Morphometric features of Pacific and American Golden-Plovers with comments on field identification

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We measured linear dimensions and evaluated identification criteria in Pacific and American Golden-Plovers (*Pluvialis fulva* and *P. dominica*) captured for banding. Most of the *fulva* sampled were wintering birds in Hawaii, representative of the mid-Pacific flyway; additional *fulva* and all *dominica* were from breeding grounds on the Seward Peninsula, Alaska. The sexes were monomorphic in *dominica*, and for all practical purposes in *fulva* as well. On average, *fulva* females had shorter head, bill, and tarsus lengths than males, but at a scale of <1.0 mm for each dimension. Interspecific comparisons showed longest wings in *dominica*, longest bills and tarsi in *fulva*, and no difference in head lengths. Unpublished data provided by colleagues studying plovers in Siberia and Canada enabled us to compare our Alaska findings with breeding grounds elsewhere. There appears to be little, if any, variation in *fulva* wing lengths from the eastern end (Seward Peninsula) to near the western end of the breeding range (Taimyr Peninsula); however, other linear dimensions decreased from east to west. American Golden-Plovers breeding on the Seward Peninsula (western end of their range) had shorter wings and tarsi, but longer bills than birds nesting at the opposite end of the range near Churchill, Manitoba. We found most field identification criteria described in the literature to be less than satisfactory because of variability and overlap between the two species. The only reliable characteristics were breeding plumage, number of primaries exposed beyond the longest tertials (2–3 in *fulva*, 4–5 in *dominica*), and primary projection past the end of the tail (estimated at 0–9 mm in *fulva*, 12–22 mm in *dominica*). In field situations involving moulting birds and birds in non-breeding plumage, unequivocal species identification may be impossible in some cases.

INTRODUCTION

The purposes of this paper are to report measurements obtained during banding of Pacific and American Golden-Plovers (*Pluvialis fulva* and *P. dominica*), and to shed light on criteria useful in identifying these somewhat similar species. Our long-term studies of plover ecology in Hawaii and Alaska together with more recent radiotelemetry investigations (Johnson *et al.* 1993; 1997a,b; 2001a,b,c) have involved numerous marked birds, with an especially large set of dimensions for *fulva*. The two taxa are relatively easy to distinguish when birds are in breeding plumage during spring and summer, but at other times identification can be problematic. Because species identity was certain for all plovers we sampled (every individual in breeding plumage), this was an ideal opportunity to evaluate various interspecific characteristics aside from breeding coloration. Examination of these features was prompted partly by inquiries from birders seeking advice about ways to separate the two species. These observers had seen what appeared to be *fulva* (migrants in non-breeding plumage) in regions where one would expect only *dominica*. We hope the comparisons and tests of field criteria presented here will prove helpful in such situations.

STUDY AREAS AND METHODS

Most of the *fulva* (n = 544, captured 1979–2002) came from three wintering ground study sites on Oahu, Hawaii: Bellows Air Force Station, Hickam Air Force Base, and National Memorial Cemetery of the Pacific (for descriptions and locations of these areas, see Johnson *et al.* 2001a,c). Additional *fulva* (n = 14, caught in 2000) were from a wintering population about 1,300 km southwest of Oahu at Johnston Atoll (16°44'N, 169°32'W), and others (n = 44, trapped 1988–2002) from breeding grounds on the Seward Peninsula, Alaska (64°51'N, 166°05'W; see Johnson *et al.* 2001b). All of the *dominica* (n = 46, trapped 1988–2003) were nesting birds captured on the Seward Peninsula at the same sites as *fulva* (the two species breed sympatrically in that region).

The plovers captured in Hawaii were caught 1–2 hours before sunrise in mist nets (Johnson *et al.* 1997b, 2001c). At Johnston Atoll, some birds were caught in mist nets, others in a self-triggering 60 cm diameter clap-net (patterned after the "luchock" design, Priklonsky 1960) baited with boiled egg. In Alaska, both *fulva* and *dominica* were captured on their nests with either the clap-net or a drop trap.

All of the birds were banded in the spring or summer when they were either nearing departure from wintering grounds (late March–April, Oahu and Johnston Atoll) or nesting (late May–June, Alaska). Each individual was in sexually dimorphic breeding plumage when examined, and primary feathers of adults that had been replaced during the winter were completely grown (Johnson & Johnson 1983, Johnson & Connors 1996). First-year *fulva* were readily identified from their worn, retained juvenile primaries; no similar age-criterion is apparent in *dominica* (Connors 1983, Johnson & Johnson 1983, Johnson & Connors 1996, Byrkjedal & Thompson 1998).

We recorded the usual morphometric dimensions: wing length (flattened, straightened primaries) to the nearest 1.0 mm; total head length (posterior occipital to tip of bill), bill length (along culmen to junction with feathering on forehead), and tarsus length (tibio-tarsal joint to distal end of tarsus) to 0.1 mm. Each measurement followed the technique illustrated by Howes & Bakewell (1989). Sometimes, especially when we had larger catches, not all measurements were made on every individual. Our wing, head, bill, and tarsus means incorporate smaller Oahu and Seward Peninsula samples reported earlier by Johnson & Connors (1996). Several colleagues provided us with unpublished measurements from *fulva* captured (in some cases freshly collected) at various breeding ground sites in Siberia; and from *dominica* nesting near Churchill, Manitoba. These data sets, compiled with the same measurement techniques as we used, allowed statistical comparisons between our findings and dimensions of plovers from other regions.

Supplementing the standard measurements, we made a systematic effort (mostly in 2002 and 2003) to evaluate additional dimensions and characteristics that various sources (see Johnson & Connors 1996, and Byrkjedal & Thompson 1998) have considered useful as interspecific criteria. From captured birds, we recorded two features of the folded wing: the number of primary tips exposed beyond the longest tertials, and the distance (to 0.1 mm) between the tips of primaries 9 and 10. We also measured (to 0.1 mm) the length of the unfeathered tibia (from the tibio-tarsal joint to the tips of feathers encircling the proximal tibia), bill length in relation to the eye, and distance from the base of the bill to the rear edge of the eye. The two eye-related measurements were made along a straight line extending from the tip of the bill across the eye and bisecting the nasal opening. Bill length thus measured was then projected rearward to determine whether this dimension fell on or beyond the eye. From birds not in hand, we estimated with binoculars or spotting scope: the distance the primaries projected beyond the tail (using average bill length from Table 1 as a gauge), and where tertial tips were positioned in relation to length of the tail. Both of these estimates involved birds in what we judged to be typical postures during foraging and loafing behaviours.

Table 1. Length measurements (in mm) of Pacific and American Golden-Plovers[a]. Data shown as means±SD (range, *n*).

	Pacific Golden-Plover[b]	American Golden-Plover[c]
Wing	172±4.1 (158–184, 411) 168±4.2 (148–178, 191)	184±3.9 (176–192, 46)
Total head	58.5±1.3 (54.1–62.1, 433)	58.2±1.0 (55.6–60.1, 42)
Bill	24.3±1.1 (20.2–27.6, 441)	22.8±0.8 (21.0–24.7, 45)
Tarsus	45.9±1.6 (41.7–49.9, 419)	44.1±1.2 (41.9–46.6, 43)

[a] For both species, sexes are pooled throughout the table (see Results).

[b] The sample consists of birds from Oahu, Johnston Atoll, and the Seward Peninsula, Alaska (see Methods). First line of wing length = pooled adults; second line = pooled first-year birds. The two groups were separated because first-year *fulva* have wings shortened by wear of juvenile primaries. All other numbers for Pacific Golden-Plovers in the table represent pooled adult and first-year birds.

[c] Measurements are from nesting birds on the Seward Peninsula. Criteria for identifying first-year American Golden-Plovers are uncertain, thus each value = pooled sample of all birds examined.

RESULTS

Standard linear dimensions

Wing, head, bill, and tarsus measurements are shown in Table 1, and summarized here for each species.

Pacific Golden-Plover

We pooled the wing lengths of adult males and females as there was no significant difference between them ($t = 0.77$, $P = 0.44$, df = 409). Variable wear of juvenile primaries made a similar test infeasible for first-year plovers, and we pooled wing lengths for the entire first-year group. The difference in wing length between adults and first-year birds (172 mm vs. 168 mm) was highly significant ($t = 12.04$, $P < 0.0001$, df = 600). Other linear comparisons between adult and first-year males, and between adult and first-year females showed no differences in total head length (males, $t = 0.80$, $P = 0.43$, df = 246; females, $t = 1.88$, $P = 0.06$, df = 183); bill length (males, $t = 0.04$, $P = 0.96$, df = 252; females, $t = 1.27$, $P = 0.20$, df = 185); or tarsus length (males, $t = 1.03$, $P = 0.30$, df = 239; females, $t = 0.25$, $P = 0.80$, df = 176). Thus, for head, bill, and tarsus we pooled adult and first-year samples for each sex. Analysis of the pooled samples revealed slight, but nonetheless significant, differences with females averaging smaller than males for all dimensions: total head length (58.0 mm vs. 58.9 mm, $t = 7.16$, $P = <0.0001$, df = 431); bill length (24.2 mm vs. 24.5 mm, $t = 2.93$, $P = 0.003$, df = 439); and tarsus length (45.6 mm vs. 46.1 mm, $t = 2.88$, $P = 0.004$, df = 417). Dimorphism at this scale (<1.0 mm for each measurement) has essentially no practical application. Therefore, we considered it reasonable to disregard sex altogether and merge head, bill and tarsus measurements. Among adults, we found negligible correlation between wing length and tarsus length ($r^2 = 0.05$, $P = 0.0001$, df = 310), and wing length and total head length ($r^2 = 0.06$, $P = <0.0001$, df = 318). For pooled adults and first-year birds, there was slight positive correlation between total head length and tarsus length ($r^2 = 0.20$, $P = <0.0001$, df = 406), and tarsus length and bill length ($r^2 = 0.10$, $P = <0.0001$, df = 416).

American Golden-Plover

We pooled wing lengths since there was no significant difference between males and females ($t = 1.50$, $P = 0.14$, df = 44). The same was true of total head length ($t = 0.31$, $P = 0.76$, df = 40), bill length ($t = 1.32$, $P = 0.19$, df = 43), and tarsus length ($t = 0.25$, $P = 0.80$, df = 41). There was essentially no correlation between wing length and tarsus length ($r^2 = <0.01$, $P = 0.72$, df = 41); negligible correlation between wing length and total head length ($r^2 = 0.02$, $P = 0.41$, df = 40), and tarsus length and bill length ($r^2 = 0.04$, $P = 0.19$, df = 41); and weak positive correlation between total head length and tarsus length ($r^2 = 0.17$, $P = 0.007$, df = 40).

Interspecific comparison

Wing lengths were much different in the two species with *dominica* averaging 12 mm longer than *fulva*. We found no significant difference between total head lengths (58.5 mm in *fulva* vs. 58.2 mm in *dominica*; t = 1.52, P = 0.13, df = 473). However, bill and tarsus lengths were significantly different: 24.3 mm in *fulva* vs. 22.8 in *dominica* (t = 9.43, P = <0.0001, df = 484); and 45.9 in *fulva* vs. 44.1 in *dominica* (t = 7.20, P = <0.0001, df = 460).

Variation across breeding ranges

In each species, we found statistically significant differences between our sample populations and comparable unpublished measurements from other geographic areas (Table 2). *P. fulva* from the Alaska end of the species' range showed a clear tendency for larger size in all dimensions except wing length as compared to birds near the opposite end of the range on the Taimyr Peninsula; and *dominica* from the Seward Peninsula had shorter wings and tarsi than birds at Churchill, but averaged longer bills than the latter (Table 2).

Features and measurements relating to field identification

Disregarding breeding plumage, the number of primary tips exposed beyond the longest tertials and the projection of primary tips relative to the distal end of the tail were the most satisfactory interspecific criteria (Table 3). All birds captured for banding and numerous free-ranging individuals were clearly separable (though see Fig. 2) to species from primary tips visible past the tertials (2–3 in *fulva*, 4–5 in *dominica*). Of 44 *fulva* in the hand, almost all (42) had three exposed tips, only two individuals showed two tips; among 23 captured *dominica*, 22 had four exposed primaries and one bird five. Similarly, the projection of primary tips past the tail was obviously different in the two species. Among *fulva* (n = 50), estimates ranged from 0 mm (primary tips aligned with rectrix tips, in a few cases the primaries actually fell slightly short of the end of the tail) to an estimated maximum of 9 mm beyond the tail. In *dominica* (n = 34), estimated projection past the tail ranged from 12–22 mm. Relative to the bill, these dimensions approximate primary projection of <½ bill length in *fulva* and ≥½ bill length in *dominica*.

Other identification clues (bill length, tarsus length, distance between the tips of primaries 9 and 10, length of the unfeathered tibia, bill/eye relationships, and tips of tertials in relation to the tail) were less useful field characteristics as we found considerable interspecific overlap for all of these features (Tables 1 & 3). The separation between primary tips 9 and 10 ranged from 0 mm (feathers the same length) to 6 mm among *fulva*, and from 2–9 mm in all *dominica* but one (the latter individual scaled 0.5 mm). Of 44 *fulva*, 9 birds (20%) showed primary tip separation of 1 mm or less; most *dominica* (17 of 23, 74%) exceeded 4 mm. Mean length of the unfeathered tibia differed significantly between the two plovers (t = 7.82, P = <0.0001, df = 58) with *fulva* averaging nearly 4 mm longer than *dominica*. When projected rearward, the bill extended beyond the eye in nearly all *fulva* (91%) and most *dominica* (62%) with mean distance past the rear edge of the eye 2.6 mm and 1.6 mm, respectively. Although mean distance from the base of the bill to the rear

Table 2. Comparable mean linear measurements (in mm) of Pacific and American Golden-Plovers from different parts of their breeding ranges[a].

Region[b] & source	Wing	Total head	Bill	Tarsus
P. fulva[c]				
1. This study, Seward Peninsula sample only	170 (158–178, 44)[d]	57.2 (54.1–59.3, 44)	23.2 (20.2–25.5, 44)	44.8 (42.0–48.2, 44)
2. Anadyr region, P. Tomkovich (in litt.)	172 (166–177, 11)	56.9 (55.2–59.0, 10)	23.5 (21.9–26.6, 11)	43.9 (42.5–46.6, 10)
3. northeastern Yakutia, Gavrilov (1998)	170 (59)	–	**26.2** (59) P = <0.0001	**43.3** (59) P = 0.003
4. eastern Taimyr Peninsula, M. Soloviev & T. Sviridova (in litt.)	**167**(158–174, 75) P = <0.0001	**56.4** (53.3–58.6, 79) P = 0.002	22.9 (20.2–25.6, 79)	**43.5** (40.5–47.4, 79) P = <0.0001
5. northern Taimyr Peninsula, P. Tomkovich (in litt.)	170 (162–178, 23)	**56.2** (54.5–57.9, 9) P = 0.049	**22.6** (20.8–23.9, 23) P = 0.047	44.3 (41.8–50.4, 23)
6. western Taimyr Peninsula, H. Schekkerman & I. Tulp (in litt.)	169 (158–177, 56)	**56.4** (51.4–59.3, 56) P = 0.009	**22.1** (19.9–24.8, 57) P = <0.0001	**42.9** (39.3–47.9, 56) P = <0.0001
P. dominica				
7. This study, Seward Peninsula	184 (176–192, 46)	58.2 (55.6–60.1, 42)	22.8 (21.0–24.7, 45)	44.1 (41.9–46.6, 43)
8. Churchill, Manitoba J. Klima (in litt.)	**190** (183–198, 31) P = <0.0001	58.7 (56.2–60.4, 3)[e]	**22.3** (20.8–24.2, 30) P = 0.014	**44.9** (41.7–47.6, 38) P = 0.007

[a] Bold indicates those dimensions that differ significantly (by t-tests at 0.05 level of significance) from our Seward Peninsula samples (no. 1, *fulva*; or no. 7, *dominica*).

[b] Geographic coordinates: 1 & 7 Seward Peninsula this study – 64°51'N, 166°05'W; 2. Anadyr region – two sites at 64°22'N, 177°25'E and 64°55'N, 168°35'E; 3. northeastern Yakutia – approx. 68°N, 160°E; 4. eastern Taimyr – 72°51'N, 106°02'E; 5. northern Taimyr – three sites between 76°04'N, 98°32'E and 73°37'N, 82°20'E; 6. western Taimyr – 73°20'N, 80°32'E; 8. Churchill – 58°44'N, 93°49'W.

[c] All of our dimensions for Seward Peninsula *fulva* represent pooled adult (n = 35) and first-year birds (n = 9). In Table 1, we calculated wing lengths separately for the two age groups, but here we have merged them for consistency with other wing length means in the table which presumably include at least some first-year individuals.

[d] Ranges and/or sample sizes in parentheses.

[e] Insufficient data for t-test.

margin of the eye showed only slight interspecific variation (22.0 mm in *dominica* vs. 21.4 mm in *fulva*, Table 3), the difference was statistically significant (t = 3.02, P = 0.003, df = 71). Almost all *fulva* had tertials extending close to the end of the tail. This feature varied among *dominica* with tertial tips ranging from about mid-tail to near its terminus like *fulva*.

DISCUSSION

Recent radio-tagging studies of Pacific Golden-Plovers have shown a major mid-Pacific migratory link between wintering grounds on Oahu and breeding grounds in Alaska (Johnson *et al.* 1997b, 2001a; O.W. Johnson *et al.* unpubl. data). From these findings and other records (Johnson & Connors 1996), it is reasonable to assume that *fulva* wintering in the north-central Pacific are from the eastern end of the breeding range – especially Alaska and perhaps also adjacent Siberia. Notably, Barter's (1988) measurements of *fulva* in Victoria, Australia (total head length of 57.2 mm, n =30; wing and bill lengths in Table 4), suggest similar provenance for birds in that part of the winter range. Alaska nesting grounds are at the extreme eastern end of the Pacific Golden-Plover breeding range, most of which extends westward across Siberia to the Yamal Peninsula. Conversely, our sample of American Golden-Plovers is from the western end of their North American breeding range, and in a region where *fulva* and *dominica* nest sympatrically. Details of breeding and wintering distribution for both plovers are described by Johnson & Connors (1996), Byrkjedal & Thompson (1998), and Johnson *et al.* (2001a).

Our findings of significant interspecific differences (i.e., *fulva* averaging shorter wings, but longer tarsus and bill than *dominica*), and essentially no intraspecific variation in measurements between the sexes in either species agree with earlier studies (Connors 1983, Cramp & Simmons 1983, Paulson 1993, Johnson & Connors 1996, Byrkjedal & Thompson 1998). Sexual monomorphism also is characteristic of the other two *Pluvialis* species (Eurasian Golden-Plover *P. apricaria* and Grey Plover *P. squatarola*; Jukema and Piersma 1992, Byrkjedal & Thompson 1998, Yalden & Pearce-Higgins 2002). Table 4 summarizes published dimensions for *fulva* and *dominica*. We refer to this compilation mostly in passing since comparing these reports with present findings is complicated by several factors including: differences in methodology [particularly when measuring wing lengths as the sources in Table 4 variously used chord dimensions (Johnston & McFarlane 1967, Connors 1983), flattened primaries, possibly not straightened (Parmelee *et al.* 1967), flattened and straightened primaries (Vaurie 1964, Prater *et al.* 1977, Cramp & Simmons 1983, Barter 1988, Johnson *et al.* 1989), or unspecified methods (Dementiev *et al.* 1951, Kozlova 1961, Portenko 1972, Byrkjedal & Thompson 1998)]; shrinkage of museum specimens which tends especially to reduce wing lengths (Prater *et al.* 1977); and unknown fractions of first-year *fulva* in most samples (i.e., birds with worn juvenile primaries, see Methods) which would bias wing length means. Determining maximum wing length by flattening and straightening primaries, thus eliminating all curvatures, is much the preferred method (see Evans 1986) as it rules out variation in measuring technique. In living and/or freshly collected *fulva*, the difference between this and other methods (chord, or flattened primaries not straightened) has been found to vary for individual birds by 4–12 mm (O.W. Johnson unpubl., M. Soloviev & T. Sviridova in litt., P. Tomkovich in litt.); presumably, *dominica* vary similarly. We discount the short tarsus lengths (Table 4) reported in each species by Vaurie (1964) and Prater *et al.* (1977) as they deviate from the rest of the table and probably indicate a difference in measurement techniques.

In Table 2 we compare our findings on the Seward Peninsula with unpublished dimensions from breeding grounds elsewhere. Because all these data were obtained using the same measurement procedures, problems like those mentioned above are of little concern. Reading downward, the records for *fulva* are arranged from east to west. In a systematic review of the genus *Pluvialis* from museum specimens, Vaurie (1964) reported mean *fulva* wing lengths of 171 mm in Alaska (almost the entire sample was "collected on the Seward Peninsula") vs. 166 mm in "northeastern Siberia" (exact locations not indicated). Vaurie's findings, along with other measurements from Siberia (Table 4), implied that

Table 3. Features associated with field identification of Pacific and American Golden-Plovers[a,b]. Mean in mm±SD (range, n) given where possible.

	Pacific Golden-Plover	American Golden-Plover
Primary tips exposed beyond longest tertials	2–3 in all birds (n = 44)	4–5 in all birds (n = 23)
Primary projection past end of the tail[c]	0–9 mm (n = 50)	12–22 mm (n = 34)
Distance between the tips of primaries 9 & 10	2.7±1.7 (0–6.0, 44)	5.0±1.7 (0.5–9.0, 23)
Length of unfeathered tibia	20.4±1.8 (17.6–24.1, 37)	16.7±1.7 (14.8–21.2, 23)
Percent with bill projecting beyond rear edge of eye[d]	91% (40 of 44)	62% (18 of 29)
Bill projection beyond eye[d]	2.6±1.2 (0.2–5.2, 40)	1.6±0.9 (0.3–3.7, 18)
Base of bill to rear edge of eye[d]	21.4±0.9 (19.0–23.1, 44)	22.0±0.9 (20.0–24.0, 29)
Tertial length relative to tail length[c]	tertials extend to distal third of tail, end at or near tail tip in most birds	variable from half to distal third of tail

[a] Features considered here are based on descriptive summaries of the two species by Johnson & Connors (1996) and Byrkjedal & Thompson (1998).

[b] Where n = 40 or 44 *fulva*, the sample consists of 12 from the Seward Peninsula, Alaska, remainder captured on Oahu, Hawaii; where n =37, 28 were caught on Oahu and 9 on the Seward Peninsula. All *dominica* were trapped on the Seward Peninsula.

[c] Estimates based on observations of free-ranging birds (see Methods).

[d] See Methods for procedures relating to bill/eye measurements.

Alaskan *fulva* tended to be longer-winged than Siberian *fulva* (Johnson & Connors 1996, Byrkjedal & Thompson 1998). However, the wing lengths reported here from living and freshly collected birds do not substantiate this as we found with only one exception (eastern Taimyr) no significant variation from the Seward Peninsula westward (Table 2). With regard to other linear dimensions, there were no apparent differences between our Alaska sample and *fulva* measured in the Anadyr region of eastern Siberia. This changed further westward in Siberia where birds had significantly shorter (though actual values are relatively small) heads, bills, and tarsi (Table 2). A similar east to west pattern is evident in bill and tarsus measurements compiled from museum specimens by Byrkjedal & Thompson (1998). Because the head, bill, and tarsus samples in Table 2 overlapped broadly between regions, none of these dimensions offers much promise as a criterion for identifying *fulva* from specific areas of the breeding range. Notably, Gavrilov's (1998) mean bill measurement from Yakutia is approximately 3–4 mm longer than any other *fulva* sample in Table 2. Whether this has to do with measurement technique or reflects a regional difference (we suspect the former) is uncertain.

Our sample of American Golden-Plovers in western Alaska had significantly shorter wings and tarsi, and longer bills than their counterparts across the continent at Churchill, but measurements in the two groups overlapped substantially (Table 2). Contrary to our findings from live birds, Byrkjedal & Thompson's (1998) examination of *dominica* study skins collected at opposite ends of the breeding range ("SW" and "NW Alaska" compared to "W. Hudson B.") showed only slightly shorter wings in the west (approximately 180 mm vs. 182 mm), nearly equivalent bill lengths, and longer tarsi in the west (about 44 mm vs. 42 mm).

The remaining discussion concerns field identification of the two species, and includes certain features of plumages, moulting, and migration (for detailed treatments of the latter topics, see Johnson & Connors 1996, Byrkjedal & Thompson 1998). Because *dominica* begin departing their South American wintering grounds as early as January, most pre-breeding moulting takes place while birds are en route north. A similar pattern occurs with *fulva* wintering in the far Southern Hemisphere, whereas birds in Hawaii typically complete their pre-breeding moult before departure. Thus in both species, the plumages of spring transients may vary from partial breeding (with attendant problems of identification) to full breeding depending on where and when the plovers are observed. From roughly April to July, breeding plumage is fully developed and identification problems are minimal as birds (especially males) show well defined interspecific differences in breeding coloration that are clearly depicted in most field guides. Adults begin their post-breeding body moult on the nesting grounds, and by fall migration the mix of old and new feathers may blur the distinction between species. Various sources (e.g., Golley & Stoddart 1991, Johnson & Connors 1996, Mullarney *et al.* 1999, Sibley 2000) have pointed out that in all plumages

Table 4. Mean linear measurements (in mm) of Pacific and American Golden-Plovers from other investigations[a,b].

Region & Source(s)	Wing	Bill	Tarsus
P. fulva			
Siberia (mostly museum specimens: Dementiev *et al.* 1951, Kozlova 1961, Vaurie 1964, Portenko 1972, Cramp & Simmons 1983)	160–166 (26–121)	23.4 (51)[c]	43.5 (51)[c]
Alaska, Siberia, St. Lawrence Is., Japan, Korea, China, Pacific Islands (museum specimens: Connors 1983)	165 (60)	23.5 (60)	44.4 (60)
Seward Peninsula (museum specimens: Vaurie 1964)	171 (46)	29.3 (46)[d]	40.9 (46)
Wake Island (freshly collected specimens: Johnston & McFarlane 1967)	163 (43)	—	—
Enewetak Atoll (freshly collected specimens: Johnson *et al.* 1989)	172 (31)	—	—
Australia (captured specimens: Barter 1988)	174 (35)	23.7 (31)	—
Not indicated (museum specimens: Prater *et al.* 1977)	163 (60)	22.5 (70)	41.6 (68)
Not indicated (museum specimens: Byrkjedal & Thompson 1998)	164 (193)	22.9 (189)	43.8 (192)
P. dominica			
northern Canada (freshly collected & museum specimens: Vaurie 1964, Parmelee *et al.* 1967, Cramp & Simmons 1983)	181–185 (8–148)	21.7–23.3 (8–147)[e]	42.4–43.3 (8–147)[e]
Alaska, Canada (museum specimens: Connors 1983)	177 (77)	22.6 (77)	43.7 (77)
Pt. Barrow (museum specimens: Vaurie 1964)	184 (32)	30.7 (32)[d]	40.0 (32)
Not indicated (museum specimens: Prater *et al.* 1977)	183 (40)	23.1 (54)	41.4 (56)
Not indicated (museum specimens: Byrkjedal & Thompson 1998)	179 (282)	22.5 (279)	43.4 (273)

[a] Portions of the table are from a compilation by Johnson & Connors (1996).

[b] Some sources give measurements for each sex. Based on ample evidence of no linear variation between the sexes (see text), we simplified the table by averaging these measurements. Where a range is shown, the data represent different parts of a particular region. Sample sizes listed in parentheses.

[c] Bill and tarsus measurements from Cramp & Simmons (1983).

[d] Measured from skulls.

[e] Bill and tarsus measurements from Parmelee *et al.* (1967), Cramp & Simmons (1983).

fulva typically have more brightly coloured yellowish upperparts than *dominica*, the latter tending to be greyish. While this difference is often a useful field distinction, particularly with birds in either juvenile or non-breeding plumage, it is by no means infallible. We have observed individual *fulva* with *dominica*-like greyish feathering (similar to Plate 13 in Golley & Stoddart 1991) during fall and winter in Hawaii; and other workers have noted deceptive interspecific overlap in juvenile and non-breeding plumages such that coloration could not be used to identify the species of some individuals (Connors 1983, Dunn *et al.* 1987, Marchant & Higgins 1993, Paulson 1993, Beaman & Madge 1998).

Most identification problems will occur from August to March when birds are not in breeding plumage, and during that period structural features (Table 3) become especially important as interspecific criteria. Of the features listed, the first two (exposed primary tips and primary projection beyond the tail) were by far the most useful and accurate. Presumably, the number of primaries visible beyond the tertials (2–3 in *fulva*, 4–5 in *dominica*) remains a reliable indicator throughout fall migration as tertials probably are not shed until birds reach winter quarters. However, the moult and wear of tertials need further evaluation. It is important to note that very close spacing of primary tips 9 and 10 (relatively common in *fulva*, much less frequent in our sample of *dominica*) may give the visual impression of a single feather when viewed in the field, and thus lead to an incorrect count. This is unlikely to result in misidentification of *fulva*, but it could be misleading for some *dominica* (i.e., counting three tips past the tertials when there are actually four). Projection of the outermost primaries past the tail (0–9 mm in *fulva*, 12–22 mm in *dominica*) is likely a solid criterion during most of the year in both species, except when these feathers are being replaced during the annual moult on wintering grounds (Johnson & Connors 1996, Byrkjedal & Thompson 1998).

Although our measurements further substantiated that *fulva* have on average a longer bill and leg (both tarsus and unfeathered tibia) and less distance between the tips of primaries 9 and 10 than *dominica*, there was considerable interspecific overlap (Tables 1 & 3). Thus, these features have only limited application in the field. Other investigators reached similar conclusions about leg and bill lengths pointing out the subjective nature of estimating such dimensions in field situations (see caveats in Dunn *et al.* 1987, Golley & Stoddart 1991, Paulson 1993, Mullarney *et al.* 1998). Some have suggested bill shape as a helpful identification feature. However, descriptions are confusing and somewhat contradictory: e.g., *fulva* have the "slimmest bill" and *dominica* have "a broader base to the bill" (Golley & Stoddart 1991), *fulva* have a "thick" bill as compared to a "short thin bill" in *dominica* (Alsop 2001), "bill appears thicker" in *fulva* (National Geographic Society 2002). Our photos (Fig. 1) show that these subtleties are inconsistent and certainly too subjective to be reliable field criteria.

We were especially curious as to the usefulness of bill/eye relationships put forth by Byrkjedal & Thompson (1998) who state that when the bill is projected rearward it "reaches well beyond the eye in Pacific, but barely across the eye in American Golden-Plovers". Although we often found this to be correct, there also were individuals in each species with the opposite pattern such that their identities (if based only on this characteristic) could easily be misinterpreted (Table 3, Fig. 1). Moreover, this criterion was difficult to apply in the field as bill length relative to the eye was frequently impossible to assess without the bird in hand.

The tertial/tail relationship as a field mark was described by both Golley & Stoddart (1991) and Byrkjedal & Thompson (1998). According to the latter source, "the tip of the longest tertial ends just beyond the tail basis in the American, but over the outer third of the tail in the Pacific". Most of the *fulva* we observed conformed to the stated pattern, but *dominica* were more variable with tertials ranging from about the half-way point on the tail to the distal third. In a few instances, we noted individuals with tertials somewhat shorter (*fulva*) or longer (*dominica*) than more typical birds (Figs 2 & 3). All such variants retained species-specific wing and tail features (i.e., visible primary tips and primary projection beyond the tail), though the wings of the *dominica* shown in Fig. 2 required close viewing to confirm four exposed primary tips. Conceivably, someone observing the same plover at much greater distance might be able to see only three exposed primaries (suggesting *fulva*) on a bird that could be in partial breeding or nonbreeding plumage. However, there should be no confusion as to species since the long primary projection of this individual (about the same length as the bill) would clearly indicate *dominica*.

Based on our findings of extensive morphometric overlap between *fulva* and *dominica* along with scant statistical correlation between linear measurements, we conclude that there are only three reliable visual criteria for distinguishing these two plovers in the field: primary exposure beyond the tertials, primary projection past the end of the tail (both features less accurate when birds are moulting on wintering grounds), and breeding plumage during spring and part of the summer. Other features (bill and leg lengths, distance between tips of primaries 9 and 10 on the folded wing, etc.) are often helpful in any season, but they can also be misleading.

The two species are illustrated and described relatively well in major field guides (Mullarney *et al.* 1999, Kaufman 2000, Sibley 2000, Alsop 2001, National Geographic Society 2002). However, there are problems in some of these guides that might cause confusion: Kaufman gives no details on primary/tertial/tail characteristics saying only that "fall and winter" *fulva* "have shorter wingtips" than *dominica*; Mullarney *et al.*, Kaufman, and Alsop all lack sufficient information on females and sexual dimorphism; neither Kaufman nor Alsop treat juvenile plumages adequately; Sibley gives confusing plumage time frames for both taxa as adults with "nonbreeding" feathering in "Apr" and full "breeding" plumage in "Sep" do not fit known moult schedules (Johnson & Connors 1996, Byrkjedal & Thompson 1998); the breeding range map for *fulva* in Alaska (see Johnson *et al.* 2001a) needs revision in each of the field guides listed (except Mullarney *et al.* which does not include a map); Sibley describes a "flight song" only for *dominica* as "wit wit weee wit wit weee", but a very similar call also is characteristic of *fulva* and in both species this vocalization is often given on the ground (see "complex whistle" in Johnson & Connors 1996, "trilling song" in Byrkjedal & Thompson 1998), neither the foregoing call nor any of several other breeding ground vocalizations (all fundamental to separating the two forms on the tundra, see Connors *et al.* 1993, Johnson & Connors 1996, Byrkjedal & Thompson 1998) are mentioned in any of the other treatments. Of the field guides listed, Mullarney *et al.* and Sibley provide the most useful comparisons of the two species. For anyone seeking a photographic array of these plovers, we recommend: Dunn *et al.* (1987), Golley & Stoddart (1991), Paulson (1993), Rosair & Cottridge (1995) though one of the *fulva* they label as "breeding male" is actually a moulting bird of uncertain sex, and Byrkjedal & Thompson (1998).

Finally, our best advice to birders trying to interpret a questionable plover in non-breeding plumage is to concentrate mostly on its primary tip exposure and primary projection characteristics. Recognize also (we concur with Hayman *et al.* 1986, Dunn *et al.* 1987, Paulson 1993, Kaufman 2000) that despite the best efforts of dedicated observers to confirm extralimital records of these plovers, some of the latter will be impossible to identify with certainty.

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Fig. 1. Bill/eye relationships in plovers nesting on the Seward Peninsula, Alaska. By scaling along a straight line passing from the tip of the bill across the nasal opening to the eye (see Methods), the reader can easily verify the following dimensions: *upper left* – male *fulva*, backward projection of bill extends beyond the eye; *upper right* – female *fulva*, bill projects to rear edge of eye; *lower left* – male *dominica*, bill falls at rear of eye; *lower right* – female *dominica*, bill extends beyond the eye. Left hand photos are consistent with Byrkjedal & Thompson's (1998) rearward projection of the bill as an interspecific criterion (see Discussion); right hand photos are not. Also, note variability in the shapes of bills (see Discussion).

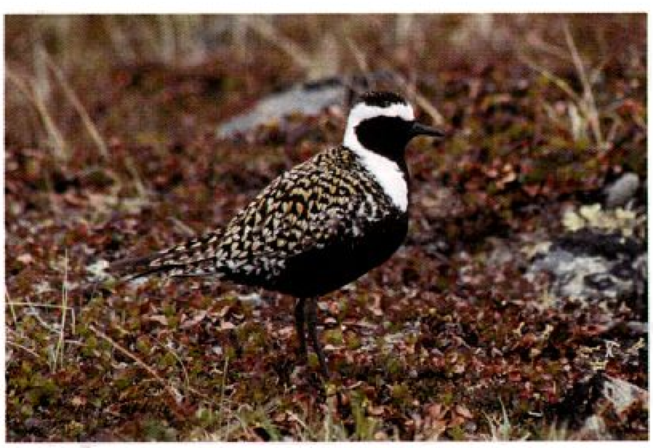

Fig. 2. Breeding male *dominica* photographed on the Seward Peninsula, Alaska. This individual shows the lengthy projection of primaries past the tail characteristic of the species. However, the tertials are unusual as they extend *fulva*-like to near the distal end of the tail. As the bird moved about while being photographed, it was evident that the tip of the 7th primary was visible (but just barely) beyond the longest tertial.

Fig. 3. Two male *fulva* in breeding plumage just before spring migration from Oahu. Like many *fulva*, both birds have primary tips more or less aligned with the end of the tail, but their tertials resemble those of some *dominica* in that they extend only to about half the length of the tail.