Predictable Evolution Toward Flightlessness in Volant Island Birds

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Purpose of Research

- To investigate whether volant island bird populations tend to change shape in a way that converges to a flightless form
- Evolution has occurred in island bird lineages, showing reduction of the flight muscles and enlargement of the hind limbs, thus leading to flightlessness
- Whether the island rule relates to bird species
- “Whether island size, landbird species richness, raptor species richness, and the presence of mammalian predators could predict shifts in the relative investment in forelimbs versus hind limbs in 366 bird populations from 80 islands across the Pacific and Caribbean”

Background

- Island rule: The tendency for island taxa to converge toward intermediate body size after colonizing islands
  - This rule has been proven inconsistent with predicting evolutionary trends in island bird populations
- Island birds have been analyzed to inspire the theory of evolution through natural selection
  - Bodies and bills of island bird change in size in response to a generalist niche in low species richness areas
- Further studies have shown idiosyncratic patterns in evolution related to body and bill size
  - So, are there predictable evolutionary tendencies that apply to island birds
- Most noteworthy evolutionary trend is the loss of flight in island birds

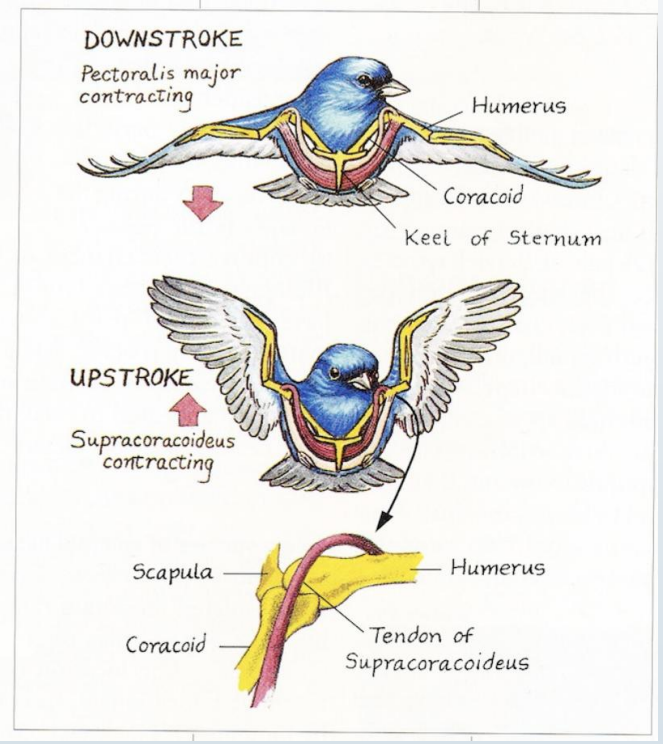
Background

- Changes towards flightlessness are fast and irreversible
  - Reallocation of mass from forelimbs to hind limbs and almost complete removal of important flight muscle
- More than 1,000 lineages of island birds have lost the ability to fly
  - Rails, parrots, pigeons, owls, waterfowl and passerines
- Loss of flight requires limited predators and foraging without the use of flight
  - Kingfishers, hummingbirds, whistlers, and white-eyes

Kakapo

Victoria crowned pigeon

Materials & Methods



- They weighed 2 main flight muscles in more than 8,000 bird remains:
  - pectoralis major
  - supracoracoideus
- Totaling 868 landbird species, 38 of them restricted to islands
- Island sizes: 786,000 km^2 with >620 landbird species to 19 km^2 with only 3 species

Materials & Methods

- Between continents:
  - Looked at forelimb and hind limb investment in bird population from different islands differing in size and ecological characteristics
  - Measured skeletal remains from museums that included island taxa from 9 families
    - Also included were taxa that use flight to forage (fruit-doves, kingfishers, hummingbirds, monarch flycatchers, and other songbirds)
  - Focused on the lengths of the sternal keel and the tarsometatarsus
    - Negative correlation (13 out of 15 focal taxa)
  - From analysis of keel and tarsometatarsus lengths, they developed an index of hind limb vs. forelimb investment
    - Large values = larger flight muscles and shorter legs

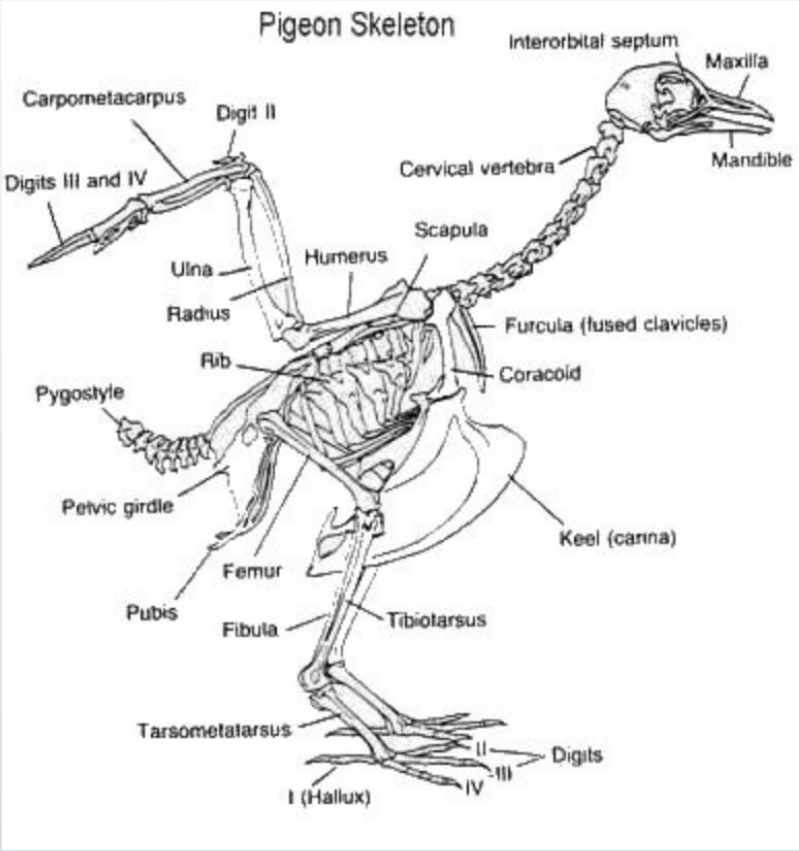
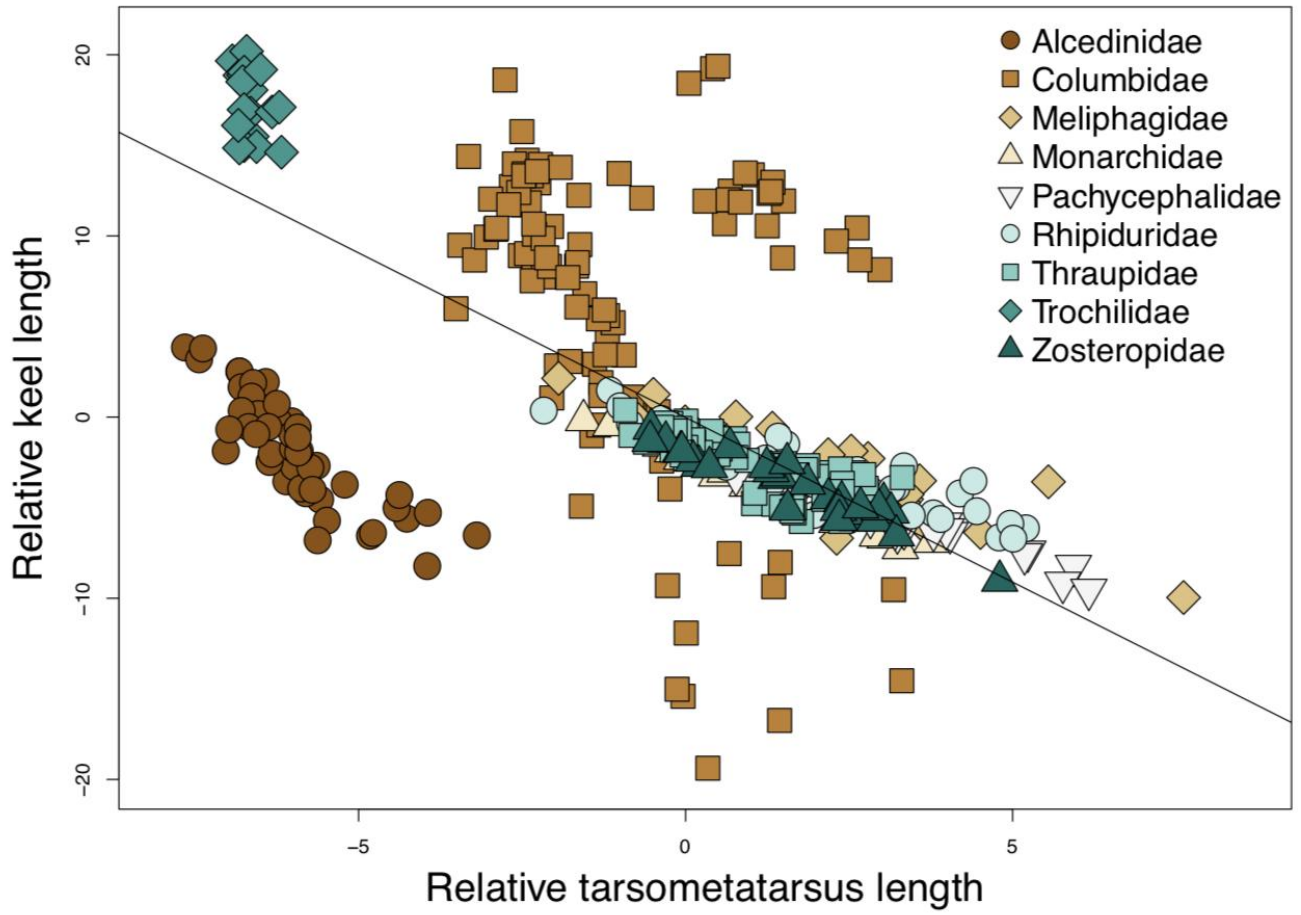


Fig. S1. Keel length is negatively correlated with tarsometatarsus length within and across taxa. Relative lengths of the keel and tarsometatarsus are the residuals of a regression of keel and tarsometatarsus lengths, respectively, by the first principal component, an indicator of overall body size



Results

- Island restricted species had smaller flight muscles compared to their continental relatives
- Smaller flight muscles and longer legs have evolved repeatedly on islands with low species richness and no mammalian predators
- Forelimb-hindlimb index positively correlated to raptor species richenss, landbird species richness, and island area in 366 island population
- Island species richness explained almost 60% of variation in the forelimb-hindlimb index in todiramphus kingfishers on 27 Pacific islands
  - Representing 32 distinct populations
- Models that contained sex as a factor explained significantly more variation but no other interactions

Results

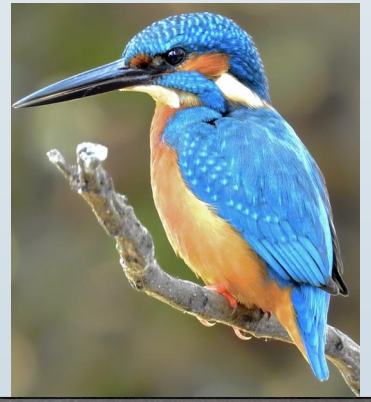
- Keel length as dependent variable
  - Keels decreased in size while increasing in leg length on islands with low raptor and landbird species richness
- Island Rule
  - Body size negatively correlated to island species richness and island area
  - No consistent patterns of directional body size changes showed in individual linages
  - No significant relationship between degree or direction of body size changes on islands and the mean body size

Conclusion

- Island bird species have evolved smaller flight muscles compared to their continental relatives
- Smaller flight muscles and longer legs were caused by increasing insularity and the limited number of avian and mammalian predators in 366 populations of Caribbean and Pacific birds
- Smaller islands showed priority shifts from forelimbs to hind limbs that are comparable to flightless birds.
- Bird populations are evolving towards flightlessness, even those that are destined to never develop flightlessness
  - Consistent across 9 families and four orders varying in lifestyle, foraging behavior, flight style, and body size
- These evolutionary changes are in response to ecological pressures linked to small, species-poor islands

Other Possible Reasons

- Reduced flight muscles may have indirectly caused the length of bird legs to increase due to energetic tradeoff
- Longer legs may have been favored for perching and ground foraging
  - However even birds that tend not to cling, hang, hop, or walk and depend on flight for foraging and breeding have longer legs on islands of low species richness



Why is this Important?

- Changes in bird morphology could potentially reduce the physical capacity to escape by flight and decrease the potential for small island taxa to diversity by dispersal
- Birds loose the ability to escape by flight, thus increasing extinction risk
- Reducing the chances of over-water dispersal from small island populations
  - Island populations would evolve on independent trajectories

Critiques

- The authors of this article were testing a few different hypothesizes, thus making the result confusing to understand because it was difficult to link the results to the tests
- The order of the paper seemed flipped. It started with results, which was difficult to understand without more knowledge of tests

Questions?