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Human disturbance of breeding Wood Sandpipers *Tringa glareola*: implications for "alert distances" in prescribing protective buffer zones

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Separation of animals and humans using a protective set-back distance (Minimum Approaching Distance) is a popular tool for conservation managers to promote wildlife-human coexistence. In several cases, Minimum Approaching Distance is based on how animals respond to an approaching human, using Flight Initiation Distance or Alert Distance. Alert Distance, when animals first show increased vigilance to an approaching human, is considered the best basis for Minimum Approaching Distance because animals have time to adapt their response. Alert Distance is frequently difficult or impossible to measure in practice, however, especially in breeding birds. Using a study of breeding Wood Sandpipers *Tringa glareola*, in which Alert Distance could not be measured directly, we tested three possible solutions to this dilemma. Alarm Call Distance did not appear to provide a useful substitute for Alert Distance because sandpipers probably alarm called after they had first detected a human. Published predictions of Alert Distance using body mass also failed to provide realistic estimates of disturbance distances in Wood Sandpipers. The "fixed-slope rule", which predicts that Alert Distance is about double Flight Initiation Distance, was not supported by relationships between Alarm Call Distance and Flight Initiation Distance, but was supported by a relationship between an estimated Alert Distance surrogate and Flight Initiation Distance. This suggests that this rule may have general utility in predicting Alert Distance when only the more readily measured Flight Initiation Distance metric is known. A Minimum Approaching Distance (protective buffer zone) of 160 m is recommended for breeding Wood Sandpipers.

1. Introduction

The creation of protected buffer zones around centres of wildlife activity in which human activity is restricted is a common tool of conservation managers to promote human-wildlife coexistence (e.g., Rodgers & Smith 1997). Buffer zones are based on a set-back distance at which humans or human activities should be separated from sensitive wildlife locations or areas (a Minimum Approaching Distance) which can be estimated using various formulae from empirical measures of the distance at which a human disturbs animals (Fernández-Juricic *et al.* 2005). This approach and the formulation of fixed buffer zones can be criticised on several grounds, however, because animals apparently respond to humans as perceived predators (Ydenberg & Dill 1986, Lima & Dill 1990, Beale & Monaghan 2004) and, as such, the response is dynamic and variable according to many different circumstances and forms of human disturbance (e.g., Ruggles 1994, Hill *et al*. 1997, Gutzwiller & Marcum 1997, Gill *et al*. 2001, West *et al*. 2002, Beale & Monaghan 2004, Blumstein *et al*. 2005, Fernández-Juricic *et al*. 2005, Geist *et al*. 2005).

Despite such valid criticisms and, provided adjustments can be made to buffer zones which are responsive to differences in sensitivity to human disturbance (Rodgers & Smith 1997, Beale & Monaghan 2004), using empirical observations of animals' response to human approaches has remained popular as a basis for a Minimum Approaching Distance (protected buffer zone) (e.g., Knight & Temple 1995, Richardson & Miller 1997, Fernández-Juricic *et al*. 2005). Generally, Flight Initiation Distance, the distance between an approaching human and an animal when the animal takes flight in response to the human, has formed the empirical basis of Minimum Approaching Distance (Richardson & Miller 1997, Fernández-Juricic *et al*. 2001). Flight Initiation Distance may fail to provide an adequate basis for the prevention of disturbance, however, because it may not include an area in which animals can adapt their response to humans (Rodgers & Smith 1997, Fernández-Juricic *et al*. 2001) or, in the case of breeding animals, does not prevent temporary detrimental effects of parents deserting nest contents and/or attentiveness to young. Hence, Alert Distance, the distance at which the animal begins to exhibit alert behaviours to an approaching human (typically the adoption of vigilant behaviour: Rodgers & Smith 1997, Fernández-Juricic *et al*. 2001), has been considered preferential to Flight Initiation Distance as a basis for Minimum Approaching Distance because it provides for an area (the difference between Flight Initiation Distance and Alert Distance) which allows animals to adapt their response to humans (Rodgers & Smith 1997, Fernández-Juricic *et al*. 2001).

Consequently, four of the five methods transcribing Alert Distance or Flight Initiation Distance to Minimum Approaching Distance (and, thus, buffer zones), reviewed by Fernández-Juricic *et al*. (2005) employed Alert Distance. Although Alert Distance is a preferential basis for Minimum Approaching Distance, it has been recorded less often than Flight Initiation Distance (Whitfield *et al*. 2008), which may be due, at least in part, to the difficulty in recording what may be a subtle change in behaviour (e.g., González *et al*. 2006). Indeed, in general, in the field of prescribing Minimum Approaching Distance or buffer zones, there is a shortage of empirical measures of disturbance distances and, especially, Alert Distance in breeding birds (Ruddock & Whitfield 2007, Whitfield *et al*. 2008).

Therefore, there is a serious difficulty facing conservation managers wishing to prescribe protective buffer zones on the best behavioural metric, in that this metric, Alert Distance, can often not be recorded in the field. In this study we use the Wood Sandpiper *Tringa glareola* (a wader or shorebird), in which this problem is manifest, because Alert Distance cannot be recorded directly when breeding, to test three possible solutions. These possible solutions are: 1) use of alarm calling distance as a surrogate for Alert Distance, since alarm calling occurs in many breeding animals and is a more obvious indicator of alert behaviour than a vigilant posture; 2) use of body mass as a predictor of Alert Distance (Blumstein *et al*. 2005); and 3) use of the "fixed-slope rule" (Flight Initiation Distance = 0.44 × Alert Distance) to predict Alert Distance when Flight Initiation Distance is known (Cardenas *et al*. 2005, Gulbransen *et al*. 2006). In addition, since Wood Sandpiper is listed on Annex I of the EC Wild Birds Directive (2009/147/EC) as requiring special protection provisions within the European Union, but there have been no published empirical estimates of either Flight Initiation Distance or Alert Distance for this species when breeding (Ruddock & Whitfield 2007) we also present measures of disturbance distances and recommendations for Minimum Approaching Distance.

2. Methods

The study was conducted between 22 June and 2 July 2007 to the south, northeast and northwest of Kautokeino (69°00' N, 23°02' E: UTM 7655677) in north Norway. Wood Sandpipers bred in a range of habitats in the study sites, ranging from palsa mires to river floodplains, but typically were found in areas of willow *Salix* spp. scrub in the ecotone between dry land and wet marsh. Small birch *Betula* spp. trees and bushes usually dominated the dry land, and *Sphagnum* mosses, sedges *Carex* spp. and cotton grass *Eriophorum* spp. dominated the wet marsh. From extensive previous knowledge of several of our study sites, and their location, breeding Wood Sandpipers were not subject to any human disturbance, other than research activities. Wood Sandpiper parents share incubation and early chick-rearing, with the female usually leaving the male to care alone for chicks older than 7–10 d (Cramp & Simmons 1983). Wood Sandpipers with broods of young are readily recognised because, in common with other *Tringa*, parental behaviour changes radically from being largely silent and secretive during incubation to highly vocal and conspicuous once the chicks hatch (Cramp & Simmons 1983). All study subjects were birds with broods of young on the basis of parental behaviour and, in nine of 27 cases, confirmed by sightings of chicks. Efforts to confirm the presence and location of chicks were not made in every case to reduce disturbance and because thick vegetation often prevented confirmation. Judging by a) the timing of appearance of birds exhibiting chick-rearing behaviour, b) observations of chicks in study broods, and c) contemporary observations and capture of non-study broods, all study broods were less than 10 d old, with the majority probably being less than 7 d old. Only one of the 27 study subjects was isolated from other breeding sites of Wood Sandpipers in the sense that it was unlikely that other chick rearing sandpipers could be seen and/or heard by the study subject. However, as Wood Sandpipers were common on all of our study sites, and by distancing our recording of study subjects we endeavoured to sample only subjects that had not already been exposed to the alarm calls of other birds on the same day. From the location of study subjects, none was recorded more than once.

Study subjects were approached directly at a steady walking pace (c. 0.5 m/s) by a single observer at a starting distance of over 150 m in all but two cases where due to topography the starting distance was 120 m (mean starting distance 170 m, $n = 27$). Locating potential study subjects at distance was initially achieved by identification of potentially suitable breeding habitat at distance: as noted earlier, in the ecotone between dry land and wet marsh in scrub, a relatively narrow habitat in our study sites. Observations of several non-study subjects suggested that at 150–200 m an observer elicited no overt signs of disturbance in Wood Sandpipers and so starting distance should not have influenced the results (Blumstein 2003, Blumstein *et al*. 2003, 2005): "guard" birds were persistently vigilant. Both Wood Sandpiper parents typically care for young chicks with a division in roles between a "guard" bird which maintains an alert posture at a "look-out" location, often an elevated position such as a hummock, bush or tree (*Salix* or *Betula* spp.), with a clear view of the surrounding area, and a "non-guard" bird which broods and stays close to chicks in mire feeding areas dominated by *Sphagnum*, *Carex* and *Eriophorum* spp. vegetation. Non-guard birds were usually not visible to the observer at the starting distances employed, but guard birds were usually visible.

Due to the vigilant role and persistent alert posture of guard birds and the location of non-guard birds it was impossible to record Alert Distance in Wood Sandpipers and so the distance between observer and bird at which an alarm call was first uttered was recorded as a surrogate (Alarm Call Distance). The Flight Initiation Distance or distance at which a bird took flight in response to the approaching observer was also recorded (typically birds flew towards, rather than away from the observer). Distances were recorded by the use of pacing which had been calibrated for measured length and checked for consistency in pre-and post-study exercises, and by the use of a Geographical Positioning System (GPS: accurate to 3 m), especially in situations where the presence of water prevented distance-measurement by pacing. In ten trials at pre-selected random distances between 50 m and 100 m, distance estimates made first by pacing were all within 5 m of distance estimates made subsequently by GPS.

Alarm Call Distance and Flight Initiation Distance were recorded for guard birds in all cases and for non-guard birds whenever possible. In four cases the exact location of a non-guard bird could not be determined prior to it flushing and in eight cases only a guard bird was present. The initial location of a guard bird as either on the ground or perched (at the top of a bush or short tree) was also recorded. If chicks were seen their location with regard to parents was recorded as well as the distance between the observer and the chicks when a parental reaction was first noted. Each study subject was approached once by the same observer, with no re-sampling. All approaches were made in the afternoon or early evening under weather conditions of light winds and cloudy or intermittently sunny weather with the observer wearing dark green clothing.

To compare the observed results against those predicted for Alert Distance by Blumstein *et al.* (2005) on body mass the maximum body mass (90 g) for Wood Sandpipers noted by Cramp & Simmons (1983) was $\log_{10}$ transformed and used to derive expected Alert Distance from equation (1): $\log_{10}$ Alert Distance = 0.574 + 0.347 × $\log_{10}$ body mass (Blumstein *et al.* 2005: Fig. 5a). Equation (1) was based on raw data collated by Blumstein *et al.* (2005) for a number of species when foraging or resting/loafing before accounting for phylogeny and observer starting distance. Blumstein *et al.* (2005) understandably accounted for phylogeny when testing for a relationship between body mass and disturbance distance because related species are not necessarily phylogenetically independent, and preferred a predictive equation based on body mass which accounted for starting distance and phylogeny. However, in the present study starting distance was not an influential factor and equations involving phylogenetic contrasts could not be related to Wood Sandpiper. As the maximum body mass noted by Cramp & Simmons (1983) was larger than the maximum recorded for Wood Sandpiper on the present study sites (68 g, unknown gender: R. Rae unpubl.data) an expected Alert Distance was also derived from this site-specific mass value.

The fit of the study's result to the "fixed slope rule" (Flight Initiation Distance = 0.44 × Alert Distance), originally documented in galahs *Cacatua roseicapilla* by Cardenas *et al.* (2005) and subsequently supported by Gulbransen *et al.* (2006) in three other species, was assessed by a Gaussian GLM with the intercept forced through the origin (Gulbransen *et al.* 2006) and guard Flight Initiation Distance or non-guard Flight Initiation Distance as explanatory variables and guard Alarm Call Distance or non-guard Alarm Call Distance as respective response variables. As noted earlier, however, guard Wood Sandpipers may have reacted to disturbance before alarm calling and so Alarm Call Distance is liable to be less than Alert Distance. To circumvent this potential difficulty, it was assumed that non-guard parents first became alert to the observer's presence when guard parents alarm called (since the view of non-guards at that juncture was obstructed by vegetation). Thus, Alert Distance for non-guard parents should be distance between observer and non-guard parent when the guard parent alarm called. Hence, since guard Alarm Call Distance and both parents' relative positions when the guard parent alarm called were recorded, non-guard Alert Distance could be estimated and then used as response variable in a Gaussian GLM with non-guard Flight Initiation Distance as explanatory variable, and the intercept forced through the origin (Gulbransen *et al.* 2006). Significance was inferred by a value of $p < 0.05$ and effect size of a parameter was described by a partial eta-squared value (Cohen 1988).

3. Results

On average guard parents alarm called at 72 m (range = 33–100 m) and flushed at 59 m (range = 15–100 m) whereas non-guard parents alarm called at 44 m (range = 23–65 m) and flushed at 38 m (range = 21–60 m) (Table 1). Guard parents invariably alarm called and took flight at greater distances than non-guard parents (Alarm Call Distance, paired *t*-test, $t = 7.63$, df = 13, $p < 0.001$; Flight Initiation Distance, paired *t*-test, $t = 4.57$, df = 13, $p = 0.001$) (Table 1). Guard and non-guard Alarm Call Distance were correlated ($r = 0.619$, $p = 0.018$) but guard and non-guard Flight Initiation Distance were not ($r = 0.400$, $p = 0.156$). Guard Alarm Call Distance and Flight Initiation Distance were significantly higher for perched birds (Alarm Call Distance mean = 75 m, Flight Initiation Distance mean = 64 m, $n = 21$) than for birds on the ground (Alarm Call Distance mean = 60 m, Flight Initiation Distance mean = 43 m, $n = 6$) (Alarm Call Distance, $t = -2.350$, $p = 0.025$; Flight Initiation Distance, $t = -2.219$, $p = 0.036$). Guard and non-guard parents were on average 14 m (range:

Table 1. Descriptive statistics for disturbance distances in chick-rearing Wood Sandpipers in response to a single approaching pedestrian observer: G = guard parent, NG = non-guard parent, ACD = Alarm Call Distance, FID = Flight Initiation (flush) Distance, AD = Alert Distance (see text for estimation), BROOD = distance between observer and chicks at which first parental response (G_ACD) was recorded. Upper 90% and 95% = upper 90 and 95 percentile of parameter records respectively.

Statistic	G_ACD	G_FID	NG_ACD	NG_FID	NG_AD	BROOD
n	27	27	14	14	14	9
Mean	72	59	44	38	74	74
SD	15	21	13	13	14	17
SE	3	4	4	3	4	6
95% CL	6	8	7	7	7	11
Upper 90%	94	80	62	54	92	96
Upper 95%	100	94	65	57	97	98

3–32 m, $n = 9$) and 2 m (range: 1–3 m, $n = 6$) from where chick(s) were seen respectively.

Predicted Alert Distance for Wood Sandpiper based on body mass predictions of Blumstein *et al.* (2005) was 18 m (for 90 g mass) and 16 m (for 68 g mass). (An equation presented by Blumstein *et al.* (2005) which accounted for observer starting distance produced even poorer predictions for chick rearing Wood Sandpipers, and so we have not presented it.)

For guard parents the slope of the linear regression between Alarm Call Distance and Flight Initiation Distance was 0.8 (95% CL = 0.8–0.9, partial eta-squared = 0.943, $p < 0.001$) and for non-guard parents it was 0.86 (95% CL = 0.8–0.9, partial eta-squared = 0.989, $p < 0.001$). For non-guard parents the slope of the linear regression between estimated Alert Distance and Flight Initiation Distance was 0.5 (95% CL = 0.4–0.6, partial eta-squared = 0.887, $p < 0.001$) (Fig. 1).

4. Discussion

4.1. Estimating Alert Distance

Several studies have noted the difficulty in recording Alert Distance in breeding birds and this probably explains why Flight Initiation Distance is a more common metric in disturbance studies (e.g., Fernández-Juricic *et al.* 2005, González *et al.* 2006, Ruddock & Whitfield 2007, Whitfield *et al.* 2008). This difficulty is well-illustrated by breeding waders. Our study did not record disturbance distances in incubating Wood Sandpipers but sev-

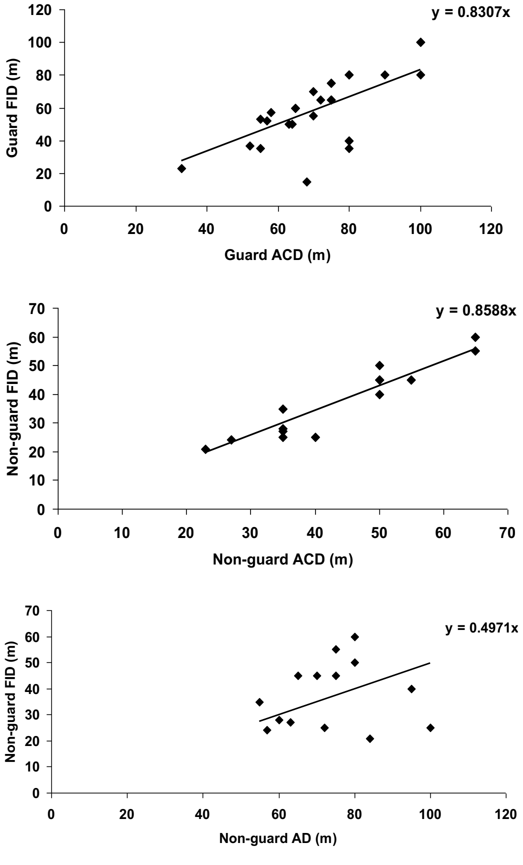

Fig. 1. Relationships between Alarm Call Distance (ACD) and Flight Initiation Distance (FID) for guard (upper plot) and non-guard (middle plot) parent Wood Sandpipers, and between estimated Alert Distance (AD) and FID for non-guard parents (lower plot). Linear trend lines are shown, with intercepts forced through the origin (text gives confidence limits for the slopes).

eral authors have noted that Flight Initiation Distance for sitting birds is very short and probably typically less than 5 m, with 10 m the maximum (Cramp & Simmons 1983, Nethersole-Thompson & Nethersole-Thompson 1986, Ratcliffe 2005). Wood Sandpiper nests are concealed in vegetation so it is probably impossible to record Alert Distance for incubating birds and non-incubating partners are often away from the nest site and do not adopt guarding behaviour (Cramp & Simmons 1983, Nethersole-Thompson & Nethersole-Thompson 1986, Ratcliffe 2005). This same difficulty in recording Alert Distance for incubating birds probably applies to a large number of other wader species (Cramp & Simmons 1983). We found that it was also practically impossible to record Alert Distance directly in chick-rearing Wood Sandpipers due either to their concealment in vegetation (non-guard parents) or to their near-constant vigilant behaviour (guard parents); traits common to many other waders with a similar parental care system.

As well as problems due to concealment of view between subject animal and human "disturbance/observer" or high persistence of "background" vigilance, as illustrated by breeding waders, there is also the simple problem of accurate recording of vigilant posture at distance. Fernández-Juricic *et al.* (2001) noted that alert postures could be detected in parkland birds away from nest sites at an average distance of 35 m, which is substantially less than (even) Flight Initiation Distance in many other species when breeding (González *et al.* 2006, Ruddock & Whitfield 2007, Whitfield *et al.* 2008). We suggest, therefore, that although when applying measures of disturbance distance to design or recommend protective buffer zones Alert Distance can be viewed as the preferential basis (Rodgers & Smith 1997, Fernández-Juricic *et al.* 2001, 2005), at least in many breeding birds, practice can not match theoretical requirements.

Our study examined three potential solutions to this problem. First, Alert Distance has been defined as the distance between an approaching human at which point the animal begins to exhibit alert behaviours to the approaching human, including alarm calling (Rodgers & Smith 1997, Fernández-Juricic *et al.* 2001) but our results suggested that Alarm Call Distance is probably not the point at which alert behaviours are first displayed. Hence, an obvious indication of alert behaviour, alarm calling, is an inadequate measure of Alert Distance, as typically defined by previous studies.

Second, we tested the use of equations to predict Alert Distance based on body mass (Blumstein *et al.* 2005). For chick-rearing Wood Sandpipers the equations of Blumstein *et al.* (2005) predicted average Alert Distance estimates of 16–18 m. Although Alert Distance could not be directly measured in the present study, these predictions were clearly severe underestimates given that on average, for guard birds, Alarm Call Distance was 72 m and Flight Initiation Distance was 59 m; if it is assumed that Alert Distance is about twice Flight Initiation Distance (see later) then average Alert Distance for guard birds was probably about 120 m, almost an order of magnitude greater than predictions. With only a single species in the present study, clearly it may be presumptuous to dismiss the predictive value of Blumstein *et al.*'s (2005) equations, and predictions may have been appropriate for incubating, but not chick-rearing wood sandpipers: other studies have also noted the influence of stage of breeding on parental reactions to human intruders (Bauwens & Thoen 1981, Galeotti *et al.* 2000). A more wide-ranging review of disturbance distances in breeding birds, however, has also found similar substantial discrepancies between predictions and observations based on these body mass equations (Whitfield *et al.* 2008). While more studies are always desirable, we do not recommend that disturbance-free zones are based on the body mass equations of Blumstein *et al.* (2005), given our results for Wood Sandpipers and those of Whitfield *et al.* (2008), especially when they make predictions that seem often to be orders of magnitude lower than derived by other methods.

The third possible solution, using the fixed-slope rule, may have greater utility in that although ratios between Alarm Call Distance and Flight Initiation Distance in chick-rearing Wood Sandpipers were significantly higher than 0.44, Alarm Call Distance was apparently not a reliable surrogate for Alert Distance, and the slope between estimated Alert Distance and Flight Initiation Distance (0.50) for non-guard birds was statistically indistinguishable from 0.44, confirming previous studies in other species (Cardenas *et al.* 2005, Gulbransen *et al.* 2006). Several wader species sit "tight" when incubating, only leaving the nest when a human is extremely close (Cramp & Simmons 1983), and this tactic will probably generate Flight Initiation Distance:Alert Distance ratios that are much lower than 0.44. But for such species, reaction distances during chick-rearing are much greater and so are probably a better basis for preventing human disturbance. Expert opinions on Alert Distance and Flight Initiation Distance in 26 bird species when chick rearing generated a slope of 0.60 (95% CL = 0.52–0.67) which although significantly higher than the 0.44 fixed-slope rule, is not inconsistent with the notion that Flight Initiation Distance is approximately half that of Alert Distance (Whitfield *et al*. 2008). More empirical studies are highly desirable but an assumption that, approximately, Alert Distance = Flight Initiation Distance × 2 may offer the best scope for deriving Alert Distance estimates when they are impossible to measure in practice.

4.2 Minimum Approaching Distance in Wood Sandpipers and other waders

Fernández-Juricic *et al*. (2005) reviewed five methods which used measures of Flight Initiation Distance and/or Alert Distance to derive Minimum Approaching Distance. In Wood Sandpipers these methods produced Minimum Approaching Distance values between 94 m and 218 m (D.P. Whitfield & R. Rae unpubl. data). On the basis of the slope between estimated Alert Distance and Flight Initiation Distance in non-guard birds, in which Flight Initiation Distance was approximately half-Alert Distance, then 90% of guard Wood Sandpipers had an Alert Distance of 160 m or less (80 m × 2: see Table 1). This corresponded to the distance at which observations of non-study subjects did not apparently incur any signs of disturbance and which dictated the observer starting distance. Given sample sizes that are likely for breeding birds, a 90 percentile for Alert Distance may be preferable to a 95 percentile in estimating Minimum Approaching Distance because it reduces the influence of any outliers but still potentially prevents disturbance of the large majority of the population. As our study sites were largely free of human disturbance (other than our presence) there would be no basis for revising our recommended 160 m Minimum Approaching Distance upwards to account for potential habituation within our study, which may not apply in other circumstances closer to human habitation. A 160 m Minimum Approaching Distance for Wood Sandpipers carries several other implicit assumptions (Fernández-Juricic *et al*. 2005), of which three are worth highlighting, because Minimum Approaching Distance is sensitive to variation in Alert Distance.

First, Alert Distance and Flight Initiation Distance in breeding Wood Sandpipers apparently vary with time (stage of breeding) but a 160 m Minimum Approaching Distance should encompass the apparently lower reaction distances during incubation. Reaction distances of parents appear to decrease when chicks are older than in the study subjects (R. Rae unpubl.data), probably in part because older chicks are better-equipped to survive (Ruhlen *et al*. 2003, Ruthrauff & McCaffery 2005), and so our concentration on birds with young broods should not have underestimated Minimum Approaching Distance. Our study cannot comment empirically on the sensitivity of Wood Sandpipers that are prospecting for nesting sites at the beginning of the breeding season, and how this may affect our recommended 160 m Minimum Approaching Distance, although we revisit this issue later.

Second, perched Wood Sandpipers responded at greater distances than did birds on the ground, a result contradicting a negative effect of perch height on disturbance distances in other studies (Watson & Pierce 1998, Blumstein *et al*. 2004, Fernández-Juricic *et al*. 2004, 2005). The difference may be that Wood Sandpipers with chicks fly towards a predator and effectively mob or scold it with persistent and loud alarm calls, rather than attempt to escape it, and greater elevation may allow earlier detection and mobbing. The maximum perch height in the study subjects was about 4 m, although other birds were seen to use higher perches e.g., top of power pole at over 8 m. Consequently, in areas where higher perch trees for guard birds are available (further south in Scandinavia, for example) response distances may be greater whereas in tree-less habitats (at several Scottish breeding sites: Nethersole-Thompson & Nethersole-Thompson 1986) response distances may be lower. We would urge that our recommended Minimum Approaching Distance should not be reduced in situations where, through habitat, response distances on alarm calling or flight initiation would appear to be reduced.

Third, though subjectively, it was apparent during fieldwork that tangential approaches to chick-rearing Wood Sandpipers did not elicit greater reaction distances than direct approaches; consistent with some (e.g., Burger & Gochfeld 1981) but not other studies (e.g., Fernández-Juricic *et al*. 2005). Moreover, but again subjectively, an additional impression during fieldwork was that the direct approach of up to three observers did not dramatically increase Alarm Call Distance or Flight Initiation Distance above those engendered by a single observer (Beale & Monaghan 2004, Geist *et al*. 2005).

For the Wood Sandpiper, Currie & Elliot (1997) recommended that a "provisional safe working distance" for birds with chicks was 200 m increasing to about 400 m during incubation and extending to 600 m during "nest building". Currie & Elliot (1997) provided no empirical justification for their recommendations, and our study and the literature indicate that these distances are too precautionary when birds have an active breeding attempt, and are especially wayward for incubating birds. Currie & Elliot (1997) also recommended that a wide suite of species was more sensitive to disturbance when incubating than when with chicks. This recommendation was not supported by expert opinions on disturbance distances marshalled by Whitfield *et al*. (2008). Rather the converse was statistically more likely: behaviourally, breeding birds were more sensitive to disturbance with chicks. This is a common observation for many birds (e.g., Montgomerie & Weatherhead 1988, Palestis 2005) and, in our experience, applied to all of the dozen or so species of waders in our study areas.

While we share empirical ignorance with Currie & Elliot (1997) on the pre-breeding ("nest building") phase, we would suggest that for the Wood Sandpiper and other breeding waders a protective buffer zone based on disturbance measures during the early chick phase should provide adequate protection when nest sites are being prospected for. Finney *et al*. (2005) would also apparently support this notion.

In a study of recreational disturbance of breeding Eurasian Golden Plover *Pluvialis apricaria* Finney *et al*. (2005) suggested that Alarm Call Distance (approximately, on average, 200 m: Yalden & Yalden 1989) derived from birds with chicks provided a good proxy for the distance at which breeding birds avoided a recreational footpath (an average of 200 m). Finney *et al*. (2005) also suggested that, for breeding waders, studies of birds alarm calling with chicks could be used to indicate the distances from sources of disturbance over which habitat occupancy is likely to be reduced. While we agree with Finney *et al*. (2005) that observed behavioural responses of waders with chicks can serve as a basis for protective set-back distances, we would highlight that: a) birds have probably already been "disturbed" by the time that they alarm call, and; b) using an average of a behavioural "disturbance" metric only prevents more-or-less half of the birds from displaying that behaviour.

However, subject to further research there may be an argument for the larger wader species (e.g., godwits *Limosa* spp. and curlews *Numenius* spp.) for a different approach to that which we have adopted here. Many of these wader species, that are larger than the Wood Sandpiper and less prone to predation as adults, engage more in active "mobbing behaviour" (e.g., Jónsson & Gunnarsson 2010), thereby warranting further studies in considering the relationship between Alarm Call Distance and "disturbance". In general, nevertheless, we would urge that empirically derived measures of disturbance should be gathered more frequently, and that these measures should preferably be used by conservation managers as a basis for practical application of set-back distances or protective buffer zones or Minimum Approaching Distances (different terms for the same principle), rather than subjective measures that can be more prone to challenge.

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Ihmisen aiheuttama häirintä pesiville liroille: ”valpastumisetäisyyden” merkitys suojavyöhykkeiden asettamisessa

Ihmisten ja eläinten erottelu suojavyöhykkeillä (pienin lähestymisetäisyys) on suosittu suojelutoimi, jota käytetään villien eläinten ja ihmisten rinnakkaiselon edistämiseksi. Monissa tapauksessa asetettu pienin lähestymisetäisyys perustuu siihen, miten eläimet reagoivat lähestyvään ihmiseen, esimerkiksi tarkastelemalla lentoonlähtöetäisyyttä tai valpastumisetäisyyttä. Valpastumisetäisyys, jolla eläimet alkavat osoittaa lisääntynyttä valppautta lähestyvän ihmisen johdosta, pidetään parhaimpana lähtökohtana pienimmän lähestymisetäisyyden asettamiselle, koska silloin eläimille jää aikaa sopeuttaa responssiaan. Valpastumisetäisyys on kuitenkin usein vaikea tai mahdoton mitata käytännössä, varsinkin pesivillä linnuilla.

Tässä tutkittiin pesiviä liroja, joiden valpastumisetäisyyttä ei voitu mitata suoraan, ja tarkasteltiin kolmea mahdollista ratkaisua tähän pulmaan. Varoitusetäisyys, jolla linnut alkoivat esittää varoitusääniä, ei vaikuttanut hyödylliseltä korvikkeelta valpastumisetäisyydelle. Myöskään aiemmin julkaistut ruumiinpainoon perustuvat ennusteet eivät antaneet realistista kuvaa liron häirintäetäisyyksistä.

”Kiinteän kulmakertoimen sääntö” – joka ennustaa valpastumisetäisyyden olevan lentoonlähtöetäisyys jaettuna luvulla 0,44 – ei toiminut verrattaessa lentoonlähtö- ja varoitusetäisyyttä. Sen sijaan, tämä sääntö toimi kohtalaisen hyvin verrattaessa lentoonlähtöetäisyyttä ja erästä valpastumisetäisyyden arviota. Tämän löydöksen perusteella, kiinteän kulmakertoimen sääntö voi olla yleisemmin hyödyllinen valpastumisetäisyyden arvioinnissa, tilanteissa joissa vain helpommin mitattava lentoonlähtöetäisyys on tiedossa. Suosittelemme pesivien lirojen pienimmäksi lähestymisetäisyydeksi (suojavyöhykkeeksi) 160 m.

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