 11 | Yakushima, Kagoshima, Japan |
| MB | 130.389 | 32.583 | 11 | Kami-Amakusa, Kumamoto, Japan |
| MB | 136.675 | 35.148 | 4 | Aisai, Aichi, Japan |
| MB | 126.377 | 36.404 | 29 | Taean, South Chungcheong, South Korea |
| MB | 139.366 | 38.055 | 9 | Tainai, Niigata, Japan |
| MB | 121.699 | 39.317 | 15 | Jinzhou, Dalian City, Liaoning Province |
| MB | 161.626 | 57.353 | 7 | Karaginsky, Kamchatka Krai, Russia |
| MB | 158.349 | 58.002 | 3 | Tigilsky, Kamchatka Krai, Russia |
| RB\* | 120.059 | 23.074 | 5 | Qigu, Tainan City, Taiwan Province, China |
| RB\* | 117.675 | 23.946 | 10 | Zhangpu, Zhangzhou City, Fujian Province |
| RB\* | 118.677 | 24.914 | 13 | Fengze, Quanzhou City, Fujian Province |
| RB\* | 119.946 | 26.767 | 9 | Xiapu, Ningde City, Fujian Province, China |
| RB\* | 120.781 | 27.789 | 2 | Ruian, Wenzhou City, Zhejiang Province |
| RB\* | 121.806 | 29.501 | 10 | Xiangshan, Ningbo City, Zhejiang Province |
| RB | 121.966 | 30.960 | 2 | Pudong New Area, Shanghai |
| RB | 121.768 | 31.647 | 22 | Chongming, Shanghai |
| RB\* | 119.957 | 34.436 | 20 | Xiangshu, Yancheng City, Jiangsu Province, China |
| RB | 119.083 | 37.818 | 19 | Kenli, Dongying City, Shandong Province |
| RB | 117.709 | 38.494 | 4 | Nandagang, Cangzhou City, Hebei Province |
| RB | 122.434 | 39.484 | 9 | Pulandian, Dalian City, Liaoning Province |
| RB | 123.215 | 39.693 | 5 | Zhuanghe, Dalian City, Liaoning Province, China |
| RB\* | 122.523 | 43.850 | 3 | Horqin, Tongliao City, Inner Mongolia Autonomous Region |
| RB\* | 121.587 | 43.917 | 2 | Kailu, Tongliao City, Inner Mongolia Autonomous Region |
| RB\* | 123.567 | 44.058 | 9 | Shuangliao, Siping City, Jilin Province |
| RB\* | 123.152 | 44.304 | 9 | Horqin,Tongliao City, Inner Mongolia Autonomous Region |
| RB\* | 127.808 | 46.276 | 9 | Mulan, Harbin City, Heilongjiang Province |
| RB\* | 120.208 | 63.542 | 3 | Verkhnevilyuysky, Sakha Republic, Russia |
| RB\* | 124.008 | 70.552 | 3 | Bulunsky, Sakha Republic, Russia |
| RB\* | 96.082 | 71.401 | 2 | Ust’-Avam, krasnoyarskiy Kray ,Russia |
| **Southward migration** | | | | |
| Population | Longitude | Latitude | Stopover duration | Site |
| MB\* | 156.288 | 56.611 | 16 | Tigilsky, Kamchatka Krai, Russia |
| MB\* | 155.775 | 54.755 | 5 | Sobolevsky, Kamchatka Krai, Russia |
| MB\* | 155.989 | 53.981 | 27 | Sobolevsky, Kamchatka Krai, Russia |
| MB\* | 156.492 | 52.805 | 21 | Ust-Bolsheretsky, Kamchatka Krai, Russia |
| MB\* | 127.694 | 39.325 | 2 | Munchon, Kangwon Province, North Korea |
| MB | 126.452 | 36.564 | 33 | Hongseong, South Chungcheong, South Korea |
| MB\* | 152.640 | -3.072 | 23 | Namatanai, New Ireland, Papua New Guinea |
| MB\* | 149.473 | -9.594 | 19 | Alotau, Milne Bay, Papua New Guinea |
| MB\* | 149.765 | -9.607 | 36 | Alotau, Milne Bay, Papua New Guinea |
| MB\* | 147.830 | -10.060 | 11 | Rigo, Central, Papua New Guinea |
| MB | 152.324 | -24.768 | 6 | Burnett, Queensland, Australia |
| RB\* | 132.425 | 65.459 | 2 | Verkhoyanskiy u, Sakha Republic, Russia |
| RB\* | 136.864 | 64.489 | 3 | Tomponskiy u, Sakha Republic, Russia |
| RB | 141.911 | 58.940 | 16 | Okhotsky, Khabarovsk Krai, Russia |
| RB | 162.054 | 58.344 | 3 | Karaginsky, Kamchatka Krai, Russia |
| RB\* | 156.455 | 52.775 | 26 | Ust-Bolsheretsky, Kamchatka Krai, Russia |
| RB | 120.744 | 40.573 | 11 | Xingcheng, Huludao City, Liaoning Province |
| RB | 122.262 | 40.481 | 7 | Gaizhou, Yingkou City, Liaoning Province |
| RB\* | 125.331 | 39.437 | 13 | Sukchon, South Pyongan Province, North Korea |
| RB | 119.020 | 39.230 | 6 | Leting, Tangshan City, Hebei Province |
| RB | 119.086 | 37.823 | 39 | Kenli, Dongying City, Shandong Province |
| RB\* | 119.231 | 35.030 | 36 | Ganyu, Lianyungang City, Jiangsu Province |
| RB\* | 119.961 | 34.432 | 29 | Xiangshui, Yancheng City, Jiangsu Province |
| RB\* | 120.638 | 27.572 | 12 | Longgang , Wenzhou City, Zhejiang Province |
| RB\* | 120.647 | 27.563 | 24 | Longgang, Wenzhou City, Zhejiang Province |
| RB\* | 119.533 | 25.677 | 27 | Fuqing City, Fuzhou City, Fujian Province |
| RB\* | 118.664 | 24.806 | 24 | Jinjiang, Quanzhou City, Fujian Province |
| RB\* | 113.445 | 22.472 | 2 | Zhongshan, Guangdong Province |
| RB\* | 120.890 | 14.709 | 21 | Bulacan, Philippines |
| RB\* | 119.259 | -1.975 | 8 | Mamuju, Sulawesi Barat, Indonesia |
| RB\* | 147.347 | -2.067 | 69 | Manus, Papua New Guinea |
| RB\* | 120.339 | -3.993 | 8 | Wajo, Sulawesi Selatan, Indonesia |
| RB\* | 120.336 | -4.025 | 38 | Wajo, Sulawesi Selatan, Indonesia |
| RB\* | 121.739 | -4.828 | 13 | Bombana, Sulawesi Tenggara, Indonesia |
| RB\* | 123.108 | -10.666 | 10 | Rote Ndao, Nusa Tenggara Timur, Indonesia |
| RB | 132.000 | -12.284 | 10 | South Alligator, Northern Territory, Australia |
| RB | 124.830 | -15.246 | 6 | Wyndham-East Kimberley, Western Australia, Australia |
| RB | 123.900 | -16.203 | 8 | Derby-West Kimberley, Western Australia, Australia |

\*Newly recognized sites in this study comparing with the sites listed in Bamford et al. 2008 and Conklin et al. 2014.

**Table S2 Results of linear mixed model testing for the effect of overall stopover duration (Rstopover duration) and travel speed (Rtravelled speed) on the overall migration speed (Rmigration speed) of Whimbrels**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Model parameter** | **Chi square** | **df** | ***P* value** | **Estimate** | **SE** | ***t* value** |
| Intercept |  |  |  | ‒0.063 | 0.055 | ‒1.15 |
| Roverall stopover duration | 54.812 | 1 | **< 0.001** | ‒0.907 | 0.123 | ‒7.40 |
| Rtravel speed | 3.777 | 1 | 0.06 | 0.142 | 0.073 | 1.94 |

Population (Moreton Bay or Roebuck Bay) was set as a random variable. Rmigration speed, Rstopover duration, and Rtravel speed were estimated as the log-ratio for each individual between northward and southward migration.

**Table S3 Distance and duration of the first-leg flights during northward migration of shorebirds in Australia and New Zealand**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Species** | **Scientific name** | **Nonbreeding site** | **Flight**  **distance (km)** | **Percentage of total migration distance (%)** | **Flight**  **duration (days)** |
| Bar-tailed Godwit 1 | *Limosa lapponica baueri* | New Zealand | 10060 | 60 | 7.2 |
| Bar-tailed Godwit 1 | *Limosa lapponica menzbieri* | Northwest Australia | 5860 | 58 | 4.1 |
| Eastern Curlew 2 | *Numenius madagascariensis* | Moreton Bay | 7113 | 54 | 10 |
| Grey-tailed Tattler 3 | *Tringa Brevipes* | Moreton Bay | 5839 | 60 | 5.3 |
| Great Knot 4 | *Calidris tenuirostris* | Northwest Australia | 2928 | 30 | 3.6 |
| Ruddy Turnstone 5 | *Arenaria interpres* | South Australia | 6030 | NA | 5.3 |
| Eastern Curlew 6 | *Numenius madagascariensis* | Victoria | 8600 | 79 | 7.3 |
| Sanderling 6 | *Calidris alba* | Esperance | 5000 | NA | 4.3 |
| Greater Sandplover 6 | *Charadrius leschenaultii* | Northwest Australia | 3700 | 48 | 3.1 |
| Ruddy Turnstone 6 | *Arenaria interpres* | King Island | 6367 | NA | 5.2 |
| Ruddy Turnstone 6 | *Arenaria interpres* | Northwest Australia | 4900 | NA | 4.3 |
| Ruddy Turnstone 6 | *Arenaria interpres* | South Australia | 7400 | NA | 5.4 |

NA: Data not available.

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Driscoll PV, Ueta M. The migration route and behaviour of Eastern Curlews *Numenius madagascariensis*. Ibis. 2002;144:E119‒30.

Coleman JT, Milton DA, Akutsu H. The migratory movements of Grey-tailed Tattler *Tringa brevipes* from Moreton Bay. Stilt. 2018;72:2‒8.

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Minton C, Gosbell K, Johns Penny, Christie M, Klaassen M, et al. New insights from geolocators deployed on waders in Australia. Wader Study Group Bull. 2013;120:37‒46.

**Table S4 Migration parameters (means) of Whimbrels in the East Asian-Australasian Flyway (EAAF, nonbreeding at Moreton Bay (MB) and Roebuck Bay (RB) in Australia), the Eurasian-Africa Flyway (breeding in Iceland), and the America Flyway (breeding in Manitoba, Canada)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Migration parameters** | **MB** | **RB** | **EAAF** | **Iceland** | **Manitoba** |
| Date of departure from nonbreeding site | 18-Apr | 19-Apr | 19-Apr | 12-Mar | 17-Apr |
| Date of arrival at breeding site | 3-Jun | 28-May | 30-May | 28-Mar | 26-May |
| Duration of northward migration (days) | 45 | 39 | 41 | 16 | 39 |
| Distance of northward migration (km) | 12991 | 11018 | 11609 | 6701 | 9798 |
| Migration speed during northward migration (km/day) | 291 | 289 | 290 | 398 | 251 |
| Travel speed during northward migration (km/day) | 898 | 824 | 846 | 2127 | 1960 |
| Stopover duration during northward migration (days) | 29 | 24 | 26 | 12 | 34 |
| Number of stopover sites during northward migration | 3 | 3 | 3 | NA | NA |
| Duration of stay at breeding site (days) | 57 | 59 | 59 | 95 | 64 |
| Date of departure from breeding site | 29-Jul | 27-Jul | 28-Jul | 9-Aug | 29-Jul |
| Date of arrival at nonbreeding site | 22-Oct | 25-Oct | 24-Oct | 13-Aug | 17-Aug |
| Duration of southward migration (days) | 84 | 94 | 90 | 4 | 22 |
| Distance of southward migration (km) | 12565 | 11418 | 11848 | 6131 | 9251 |
| Migration speed during southward migration (km/day) | 149 | 134 | 140 | 1441 | 616 |
| Travel speed during southward migration (km/day) | 745 | 683 | 706 | 1310 | 1542 |
| Stopover duration during southward migration (days) | 66 | 66 | 66 | 0 | 16 |
| Number of stopover sites during southward migration | 4 | 4 | 4 | 0 | 1 |
| Duration of stay at nonbreeding site (days) | 179 | 177 | 177 | 250 | 240 |

Data for the Iceland population are from Alves et al. (2016) and Carneiro et al. (2019), and data for the Manitoba population are from Johnson et al. (2016). NA: Data not available.