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SHORT COMMUNICATION

"Shortest-distance" method is more accurate than conventional method in estimating flight initiation distances for close, perched birds

Kent B. Livezey[1] · **Daniel T. Blumstein**[2]

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Abstract The conventional method to determine avian flight initiation distance (the distance at which birds exposed to an approaching human activity initiate escape behavior) overestimates this distance for perched birds because it uses the distance between the bird and the ground at the person's feet rather than the distance between the bird and the part of the person's body closest to the bird. Here, we introduce an alternative "shortest-distance" method that more accurately estimates flight initiation distance, especially for close, perched birds.

Keywords Disturbance · Flight initiation distance · Shortest-distance method

Zusammenfassung

Die Methode der „kürzesten Strecke" ist genauer als die konventionelle Methode zur Abschätzung von Fluchtdistanzen in der Nähe sitzender Vögel

Die konventionelle Methode, die Fluchtdistanz von Vögeln zu bestimmen, d. h. den Abstand zu ermitteln, bei dem bei Vögeln, die mit einer sich nähernden menschlichen Aktivität konfrontiert werden, Fluchtverhalten ausgelöst wird, überschätzt diese Entfernung für sitzende Vögel. Sie misst nämlich eher die Strecke zwischen dem Vogel und dem Boden zu Füßen der Person zugrunde legt als den Abstand zwischen dem Vogel und dem diesem am nächsten befindlichen Körperteil der Person. Hier stellen wir eine alternative Methode der „kürzesten Strecke"vor, welche genauere Schätzungen für die Fluchtdistanz liefert, speziell bei in der Nähe sitzenden Vögeln.

Avian flight initiation distance (FID) is the distance at which a bird exposed to an approaching human activity initiates escape behavior (e.g., walking, running, flying, diving; see Cooper and Blumstein 2015 for a complete review). FIDs for forest birds in the Pipeline Road area, Soberanía National Park, Panama, are being quantified by the first author. The dense primary and secondary rainforests of this area contain more than 400 bird species (Angehr et al. 2008), many of which allow remarkably close approaches due to the dense vegetation (which often blocks the view of birds more than 6–8 m away) and the birds' lack of fear of humans. For example, FIDs for Fasciated Antshrike (*Cymbilaimus lineatus*), Black-crowned Antshrike (*Thamnophilus atrinucha*), Dot-winged Antwren (*Microrhopias quixensis*), Checker-throated Antwren (*Epinecrophylla fulviventris*), White-flanked Antwren (*Myrmotherula axillaris*), Dusky Antbird (*Cercomacra tyrannina*), Southern Bentbill (*Oncostoma olivaceum*), and Olivaceous Flycatcher (*Rhynchocyclus olivaceus*) often range from 1 to 3 m. Indeed, sometimes these species continue to forage without showing any sign of disturbance when only 1–3 m directly above people. When birds perched at or above head level move away, often they look at the person (often appearing to make eye contact) for several seconds before doing so. While conducting this fieldwork, it became apparent that an aspect of the conventional way to calculate FID could be improved for close approaches to perched birds in the forest.

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✉ Kent B. Livezey
kentbl@gmail.com

[1] East Coast Tower, Costa del Este, Panama 33192-4177, Panama

[2] Department of Ecology and Evolutionary Biology, University of California, 621 Young Drive South, Los Angeles, CA 90095-1606, USA

Depending on the location of the bird, the conventional method employs one of two ways to calculate FID (e.g., Blumstein 2006). For birds on the ground, conventional FID is the horizontal distance (HD) between the ground at the person's feet and the bird. For perched birds, conventional FID (see fig. 1 in Møller 2010) is the hypotenuse of the right triangle consisting of one leg—the horizontal distance between the ground at the person's feet and the bird—and the other leg—the vertical distance between the ground directly below the bird and the bird's perch height (PH; Fig. 1a). We are unaware of any other published methods to estimate FIDs.

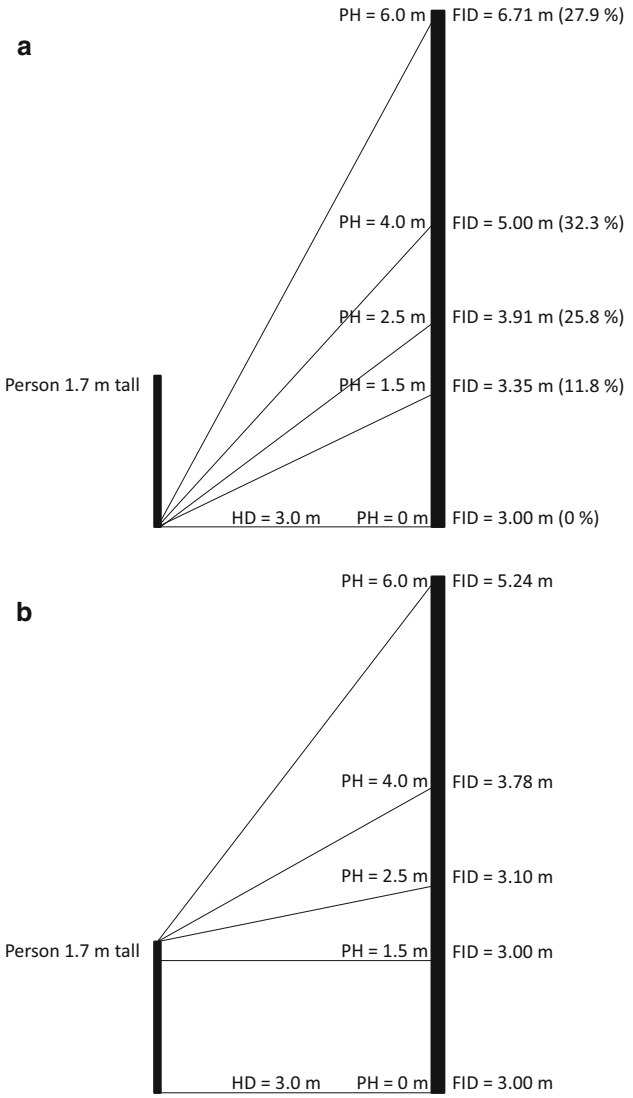

Fig. 1 Flight initiation distances (FIDs) of birds using **a** the conventional method and **b** the shortest-distance method. Horizontal distances (HDs) in (**a**) and (**b**) are 3.0 m from a person 1.7 m tall, and perch heights (PHs) are 0, 1.5, 2.5, 4.0, and 6.0 m. Percentages in (**a**) are percent overestimations using the conventional method versus the shortest-distance method

For on-the-ground birds, estimating FIDs in this way is straightforward and simple. For perched birds, however, we suggest it makes more sense to use the shortest distance between the person and the bird because we do not expect that birds react to a person's feet but, rather, to a person's close proximity. In addition, eyes (not feet) have been shown to elicit antipredator responses in birds (Curio 1975) and reptiles (Burger et al. 1991). Prior work (Møller 2010) has shown that HD and PH differentially affect FIDs. Until it is known how to distinguish between these effects, or for studies that are not interested in distinguishing between these effects, we suggest simply using the shortest distance between the person and the bird. Consequently, we introduce an alternative "shortest-distance" method, as follows. For birds on the ground to birds perched at the person's height, shortest-distance FID equals the HD between the person and the bird (Fig. 1b). For birds perched above the person's height, shortest-distance FID equals the distance between the top of the person's head and the bird, which is the hypotenuse of the right triangle consisting of one leg—the HD between the person and the point directly below the bird—and the other leg—the PH minus the person's height (Fig. 1b).

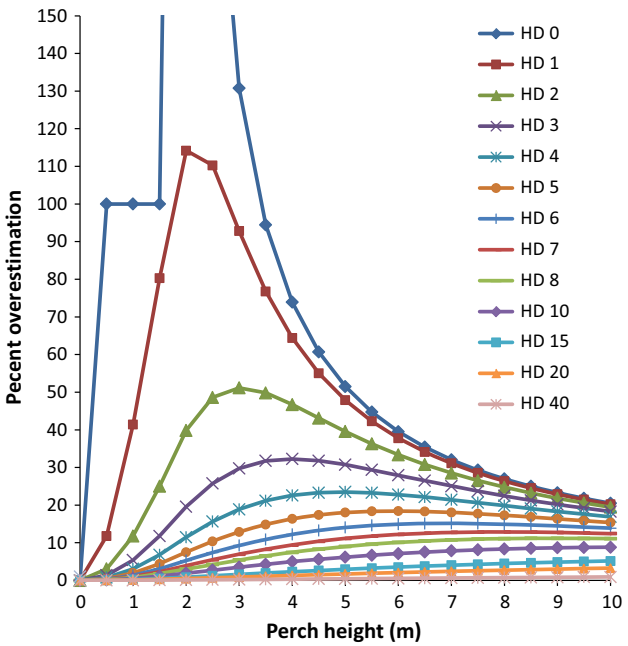

Fig. 2 Percent overestimation of flight initiation distances (FIDs) from a person 1.7 m tall by conventional method versus shortest-distance method. For example, when horizontal distance (HD) is 1 m, overestimation is 41.4 % at perch height (PH) of 1 m, 114.2 % at PH of 2 m, 92.8 % at PH of 3 m, 64.4 % at PH of 4 m, 47.9 % at PH of 5 m, 37.8 % at PH of 6 m, etc. The most extreme cases of overestimation (off graph) occur when the bird is very close and directly overhead: when HD is 0 m at PH of 2.0 m (566.7 %) and PH of 2.5 m (212.5 %)

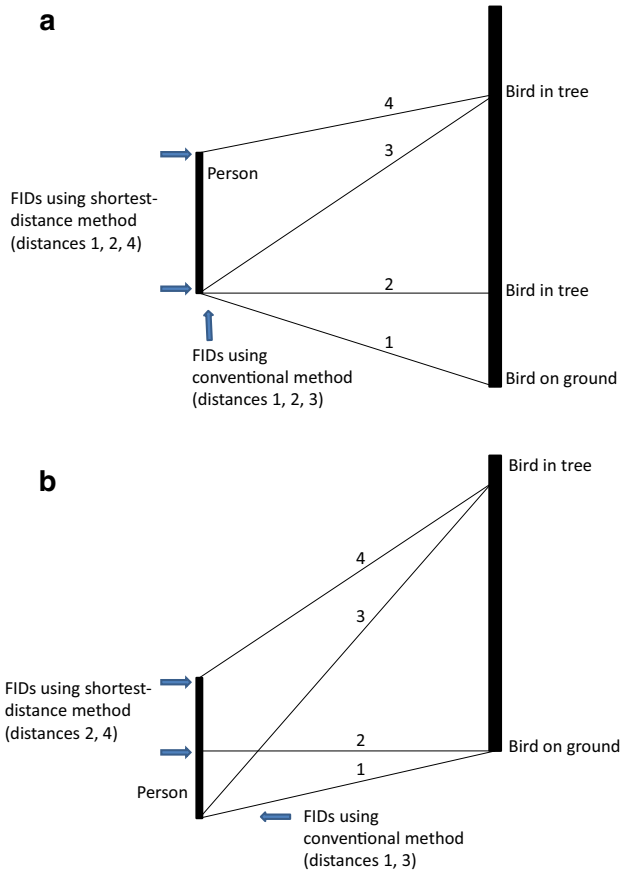

Fig. 3 **a** Generalized flight initiation distances (FIDs) for birds in trees with bases downhill of the person's feet. The conventional and shortest-distance methods estimate FIDs equally for birds on the ground (*1*) and for birds level with the person's feet (*2*). However, the conventional method (*3*) overestimates FIDs compared to the shortest-distance method (*4*) for birds situated above the person's feet: $3 > 4$. **b** Generalized flight initiation distances (FIDs) for birds in trees with bases uphill of the person's feet. The conventional method (*1, 3*) overestimates FIDs compared to the shortest-distance method (*2, 4*): $1 > 2$, $3 > 4$

Variation in the height of people ($n = 20$, range = 1.55–1.92 m, mean = 1.70 m) was shown to not affect FID (Van Dongen et al. 2015; generalized linear mixed models effect $= -0.001 \pm 0.005$, $F_{1,282} = 0.1$, $P = 0.80$), so standardizing person height could be done without affecting FIDs. Average height of people for the countries with data on at least 95 % of the population taken from 2000 to present ($n = 18$; e.g., Australia, Brazil, Canada, China, England, France, Germany, Scotland, United States, Wales) is 1.66 m (Wiki 2016), so 1.7 m could be the standard person's height.

To illustrate the potential overestimation of FIDs when using the conventional method for perched birds, we calculated the percent difference between the conventional method and the shortest-distance method for a variety of HDs and PHs, assuming a 1.7-m-tall person (Fig. 2). As HD and PH decrease, the percentage that FID is overestimated increases (Figs. 1a, 2). Calculations for both methods require there to be a right triangle at the base of the tree on which the bird is perched, which means the terrain between the person and the tree must be flat; however, the terrain often is not flat. To our knowledge, there is no published method to quantify FIDs in non-flat ("hilly") terrain. To modify these methods for hilly terrain, we retained the general means used for flat areas, which is the distance between the person's feet and the bird for the conventional method and the distance between the closest part of the person's body and the bird for the shortest-distance method. In hilly terrain, the conventional method overestimates FIDs whenever the bird is located above the person's feet (Fig. 3). If indeed birds pay attention to the closest part of the approaching person's body, our proposed shortest-distance method more accurately estimates the distances at which birds flush from disturbances than does the conventional method. Therefore, depending upon the aims of a study, this shortest-distance method may be preferable.

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