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4

5 **Observer effects occur when estimating alert but not flight initiation distances**

6

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18

19 Running Head: Observer effects in estimating flight distances

20 **Additional keywords:** FID, disturbance, waterfowl, walker, wetland, flush,  
21 pedestrian, and vigilance

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23 **Abstract.**

24 **Context.** The estimation of alert (vigilance) and flight-initiation (escape) distances  
25 (AD and FID) has underpinned theoretical and applied studies of the escape  
26 behaviour and management of disturbance to wildlife. Many studies use multiple  
27 observers, and some conduct meta-analyses; these efforts assume no observer  
28 effects in the estimation of these distances.

29 **Aims and methods.** We compare the estimates of FID and AD under ideal  
30 conditions (i.e. of black swans *Cygnus atratus*, a large species with obvious  
31 behaviour, and at a location where swans allowed close approaches in open  
32 habitats), by one experienced and four inexperienced observers.

33 **Results.** FID did not differ between observers but AD differed between the  
34 experienced and all inexperienced observers, and among inexperienced observers.  
35 Thus, FID estimates appear more repeatable than those of AD. Experience  
36 apparently results in more conservative estimates of AD.

37 **Implications.** We recommend the use of FID rather than AD for comparative  
38 analyses which involve multiple observers, since FID is more reliably measured.

39

## 40 **Introduction**

41 The disruption of behaviour or physiology in the presence of a threatening stimulus,  
42 such as a person, is known as disturbance (Hill *et al.* 1997). The distance at which  
43 an animal becomes vigilant is known as 'Alert Distance' (AD; Blumstein 2006) and  
44 the distance at which it flees from a threat is known as the 'Flight-initiation Distance'  
45 (FID; Hediger 1934; Stankowich and Blumstein 2005). These distances are usually  
46 highly correlated and they describe an escalation in response to threat (Eason *et al.*  
47 2006; Weston *et al.* 2012). ADs and FIDs offer insights into the behavioural and  
48 evolutionary ecology of escape, threat perception, and options for managing  
49 disturbance, for example, through designating buffers (Rodgers and Smith 1997;  
50 Weston *et al.* 2012; Guay *et al.* In Press-b).

51

52         Recently, detailed summaries of FIDs for many bird taxa have been  
53 published, with a call for more publication of raw data to facilitate enhanced  
54 management of disturbance, and to aid comparative studies of FID. Additionally,  
55 recommendations for standard data collection have been made (Weston *et al.* 2012).  
56 Inevitably, these summaries contain data from multiple observers, and given that  
57 some subjectivity may be expected in judging the exact moment at which vigilance or  
58 escape is initiated, inter-observer variation in estimating ADs and FIDs may exist.  
59 However, escape may be more detectable to observers than more subtle  
60 behavioural responses such as alertness. Observer differences have been  
61 documented in aspects of ornithological field work, including surveys (Cunningham  
62 *et al.* 1999), mapping (Verner and Milne 1990), estimates of abundance (Van Der  
63 Meer and Camphuysen 1996), reporting of tag numbers on birds (Mulder *et al.*  
64 2010), and estimating prey size (Goss-Custard *et al.* 1987). However, we are

65 unaware of any studies of observer effects in estimating the distance at which  
66 behaviours, such as alertness and flight, occur. If inter-observer variation exists in  
67 estimating these distances, then analysis of AD or FID data should account for the  
68 influence of observer.

69

70         This study examines whether inter-observer effects exist in estimating ADs  
71 and FIDs using a system where both alert and flight behaviours were easily  
72 observable, thus minimising the impact of subjective interpretation of behaviour on  
73 the measurements. We also used accurate methods of measuring distance, thus  
74 discounted the effect of distance perception on our measurements. The system we  
75 examine thus represents a 'best case' situation with respect to the collection of ADs  
76 and FIDs.

77

78

79 **Methods**

80 *Study species*

81 The black swan (*Cygnus atratus*), a large waterfowl endemic to Australasia, was  
82 selected as the model species. We selected this species because swans are large  
83 and obvious, with readily observable behaviours, and they forage in short grass  
84 without visual obstruction, in an easily accessible urban location.

85

86 *Study site*

87 The study was conducted within Melbourne's inner urban matrix, at Albert Park Lake  
88 (37°50'S, 144°58'E; Victoria, Australia) between 17 July and 30 August 2012. The  
89 225 ha parkland contains a 48.5 ha artificial lake with a concrete edge. The lake  
90 harbours a large and apparently highly habituated population of *C. atratus* which  
91 forage on the extensive grassy verges and frequently encounter pedestrians (see  
92 Weston *et al.* 2012 for a discussion of other possible explanations of shorter FIDs in  
93 areas where people are common). Habituation, the processes whereby animals  
94 learn to reduce responses upon exposure to a stimulus, is thought to reduce FID,  
95 and is one possible explanation of the particularly short FIDs we report here. Despite  
96 the high density of people, swans still avoid pedestrians and display increased  
97 stress-induced corticosterone levels in reaction to handling (Monie 2011; Payne *et al.*  
98 2012). Most swans in the population have been marked with a neck collar  
99 allowing identification from a distance (Guay and Mulder 2009; Mulder *et al.* 2010).

100

101 *Volunteers*

102 Four university students or recent graduates were recruited for this project. All  
103 students had some experience working with wildlife, but none had ever measured

104 FIDs or ADs. Prior to the start of the project, each observer received a 2-hour  
105 training session, at the study site, with one experienced observer who had measured  
106 in excess of 700 FIDs in various species of birds including *C. atratus*, and who also  
107 collected FIDs and ADs for this study. Training involved learning the basic protocols,  
108 then conducting approaches in conjunction with the experienced observer, to  
109 standardise protocols and agree which behavioural cues constituted alertness and  
110 flight. Training of this type has been suggested for studies where new observers are  
111 recruited (Fernández-Juricic *et al.* 2001). Following the training session, each  
112 observer was provided with all required equipment (see below) and instructed to  
113 return to the site and measure between 40 and 50 FIDs and ADs for *C. atratus* in  
114 their own time. Fieldwork was scheduled to ensure that no two observers were  
115 present at the field site simultaneously.

116

#### 117 *Measurements of FID and AD*

118 Alert distance was defined as the distance between an observer and a swan at  
119 which a foraging or resting swan raised its head and looked at the observer (after  
120 Fernández-Juricic *et al.* 2002). FID was defined as the distance between an  
121 observer and a swan at which time the swan initiated escape behaviour either  
122 through walking, running or flying away (Weston *et al.* 2012).

123

124 Swans to be observed ('focal' swans) were selected as follows: a haphazard  
125 starting point was selected on the lake shore and the lake was circumnavigated in a  
126 randomly selected direction determined by coin toss. Only collared swans standing  
127 up and foraging on land were studied and they were targeted as they were  
128 encountered. Additionally, we selected only individuals not currently disturbed, and

129 situated further than 10 m away from other park users. Typically, the observer would  
130 walk alone along the path around the lake until a group of swans was detected. The  
131 approach was then started from the point where the swan was identified. We  
132 recorded neck collar identification to determine sex (white collars for females, black  
133 for males; Guay *et al.* 2009), using binoculars or the range finder, either from a  
134 distance before the approach or after the approach was complete. We avoided  
135 repeat sampling of individuals on the same day. The closest swan to the observer at  
136 the start of the approach was always selected for observation (i.e. was the focal  
137 bird). Non-focal swans located further from the observer that had been disturbed  
138 during an experimental approach were excluded as candidates for following  
139 approaches.

140

141 All approaches were made parallel to the shore of the lake because angle of  
142 approach can influence response in birds (Burger *et al.* 2010). All approaches were  
143 conducted at standard walking speed (*c.* 1 m sec<sup>-1</sup>; Glover *et al.* 2011). We used a  
144 Bushnell® Elite 1500 Laser Rangefinder to record FID ( $\pm$  1 m). Start Distance (SD),  
145 the distance from the focal bird at which the experimental approach is started, is an  
146 important parameter influencing the response of birds (e.g. Blumstein 2003). Given  
147 the difficulties of standardising SD as part of our experimental design, we measured  
148 SD and controlled for it by including it as a covariate in our analyses. Measurements  
149 were conducted as follows: the initial distance between the bird and the observer  
150 (SD) was measured directly using the range finder. A marker was then left at the  
151 starting point. Following the alert and flight responses (i.e., the target swan taking a  
152 step or flying), separate markers were placed on the ground. Flight can be confused  
153 with foraging movements in some species, which can lead to an overestimate of FID

154 (Chamaillé-Jammes and Blumstein 2012). However, *C. atratus* adopt an alert  
155 posture with the neck raised high before initiating escape behaviour, which permits  
156 unambiguous identification of flight. This simplifies the analyses of the relationship  
157 between SD and FID and allows the use of ordinary least-squares regression rather  
158 than quantile regression (Chamaillé-Jammes and Blumstein 2012). At the completion  
159 of the approach, the observer moved to the initial position of the swan and measured  
160 the distance to the different markers using the rangefinder. The perpendicular  
161 distance between the initial position of the swan and the edge of the lake was also  
162 measured using a range finder because distance from shore has been shown to  
163 influence FID in *C. atratus* (Guay *et al.* In Press-a). For each approach we also  
164 recorded potential covariates, namely sex and group size (number of swans within  
165 10 m of the focal bird).

166

### 167 *Statistical analyses*

168 Data were analysed using General Linear Mixed Models (GLMM) on IBM SPSS (v.  
169 20, IBM Corporation, Armonk, NY, USA) with a random factor of swan identity  
170 included to account for the influence of multiple sampling of the same collared swan  
171 on different days. All two-way interactions were included in the model. All distances  
172 and group size were  $\log_{10}$  transformed prior to analysis to improve normality  
173 (Blumstein 2006). For significant factors, we calculated pairwise comparisons based  
174 on estimated marginal means to determine where significant differences resided.  
175 Summary statistics are presented as means  $\pm$  one standard deviation and include  
176 the range and sample size in brackets.

177

178



179 **Results**

180 Overall, AD was  $28.2 \pm 15.9$  m (3 – 85;  $n = 218$ ; 38 – 50 per observer) and FID was  
181  $13.9 \pm 10.8$  m (0.2 – 63;  $n = 225$ ; 40 – 50 per observer). As expected, AD was highly  
182 correlated with FID ( $R^2 = 0.342$ ,  $F_{1, 216} = 112.3$ ,  $P < 0.001$ ) and was recorded in  
183 96.9% of approaches. GLMM results revealed an observer effect for AD but not FID,  
184 no effect of group size for either response distance, a significant effect of distance  
185 from shore for FID but not AD and an effect of start distance on FID and AD (Table  
186 1). Pairwise comparisons revealed that estimates of AD were higher for  
187 inexperienced observers than for the experienced observer. Although three of four  
188 inexperienced observers did not differ from one another, inexperienced observer 1  
189 differed from inexperienced observer 2 ( $p = 0.003$ ; see Figure 1) and inexperienced  
190 observer 3 ( $p = 0.043$ ; see Figure 1). Thus, FID estimates appear more reliable than  
191 those of AD.

192

193 INSERT TABLE 1 AND FIGURE 1

194

195

196 **Discussion**

197 While some studies of FID and/or AD involve only one observer (e.g. Møller and  
198 Erritzøe 2010; Glover *et al.* 2011; Guay *et al.* In Press-b), those conducted over  
199 large geographical or taxonomic scales inevitably use multiple observers (e.g.  
200 Blumstein 2006; Weston *et al.* 2012). Variation between observers can result in poor  
201 precision, thus requiring increased sample sizes or statistical control of bias (Verner  
202 and Milne 1990; Cunningham *et al.* 1999). We found consistent estimates of FID  
203 among observers, suggesting that inter-observer differences are negligible, at least  
204 for the species and observers we tested. It appears that the training we provided to  
205 novice observers was adequate to ensure consistency in FID estimates.

206

207 Alert distances have been proposed as a way of defining buffer distances to  
208 manage disturbance to birds; unlike setting buffers using FIDs, buffers set using ADs  
209 may additionally reduce behavioural disruption associated with vigilance (Fernández-  
210 Juricic *et al.* 2001). Several workers have also studied tolerance of birds to people,  
211 using the difference between AD and FID as a measure (Fernández-Juricic *et al.*  
212 2001; O'Neal Campbell 2006). However, inter-observer differences were evident in  
213 the estimation of AD, and the difference between AD and FID varied dramatically  
214 between the observers we used; FID was estimated to be between 30 - 60% of AD  
215 among observers. Experience apparently results in more conservative estimates of  
216 AD, estimates of which apparently vary between inexperienced observers. AD is  
217 arguably more difficult to define and detect than FID, and several of the novice  
218 observers apparently used different behavioural cues to determine alertness or were  
219 less able to detect it. In general, vigilance in birds involves a greater variety of

220 behaviours and postures than escape, these are often subtle, and vigilance may  
221 occur more frequently than escape, making the clear definition and recognition of  
222 alertness difficult. Birds often display alert behaviour even in absence of humans. *C.*  
223 *atratus* on land spend 8.2% of their time alert (unpubl. data). Failure to discriminate  
224 general alert behaviour from alertness directed toward the approaching investigator  
225 may result in overestimated AD. Additionally, birds may not necessarily become alert  
226 before initiating escape behaviour and vigilance may occur before birds adopt  
227 behaviours which observers recognise as alertness (Lima and Bednekoff 1999),  
228 which is not the case when measuring escape. Indeed, Weston *et al.* (2012)  
229 separately defined Detection Distance from AD. In our experience, AD is less  
230 efficient to measure than FID (AD is often not discernible during an approach); in a  
231 study of shorebird flight behaviour, AD's were reported by one experienced observer  
232 in only 23.8% of 753 approaches (unpubl. data) and in a study of waterbirds an  
233 experienced observer recorded AD in 14.6% of 245 approaches (unpubl. data),  
234 either because alertness was sometimes difficult to detect or did not always occur. In  
235 this study we recorded AD on almost every approach, a reflection of the study  
236 species and site. Thus, AD is less reliable, and sometimes less reliably recorded,  
237 than FID.

238

239         As for any study of ADs and FIDs, the applicability of these results to other  
240 species, habitats, and circumstances (e.g. observers, training regimes) remains to  
241 be examined (see Fernández-Juricic *et al.* 2001). However, repeatability of both AD  
242 and FID warrants consideration when analysing multi-observer datasets, and  
243 applying their findings to the management of disturbance. Where multiple observers

244 are used, it may sometimes be appropriate to report inter-observer reliabilities in  
245 estimating FIDs.

246

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361

362

363

364 **Table 1.** General Linear Mixed Model results of the logged Flight-initiation and Alert  
 365 Distance against observer identity, log of swan group size, log of starting distance,  
 366 and log distance from shore. \* indicate parameters which have been log<sub>10</sub>  
 367 transformed, \*\* indicated significant results.

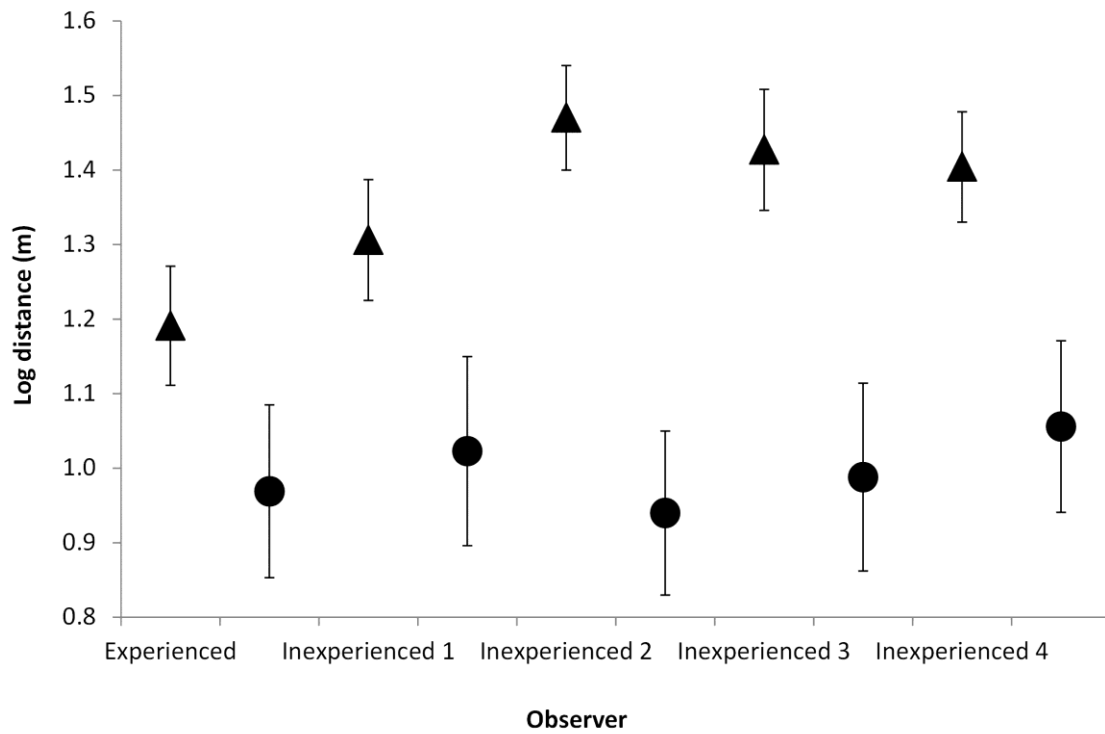
368

Parameter	Flight-initiation Distance*	Alert Distance*	Qualitative results the same?
Observer identity	$F_{4,216.525} = 0.620, p = 0.649$	$F_{4,208.428} = 8.476, p < 0.001$ **	No
Starting distance*	$F_{1,213.609} = 6.402, p = 0.012$ **	$F_{1,205.803} = 39.295, p < 0.001$ **	Yes
Group size*	$F_{1,216.771} = 0.688, p = 0.408$	$F_{1,208.848} = 0.383, p = 0.537$	Yes
Distance from shore*	$F_{1,172.814} = 12.066, p = 0.001$ **	$F_{1,187.303} = 0.019, p = 0.891$	No

369

370

371 **Figure 1.** The Alert (triangle) and Flight-initiation (circles; both logged) Distances for  
372 one experienced and four inexperienced observers who approached *C. atratus*.  
373 Estimated marginal means and 95% confidence intervals are shown.



374

375

376