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PRIMARY MOULT SHOULD BE RECORDED INSIDE OUT

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The primary moult scores of Red-necked Stints obtained when moult is recorded from the inside to the outside of the wing differ from those obtained when moult is recorded from the outside in. It is suggested that this is because moult of inner primaries is more likely to be recorded accurately when the inner primary is used as the starting point.

Much has been written over the years (e.g. Ashmole *et al.* 1961) on whether primaries should be numbered from the inside towards the outside of the wing (i.e. 'inside out' or 'outwards') or from the outside towards the centre (i.e. 'outside in' or 'inwards'). Earlier authors (e.g. Witherby *et al.* 1938-1941) favoured the latter practice but, with some notable exceptions (e.g. Svensson 1984; Grant and Mullarney 1989), the more recent authoritative texts would seem to prefer numbering primaries from the inside out (e.g. Cramp and Simmons 1977 *et seq*; Ginn and Melville 1983; Marchant and Higgins 1990; Jenni and Winkler 1994). It is conventional and recommended practice for banders recording primary moult to work in the same way, from the inside out. Nevertheless, some workers still record primary moult from the outside in; we suspect this practice is more common in Britain than elsewhere, despite the apparent intention of the British Trust for Ornithology moult card for primary moult to be recorded from the inside out (Ginn and Melville 1983).

If the same data resulted regardless of the direction in which primary moult was recorded, the personal preferences of individual banders would be of little import. While examining a large data set on moulting adult Red-necked Stints *Calidris ruficollis* captured in coastal Victoria (Rogers *et al.* 1996), we found this not to be the case. The data set contains records of active primary moult of 7 812 Red-necked Stints banded by the Victorian Wader Study Group between 1978 and mid-1995. Data were recorded using the standard methods summarized in Figure 1 and described more fully in Ginn and Melville (1983) and Marchant and Higgins (1990). Red-necked Stints have an outwards sequence of primary moult, beginning moult at the inner primary (p1) and finishing with the outermost (p10). The very few unconventional moults (in which this did not apply) were excluded from consideration.

It is difficult to see how a controlled experiment to gather data allowing formal comparison of inwards and outwards primary moult-recording could be gathered without biassing the very error rates it is intended to investigate. The Red-necked Stint data set was unusual in that primary moult was recorded inwards for 1 790 and outwards for 6 022 birds. Over 98 per cent of the former were recorded between 1979 and 1981 by experienced banders; the same banders recorded primary moult from the inside out in other years of the study. Reasons for the diversion from usual practice in the 1979–1981 period are lost in the mists of time.

Differences in timing of moult of adult Red-necked Stints in Victoria from year to year are negligible (pers. obs.), as would be expected in a strongly migratory wader that shows great consistency in the timing of its brief breeding season and annual cycle of mass change (Rogers *et al.* 1996). Yet Figure 2 shows that there were striking differences between the primary moults recorded from the outside in, and from the inside out. The figure plots the percentage of times each active feather score was recorded for each primary. So, for example, when primary 3 was actively moulting and moult was recorded outwards, the frequencies with which feather scores of 1, 2, 3, and 4 were recorded were 45 per cent, 16 per cent, 20 per cent, and 19 per cent. The most marked feature of this figure is the relatively high frequency of recording feather scores of 1 on the inner three primaries when moult was recorded outwards; this is almost exactly counterbalanced by the high frequency with which feather scores of 4 were obtained for the inner three primaries when moult was recorded inwards. It is also interesting that feather scores of 1 and 2 were recorded more frequently for all but the two outer primaries when moult was recorded outwards. Why these differences should occur requires explanation. We suggest that recording primary moult from the outside in is wrong because it does not obligate identification of the innermost primary.

Sometimes, a processor recording primary moult from the inside out gets to the end of the wing without having found 10 primaries; it is then necessary to search the wing for the missing feather or gap. On the other hand, processors recording moult from the outside in may inadvertently miss gaps or pins and, not realizing that the end of the primaries has been reached, record one or more outer secondaries as inner primaries. This is an easy mistake to make when rushed. In effect, the outside-in moult-recorder lacks, through non-identification of the innermost primary, a means of knowing if a mistake is being made.

Figure 2 also shows that the outer two primaries are more likely to be given a score of 4 when moult is recorded from the inside out. Presumably outside-in processors were more apt to consider the outer primaries

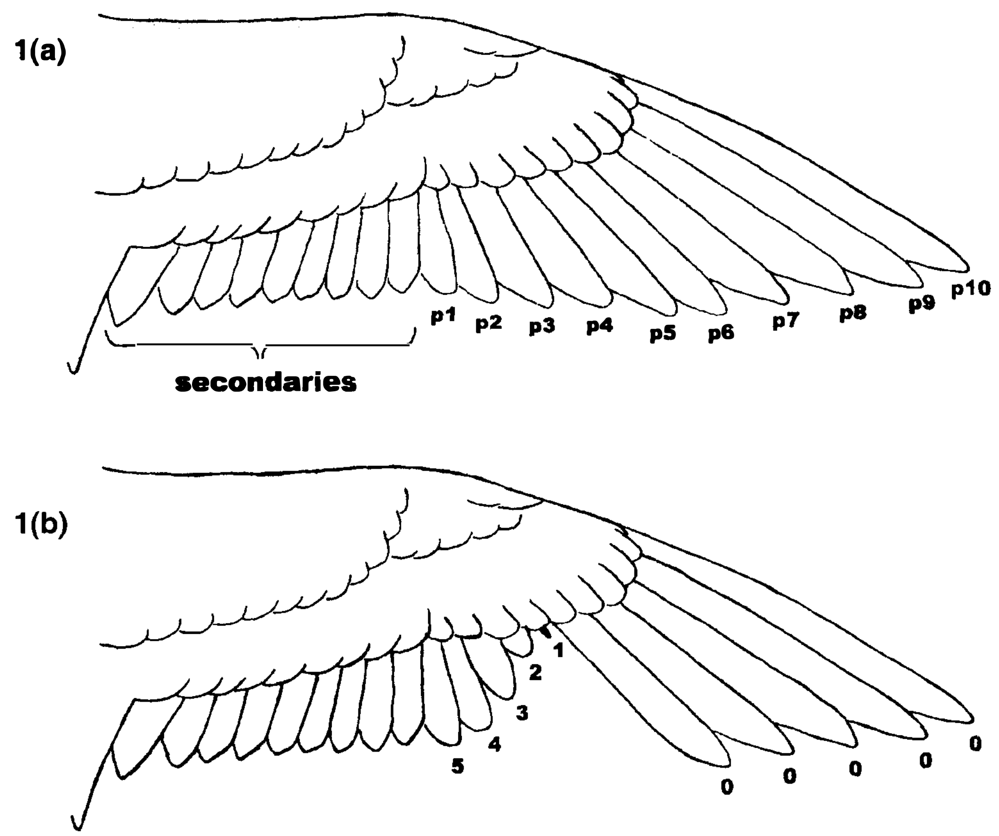

Figure 1. *(a) Outstretched wing of a non-moulting Red-necked Stint (dorsal view) with primaries numbered from the inside to the outside of the wing. Primary 1 is abbreviated to p1, and so forth. (b) Outstretched wing of a moulting Red-necked Stint (dorsal view) with the primary moult formula* $5^1 4^1 3^1 2^1 1^1 0^5$. *Growth stage of each primary is indicated on the figure: 0 = Old feather; 1 = feather that is missing or still in pin; 2 = feather that is out of pin but less than one-third grown; 3 = feather that is between one-third and two-thirds grown; 4 = feather that is more than two-thirds grown, but not fully grown; 5 = New, fully grown feather.*

to be fully grown than were inside-out processors. We are not sure why this should be so. Richard Major (pers. comm.) has suggested that inside-out moult-recorders benefit from a better frame of reference when examining the outer primaries; having seen the rest of the trailing edge of the wing while examining the inner primaries, they may be more likely to notice if the outer primaries are slightly shorter than they would be if fully grown.

Ashmole *et al.* (1961) wrote, '... the numbering of primaries by *any* method will not be reliable unless the position of the carpal joint is in fact established and unless the possibility of one or more of the primaries being absent (or only partially grown) is eliminated by counting all of them'. If this is true of counting feathers, how much more likely is it to be relevant to the correct recording of their moult? It is disturbing that for a wader studied by a highly competent banding team, there should be detectable differences between the records taken by inside-out and outside-in moult-recorders. We suspect that it may be still easier to make a mistake in many passerines in which the difference in shape of the outer secondaries and inner primaries is less marked than it is in waders.

Should the results presented here apply generally, systematic bias could be introduced to results based on recorded primary moult by the direction in which it was recorded. In our sample of Red-necked Stints, the apparent tendency of outside-in moult recorders to overlook inner primaries at stage 1 of growth, and to misidentify secondaries as fully grown inner primaries, will result in them recording higher primary moult scores than actually exist. Primary moult scores are often used in analytical methods for estimating the starting date and duration of moult (e.g. Underhill and Zucchini 1988; Underhill *et al.* 1990). In theory these methods can be used to test whether slight differences in timing of primary moult occur between populations, but such subtle comparisons will be of little value if the primary moult scores on which they are based are subject to substantial error.

It is clearly highly desirable that moult studies should report not only the direction in which the primaries are numbered as recommended by Ashmole *et al.* (1961) and Jenni and Winkler (1994) but also the direction in which moult was recorded in the field. This is also an important consideration when analysing data sets in which primary moult was recorded by a number of observers.

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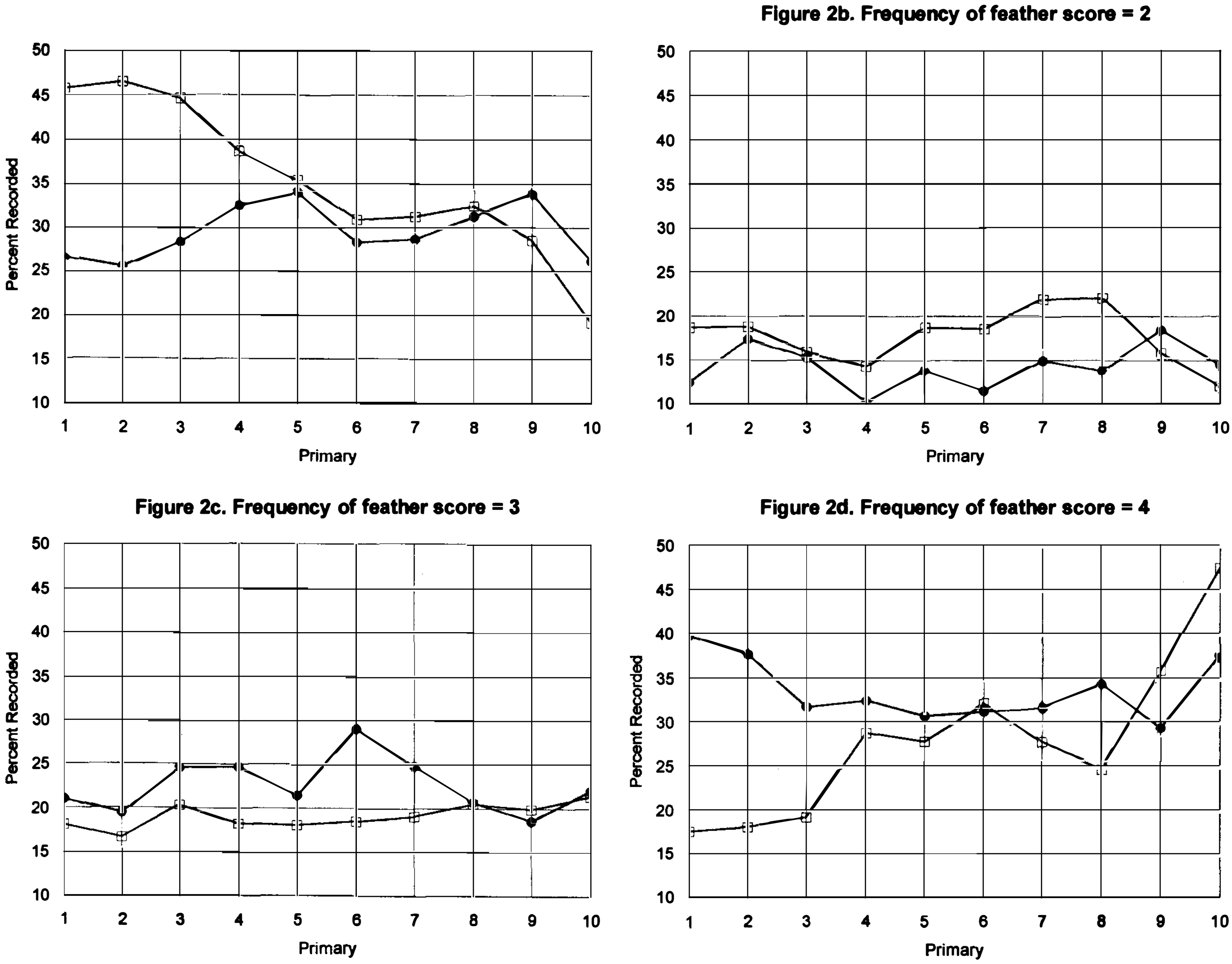

Figure 2. *Frequency with which each active moult score recorded for each primary. Empty squares, moult recorded inside out; filled circles, moult recorded outside in. Number of moulting feathers (Primary 1 = Innermost):*

Primary:	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Outwards recording:	1 047	994	936	921	882	915	1 018	980	1 049	1 614
Inwards recording:	256	247	236	255	247	262	335	406	393	409

inventing Australasian wader studies, and Mark and Terry Barter for ensuring that all this effort was not wasted by computerising all data recorded by the VWSG. Annie Rogers and Richard Major are thanked for their helpful comments on drafts of this paper and Andrew Dunn for his help with Figure 1.

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