Disturbance of foraging Knots by aircraft in the Dutch Wadden Sea in August-October 1992

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Knots *Calidris canutus* were observed during low-water periods on Hengst, a mudflat complex south of the island of Vlieland in the westernmost part of the Dutch Wadden Sea. In the period 19 August to 12 October 1992 we registered their numbers and behaviour on 13 days with low-flying (c. 50 m above surface level) aircraft (usually jet fighter) activity and on 20 days without such aircraft activity. Large numbers of Knots were rarely present on days with aircraft activity. On aircraft-days, Knot flocks showed a greater tendency to fly up at large distances upon the approach of 2-3 human observers. They also more frequently took to the air without apparent reason on such days. Under foggy conditions the alarm response to jet fighters appeared more severe. In the course of the study period there was perhaps a limited degree of habituation to jet fighter activity. Light airplanes caused very strong disturbance even when flying at altitudes above 100 m.

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The Wadden Sea is of huge international importance to migrating waterbirds. It is also intensively used as a military aircraft training ground, but there has been little study on the effects of military and other aircraft on the numbers and behaviour of waders during low water (see summary in Smit & Visser 1993). Our recent incidental observations on Knots *Calidris canutus* foraging on an intertidal area close to the jet fighter target area on Vlieland in the western Dutch Wadden Sea, are thus of interest. The day-to-day variability in the degree of military activity, ranging from none to high-intensity flying by jet fighters, allowed us to compare the numbers and behaviour of Knots in the presence and absence of low-flying jet fighters. Since we were often in the field during weekends, when there was no military flying, we obtained many 'control'-days. On two Saturdays this calm was, however, replaced by the activity of low-flying light 'tourist' airplanes.

Our work was carried out on a sandflat complex called 'Hengst'. This lies east of the entrance of the North Sea into the Wadden Sea (Eyerlandse Gat) between the islands of Texel to the south-west and Vlieland to the north (The Netherlands, 53°10'N, 04° 56'E). Hengst, consisting of area called Ballastplaat along its southern edge and Steenplaat in the north and covering c. 1650 ha, is surrounded by deep gullies and can be reached only by boat. Part of the northern shore of Hengst has the status of Harbour Seal Reservation, and no people are permitted there between 15 May and 1 September. The entire area is officially designated as a 'quiet area' (Stiltegebied) and is part of the Ramsar designation for the Wadden Sea and a National Nature Reserve. Despite all these designations, the area is used also as an approach and turning space for low-flying NATO jet-fighters attacking practice targets in a bombing range. The jet fighters usually overflew the area at estimated heights of ≥50 m, although sometimes as low as 10 m (S. Boon pers. comm.), firing repeatedly at targets on the western half of Vlieland, 6 km north of Hengst. On target-practice days we registered up to three passing jet fighters per minute, but the intensity was more usually in the order of 3 thunderingly loud passages per 5 min. Flight activity lasted usually for 2-5 hr per day, but sometimes continued for much longer into the night.

Between 19 August and 12 October 1992 we spent 39 days in the field. A field day consisted of a visit to the intertidal study area by inflatable Zodiac-boat starting as soon as part of the mudflats became drained. Visits were always in daylight and usually lasted 4-5 hrs, but sometimes only 2 h and rarely 7 h, the period depending largely on the vagaries of tide and weather. When on the sandflats we were occupied chiefly either by benthic sampling or by intensive observations on the foraging behaviour of Knots. In addition, we always made an estimate of the numbers of Knots on Hengst in the course of each field day.

On most observation days we recorded the presence or absence of jet fighters and other aircraft and we tried to describe their activity. We also took notes on three aspects of the behaviour of Knots. Firstly we scored the

Table 1. Observed effects of disturbance by two categories of aircraft (light airplanes and jet fighters) on the numbers and behaviour of Knots on Hengst during low-water periods. Incidences of approachability and restlessness are scored as x out of y field days.

Condition	n (days)	Average no. of Knots	Incidence of low approachability	Incidence of restlessness
No. aircraft	20	6,392	1/9	1/9
Light airplanes	2	9,000	2/2	2/2
Jet fighters	11	2,691	1/5	4/7

extent to which they were approachable by human observers. In areas without jet fighter activity such as near Griend, farther east in the Wadden Sea, Knot flocks are usually approachable to distances of 60 m or less (2 or 3 observers slowly walking towards the flock without it taking flight) (Piersma *et al.* in prep.). Such approachability was also observed on Hengst, but on some days the birds' approachability was much lower, with flocks flying away at distances of 120 m or more from observers. The difference between the categories of high (< 60 m) and low (> 120 m) approachability was quite distinct. We noted also the frequency at which flocks were flying up during low water. The resulting flights usually lasted only about 30 s before birds landed close to their starting point. On some days, when there were many of these round-flights, the Knots gave an impression of strong restlessness. We use this degree of restlessness to give a field day-specific restlessness score. Finally we noted whether or not during a low-water period (many) Knots left Hengst for other areas, usually located to the east and north-east. These areas are less harried by low-flying military aircraft since they lie farther from the target area on Vlieland. Chi-square statistics were carried out with StatXact (Cytel 1991).

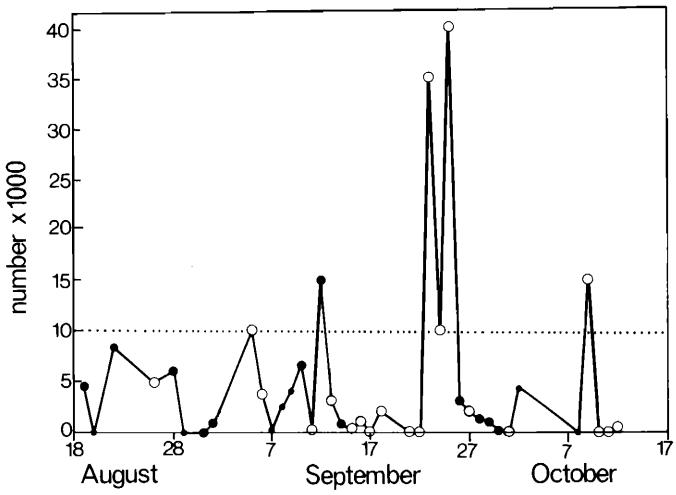

Figure 1. Variation in the maximum numbers of Knots counted on field days on Hengst from 19 August to 12 October 1992. Open circles indicate field days without aircraft activity, big dots indicate days with jet fighter or small airplane activity and small dots days when no information on aircraft activity was collected.

The maximum daily number of Knots present on Hengst fluctuated greatly between 19 August and 12 October. Numbers varied from no birds to a maximum of 40,000 birds (Figure 1). During the study period, the Knots present in the Wadden Sea are considered to be mostly of the *islandica*-subspecies and are undergoing a complete wing-, tail- and contour-feather moult (Boere & Smit 1980, Davidson & Wilson 1992, pers. obs.). This period is well before many birds have started the post-moult movement to their early winter areas such as the Wash in Britain . Hence, we would not expect temporal trends in the size of the local Knot population in the course of our study period, and indeed no such trend occurred (Figure 1). On jet fighter-days the average numbers of Knots on Hengst are much lower than on field days without aircraft (Table 1). Indeed, in five of the six cases when Knots numbered more than 10,000 birds, there was no aircraft activity. (This difference is not statistically significant from the 'null'-expectation based on the ratio of negative and positive aircraft days when numbers of Knots are lower than 10,000, exact p-value is 0.37 for a two-sided likelihood ratio test based on the Chi-square distribution.) Another way to look at the count data is to compare successive days with and without aircraft activity in order to avoid a possible seasonal bias (though admittedly introducing another one: carry-over effects between days). In 3 pairs of days the numbers of Knots were higher on the aircraft-free day, and in 5 pairs of days the numbers were lower on the aircraft-free day. Longer-term studies are required to establish if such effects are statistically significant.

During days when either jet fighters or light airplanes were active, the Knot-flocks on Hengst were less approachable than on days without aircraft (Table 1; the exact p-value according to a likelihood ratio test on the basis of a Chi-square distribution is 0.06, i.e. there is only a 6% chance of mistakenly attributing significance). Knots showed also a statistically significant greater restlessness (exact p=0.02). It should be noted that on all days that the Knots were difficult to approach they were also independently scored as restless. On days when they were easy to approach they were 'calm'. There was, however, one day without aircraft when

birds were difficult to approach. This was after a heavy night-time military shooting/training session close to their roost on south-central Vlieland. We suspect that this resulted in a heavy disturbance on the high-tide roost during darkness, and that the birds' restlessness may have been a lasting effect of this great disturbance.

Finally there are a few more qualitative phenomena to report. At the start of the study period in late August, a time when the majority of Knots must just have arrived, there was a more marked response to jet fighter flights than later on. The response to overflying jet fighters initially consisted of very short flights of part of the flock while other individuals remained on the ground but showed a light crouching response, stopping feeding for a time and looking up. With heavy jet fighter activity (>3 passages per min.) this crouching behaviour was shown even at the end of the study period. We had the definite impression that under foggy conditions the Knot flocks showed a more severe response to jet fighter overflights than under clear conditions but we could not properly quantify this effect. When light airplanes played low over the mudflats on 12 and 26 September the response was, however, clearly severe: Knot flocks left the area directly after the disturbance began.

Although there is thus some reason to believe that Knots become a little behaviourally 'adjusted' (i.e. habituated: less disturbed) once they have gained experience of the jet fighter-phenomenon this holds only for the individuals that are persistent in using the area throughout the season. The presence of low-flying jet fighters is likely at least subtly, and possibly severely, to decrease the carrying capacity of the area for Knots. The subtle effect is that a decrease in approachability is indicative of a much greater susceptibility to light disturbances. It is therefore a multiplier effect, and even small multiplier effects can do great damage given the right (negative) conditions. The possibly severe effect is that the increase in the numbers of unproductive flights during low-water periods decreases the overall time spent feeding and increases the energy expenditure (see also Belanger & Bedard 1989, 1990). Such opposite effects are prone to lead to a negative energy balance. There is no doubt in our minds that Knots find it very difficult to adjust to light airplanes in particular.

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